Protecting America's Future

Y-12 NATIONAL SECURITY COMPLEX

MANAGED BY
BWXT Y-12, L.L.C.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

UCN-13672 (11-03)

Y/TS-1983/R1/V1-V5

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

Y/TS-1983/R1/V1-V5

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This document is a compendium of water quality and hydrologic characterization data obtained through December 2005 from the network of groundwater monitoring wells and surface water sampling stations (including springs and building sumps) at the U.S. Department of Energy (DOE) Y-12 National Security Complex (Y-12) in Oak Ridge, Tennessee that have been sampled since January 2003. The primary objectives of this document, hereafter referenced as the Y-12 Groundwater Protection Program (GWPP) Compendium, are to:

- Serve as a single-source reference for monitoring data that meet the requirements of the Y-12 GWPP, as defined in the Y-12 GWPP Management Plan (BWXT Y-12 L.L.C. [BWXT] 2004);

- Maintain a detailed analysis and evaluation of the monitoring data for each applicable well, spring, and surface water sampling station, with a focus on results for the primary inorganic, organic, and radiological contaminants in groundwater and surface water at Y-12; and

- Ensure retention of "institutional knowledge" obtained over the long-term (>20-year) history of groundwater and surface water monitoring at Y-12 and the related sources of groundwater and surface water contamination.

To achieve these goals, the Y-12 GWPP Compendium brings together salient hydrologic, geologic, geochemical, water-quality, and environmental compliance information that is otherwise disseminated throughout numerous technical documents and reports prepared in support of completed and ongoing environmental contamination assessment, remediation, and monitoring activities performed at Y-12.

The following subsections provide background information regarding the overall scope and format of the Y-12 GWPP Compendium and the planned approach for distribution and revision (i.e., administration) of this "living" document.

1.1 SCOPE

This Y-12 GWPP Compendium includes groundwater monitoring wells granted "active" status in accordance with the Y-12 GWPP Monitoring Optimization Plan (MOP), including wells for which the monitoring status has changed to "inactive" at some time following the sampling events described in this document. The MOP grants active status to any well that meets one or more of the following criteria: (1) the well is designated for monitoring in compliance with applicable state and federal regulations and/or the requirements of DOE Orders; (2) the well is designated for hydrologic monitoring (e.g., water-level elevations); (3) the well is known to yield contaminated groundwater; (4) the well is located hydraulically downgradient of facilities at Y-12, including any known source(s) of groundwater contamination; and (5) the well provides unique hydrologic and/or groundwater quality information (BWXT 2006a). The Y-12 GWPP Compendium provides the following information for wells granted active status under the MOP:

- A summary of pertinent well-construction information (e.g., total depth);

- An overview of the groundwater sampling history for the well and a discussion of distinguishing sampling characteristics (e.g., large water-level fluctuations);

- A discussion of the hydrologic characteristics for the well, based primarily on presampling depth-to-water measurements/groundwater elevations, along with a summary of available results for hydrologic tests (e.g., hydraulic conductivity tests);

- A discussion of the geochemical characteristics of the groundwater in the well based on available analytical results for primary anions and cations, including a discussion of results showing unusually high or low ion concentrations, or other similarly distinctive geochemical characteristics;

- A detailed narrative evaluation of the available analytical results for the well, supported by time-series plots and data summary tables, based on monitoring results that meet the requirements of the Y-12 GWPP for the primary groundwater contaminants at Y-12: nitrate, uranium, volatile organic compounds (VOCs), and radioactivity (gross alpha activity and gross beta activity); and

- A list of plans, documents, and technical reports cited for more detailed information.

The Y-12 GWPP Compendium presents a *Brief* of the above-listed information for each well, which includes a *Summary Cover Sheet* and corresponding *Data Evaluation Narrative*, each of which is divided into the following sections: (1) Installation, Construction, and Location; (2) Sampling History and Characteristics; (3) Hydrologic Characteristics; (4) Geochemical Characteristics; (5) Contamination, with subsections for nitrate, uranium, VOCs, gross alpha activity, gross beta activity, and other contaminants (if any); and (6) References. Section 2 of this introductory report provides a detailed explanation of the data presented in the *Summary Cover Sheet* for each well and Section 3 outlines the types of information provided in the corresponding *Data Evaluation Narrative*.

This Y-12 GWPP Compendium also includes a number of natural springs and surface water sampling locations in the drainage basins associated with Y-12, including sampling locations that are outside the boundary of the DOE Oak Ridge Reservation. The Y-12 GWPP uses these sampling locations for the purposes of Exit Pathway/Perimeter monitoring in accordance with the requirements of DOE Order 450.1. Several of these sampling locations also meet the requirements of other monitoring programs and organizations at Y-12, including National Pollution Discharge Elimination System (NPDES) monitoring performed by the Y-12 Surface Water Program. Based only on selected sampling/analytical results that meet DOE Order monitoring requirements, the Y-12 GWPP Compendium provides the following information for each applicable spring and surface water sampling station:

- The general location of the spring or surface water sampling station, including the Y-12 grid coordinates;

- The purpose for monitoring the spring or surface water sampling station (e.g., DOE Order monitoring) and the sampling history;

- A discussion of the geochemical characteristics of the samples from the spring or surface water stations, based on available analytical results for primary anions and cations;

- A summary of water-quality conditions at each spring or surface water sampling station, based on sampling/analytical results for the following surface water contaminants at Y-12: nitrate, uranium, VOCs, radioactivity (gross alpha activity and gross beta activity), and mercury (selected locations only); and

- A list of plans, documents, and technical reports cited for more detailed information.

As with the wells, the Y-12 GWPP Compendium presents a *Brief* of the above-listed information for each spring and surface water station in a *Summary Cover Sheet* and corresponding *Data Evaluation Narrative*, each formatted with the following sections: (1) Location; (2) Sampling History; (2) Geochemical Characteristics; (4) Principal Contamination, with subsections for nitrate, uranium, VOCs, gross alpha activity, gross beta activity, and other contaminants, such as mercury; and (5) References. Much of the information included in the *Summary Cover Sheet* and *Data Evaluation Narrative* for each spring and surface water sampling station is self-explanatory or is otherwise addressed by the descriptions provided Section 2 and Section 3 of this introductory report.

The Y-12 GWPP Compendium includes only the applicable wells (i.e., those granted "active" status under the MOP) and surface water monitoring stations (including springs) that have been used for groundwater or surface water quality sampling since January 2003. Nevertheless, as described in the following sections, the compendium format accommodates the addition of other sampling locations that may be included in ongoing groundwater and surface water monitoring activities. Additionally, the compendium maintains information regarding wells that were formerly granted active status, but whose monitoring status has changed to inactive (e.g., wells plugged and abandoned to make room for buildings). With this approach, the Y-12 GWPP Compendium eventually may encompass all of the wells at Y-12 that are, or have been, granted "active" status under the MOP.

1.2 FORMAT

To facilitate use as a reference manual, the Y-12 GWPP Compendium is presented in a "handbook" format. This format is intended for wide distribution and consists of a hardcopy of this introductory report along with a compact disk containing four portable document format (PDF) files (Volumes 2, 3, 4, and 5) that have the most up-to-date *Brief* for each applicable well, spring, and surface water sampling station. The PDF files are fully searchable with compatible software (e.g., Adobe Acrobat™). The entire Y-12 GWPP Compendium is divided into five separate volumes in the manner of an encyclopedia, with this introduction being Volume 1 and the *Brief* for each applicable sampling location presented in Volume 2 (Table 1), Volume 3 (Table 2), Volume 4 (Table 3), and Volume 5 (Table 4). The referenced index tables identify the wells (listed in ascending order by well number) included in Volumes 2, 3, and 4 and list the springs and surface water sampling stations included in Volume 5.

1.3 REVISION

The Y-12 GWPP Compendium is a "living" document that will be revised (updated) annually or at an alternative frequency specified by the Y-12 GWPP Manager. The revisions will primarily involve: (1) updating the information presented in this introductory report, particularly the above-referenced index tables and the data-summary tables presented in Section 2; (2) updating the information presented in the *Summary Cover Sheet* and *Data Evaluation Narrative* for each applicable well, spring, or surface water station to incorporate the results of on-going groundwater and surface water quality monitoring activities; and/or (3) adding the *Summary Cover Sheet* and *Data Evaluation Narrative* for applicable wells, springs, or surface water stations not previously included in the Y-12 GWPP Compendium. The current revision of this document includes new *Briefs* for the wells that were sampled during CY 2005, but none of the existing *Briefs* were updated to reflect CY 2005 sampling results. The next annual revision is scheduled to include new *Briefs* and updated *Briefs* for all locations that were sampled at least once during CY 2005 or CY 2006.

Table 1. Index of monitoring wells included in Volume 2 of the Y-12 GWPP Compendium

Monitoring Well	Monitoring Well
1090	GW-133-08
55-1A	GW-133-10
55-2B	GW-133-14
55-2C	GW-133-17
55-3A	GW-133-21
55-3B	GW-133-24
55-6A	GW-134-05
56-2A	GW-134-11
56-2B	GW-134-15
56-2C	GW-134-18
59-1A	GW-134-21
59-1B	GW-134-25
59-1C	GW-134-29
60-1B	GW-134-33
60-2A	GW-134-35
GW-008	GW-134-36
GW-014	GW-135-03
GW-046	GW-135-06
GW-052	GW-135-11
GW-053	GW-135-15
GW-056	GW-135-19
GW-061	GW-135-23
GW-064	GW-135-26
GW-066	GW-135-30
GW-068	GW-135-34
GW-071	GW-135-39
GW-072	GW-141
GW-077	GW-142
GW-078	GW-143
GW-079	GW-144
GW-080	GW-145
GW-082	GW-151
GW-085	GW-153
GW-097	GW-154
GW-098	GW-156
GW-100	GW-159
GW-101	GW-169
GW-105	GW-170
GW-106	GW-171
GW-108	GW-172
GW-109	GW-173
GW-115	GW-175
GW-122	GW-176
GW-123	GW-177
GW-124	GW-178
GW-127	GW-179
GW-133-01	GW-190
GW-133-05	GW-193

Table 2. Index of monitoring wells included in Volume 3 of the Y-12 GWPP Compendium

Monitoring Well	Monitoring Well	Monitoring Well
GW-203	GW-277	GW-542
GW-204	GW-281	GW-543
GW-205	GW-286	GW-544
GW-207	GW-287	GW-557
GW-208	GW-288	GW-560
GW-217	GW-289	GW-562
GW-219	GW-291	GW-564
GW-220	GW-300	GW-601
GW-221	GW-301	GW-605
GW-222	GW-302	GW-606
GW-223	GW-305	GW-610
GW-225	GW-307	GW-611
GW-226	GW-310	GW-612
GW-227	GW-311	GW-615
GW-228	GW-312	GW-616
GW-229	GW-313	GW-618
GW-230	GW-315	GW-620
GW-231	GW-322	GW-624
GW-232	GW-336	GW-626
GW-236	GW-337	GW-627
GW-237	GW-339	GW-631
GW-242	GW-346	GW-633
GW-244	GW-363	GW-639
GW-245	GW-364	GW-653
GW-246	GW-365	GW-658
GW-247	GW-368	GW-679
GW-251	GW-380	GW-680
GW-253	GW-381	GW-683
GW-257	GW-382	GW-684
GW-269	GW-383	GW-690
GW-270	GW-505	GW-691
GW-271	GW-513	GW-692
GW-272	GW-521	GW-694
GW-273	GW-522	GW-695
GW-274	GW-526	GW-696
GW-275	GW-537	GW-698
GW-276	GW-540	

Table 3. Index of monitoring wells included in Volume 4 of the Y-12 GWPP Compendium

Monitoring Well	Monitoring Well
GW-700	GW-761
GW-703	GW-762
GW-704	GW-763
GW-706	GW-764
GW-709	GW-765
GW-710	GW-769
GW-711	GW-770
GW-712	GW-775
GW-713	GW-782
GW-714	GW-783
GW-715	GW-786
GW-722-06	GW-787
GW-722-10	GW-791
GW-722-14	GW-795
GW-722-17	GW-796
GW-722-20	GW-797
GW-722-22	GW-798
GW-722-26	GW-799
GW-722-30	GW-801
GW-722-32	GW-802
GW-722-33	GW-816
GW-723	GW-818
GW-724	GW-820
GW-725	GW-827
GW-731	GW-831
GW-732	GW-832
GW-733	GW-835
GW-735	GW-916
GW-736	GW-917
GW-737	GW-918
GW-738	GW-919
GW-739	GW-920
GW-740	GW-921
GW-742	GW-922
GW-743	GW-923
GW-744	GW-924
GW-747	GW-925
GW-750	GW-926
GW-757	GW-927
GW-760	GW-959

Table 4. Index of surface water sampling stations included in Volume 5 of the Y-12 GWPP Compendium

Station	Station
9201-1K-22SU	NT-07
9201-3C-4SP	NT-08
BCK-00.63	NT-8-E
BCK-03.30	NT-8-W
BCK-04.55	OF 51
BCK-07.87	OF 200
BCK-09.20	S07
BCK-09.40	S17
BCK-09.47	SCR1.25SP
BCK-11.54	SCR1.5SW
BCK-11.84	SCR2.1SP
BCK-11.97	SCR2.2SP
BCK-12.34	SCR3.5SP
BCK-12.47	SCR3.5SW
EMWNT-03A	SCR4.3SP
EMWNT-05	SCR7.1SP
EMW-VWEIR	SCR7.8SP
ET-4	SPR14.0SP
GHK2.51ESW	SS-1
GHK2.51WSW	SS-4
MCK 2.0	SS-5
MCK 2.05	SS-6
NPR07.0SW	SS-6.6
NPR12.0SW	SS-7
NPR23.0SW	SS-8
NT-01	STATION 8
NT-03	STATION 17
NT-04	

The revised version of the “handbook” format will include an updated hardcopy of the introductory report (this document) along with a compact disk that contains a PDF file with the updated *Brief* for each applicable well, spring, and surface water sampling station.

2.0 SUMMARY COVER SHEET

The *Summary Cover Sheet* for each applicable sampling location included in the Y-12 GWPP Compendium serves as a quick reference for general information about the well, spring, or surface water sampling station. This section provides background information regarding the contents of the *Summary Cover Sheet* for each well, which also addresses the contents of the *Summary Cover Shee*t for each spring and surface water station.

The *Summary Cover Sheet* for each applicable monitoring well included in the Y-12 GWPP Compendium, as detailed below, is divided into the following sections: (1) *Location*; (2) *Monitoring Purpose*; (3) *Well Construction*; (4) *Monitored Interval*; (5) *Sampling History*; (6) *Sampling Characteristics*, and (7) *Principal Contaminants*. Information is provided on the *Summary Cover Sheet* unless it is not available (NA) or is not applicable (“.”).

2.1 LOCATION

This section of the *Summary Cover Sheet* provides general location information for the well, including the hydrogeologic regime in which the well is located and the site (Functional Area) with which the well is affiliated. Often, the affiliated site is a source of contamination in the groundwater at the well. The Y-12 GWPP recognizes three broad hydrogeologic regimes at Y-12 (Figure 1): (1) the Bear Creek Hydrogeologic Regime (referenced as the Bear Creek Regime), which encompasses a section of Bear Creek Valley (BCV) west of Y-12; (2) the Upper East Fork Poplar Creek Hydrogeologic Regime (referenced as the East Fork Regime), which encompasses the section of BCV that includes the bulk of the process and support buildings that comprise Y-12; and (3) the Chestnut Ridge Hydrogeologic Regime (referenced as the Chestnut Ridge Regime), which encompasses a section of Chestnut Ridge directly south of Y-12.

2.2 MONITORING PURPOSE

This section of the *Summary Cover Sheet* identifies the applicable groundwater monitoring program under which samples were collected during the most recent year. Although collected for a variety of monitoring purposes, all of the data presented in this document meet U.S. Department of Energy (DOE) Order monitoring requirements. Ongoing groundwater quality monitoring activities in the hydrogeologic regimes at Y-12 are implemented in accordance with the following programs:

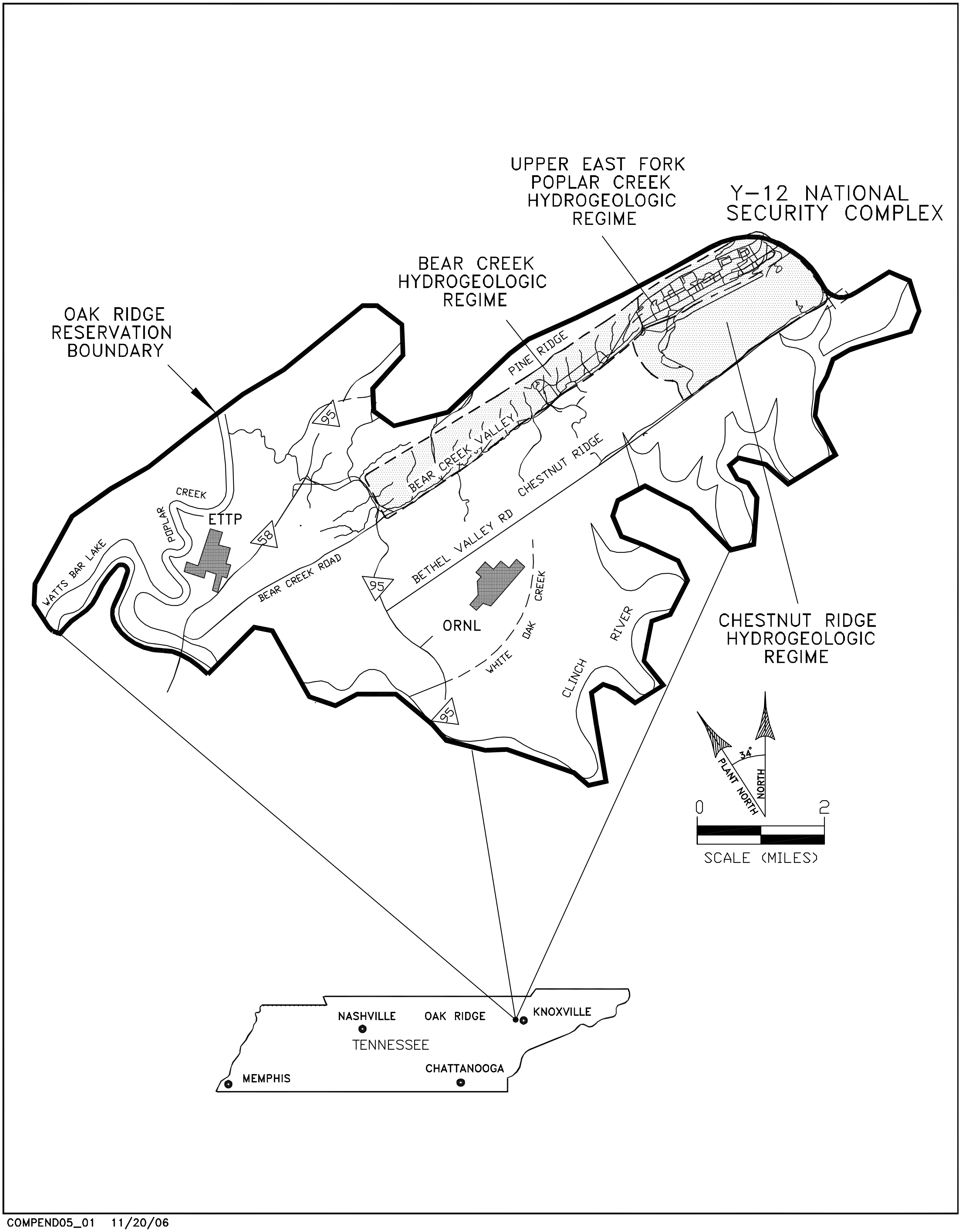


Fig. 1. Hydrogeologic regimes at the Y-12 National Security Complex.

- Resource Conservation and Recovery Act (RCRA) post-closure groundwater quality monitoring, which includes RCRA post-closure detection monitoring and RCRA post-closure corrective action effectiveness monitoring. The former is performed at closed hazardous waste disposal units (HWDUs) that have not released hazardous waste and/or hazardous waste constituents to the groundwater system, and the latter is performed at HWDUs which have released hazardous waste and/or hazardous waste constituents. The requirements for these RCRA monitoring programs are defined in the respective RCRA post-closure permit issued by the Tennessee Department of Environment and Conservation (TDEC) for each hydrogeologic regime and the applicable TDEC regulations governing groundwater monitoring at HWDUs.

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) groundwater quality monitoring, which includes: (1) CERCLA baseline monitoring to evaluate pre-remediation groundwater quality; (2) monitoring performed in accordance with the applicable CERCLA record of decision (ROD) and or related decision documents pending final approval of the ROD; and (3) monitoring performed at the Environmental Management Waste Management Facility (EMWMF), which is an active CERCLA-regulated waste disposal site located in the Bear Creek Regime west of Y-12.

- Groundwater quality monitoring performed at several operating and closed non-hazardous waste landfills located south of Y-12 in the Chestnut Ridge Regime. Monitoring at each site is performed in accordance with the operating permit/post-closure plan issued and approved by the TDEC and the TDEC regulations governing groundwater monitoring at non-hazardous solid waste disposal facilities (SWDFs).

- Groundwater quality monitoring performed in each hydrogeologic regime in compliance the requirements of DOE Order 450.1, which mandates monitoring in areas at Y-12 that: (1) are known or suspected sources of groundwater contamination and (2) where contaminants from DOE operations at Y-12 may exit areas under DOE administrative control.

In addition to groundwater quality monitoring, respective networks of groundwater monitoring wells in the Bear Creek Regime, East Fork Regime, and Chestnut Ridge Regime are used for hydrologic monitoring (i.e., are used to determine contemporaneous, regime-wide groundwater surface elevations).

2.3 WELL CONSTRUCTION

This section of the *Summary Cover Sheet* provides selected information regarding the construction of the monitoring well, as reported in: *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation* (BWXT 2003), hereafter referenced as the Y-12 Subsurface Database. Many of the monitoring wells are completed in pairs or clusters, and the *Summary Cover Sheet* notes all paired or clustered wells. For most wells, the total depth of the well (Tag Depth) is in reference to the top of the well casing, whereas other downhole measurements may be in reference to a designated measuring point marked on the top of the Well Wizard™ (TOWW) (a dedicated gas-driven bladder pump) in the well. The type of dedicated sampling equipment (to be used only for the specified well) installed in the well is noted in this section; most monitoring wells have a Well Wizard™ bladder pump. A few wells are equipped with Westbay™ multiport sampling systems that enable collection of representative samples from several discreet depth intervals. Additionally, the following acronyms and abbreviations are used for well casing materials and well screen types (if applicable):

PVC40	-	polyvinyl chloride, schedule 40
PVC/SL	-	PVC/slotted
PVC/SW	-	PVC/spiral wound
PPK	-	pre-packed screen
SF25/SJ55	-	steel; American Petroleum Institute Grade
STL	-	carbon steel
SS	-	stainless steel
SS304	-	stainless steel type 304
SS/SW	-	stainless steel, spiral wound
slot size	-	size of screen openings, in inches (e.g., 0.01)

2.4 MONITORING INTERVAL

This section of the *Summary Cover Sheet* provides selected information regarding the monitored interval for the well, as reported in the Y-12 Subsurface Database. All the monitoring wells at Y-12 that are granted active status under the Y-12 GWPP are completed with manufactured well screens or open-hole monitored intervals, respectively referenced as "Screened" and "Open Hole" on the *Summary Cover Sheet*. Also provided are the depths to the top, bottom, and midpoint of the monitored interval, as measured in ft below ground surface (bgs), and the corresponding elevations in ft above mean sea level (msl).

As noted in the Section 2.3, most of the monitoring wells granted active status under the Y-12 GWPP are equipped with a dedicated sampling pump. Therefore, this section of the *Summary Cover Sheet* for these wells shows the depth to the pump intake, which provides information regarding its relative location within the monitored interval for the well.

This section of the *Summary Cover Sheet* also identifies the geologic formation from which the monitoring well yields groundwater. The primary geologic formations in the vicinity of Y-12 are (listed in order from oldest to youngest): the Rome Formation, which forms Pine Ridge north of Y-12; the Conasauga Group formations (Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Mayville Limestone, Nolichucky Shale, and Maynardville Limestone), which underlie Bear Creek Valley (BCV) and the southern flank of Pine Ridge; and the Knox Group formations (Copper Ridge Dolomite, Chepultepec Dolomite, Longview Dolomite, Kingsport Formation, and Mascot Dolomite), which form Chestnut Ridge south of Y-12 (Figure 2).

The geologic formations in the vicinity of Y-12 comprise two broad hydrogeologic units: the aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Knox Group formations; and the aquitard, consisting of the remaining Conasauga Group formations and the Rome Formation. Fractures provide the principal groundwater flowpaths in both units, and dissolution of carbonates in the aquifer has enlarged fractures and produced solution cavities and conduits that greatly enhance its hydraulic conductivity relative to the aquitard. Flow in each unit decreases with depth and flow through the porous rock matrix is minimal in both units. Also, the bulk of the groundwater flow in each unit occurs within a highly permeable hydrogeologic zone, referenced as the "water-table interval" in this section of the *Summary Cover Sheet*, located near the interface between bedrock and weathered bedrock/residuum. In the aquifer, the water-table interval represents an extensively interconnected network of solution conduits and cavities (shallow karst network). Wells completed below the "water-table interval" are noted as monitoring a "bedrock" hydrogeologic zone.

2.5 SAMPLING HISTORY

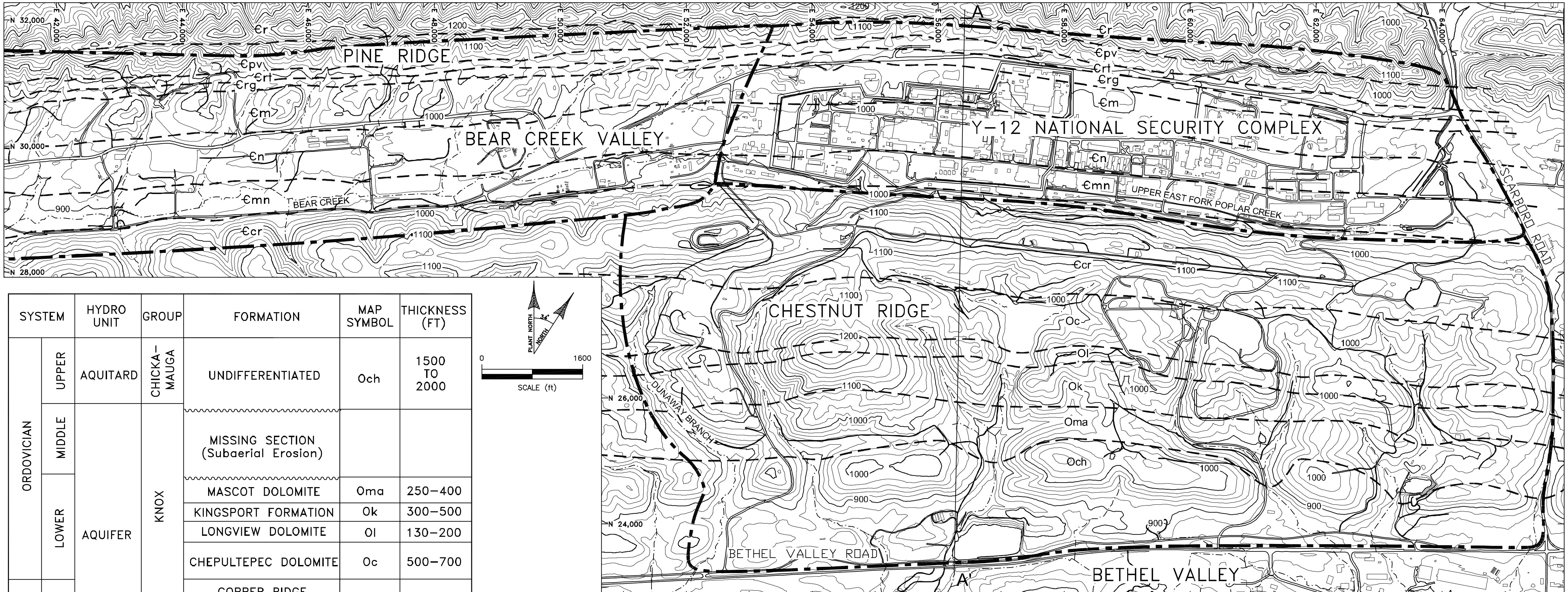
This section of the *Summary Cover Sheet* presents the groundwater sampling history for the well, including the total number of sampling events with the initial and most recent sampling dates of the current revision (see Section 1.3). The sampling history includes sampling events performed by the Y-12 GWPP (January 1986 – present), samples collected by various programs managed by Bechtel Jacobs Company LLC (October 1996 – present), and selected sampling results obtained for CERCLA remedial investigations in the Bear Creek and East Fork Regimes (1997 – 1998). The sampling history also shows the number of samples that have been obtained with the two groundwater sampling methods that have been employed by the Y-12 GWPP and other organizations: a low-flow minimal drawdown sampling method (hereafter referenced as low-flow sampling) and a "conventional" sampling method. The low-flow sampling method, which is intended to obtain representative groundwater samples that do not include stagnant water in the well casing, involves pumping groundwater from the well at a flow rate that is low enough (<300 milliliters per minute) to minimize drawdown of the water level in the well (<0.1 feet [ft] per quarter-hour) and collecting groundwater samples when regular measurements of pH, conductivity, temperature, oxidation-reduction potential (REDOX), and dissolved oxygen (DO) show minimal variation over four consecutive readings. In contrast, the conventional sampling method involves collecting groundwater samples immediately after purging at least three well volumes of groundwater from the well (if the well does not purge dry) at a much higher pumping rate (1.0 to 1.8 gallons per minute).

2.6 SAMPLING CHARACTERISTICS

Most of the groundwater monitoring wells at Y-12 that are granted active status under the Y-12 GWPP monitor uncontaminated groundwater, exhibit similar hydrologic characteristics (e.g., seasonal water-level fluctuations), and yield groundwater samples with similar geochemical characteristics. As described in the following paragraphs, analytical results some of the wells granted active status are conspicuous with regard to: (1) elevated chromium and/or nickel concentrations believed to be artifacts related to the corrosion of the stainless steel riser casing and/or well screen; (2) unusual geochemical characteristics indicative of residual contamination from the cement grout emplaced during well installation/construction; (3) analytical results that appear to reflect bias from the groundwater sampling method; (4) large temporal fluctuations in groundwater elevations; (5) unusually high or low TDS; (6) acidic (pH < 5.5) groundwater, and (7) some other distinguishing geochemical characteristic.

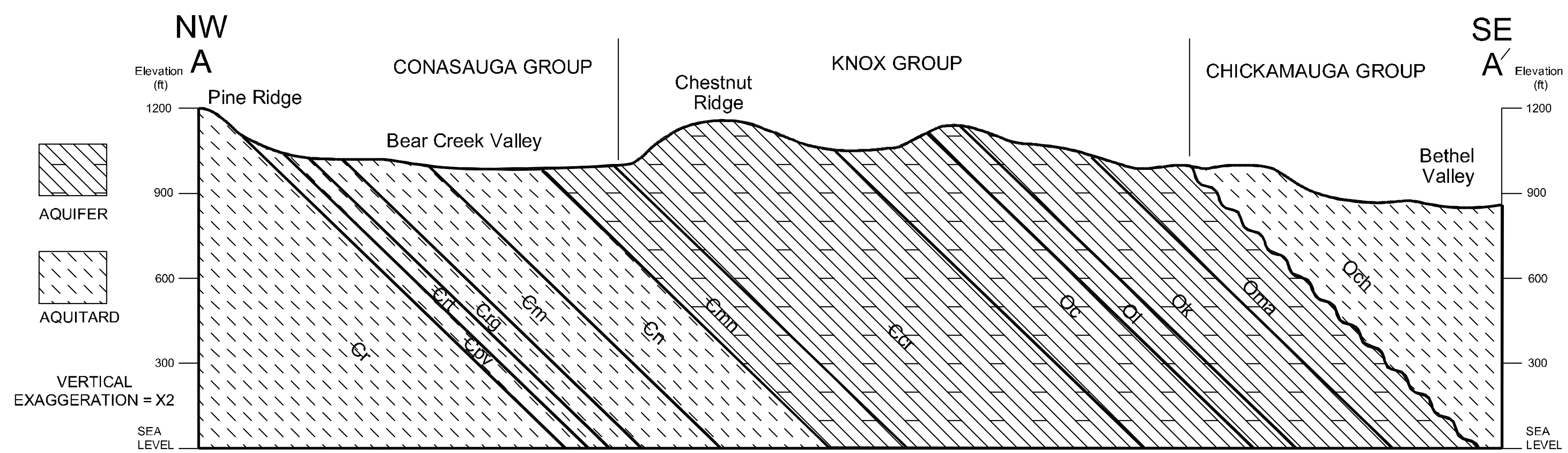
2.6.1 Well Casing/Screen Corrosion

This characteristic applies to wells that yield groundwater samples containing unusually high concentrations of chromium and/or nickel that are most likely attributable to chemical and/or microbiologically induced corrosion of the stainless steel well casing/screen. Elevated concentrations of these metals reported for samples from the following wells are believed to be artifacts of corrosion of the riser casing/well screen.



SYSTEM		HYDRO UNIT	GROUP	FORMATION	MAP SYMBOL	THICKNESS (FT)
ORDOVICIAN	UPPER	AQUITARD	CHICKAMAUGA	UNDIFFERENTIATED	Och	1500 TO 2000
ORDOVICIAN	MIDDLE	AQUIFER	KNOX	MISSING SECTION (Subaerial Erosion)		
ORDOVICIAN	LOWER	AQUIFER	KNOX	MASCOT DOLOMITE	Oma	250–400
ORDOVICIAN	LOWER	AQUIFER	KNOX	KINGSPORT FORMATION	Ok	300–500
ORDOVICIAN	LOWER	AQUIFER	KNOX	LONGVIEW DOLOMITE	Ol	130–200
ORDOVICIAN	LOWER	AQUIFER	KNOX	CHEPULTEPEC DOLOMITE	Oc	500–700
CAMBRIAN	UPPER	AQUIFER	KNOX	COPPER RIDGE DOLOMITE	Ꞓcr	800–1,100
CAMBRIAN	UPPER	AQUIFER	CONASAUGA	MAYNARDVILLE LIMESTONE	Ꞓmn	418–450
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	NOLICHUCKY SHALE	Ꞓn	490–590
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	MARYVILLE LIMESTONE	Ꞓm	346–445
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	ROGERSVILLE SHALE	Ꞓrg	90–120
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	RUTLEDGE LIMESTONE	Ꞓrt	90–120
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	PUMPKIN VALLEY SHALE	Ꞓpv	260–320
CAMBRIAN	LOWER	AQUITARD		ROME	Ꞓr	NOT DETERMINED

SOURCES: King and Haas 1987
Hatcher et al. 1992



GENERALIZED GEOLOGIC CROSS SECTION

COMPEND05_2 11/20/05

Fig. 2. Bedrock geology and topography in the vicinity of the Y-12 National Security Complex.

Table 5. Wells with suspected corrosion of the riser casing/well screen.

BEAR CREEK REGIME	EAST FORK REGIME		CHESTNUT RIDGE REGIME
GW-056	55-2A	GW-380	GW-302
GW-082	59-1A	GW-696	GW-305
GW-715	59-1B	GW-760	GW-339
	GW-190	GW-783	

Redevelopment of these wells prior to sampling is recommended to ensure collection of the most representative groundwater samples

2.6.2 Grout Contamination

This characteristic applies to wells that yield groundwater samples with unusual geochemical characteristics, including strongly basic pH (>9) and elevated concentrations of potassium (>10 mg/L), that are believed to be the result of localized contamination from cement grout circulated into the surrounding bedrock during installation and construction of the well. This grout contamination may occur several years after well installation, especially in karst areas where additional grout (significantly more than the calculated annular space) may have been used to install the well casing. Such geochemical characteristics are indicated by the monitoring results obtained from the wells listed below.

Table 6. Wells that exhibit indicators for grout contamination.

BEAR CREEK REGIME	EAST FORK REGIME	CHESTNUT RIDGE REGIME
None in the Compendium	GW-170	GW-205
	GW-620	GW-679
		GW-757

Redevelopment of these wells prior to sampling is recommended to ensure collection of the most representative (i.e., the least grout-contaminated) groundwater samples.

2.6.3 Water Level Fluctuation

This characteristic applies to wells that have presampling groundwater elevations which exhibit unusually wide temporal (seasonal) fluctuations; the value shown is the difference (in ft) between maximum and minimum depth-to-water measurements recorded during successive quarterly or semiannual groundwater sampling events. Substantial temporal variations in the groundwater elevations may suggest that the monitored interval in the well intercepts highly permeable and well-connected groundwater flowpaths. Typically wells located in the Chestnut Ridge Regime have higher water level fluctuations than wells located in the Bear Creek or East Fork Regimes. The following 20 wells, most of which are located in the Chestnut Ridge Regime, have seasonal water level fluctuations greater than 25 ft.

Table 7. Wells that exhibit wide water-level fluctuations.

BEAR CREEK REGIME	EAST FORK REGIME	CHESTNUT RIDGE REGIME		
GW-123	GW-253	1090	GW-522	GW-742
GW-923	GW-698	GW-173	GW-540	GW-743
	GW-735	GW-322	GW-544	GW-796
		GW-339	GW-560	GW-798
		GW-513	GW-709	GW-801

2.6.4 Total Dissolved Solids (TDS)

This characteristic applies to wells, listed in Table 8, that yield groundwater samples with unusually high (i.e., >850 milligrams per liter [mg/L]) or low TDS (i.e., <150 mg/L), as determined from average values reported for the samples collected since January 1990 (excluding suspected outliers).

Table 8. Wells that yield groundwater with unusually high or unusually low TDS.

WELL LOCATION	WELL DEPTH (ft bgs)	HIGH TDS (Average >850 mg/L)	LOW TDS (Average <150 mg/L)
Bear Creek Regime	<20	GW-100 GW-276 GW-101 GW-537 GW-105	GW-008 GW-237
	20 – 200	GW-085 GW-134-33 GW-246 GW-106 GW-134-35 GW-247 GW-108 GW-134-36 GW-277 GW-109 GW-229 GW-346 GW-122 GW-244 GW-526 GW-245	GW-079 GW-080 GW-287 GW-653
	>200	GW-071 GW-134-18 GW-135-23 GW-123 GW-134-21 GW-135-26 GW-133-01 GW-134-25 GW-615 GW-134-05 GW-135-03 GW-616 GW-134-11 GW-135-06 GW-710 GW-134-15 GW-135-11 GW-711	GW-066 GW-228 GW-312
East Fork Regime	<20	55-1A GW-633 GW-272 GW-691	GW-269 GW-761 GW-273 GW-787
	20 – 200	55-2B GW-274 GW-698 55-2C GW-275 GW-253 GW-690	.
Chestnut Ridge Regime	20 – 200	.	GW-300 GW-796 GW-542 GW-799 GW-564 GW-801

For some wells, the high TDS reflects the degree of groundwater contamination, particularly wells located near the former S-3 Ponds. However, other wells yield uncontaminated groundwater with unusually high TDS, including most of the deepest wells at Y-12 (TDS increases with depth) and shallower wells completed with monitored intervals that do not intercept highly permeable groundwater flowpaths. Similarly, some wells that monitor contaminated and uncontaminated groundwater yield samples with unusually low TDS, which is believed to reflect the relatively short residence time of the groundwater and implies that the wells intercept highly permeable and hydraulically active groundwater flowpaths.

2.6.5 Low pH

This characteristic applies to wells that yield groundwater samples with acidic pH (i.e., below 5.5 standard units). Average pH values determined from data (field measurements) obtained during sampling events performed since January 1990 (excluding suspected outliers) show that, as summarized below in Table 10, fourteen wells yield such acidic groundwater, most of which are located in the Bear Creek Regime.

Table 9. Wells that yield acidic groundwater samples.

BEAR CREEK REGIME		EAST FORK REGIME	CHESTNUT RIDGE REGIME
GW-008	GW-246	GW-108	
GW-046	GW-276	GW-109	.
GW-236	GW-653	GW-273	
GW-243		GW-633	

Most of these wells (GW-108, GW-109, GW-236, GW-243, GW-246, GW-273, GW-276, and GW-633) monitor the highly contaminated, acidic groundwater in the aquitard formations (e.g., Nolichucky Shale) near the west end of Y-12 that is a legacy of the historical operation of the former S-3 Ponds. Other wells that yield groundwater samples with acidic pH (e.g., GW-008, GW-046, and GW-653) monitor groundwater contaminated by chlorinated hydrocarbons, with the low pH being an indicator of ongoing chemical and/or biologically-mediated degradation of the compounds.

2.6.6 Sampling Method Sensitivity

This characteristic applies to wells that yield groundwater samples with substantially different contaminant concentrations depending on the groundwater sampling method. An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method for 18 monitoring wells (BWXT 2001). Monitoring results obtained since CY 2000 for eight additional wells that had insufficient data for the original study likewise suggested potential sampling method bias. To confirm the apparent bias, the Y-12 GWPP uses a "paired" groundwater sampling approach, whereby the low-flow sampling method is used to collect a sample one day and the conventional sampling method is used to collect a sample the next day. Both samples are then analyzed for the same suite of analytes. As shown on Table 10, paired sampling results have "confirmed" the sampling method bias for 11 wells and "disproved" the sampling bias for seven wells, with "suspected" sampling method bias pending results of paired sampling.

Table 10. Wells evaluated for apparent sampling method bias.

SAMPLING BIAS/WELL NUMBER/WELL LOCATION			PRINCIPAL CONTAMINANTS				
			NITRATE	URANIUM	VOCs	GROSS ALPHA	GROSS BETA
Confirmed	GW-072	BC	.	.	C	.	.
	GW-082	BC	.	.	C	.	.
	GW-204	EF	.	C	.	.	.
	GW-226	BC	X	C	L	C	C
	GW-612	CR	.	.	C	.	.
	GW-627	BC	.	.	L	.	.
	GW-698	EF	L	.	C	.	.
	GW-706	BC	L	X	X	X	X
	GW-725	BC	C	.	C	.	.
	GW-763	EF	.	.	C	.	.
	GW-791	EF	.	.	C	.	.
Suspected	GW-142	CR	.	C	.	C	.
	GW-151	EF	.	.	L	.	.
	GW-190	EF	.	.	C	.	.
	GW-205	CR	.	.	.	.	L
	GW-273	EF	C	.	C	.	.
	GW-382	EF	.	.	C	.	.
	GW-605	EF	.	C	C	.	C
	GW-691	EF	.	.	L		.
Disproved	GW-225	BC	X	.	C	.	.
	GW-229	BC	.	L	L	L	L
	GW-624	BC	.	.	L	.	.
	GW-626	BC	.	.	L	.	.
	GW-633	EF	C	.	L	.	L
	GW-653	BC	.	.	L	.	.
	GW-782	EF	.	.	X	L	.

Note:

Confirmed = Results of paired sampling confirm the significant difference between concentrations of specified contaminants detected in samples obtained with the conventional sampling and low-flow sampling methods.

Suspected = Historical data show a significant difference between concentrations of specified contaminants detected in samples obtained with the conventional sampling and low-flow sampling methods, but paired sampling results not needed for confirmation. Paired sampling of wells GW-072, GW-624, and GW-626 is scheduled for calendar year (CY) 2005.

Disproved = Results of paired sampling do not support the significant difference in the concentrations of specified contaminants indicated by historical conventional and low-flow sampling results.

BC = Bear Creek Regime

EF = East Fork Regime

CR = Chestnut Ridge Regime

"." = Not a contaminant in the groundwater at the well.

X = A contaminant in the groundwater at the well, but there is no clear significant difference between conventional sampling and low-flow sampling results.

C = Conventional sampling results show significantly higher concentrations of specified contaminant.

L = Low-flow sampling results show significantly higher concentrations of specified contaminant.

2.6.7 Other Characteristics

This characteristic applies to wells that exhibit other distinguishing groundwater sampling characteristics. For example, a well located in the East Fork Regime near the west end of Y-12 (GW-108) yields groundwater samples that effervesce, indicating unusual geochemistry and water quality. Where other distinctive sampling characteristics exist, a detailed discussion of the sampling characteristic(s), including a summary of the applicable geochemical data and/or hydrograph of applicable hydrologic data, is provided in the appropriate section of the data evaluation for the well.

2.7 PRINCIPAL CONTAMINANTS

This section of the *Summary Cover Sheet* provides a summary of the analytical data obtained for the well since January 1991 regarding the concentrations of the principal groundwater contaminants at Y-12: nitrate, uranium, VOCs, gross alpha activity, and gross beta activity. The data summary for each contaminant includes the number of samples (since January 1991) with concentrations that meet the data quality objectives of the Y-12 GWPP and exceed the respective screening levels listed in Table 11; the historical maximum concentration of each contaminant (and associated sampling date); and the long-term contaminant concentration trend (increasing, decreasing, or indeterminate).

Table 11. Principal contaminants and corresponding screening levels.

CONTAMINANT	SCREENING LEVEL
Nitrate (as N)	10 mg/L
Uranium	0.03 mg/L
Summed VOCs	5 micrograms per liter (µg/L)
Gross alpha activity	15 picoCuries per liter (pCi/L)
Gross beta activity	50 pCi/L

Each respective screening level for nitrate, total uranium, and gross alpha activity is the Safe Drinking Water Act (SDWA) maximum contaminant level MCL (MCL) for drinking water. The screening level for summed VOCs is set at a common MCL value. The screening level for gross beta activity is the SDWA screening value for a 4 millirem per year dose equivalent (the MCL for gross beta activity).

The maximum contaminant concentration reported for the location for the most recent revision to the Y-12 GWPP Compendium (see Section 1.3) is shown in a row of boxes located in the upper right corner of each *Summary Cover Sheet*. The contaminant levels that may be presented in the boxes are shown below in Table 12.

Table 12. Explanation for the principal contaminant concentration summary.

CONTAMINANT	NITRATE (mg/L)	URANIUM (mg/L)	SUMMED VOCs (µg/L)	GROSS ALPHA (pCi/L)	GROSS BETA (pCi/L)
Box Options/ Contaminant Concentration Range	. ND <5 5 - 10 10 - 100 100 - 1,000 >1,000	. ND <0.015 0.015 - 0.03 0.03 - 0.3 0.3 - 3.0 >3	. ND <5 5 - 50 50 - 500 500 - 5,000 >5,000	. ND <7.5 7.5 - 15 15 - 150 150 - 1,500 >1,500	. ND <25 25 - 50 50 - 500 500 - 5,000 >5,000
Screening Level	**10**	**0.03**	**5**	**15**	**50**

Note: "." = not analyzed; "ND" = not detected

3.0 DATA EVALUATION NARRATIVE

In conjunction with the *Summary Cover Sheet* for each applicable sampling location (see Section 1.1), each *Brief* in the Y-12 GWPP compendium provides a narrative description and evaluation of the hydrologic and groundwater quality data obtained to date. Each narrative follows a standard format that generally mirrors the corresponding *Summary Cover Sheet*. The following sections provide background information regarding the contents of the *Data Evaluation Narrative* for each monitoring well, which also address corresponding contents of the *Data Evaluation Narrative* for each spring and surface water station.

As detailed below, the *Data Evaluation Narrative* for each monitoring well included in the Y-12 GWPP compendium contains separate subsections regarding: (1) the installation, construction, and location of the well; (2) the sampling history for the well, including detailed descriptions of any distinguishing sampling characteristics; (3) the hydrologic characteristics of the well; (4) the geochemical characteristics of the groundwater samples from the well; (5) the concentrations and characteristics (e.g., temporal concentration fluctuations) of the principal Y-12 groundwater contaminants in the well; and (6) the list of referenced technical reports and documents. Applicable subsections of the *Data Evaluation Narrative* define site-specific and other "special" acronyms and abbreviations, but the following "universal" acronyms and abbreviations are not defined.

bgs	-	below ground surface
CERCLA	-	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	-	U.S. Department of Energy
EPA	-	U.S. Environmental Protection Agency
ft	-	feet
msl	-	mean sea level
mg/L	-	milligrams per liter
ug/L	-	micrograms per liter
PVC	-	polyvinyl chloride
pCi/L	-	picoCuries per liter
RCRA	-	Resource Conservation and Recovery Act
ROD	-	record of decisions
SDWA	-	Safe Drinking Water Act

3.1 INSTALLATION, CONSTRUCTION, AND LOCATION

This subsection of the *Data Evaluation Narrative* for each well provides a description of the location of the well, including a brief description of the applicable functional area (or other nearby topographic/geographic/cultural features), and a short overview of the construction of well. Unless noted otherwise, geographic directions are in reference to the Y-12 Administrative Grid. For wells that monitor contaminated groundwater, this section provides a description of the site that is the known or suspected source of the contamination.

3.2 SAMPLING HISTORY AND CHARACTERISTICS

This subsection of the *Data Evaluation Narrative* for each monitoring well describes the groundwater sampling history for the well, including the initial and most recent sampling dates of the current revision (see Section 1.3) for each applicable groundwater sampling method (conventional sampling and low-flow sampling). Additionally, if the well exhibits any of the sampling characteristics noted on the *Summary Cover Sheet,* as defined in Section 2.6, this subsection presents a detailed description of the sampling characteristic(s), including data summary tables and/or trend charts.

3.3 HYDROLOGIC CHARACTERISTICS

This subsection of the *Data Evaluation Narrative* for each monitoring well describes the hydrologic characteristics of the well, including an overview of local hydrogeology, a summary of available hydraulic data for the well (e.g., hydraulic conductivity test results), the typical depth to the static water level in the well, and the range of water-level fluctuations in the well. Hydrographs of presampling groundwater elevations are provided for wells that exhibit unusually large water-level fluctuations or other distinctive short- or long-term changes in static water levels in the well.

3.4 GEOCHEMICAL CHARACTERISTICS

This subsection of the *Data Evaluation Narrative* for each monitoring well describes the geochemical characteristics of the groundwater samples from the well, including the range of TDS reported for the samples; the range of field pH measurements associated with each sampling event; the major-ion chemistry of the groundwater samples; and the typical concentrations of trace metals detected in the samples. The hydrochemical facies (e.g., calcium-magnesium bicarbonate), as calculated from milliequivalent proportions for a Piper Diagram (Fetter 1994), is provided in this section. Additional information, including applicable data summary tables and/or time-series plots, is provided for wells that yield groundwater samples with: (1) unusually high or unusually low TDS; (2) strongly basic pH and other geochemical indicators of localized grout contamination; or (3) unusually high concentrations of major ions (e.g., chloride).

3.5 CONTAMINATION

This subsection of the *Data Evaluation Narrative* for each monitoring well presents separate descriptions of the analytical data for each of the primary groundwater contaminants at Y-12 (nitrate, uranium, VOCs, gross alpha activity, and gross beta activity) and a detailed evaluation of the results. For some wells, another section is included for other notable contaminants (primarily trace metals) that may be present in the groundwater at the well. The data evaluation includes analytical results that meet data quality objectives, as defined in the Y-12 GWPP Data Management Plan (BWXT 2006b). Where applicable, the data evaluation for each groundwater contaminant includes data summary tables and trend graphs.

The following "universal" acronyms and abbreviations are used without being defined in the applicable subsection of the narrative for monitoring locations.

CTET	-	carbon tetrachloride
DMB	-	dimethylbenzene
ETB	-	ethylbenzene
MC	-	methylene chloride
MDA	-	minimum detectable activity
PCE	-	tetrachloroethene
TCE	-	trichloroethene
TCFM	-	trichlorofluoromethane
VC	-	Vinyl chloride
111TCA	-	1,1,1-trichloroethane
11DCA	-	1,1-dichloroethane
11DCE	-	1,1-dichloroethene
12DCA	-	1,2-dichloroethane
12DCE	-	1,2-dichloroethene
c12DCE	-	cis-1,2-dichloroethene
t12DCE	-	trans-1,2-dichloroethene

4.0 REFERENCES

BWXT Y-12, L.L.C. (BWXT). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, September 2002.

BWXT. 2003. *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation*, Y/TS-881/R5, February 2003.

BWXT. 2004. *Groundwater Protection Program Management Plan for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/SUB/01-006512/2/R1, March 2004.

BWXT. 2006a. *Y-12 Groundwater Protection Program Monitoring Optimization Plan for Groundwater Monitoring Wells at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/TS-2031, December 2006.

BWXT. 2006b. *Y-12 Groundwater Protection Program Data Management Plan,* Y/TS-2007, Revision 3, December 2006.

Fetter, C.W. 1994. *Applied Hydrogeology*, Third Edition. Macmillan College Publishing Company, Inc. New York, New York. p. 421-423.

DISTRIBUTION

U.S. DEPARTMENT OF ENERGY

J.P. Donnelly, DOE-NNSA

TENNESSEE DEPARTMENT OF
ENVIRONMENT AND CONSERVATION
DOE-ORR OVERSIGHT DIVISION

D. Gilmore

BWXT Y-12, L.L.C.
ENVIRONMENTAL COMPLIANCE
DEPARTMENT

S.M. Field
C.C. Hill
S.B. Jones *
E.R. Schultz
O.D. Stevens
L.O. Vaughan
File - GWPP (1/1*)
EC Document Center *

Y-12 Central Files*
Y-12 Records Services (Electronic copy- OSTI)
YDCC – RC*

BECHTEL JACOBS COMPANY LLC

L.M. Sims
R.H. Ketelle
File - EMEF-DMC *

SCIENCE APPLICATIONS
INTERNATIONAL CORPORATION

W.K. Jago

UT-BATTELLE, LLC

D.B. Watson

ELVADO ENVIRONMENTAL LLC

T.R. Harrison*
J.R. Walker*

Note: * - Receives full hard copy version

Y/TS-1983/R1/V2

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

MONITORING WELLS 1090 THROUGH GW-199

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

Index of monitoring wells included in Volume 2

Well	Regime	Revision Year	Well	Regime	Revision Year	Well	Regime	Revision Year
1090	CR	2004	GW-085	BC	2004	GW-135-03	BC	2004
55-1A	EF	2004	GW-097	BC	2005	GW-135-06	BC	2004
55-2B	EF	2004	GW-098	BC	2004	GW-135-11	BC	2004
55-2C	EF	2003	GW-100	BC	2004	GW-135-15	BC	2004
55-3A	EF	2005	GW-101	BC	2004	GW-135-19	BC	2004
55-3B	EF	2005	GW-105	EF	2003	GW-135-23	BC	2004
55-6A	EF	2004	GW-106	EF	2003	GW-135-26	BC	2004
56-2A	EF	2004	GW-108	EF	2004	GW-135-30	BC	2004
56-2B	EF	2004	GW-109	EF	2003	GW-135-34	BC	2004
56-2C	EF	2003	GW-115	BC	2004	GW-135-39	BC	2004
59-1A	EF	2003	GW-122	BC	2005	GW-141	CR	2004
59-1B	EF	2004	GW-123	BC	2003	GW-142	CR	2003
59-1C	EF	2003	GW-124	BC	2005	GW-143	CR	2004
60-1B	EF	2003	GW-127	BC	2005	GW-144	CR	2004
60-2A	EF	2003	GW-133-01	BC	2004	GW-145	CR	2004
GW-008	BC	2004	GW-133-05	BC	2004	GW-151	EF	2004
GW-014	BC	2005	GW-133-08	BC	2004	GW-153	EF	2004
GW-046	BC	2004	GW-133-10	BC	2004	GW-154	EF	2004
GW-052	BC	2004	GW-133-14	BC	2004	GW-156	CR	2004
GW-053	BC	2005	GW-133-17	BC	2004	GW-159	CR	2004
GW-056	BC	2004	GW-133-21	BC	2004	GW-169	UV	2004
GW-061	BC	2005	GW-133-24	BC	2004	GW-170	UV	2004
GW-064	BC	2005	GW-134-05	BC	2004	GW-171	UV	2004
GW-066	BC	2005	GW-134-11	BC	2004	GW-172	UV	2004
GW-068	BC	2005	GW-134-15	BC	2004	GW-173	CR	2004
GW-071	BC	2004	GW-134-18	BC	2004	GW-175	CR	2004
GW-072	BC	2003	GW-134-21	BC	2004	GW-176	CR	2004
GW-077	BC	2004	GW-134-25	BC	2004	GW-177	CR	2004
GW-078	BC	2004	GW-134-29	BC	2004	GW-178	CR	2004
GW-079	BC	2004	GW-134-33	BC	2004	GW-179	CR	2004
GW-080	BC	2004	GW-134-35	BC	2004	GW-190	EF	2003
GW-082	BC	2004	GW-134-36	BC	2004	GW-193	EF	2004

Notes:

BC = Bear Creek Hydrogeologic Regime
CR = Chestnut Ridge Hydrogeologic Regime
EF = Upper East Fork Poplar Creek Hydrogeologic Regime
UV = Union Valley (East of the EF Regime)

MAXIMUM CONCENTRATION: 2004

<5	ND	.	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

1090

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE: 53,853.02
Y-12 GRID NORTH COORDINATE: 28,718.02
SURFACE ELEVATION: 1,101.58 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 1982 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 98.02 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,104.48 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 6.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/NA
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	NA	NA
BOTTOM (filter pack or open hole):	96.7	1004.88
MIDPOINT (filter pack or open hole):	NA	NA
PUMP INTAKE:	84.80	1016.78
WATER LEVEL (average):	49.29	1052.29

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	55		
CONVENTIONAL SAMPLING METHOD:	41 samples	02/13/86	04/16/97
LOW-FLOW SAMPLING METHOD:	14 samples	11/11/97	08/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/24/04	.	08/04/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 36.45 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 1090

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in 1982, completed with a screened monitored interval from an unknown depth to 96.7 ft bgs, and constructed with 6.5-inch diameter PVC (#40) riser casing and well screen (slot size unknown). The well is located on the crest of Chestnut Ridge south of Y-12, about 300 ft northwest (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge, radiologically-contaminated soils, and demolition debris. A multilayer, low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to collect forty-one samples between February 1986 and April 1997 and the low-flow sampling method used to collect fourteen samples between November 1997 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

The well yields groundwater from the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is about 49 ft bgs. Presampling depth-to-water measurements for the well indicate unusually wide (>25 ft) fluctuations in seasonal groundwater surface elevations (Figure 1). Similarly wide water-level fluctuations also are evident for other wells located along the crest of Chestnut Ridge, which is both a recharge area and a flow divide, with components of flow to the north down the steep scarp slope of the ridge, parallel to the ridge crest (and geologic strike) to the east, and southward into drainage basins on the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields chloride and sodium-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 254 – 342 mg/L;
- pH (field measurements) of 6.4 – 7.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Groundwater samples from this well typically contain chloride concentrations above 20 mg/L and sodium levels above 10 mg/L, which exceed the respective background levels (UTLs) for groundwater in the Knox Group. Elevated concentrations of these ions may reflect natural levels related to the dissolution of evaporite minerals locally disseminated in the bedrock. Alternatively, elevated chloride and sodium levels in the groundwater at this well may result from the recharge of surface water containing dissolved salt used to de-ice the South Patrol Road and Mt. Vernon Road (the well is located at the intersection of these roads). Similarly elevated levels of chloride and sodium also are evident in other wells at the UNCS (GW-302 and GW-339) that are accessed via these paved roads, whereas much lower chloride and sodium concentrations (less than respective UTLs) are evident in the wells at the site that are accessed via a gravel road (GW-203, GW-205, and GW-221).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 36 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-five of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.7 mg/L in August 2004) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0127 mg/L in July 2002) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples (between January 1991 and April 1997). Chloroform was detected in the samples collected in July 1991 (3 μg/L), August 1992 (1 μg/L), and July 1993 (0.9 μg/L). Also, a trace of 12DCE (0.9 μg/L) was detected in a sample collected in July 1991. These results may be sampling or analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and the corresponding CE, with the highest value (4.37 pCi/L in May 1992) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and the corresponding CE, with the highest value (12.3 pCi/L in January 2001) being substantially below the SDWA screening level of gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision*, IRC No. 910704.0092, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

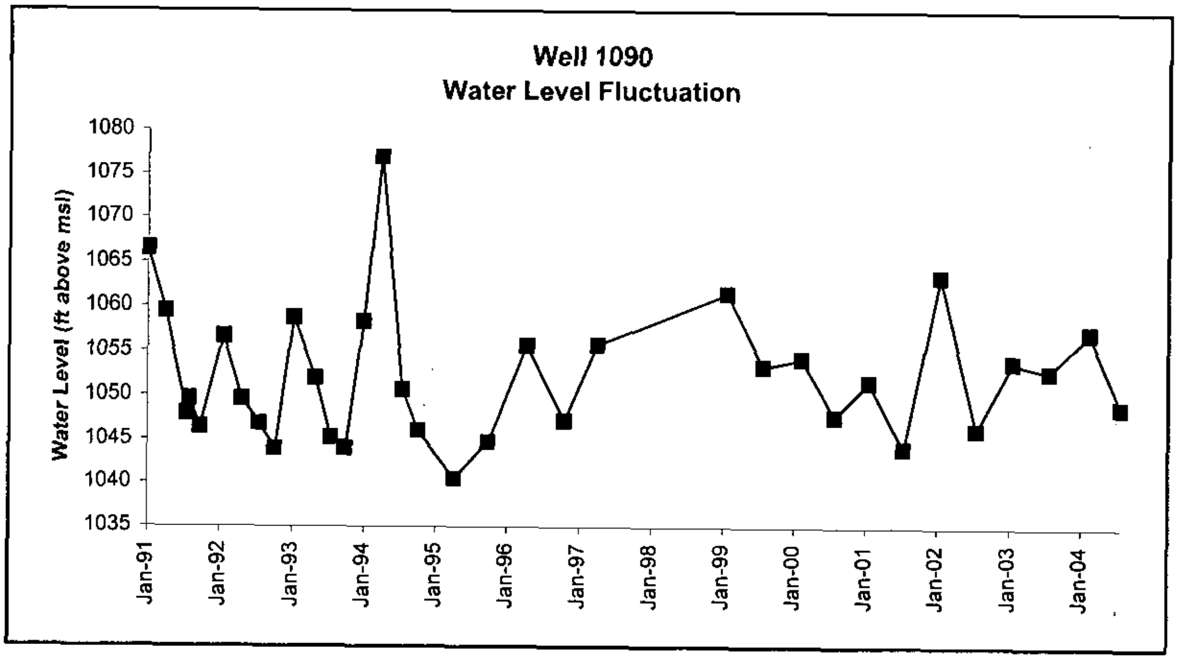

Well 1090
Water Level Fluctuation
Water Level (ft above msl)
1080
1075
1070
1065
1060
1055
1050
1045
1040
1035
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	<0.015	ND	ND	<25

55-1A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRIDB2
Y-12 GRID EAST COORDINATE: 55,014.07
Y-12 GRID NORTH COORDINATE: 30,469.88
SURFACE ELEVATION: 986.20 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/09/83 PAIRED/CLUSTERED WITH: 55-1B 55-1C
TAG DEPTH (measured): 19.22 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 986.91 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.3	974.90
BOTTOM (filter pack or open hole):	19.3	966.90
MIDPOINT (filter pack or open hole):	15.3	970.90
PUMP INTAKE:	16.29	969.91
WATER LEVEL (average):	10.30	975.90

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/05/96	06/05/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/08/04	11/16/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/08/04	.	11/16/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.28 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	13.8 mg/L	06/05/96	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 55-1A

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1983, completed with a screened monitored interval from 11 to 19 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with well 55-1B and 55-1C and is located in Bear Creek Valley (BCV), in the western section of Y-12, near the northeast corner of Bldg. 9204-4.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), a total of three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain a sample in June 1996 and the low-flow sampling method used to obtain samples in June and November 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation at the top of the Conasauga Group that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits minor (<1 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 55-1A indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well 55-1A may be primarily eastward (parallel with geologic strike) toward discharge areas in a buried northern tributary of UEFPC.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date show that the well yields mineralized, chloride- and sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 861 – 1000 mg/L;
- pH of 7.45 – 7.5 (field measurements);
- elevated levels of nitrate (>10 mg/L), sodium (>25 mg/L), sulfate (>50 mg/L), and chloride (>100 mg/L); and
- total (unfiltered sample) concentrations of trace metals (except iron and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate is the principal contaminant in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, with two of the results (13.8 mg/L in June 1996 and 12.1 mg/L in June 2004) exceeds the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are located near the west end of Y-12 approximately 2,500 ft west of the well. Operation of these former surface impoundments emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds.

With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the S-3 Ponds contaminant plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the site, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft to the east-southeast (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

Nitrate results for the groundwater samples collected to date are probably representative of concentrations in the water table interval in the Nolichucky Shale near the northern (upgradient) boundary of the S-3 Ponds contaminant plume, with the center of mass of the plume in the Nolichucky Shale being west-southwest of the well. Also, the similar nitrate concentrations evident in June 1996 (13.8 mg/L) and June 2004 (12.1 mg/L) suggest little if any long-term change in the overall flux of nitrate along the groundwater flow/contaminant transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

Two of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, but the highest value (0.000986 mg/L in November 2004) is more than an order of magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

One groundwater sample had gross beta activity above the applicable MDA and corresponding CE, and this result (19 pCi/L in June 2004) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year does equivalent (the drinking water MCL for gross beta activity). Additionally, the June 1996 sample from well 55-1A was analyzed for Tc-99 and the result was below the MDA. A beta-emitting radionuclide, Tc-99 is a "signature" component of the contaminant plume from the former S-3 Ponds (the only site at Y-12 that received wastes containing Tc-99) that is nearly as mobile as nitrate in the groundwater and shares a similar distribution in the Nolichucky Shale both east and west of the site.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

100 - 1,000	ND	500 - 5,000	ND	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

55-2B

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID B3
Y-12 GRID EAST COORDINATE: 55,199.17
Y-12 GRID NORTH COORDINATE: 30,084.88
SURFACE ELEVATION: 976.17 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH: 55-2A 55-2C
TAG DEPTH (measured): 27.69 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 977.42 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.6	956.57
BOTTOM (filter pack or open hole):	27.6	948.57
MIDPOINT (filter pack or open hole):	23.6	952.57
PUMP INTAKE:	24.95	951.22
WATER LEVEL (average):	6.15	970.02

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	5		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/10/96	06/10/96
LOW-FLOW SAMPLING METHOD:	4 samples	06/25/98	11/29/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/10/04	.	11/29/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.89 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	5	225 mg/L	11/29/04	Increasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	5	3,177 µg/L	06/10/96	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 55-2B

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed with a screened monitored interval from 20 to 28 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with well 55-2A and 55-2C and is located in Bear Creek Valley (BCV), within the west-central section of Y-12 approximately 400 ft directly east of the Waste Coolant Processing Area (WCPA), which includes the Waste Coolant Storage Tanks and the Waste Coolant Biodegradation Facility, and the Waste Coolant Processing Facility. These facilities were used between 1977 and 1985 to handle and treat large volumes of waste machine coolants that contained very high levels (several thousand parts per million) total organic carbon, chlorinated hydrocarbons, and methyl ethyl ketone (2-butanone) along with metals and depleted uranium (DOE 1998). In August 1988, the WCPA was clean-closed under RCRA, with closure-related wastes sent to the Interim Drum Yard at the west end of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), a total of five groundwater samples have been collected from the well, with the conventional sampling method used to collect one sample in June 1996 and the low-flow sampling method used to collect samples in June 1998, August 1998, June 2004, and November 2004. Note that all of the groundwater sampling dates have occurred during seasonally low groundwater flow conditions (summer and fall). Consequently, the available sampling results may not provide representative data regarding potential seasonal changes in groundwater elevations, geochemical characteristics, and contaminant concentrations (if any).

High TDS is a distinguishing characteristic of the groundwater samples from this well (see Section 4.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation at the top of the Conasauga Group that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs. Also, groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are higher in well 55-2B than in well 55-2C, which is completed at a greater depth (76 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoints (elevation) in each well (48.2 ft), the contemporaneous groundwater elevations indicate a downward vertical gradient (0.005) from the water table interval to the shallow bedrock interval.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 55-2B indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well 55-2B may be primarily eastward (parallel with geologic strike) toward discharge areas in a buried northern tributary of UEFPC.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date show that the well yields highly mineralized, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,486 – 1,930 mg/L;
- pH of 6.29 – 6.3 (field measurements);
- very high concentrations of calcium (>300 mg/L) and nitrate (>200 mg/L);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- elevated total (unfiltered sample) concentrations of strontium (>1 mg/L); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants in the groundwater at this well.

5.1 NITRATE

As shown in the data summary below, each groundwater sample collected to date had nitrate concentrations above 100 mg/L (more than 10 times the drinking water MCL for nitrate [10 mg/L]), with the most recent sampling results indicating an overall increase in nitrate levels.

Date Sampled	Nitrate as N (mg/L)
06/10/96	117
06/25/98	144
08/03/98	146
06/10/04	222
11/29/04	225

The source of the nitrate in the groundwater at this well is probably the S-3 Ponds, which are former hazardous waste surface impoundments located near the west end of Y-12 approximately 3,000 ft west of the well. Closed in 1988 and covered with a low-permeability cap (and asphalt-paved vehicle parking lot) in 1989, the long-term (34 years) historical operation of the S-3 Ponds emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., strontium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants. The distribution of nitrate in the groundwater suggests relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds. Substantially slower migration is indicated deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

Nitrate results for the groundwater samples from this well are believed to be representative of concentrations within the shallow flow system (water table interval) in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998). Moreover, the close similarity between these results and contemporaneous nitrate results for samples collected from well 55-2C obtained in June 1996 (118 mg/L), June 1998 (131 mg/L), and August 1998 (135 mg/L) indicate that the nitrate levels in the water table interval are similar to those evident at greater depth (76 ft bgs) in the bedrock. Additionally, as shown by a time-series plot (Figure 1), nitrate concentrations in the shallow groundwater at this well appear to have increased more than 90% through November 2004. Nitrate data for well 55-2C likewise show an increasing concentration trend in the deeper flow system, with an increase of 53% through November 2003 (181 mg/L). Increasing concentrations of nitrate in the groundwater at these wells possibly indicate the continued eastward migration of the center of mass of the S-3 Ponds contaminant plume in the Nolichucky Shale east of the site.

5.2 URANIUM

Two of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, and both results (0.0005 mg/L in June 1996 and 0.015 mg/L in August 1998) are less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each of the groundwater sample collected to date (Table 1): dichlorodifluoromethane (DCFM), PCE, TCE, VC, 11DCA, 11DCE, c12DCE, t12DCE, 111TCA, and 1,1,2-trichloro-1,2,2-trichlorofluoroethane, which is also known as freon-113 (F113). These compounds are components of the plume of dissolved VOCs in the groundwater that was emplace during historical operation of the WCPA. Also, soluble compounds leached from contaminated soils in the vadose zone and dissolution of constituents from potential DNAPL below the saturated zone are ongoing secondary sources of VOCs in the groundwater downgradient of this site (DOE 1998). The current network of monitoring wells does not indicate any strongly preferential groundwater flow/transport patterns in the vicinity of the WCPA, with generally eastward (parallel with geologic strike) transport/migration of the mobile components of the VOC plume suggested by the presence of "signature" VOCs in the shallow groundwater at well 55-2B and in discharge from storm drains east of the WCPA and from basement sumps in Bldg. 9204-4 and Bldg. 9201-5 (DOE 1998).

The primary VOCs in the groundwater samples collected to date are PCE, TCE, and 12DCE (c12DCE), which were detected in each sample, with the most recent results (June and November 2004) showing respective concentrations above 600 µg/L, 200 µg/L, and 800 µg/L (Table 1). Note that these concentrations are orders-of-magnitude above the respective MCL for PCE (5 µg/L), TCE (5 µg/L) and c12DCE (70 µg/L). The most recent sampling results show that F113 levels exceed 500 µg/L, but analytical results for this compound were not reported for previous samples. Maximum concentrations of DCFM, t12DCE, and 111TCA are all below 20 µg/L, although historical data are not available for DCFM and t12DCE (results for these compounds were not reported for previous samples).

Several of the VOCs in the groundwater at this well, notably PCE and TCE, are probably primary components of the wastes handled at the WCPA, whereas other compounds in the groundwater, including c12DCE and VC, may be present as a result of natural degradation of related parent compounds. Indeed, the presence of c12DCE in the groundwater is almost certainly attributable to biologically mediated degradation (sequential reductive dechlorination) of PCE. Nevertheless, the data for the geochemical indicator parameters shown in the following summary indicate that the groundwater in this well is not especially conducive to biotic degradation of chlorinated hydrocarbons.

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	June 2004	November 2004
Nitrate < 1 mg/L	222	225
Iron (II) > 1 mg/L	<0.05*	<0.05*
Sulfate < 20 mg/L	20.8	22.7
Dissolved Oxygen < 0.5 ppm	0.87**	3.69**
REDOX < 50 mV	194**	202**
pH >5 and < 9 st. units	6.29**	6.29**
Note: *Result is for total iron; **Field measurement.		

This suggests that biotic degradation occurs elsewhere (upgradient of the well), with downgradient migration of the parent compounds and degradation products via the groundwater flow/contaminant transport pathways intercepted by the monitored interval in the well.

A time-series plot of the summed VOC concentrations shows a clearly decreasing trend (Figure 2). However, PCE concentrations have increased about 20% from 1998 to 2004 while the concentrations of the other VOCs (with historical results) have decreased (Table 1). These divergent concentration trends possibly indicate continued eastward migration of the parent compound (PCE) from the WCPA and/or reduced biotic degradation upgradient of the well. Additionally, the increasing nitrate concentrations in the groundwater at this well (see Section 5.1) indicate conditions are becoming less conducive to degradation, which may allow PCE concentrations to increase relative to concentrations of degradation products (c12DCE and VC).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (20 pCi/L in November 2004) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Additionally, the June 1996 sample from well 55-2B was analyzed for Tc-99 and the result was below the MDA. A beta-emitting radionuclide, Tc-99 is a "signature" component of the contaminant plume from the former S-3 Ponds that is nearly as mobile as nitrate in the groundwater and shares a similar distribution in the Nolichucky Shale both east and west of the site.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Surface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well 55-2B: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	TCE	12DCE (Total)	c12DCE	t12DCE	11DCE
06/10/96	550	300	2200	NR	NR	42
06/25/98	510	250	1900	NR	NR	.
08/03/98	520	260	1800	NR	NR	40
06/10/04	670	250	942	930	12	26
11/29/04	630	230	862	850	12	26
MCL	**5**	**5**	**NA**	**70**	**NA**	**7**
Date Sampled	**Concentration (µg/L)**					
	VC	**111TCA**	**11DCA**	**DCFM**	**F113**	**Other**
06/10/96	38	13	33	NR	NR	Chloroform (1 J)
06/25/98	38	.	25	NR	NR	2-Butanone (37)
08/03/98	63	13	31	NR	NR	Chloroform (1 J)
06/10/04	21	4 J	19	10	500	.
11/29/04	21	4 J	18	14	470	.
MCL	**2**	**200**	**NA**	**80**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

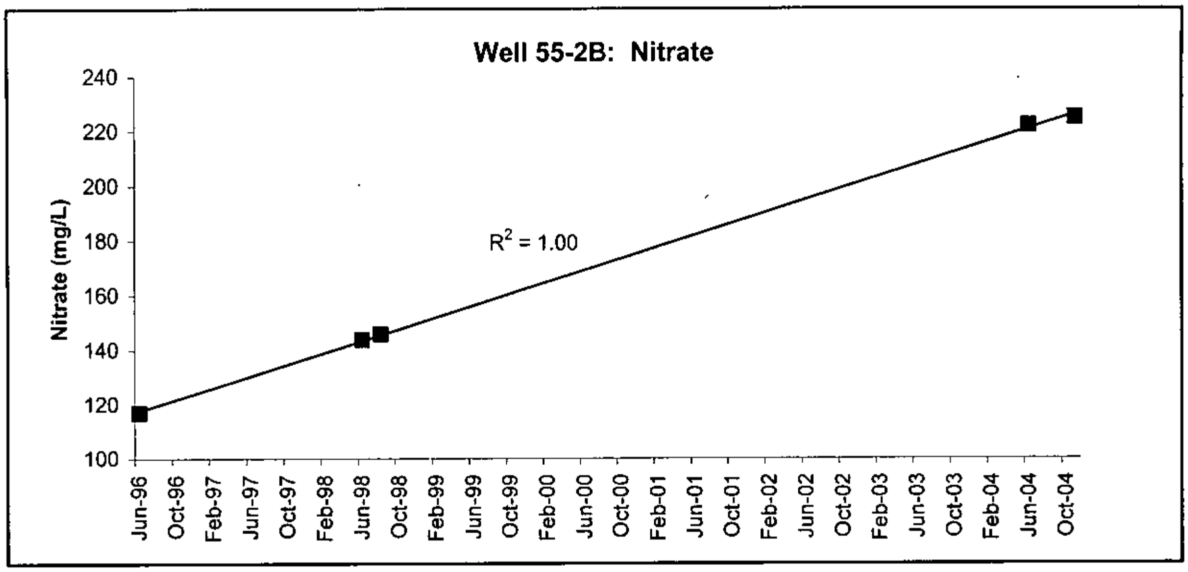


Figure 1

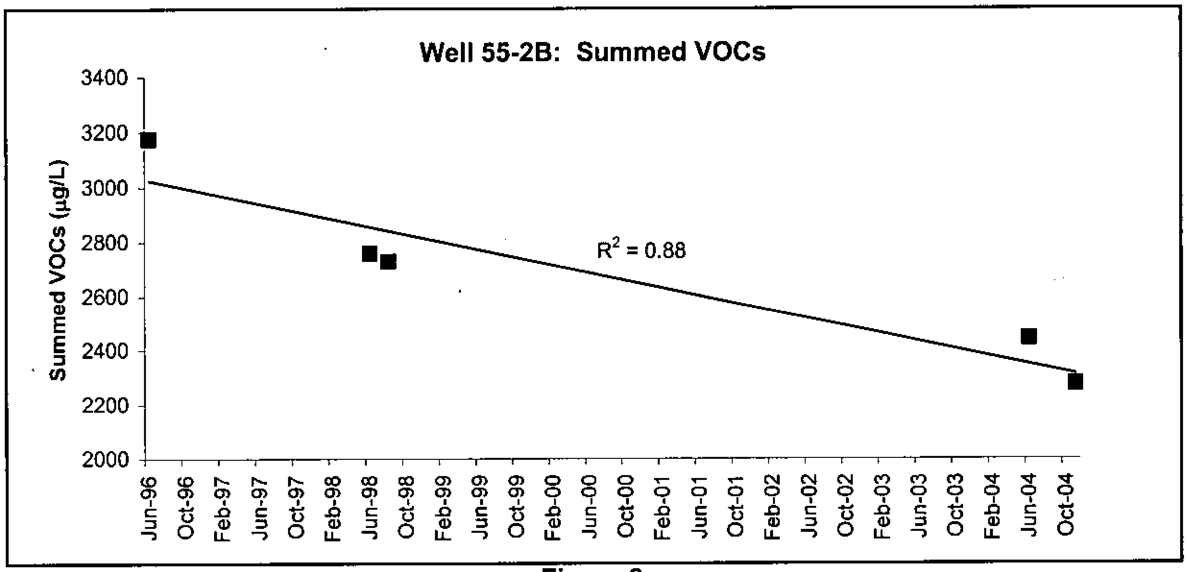


Figure 2

MAXIMUM CONCENTRATION: 2003

100 - 1,000	<0.015	500 - 5,000	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

55-2C

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID B3
Y-12 GRID EAST COORDINATE: 55,202.96
Y-12 GRID NORTH COORDINATE: 30,085.20
SURFACE ELEVATION: 976.07 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/22/83 PAIRED/CLUSTERED WITH: 55-2A 55-2B
TAG DEPTH (measured): 76.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 977.02 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	67.9	908.17
BOTTOM (filter pack or open hole):	75.9	900.17
MIDPOINT (filter pack or open hole):	71.9	904.17
PUMP INTAKE:	73.42	902.65
WATER LEVEL (average):	6.76	969.31

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	9		
CONVENTIONAL SAMPLING METHOD:	3 samples	06/09/96	03/13/97
LOW-FLOW SAMPLING METHOD:	6 samples	06/25/98	11/18/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	.	05/28/03	.	11/18/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.73 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	8	182 mg/L	05/28/03	Increasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	8	3,791 µg/L	06/09/96	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 55-2C

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during August 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothschild et. al. 1984). The well was completed with a screened monitored interval from 67.9 to 75.9 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with wells 55-2A and 55-2B and is located in Bear Creek Valley (BCV) at Comprehensive Monitoring Plan Grid B3, which is near the southwest corner of Bldg. 9201-5W in the west-central section of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the mercury investigation at Y-12, nine groundwater samples have been collected from the well, with the conventional sampling method used to obtain three samples between June 1996 and March 1997 and the low-flow sampling method used to obtain six samples between June 1998 and November 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6.75 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations. Also, the presampling groundwater elevations in this well and the two wells with which it is clustered (55-2A and 55-2B) indicate upward hydraulic gradients from the deeper bedrock (55-2C) to the shallow bedrock interval (55-2B) and downward vertical gradients from the water table interval (55-2A) to the shallow bedrock interval.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well 55-2C indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,200 – 1,550;
- pH of 6.8 – 7.1 (field measurements);
- elevated concentrations of inorganic contaminants, notably barium (>1 mg/L), nitrate (>100 mg/L), sodium (>75 mg/L), and strontium (>4 mg/L);
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except barium and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eight of the groundwater samples were analyzed for nitrate, with concentrations above 100 mg/L reported for each sample (Table 1), which are an order-of-magnitude higher than the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

Nitrate results for the groundwater samples from this well are believed to be representative of concentrations in the long-term migration/transport pathways at depth in the Nolichucky Shale east of the former S-3 Ponds. Also, increased flux of nitrate along the strike-parallel flow/transport pathways intercepted by the monitored interval in the well is suggested by the overall increase in nitrate concentrations (Figure 1), which increased about 55% between June 1998 (118 mg/L) and March 2003 (182 mg/L). Increasing flux of nitrate potentially indicates the continued eastward (strike-parallel) movement of the center of mass of the contaminant plume in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998).

5.2 URANIUM

Eight of the groundwater samples were analyzed for total uranium, with concentrations at or above the applicable analytical reporting limit detected in the samples collected in August 1998 (0.0127 mg/L) and November 2003 (0.000585 mg/L). Both concentrations are below the MCL for uranium (0.03 mg/L). Uranium is one of the primary components of the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. The low concentrations of uranium in the groundwater samples, in contrast to the very high nitrate levels in the samples, reflects the greater mobility of nitrate in the groundwater relative to that of uranium.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, the following VOCs were detected in the groundwater samples (Table 2): benzene, chloroform, PCE, TCE, toluene, TCFM, VC, 11DCA, 11DCE, 12DCE (c12DCE and t12DCE), and 111TCA. The source of the VOCs, which are not significant components of the contaminant plume originating from the former S-3 Ponds, has not been confirmed, but may be related to historical production and machining operations in Bldgs. 9201-4 and 9201-5 (DOE 1998). Considering the upward vertical hydraulic gradients noted in Section 3, it is possible that DNAPL deeper in the bedrock may be a source of the VOCs in the shallow groundwater at this well.

The principal compounds in the groundwater samples are PCE, TCE, and 12DCE, which were detected in each sample, with maximum concentrations above 500 μg/L, 300 μg/L, and 2,000 μg/L, respectively (Table 2). Secondary compounds are VC, 11DCE, and 111TCA, at least one of which were detected in all but one of the samples, with maximum concentrations slightly above (VC) and below (11DCE and 111TCA) 50 μg/L. Note that the most recent sampling results show that the concentrations of PCE, TCE, c12DCE, 11DCE, and VC remain substantially above respective MCLs (Table 2). In contrast, chloroform, benzene, TCFM, and toluene have been detected infrequently (two samples or less) at much lower concentrations.

Biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater may explain the very high levels of 12DCE (c12DCE) and the presence of VC in the groundwater samples from this well. However, as illustrated by the data summarized in Table 3, results for several indicator parameters suggest that the geochemical conditions in the well are not within the optimum range for biotic degradation (dechlorination) of chlorinated hydrocarbons. The REDOX conditions, for instance, do not show the strongly reducing (methanogenic) conditions necessary to transform 12DCE to VC (Chapelle 1996). Considering the upward hydraulic gradient indicated by presampling groundwater elevations (see Section 3.0), perhaps the monitored interval in the well intercepts groundwater flow/transport pathways for dissolved VOCs moving upward from a source (DNAPL) deeper in the bedrock where conditions are better suited for biodegradation.

A time-series plot of summed concentrations of VOCs detected in the groundwater samples (excluding false positive results) shows a clearly decreasing long-term trend (Figure 2). Also, as shown by the data summarized in Table 2, the concentrations of individual VOCs all exhibit decreasing trends. These concurrently decreasing concentration trends suggest a corresponding reduction in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the well. Reduced flux of dissolved VOCs also contrasts with the apparently increased flux of nitrate (see Section 5.1). Assuming a heterogeneous mixture of nitrate and

VOCs, the divergent trends potentially reflect groundwater transport from separate respective sources.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Five of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (26.5 pCi/L in June 1998) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well 55-2C: summary of results for selected inorganic contaminants

Sampling Date	Concentration (mg/L)			
	Nitrate (as N)	Barium	Sodium	Strontium
06/09/96	118			
03/12/97	123			
06/25/98	131			
08/03/98	135			
05/22/00	144	1.32	59.4	4.26
10/17/00	154	1.33	65.5	4.49
05/28/03	182	1.38	74	4.91
11/18/03	181	1.34	71.1	4.91
MCL	**10**	**NA**	**2**	**NA**
Note: "." = Not detected; NA = Not applicable				

Table 2. Well 55-2C: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	TCE	12DCE		
			Total	c12DCE	t12DCE
06/09/96	640	350	2,700	NR	NR
03/12/97	550	340	2,121	2,100	21
06/25/98	390	220	1,800	NR	NR
08/03/98	360	210	1,700	NR	NR
05/22/00	580	310	1,600	1,600	16
10/17/00	530	310	1,600	1,600	17
05/28/03	350	210	1,100	1,100	13
11/18/03	480	240	1,000	1,000	13
MCL	**5**	**5**	**NA**	**70**	**NA**

Date Sampled	Concentration (µg/L)				
	VC	111TCA	11DCA	11DCE	OTHER
06/09/96	.	34	45	.	Toluene (22)
03/12/97	50	13	37	42	Benzene (0.1 J); Chloroform (1 J)
06/25/98	35	.	.	.	.
08/03/98	58	10	31	38	Chloroform (1 J)
05/22/00	33	7	28	35	TCFM (6)
10/17/00	33	6	30	38	.
05/28/03	22	4 J	29	30	TCFM (4)
11/18/03	23	3 J	31	30	.
MCL	**2**	**200**	**5**	**7**	
Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported					

Table 3. Well 55-2C: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2000	Oct. 2000	May 2003	Nov. 2003
Nitrate < 1 mg/L	144	154	182	181
Iron (II) > 1 mg/L	<0.05*	<0.05*	<0.05*	<0.05*
Sulfate < 20 mg/L	18.7	18.7	16.6	17.9
Dissolved Oxygen < 0.5 ppm	2.31**	0.73**	6.15**	2.72**
REDOX < 50 mV	168**	150**	165**	180**
pH >5 and < 9 st. units	6.97 **	6.88 **	7.05**	6.94**

Note: *Results are for total iron; **Field measurement.

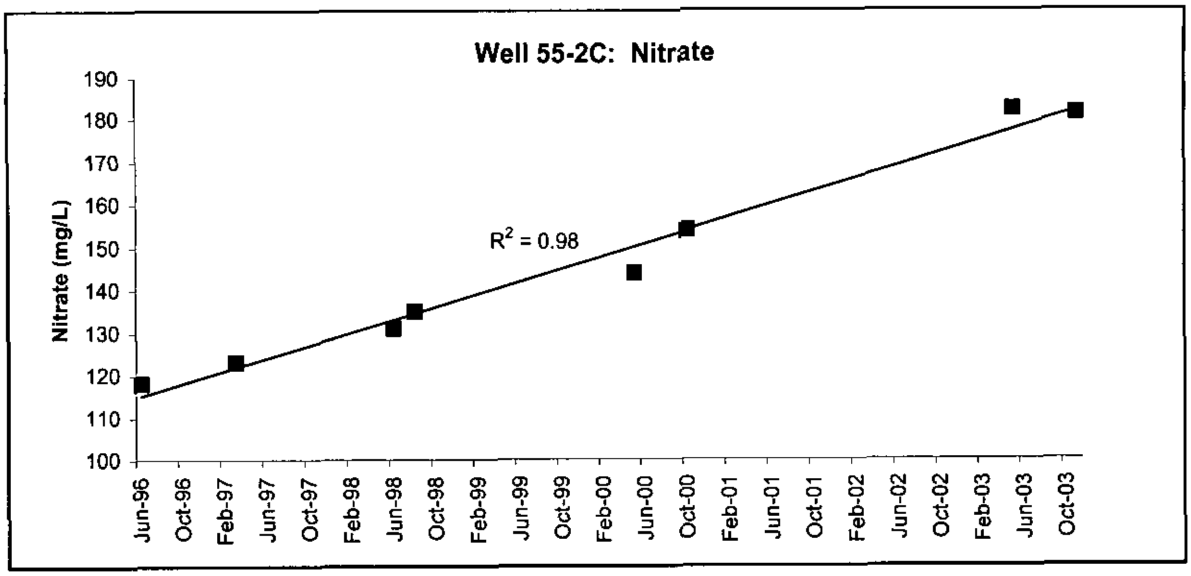


Figure 1

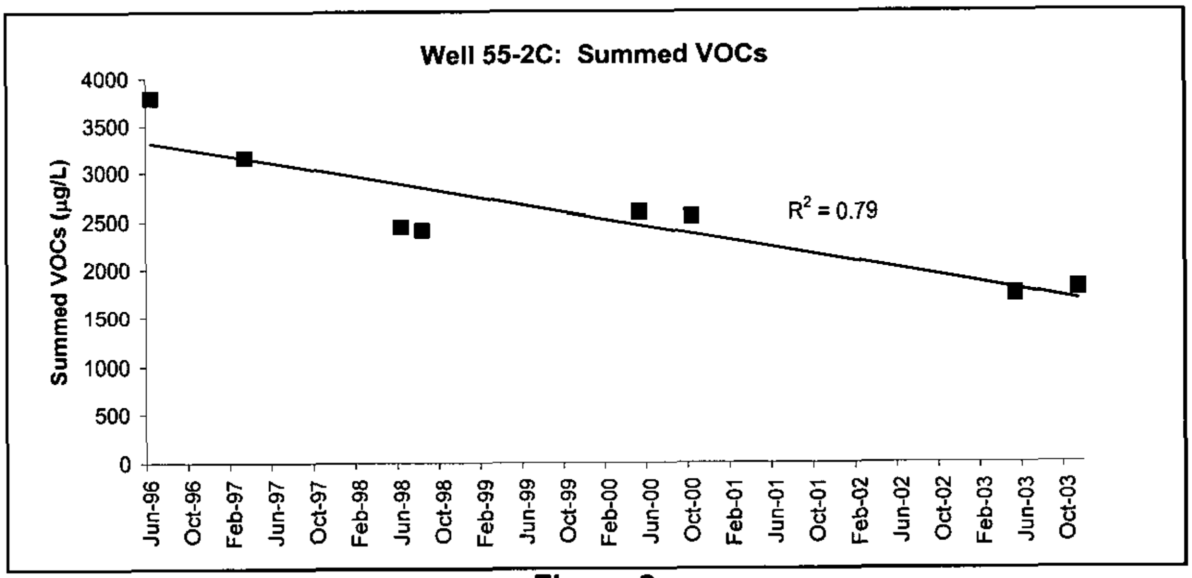


Figure 2

MAXIMUM CONCENTRATION: 2005

<5	<0.015	>5,000	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

55-3A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-5
Y-12 GRID EAST COORDINATE: 55,695.12
Y-12 GRID NORTH COORDINATE: 29,959.34
SURFACE ELEVATION: 971.59 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 1983 PAIRED/CLUSTERED WITH: 55-3B 55-3C
TAG DEPTH (measured): 14.25 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 972.46 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	6.3	965.29
BOTTOM (filter pack or open hole):	14.3	957.29
MIDPOINT (filter pack or open hole):	10.3	961.29
PUMP INTAKE:	.	.
WATER LEVEL (average):	10.74	960.85

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	1		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	1 samples	11/17/05	11/17/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	.	.	11/17/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	1	13,670 µg/L	11/17/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL 55-3A

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The exact date of installation for this well is unknown, but available information shows that the well was completed in late 1983 with a screened monitored interval from 6.3 to 14.3 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well is clustered with deeper wells 55-3B (38 ft bgs) and 55-3C (77 ft bgs) and is located in Bear Creek Valley (BCV) in the west-central section of Y-12, approximately 100 ft south of the central portion of Building 9201-5.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), only one groundwater sample has been collected from the well to date, with the low-flow sampling method used to obtain the sample in November 2005.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the upper Nolichucky Shale (the Conasauga Group), near the geologic contact with the overlying Maynardville Limestone. The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

The static water level in the well occurs at approximately 11 ft bgs. Groundwater elevations recorded during a contemporaneous sampling event (i.e., within 24 hours, November 2005) are higher in well 55-3A than in well 55-3B, which is completed at a greater depth (38 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoints in each well (23.8 ft), the contemporaneous groundwater elevations indicate a slightly downward vertical gradient (0.008) within the water table interval from well 55-3A to 55-3B.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 55-3A indicate south and southeasterly flow toward the Maynardville Limestone and UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the well is located in the immediate vicinity of a buried former northern tributary of UEFPC that trends along the eastern and southeastern side of Bldg. 9201-5 and may locally influence groundwater flow patterns.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater sample collected in November 2005 suggest that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 497 mg/L;
- pH of 7.02 (field measurement);
- very high sulfate (185 mg/L);
- low molar proportions of chloride, nitrate, potassium, and sodium (<10% of total anions/cations);
- slightly elevated nickel concentration (0.0352 mg/L); and
- total (unfiltered sample) concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate concentration is conspicuous for groundwater from such a shallow depth in the Nolichucky Shale and may be attributable to contamination associated with effluent from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater sample collected in November 2005, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

The nitrate concentration reported for the groundwater sample (2.39 mg/L) is less than the drinking MCL for nitrate (10 mg/L), but is substantially above the background level of nitrate (<0.028 mg/L) in uncontaminated groundwater from the Nolichucky Shale in BCV.

5.2 URANIUM

The uranium concentration reported for the groundwater sample (0.000995 mg/L) exceeds the analytical reporting limit but is several orders-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the following data summary, the one groundwater sample collected to date contained extremely high concentrations of PCE, TCE, and c12DCE, with the concentration of each compound being substantially lower than evident in the deeper groundwater from well 55-3B. Note that other VOCs may be present (e.g., <100 µg/L) in the groundwater at either well, but were not "detected" because the groundwater sample from each well was diluted (100X at 55-3A and 1,000X at 55-3B) to obtain an optimum matrix for analysis.

Compound	Concentration (µg/L) in November 2005	
	Well 55-3A (14 ft bgs)	Well 55-3B (38 ft bgs)
PCE	12,000	71,000
TCE	850	5,800
c12DCE	840	1,300

The extremely high concentrations of PCE in the groundwater from wells 55-3A and 55-3B indicate that PCE may be present as a dense nonaqueous phase liquid (DNAPL), with the higher PCE level evident in well 55-3B indicating that the DNAPL may occur at greater depth (i.e., >38 ft bgs) in the bedrock. The source of the PCE is not known, but may be associated with historical operations housed in Bldg. 9201-5, which is approximately 100 ft north (hydraulically upgradient) of the wells. Assuming the presence of DNAPL, a nearby source seems likely considering the nature of DNAPL migration in the subsurface, which would be expected to be density- and/or gravity-driven and to occur independent of the hydraulic gradient. Also, assuming that bedding in the Nolichucky Shale locally dips to the south (grid direction) at an angle of at least 45º, the monitored interval in the well intercepts groundwater flow/transport pathways that subcrop beneath the ground surface within 20 ft of the well. Nevertheless, considering the anisotropy imposed by the dominance of strike-parallel flowpaths (i.e., bedding-plane fractures) in the Nolichucky Shale, the source of the PCE may be located to the west of the wells.

Biologically-mediated degradation of the PCE (dissolved and DNAPL) is almost certainly the source of the TCE and c12DCE in the groundwater from wells 55-3A and 55-3B. However, relative to the PCE levels, the concentrations of TCE and c12DCE are significantly lower (<1% of PCE concentration). These results suggest that, for whatever reason, subsurface geochemical conditions are not optimally conducive to biodegradation. As indicated by the results for selected indicator parameters shown in the following summary, the geochemical conditions in the shallower groundwater from well 55-3A seem less amenable to biodegradation than evident in the deeper groundwater from well 55-3B, where very low dissolved oxygen and moderately negative REDOX suggest conditions better suited to anaerobic biodegradation (dechlorination) of the PCE and other chlorinated hydrocarbons.

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		November 2005	
		Well 55-3A (14 ft bgs)	Well 55-3B (38 ft bgs)
Nitrate	< 1 mg/L	2.39	<0.28
Iron (II)	> 1 mg/L	0.33*	0.112*
Sulfate	< 20 mg/L	185	30.5
Dissolved Oxygen	< 0.5 ppm	1.1**	0.35**
REDOX	< 50 mV	160**	-66**
pH	>5 and < 9 st. units	7.02**	7.63**
Note: *Result is for total iron; **Field measurement.			

5.4 GROSS ALPHA ACTIVITY

The groundwater sample collected in November 2005 did not have gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

The groundwater sample collected in November 2005 did not have gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant*, *Oak Ridge*, *Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Surface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	>5,000	ND	ND

55-3B

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-5
Y-12 GRID EAST COORDINATE: 55,698.77
Y-12 GRID NORTH COORDINATE: 29,958.73
SURFACE ELEVATION: 971.57 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 1983 PAIRED/CLUSTERED WITH: 55-3A 55-3C
TAG DEPTH (measured): 37.98 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 973.32 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	30.1	941.47
BOTTOM (filter pack or open hole):	38.1	933.47
MIDPOINT (filter pack or open hole):	34.1	937.47
PUMP INTAKE:	.	.
WATER LEVEL (average):	10.91	960.66

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	1		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	1 samples	11/17/05	11/17/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	.	.	11/17/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	1	78100 µg/L	11/17/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL 55-3B

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The exact date of installation for this well is unknown, but available information shows that the well was completed in late 1983 with a screened monitored interval from 30.1 to 38.1 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well is clustered with shallower well 55-3A (14 ft bgs) and deeper well 55-3C (77 ft bgs) and is located in Bear Creek Valley (BCV) in the west-central section of Y-12, approximately 100 ft south of the central portion of Building 9201-5.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), only one groundwater sample has been collected from the well to date, with the low-flow sampling method used to obtain the sample in November 2005.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the upper Nolichucky Shale (the Conasauga Group), near the geologic contact with the overlying Maynardville Limestone. The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

The static water level in the well occurs at approximately 11 ft bgs. Groundwater elevations recorded during a contemporaneous sampling event (i.e., within 24 hours, November 2005) are higher in well 55-3A than in well 55-3B, which is completed at a greater depth (38 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoints in each well (23.8 ft), the contemporaneous groundwater elevations indicate a slightly downward vertical gradient (0.008) within the water table interval from well 55-3A to 55-3B.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 55-3B indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the well is located in the immediate vicinity of a buried former northern tributary of UEFPC that trends along the eastern and southeastern side of Bldg. 9201-5 and may locally influence groundwater flow patterns.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater sample collected in November 2005 suggest that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 264 mg/L;
- pH of 7.63 (field measurement);
- elevated chloride (32.7 mg/L);
- low molar proportions of nitrate, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated chloride concentration is conspicuous for groundwater from such a shallow depth in the Nolichucky Shale and may be attributable to contamination associated with effluent from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. It is also possible that the elevated chloride levels are at least partially attributable to the degradation of the chlorinated hydrocarbons in the groundwater (see Sect. 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater sample collected in November 2005, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

The concentration of nitrate in the one groundwater sample collected to date did not exceed the analytical reporting limit.

5.2 URANIUM

The concentration of uranium in the one groundwater sample collected to date did not exceed the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the following data summary, the one groundwater sample collected to date contained extremely high concentrations of PCE, TCE, and c12DCE, with the concentration of each compound being substantially higher than evident in the shallower groundwater from well 55-3A. Note that other VOCs may be present (<1,000 μg/L) in the groundwater at either well, but were not "detected" because the groundwater sample from each well was diluted (1,000 X) to obtain an optimum matrix for analysis.

Compound	Concentration (μg/L) in November 2005	
	Well 55-3A (14 ft bgs)	Well 55-3B (38 ft bgs)
PCE	12,000	71,000
TCE	850	5,800
c12DCE	840	1,300

The extremely high concentrations of PCE in the groundwater at wells 55-3A and 55-3B indicate that PCE may be present as a dense nonaqueous phase liquid (DNAPL), with the higher PCE level evident in well 55-3B indicating that the DNAPL may occur at greater depth (i.e., >38 ft bgs) in the bedrock. The source of the PCE is not known, but may be associated with historical operations housed in Bldg. 9201-5, which is approximately 100 ft north (hydraulically upgradient) of the wells. Assuming the presence of DNAPL, a nearby source seems likely considering the nature of DNAPL migration in the subsurface, which would be expected to be density- and/or gravity-driven and to occur independent of the hydraulic gradient. Also, assuming that bedding in the Nolichucky Shale locally dips to the south (grid direction) at an angle of at least 45º, the monitored interval in the well intercepts groundwater flow/transport pathways that subcrop beneath the ground surface within 50 ft of the well. Nevertheless, considering the anisotropy imposed by the dominance of strike-parallel flowpaths (i.e., bedding-plane fractures) in the Nolichucky Shale, the source of the PCE may be located to the west of the wells.

Biologically-mediated degradation of the PCE (dissolved and DNAPL) is almost certainly the source of the TCE and c12DCE in the groundwater from wells 55-3A and 55-3B. However, relative to the PCE levels, the concentrations of TCE and c12DCE are significantly lower (<1% of PCE concentration). These results suggest that, for whatever reason, subsurface geochemical conditions are not optimally conducive to biodegradation. As indicated by the results for selected indicator parameters shown in the following summary, the geochemical conditions in the shallower groundwater from well 55-3A seem less amenable to biodegradation than evident in the deeper groundwater from well 55-3B, where very low dissolved oxygen and moderately negative REDOX suggest conditions better suited to anaerobic biodegradation (dechlorination) of the PCE and other chlorinated hydrocarbons.

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	**November 2005**	
	Well 55-3A (14 ft bgs)	**Well 55-3B (38 ft bgs)**
Nitrate < 1 mg/L	2.39	<0.28
Iron (II) > 1 mg/L	0.33*	0.112*
Sulfate < 20 mg/L	185	30.5
Dissolved Oxygen < 0.5 ppm	1.1**	0.35**
REDOX < 50 mV	160**	-66**
pH >5 and < 9 st. units	7.02**	7.63**

Note: *Result is for total iron; **Field measurement.

5.4 GROSS ALPHA ACTIVITY

The groundwater sample collected in November 2005 did not have gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

The groundwater sample collected in November 2005 did not have gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant*, *Oak Ridge*, *Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Surface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

55-6A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9103
Y-12 GRID EAST COORDINATE: 55,906.66
Y-12 GRID NORTH COORDINATE: 30,667.34
SURFACE ELEVATION: 986.82 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 1983/1984 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 12.77 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 989.04 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.9	981.92
BOTTOM (filter pack or open hole):	12.9	973.92
MIDPOINT (filter pack or open hole):	8.9	977.92
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	6.75	980.07

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/05/96	06/05/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/07/04	11/16/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/07/04	.	11/16/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.16 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 55-6A

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed in the fall of 1983 or the winter of 1984 with a screened monitored interval from 4.9 to 12.9 ft bgs, and constructed with nominal 4.5-inch PVC (#40) riser casing attached to stainless steel (Type 304) well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV), within the east-central section of Y-12 just south of the Abandoned Nitric Acid Pipeline (ANAP). Operated between 1951 and 1984, the ANAP transferred nitric-acid wastes generated in processing facilities westward into the former S-3 Ponds, which is a closed hazardous waste disposal site located near the west end of Y-12 approximately 4,000 ft west of well 55-6A.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, groundwater samples were collected from the well in June 1996, June 2004, and November 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in Maryville Limestone (the Conasauga Group). The bulk of the groundwater flow in the Maryville Limestone occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits minor (2 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 55-6A indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well 55-6A may be primarily eastward (parallel with geologic strike) toward discharge areas in a buried northern tributary of UEFPC.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 255 – 362 mg/L;
- pH of 6.5 – 6.8 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that none of the principal contaminants present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, and the maximum result (1.88 mg/L in November 2004) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, and this result (0.00737 mg/L in November 2004) is more than an order of magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

One of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, and this result (5.5 pCi/L in June 2004) is below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

56-2A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID C3
Y-12 GRID EAST COORDINATE: 56,228.72
Y-12 GRID NORTH COORDINATE: 29,880.85
SURFACE ELEVATION: 962.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH: 56-2B 56-2C
TAG DEPTH (measured): 15.03 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 963.53 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	7.1	955.42
BOTTOM (filter pack or open hole):	15.1	947.42
MIDPOINT (filter pack or open hole):	11.1	951.42
PUMP INTAKE:	11.99	950.53
WATER LEVEL (average):	8.01	954.51

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	3 samples	03/23/98	11/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/09/04	.	11/18/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.97 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	3	59 μg/L	03/23/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL 56-2A

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed with a screened monitored interval from 7.1 to 15.1 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with well 56-2B and 56-2C and is located in Bear Creek Valley (BCV), within the west-central section of Y-12, about 150 ft south of the southwestern corner of Bldg. 9201-4.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), a total of three groundwater samples have been collected from the well to date, with the low-flow sampling method used to obtain samples in March 1998, June 2004, and November 2004.

The well does not exhibit distinguishing sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in upper Nolichucky Shale (the Conasauga Group), near the geologic contact with the overlying Maynardville Limestone. The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs. Additionally, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show higher groundwater elevations in well 56-2A than in well 56-2B, which is completed at a greater depth in the water table interval in the Nolichucky Shale (39 ft bgs), and are slightly lower than the groundwater elevations in well 56-2C, which is completed much deeper (77 ft bgs) in the Nolichucky Shale (shallow bedrock interval). Based on the distance between the monitored interval midpoints (elevations) in each well, the contemporaneous groundwater elevations indicate a downward vertical gradient (0.015) within the water table interval from well 56-2A to 56-2B, and an upward vertical hydraulic gradient (0.015) from the shallow bedrock (56-2C) to the water table interval (56-2B).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 56-2A indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the well is located in the immediate vicinity of a buried former northern tributary of UEFPC that trends along the western and southwestern side of Bldg. 9201-4 and may locally influence groundwater flow patterns.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date show that the well yields chloride- and sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 365 – 411 mg/L;
- pH of 7.1 – 7.2 (field measurements);
- elevated concentrations of chloride (>30 mg/L) and sulfate (>50 mg/L);
- low molar proportions of nitrate, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate and chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, and the maximum result (0.468 mg/L in November 2004) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

One of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, and this result (0.0005 mg/L in March 1998) is more than an order of magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the data summary below, each of the groundwater samples collected to date contained low levels of PCE, TCE, and c12DCE, with the most recent results showing PCE concentrations slightly above and below the drinking water MCL (5 µg/L).

Date Sampled	Concentration (µg/L)		
	PCE	**TCE**	**c12DCE**
03/23/98	48	10	13
06/09/04	7	2 J	3 J
11/18/04	4 J	1 J	3 J
MCL	**5**	**5**	**70**
Note: J = Estimated value			

Historical spills and leaks of chlorinated solvent products and wastes during production and machining operations in Building 9201-5, which is located approximately 500 ft northwest of the well, and/or Building 9201-4 is the suspected source(s) of the dissolved VOCs in the groundwater at this well (DOE 1998). The Waste Coolant Processing area, located about 1,500 ft west (upgradient and along geologic strike) of the well is another potential source of VOCs.

As shown in the preceding data summary, the results indicate that VOC concentrations in the groundwater at the well decreased more than 80% through November 2004. This suggests a long-term decrease in the relative flux of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well, which in turn suggests a corresponding decrease in flux from the applicable source area(s).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Surface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	500 - 5,000	ND	ND

56-2B

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID C3
Y-12 GRID EAST COORDINATE: 56,225.60
Y-12 GRID NORTH COORDINATE: 29,883.61
SURFACE ELEVATION: 962.21 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH: 56-2A 56-2C
TAG DEPTH (measured): 38.63 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 962.45 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	30.8	931.41
BOTTOM (filter pack or open hole):	38.8	923.41
MIDPOINT (filter pack or open hole):	34.8	927.41
PUMP INTAKE:	35.76	926.45
WATER LEVEL (average):	7.73	954.48

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 3

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	3 samples	03/23/98	11/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/09/04	.	11/18/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.03 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	3	1,629 µg/L	11/18/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL 56-2B

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed with a screened monitored interval from 30.8 to 38.8 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with well 56-2A and 56-2C and is located in Bear Creek Valley (BCV), within the west-central section of Y-12, about 150 ft south of the southwestern corner of Building. 9201-4.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, including an investigation of the source(s) and extent of subsurface mercury contamination within Y-12 (Rothschild et al 1984), a total of three groundwater samples have been collected from the well to date, with the low-flow sampling method used to obtain samples in March 1998, June 2004, and November 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in upper Nolichucky Shale (the Conasauga Group), near the geologic contact with the overlying Maynardville Limestone. The bulk of the groundwater flow. in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (saprolite and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs. Additionally, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show lower groundwater elevations in well 56-2B (38.8 ft bgs) than in wells 56-2A and 56-2C, which are completed at shallower (15.1 ft bgs) and deeper (77.3 ft bgs) depths, respectively, in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate a downward vertical gradient (0.015) within the water table interval from well 56-2A to 56-2B, and an upward vertical hydraulic gradient (0.015) from the shallow bedrock (56-2C) to the water table interval (56-2B).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well 56-2B indicate south and southeasterly flow toward UEFPC. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the well is located in the immediate vicinity of a buried former northern tributary of UEFPC that trends along the western and southwestern side of Bldg. 9201-4 and may locally influence groundwater flow patterns.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date show that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 384 – 433 mg/L;
- pH of 7.4 – 7.6 (field measurements);
- sulfate concentrations above 100 mg/L;
- low molar proportions of chloride, nitrate, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, and the maximum result (1.29 mg/L in November 2004) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the data summary below, each of the groundwater samples collected to date contained PCE, TCE, 12DCE isomers, and 11DCE; the sample collected in June 2004 also contained 1,1,2-trichloro-1,2,2-trifluorethane, which is also known as freon-113 (F113).

Date Sampled	Concentration (µg/L)					
	PCE	TCE	c12DCE	t12DCE	11DCE	F113
03/23/98	870	50	74	1 J	3 J	NR
06/09/04	770	61	98	2 J	2 J	3 J
11/18/04	1,400	85	140	2 J	2 J	.
MCL	**5**	**5**	**70**	**100**	**7**	**NA**
Note: "." = Not detected; NR = Not reported; J = Estimated value						

Historical spills and leaks of chlorinated solvent products and wastes during production and machining operations in Building 9201-5, which is located approximately 500 ft northwest of the well, and/or Building 9201-4 is the suspected source(s) of the dissolved VOCs in the groundwater at this well (DOE 1998). The Waste Coolant Processing area, located about 1,500 ft west (upgradient and along geologic strike) of the well is another potential source of VOCs.

As shown in the preceding data summary, the most recent sampling results show that the concentrations of the PCE, TCE, and c12DCE remain substantially above respective drinking water MCLs. Moreover, the concentrations of PCE, TCE and c12DCE evident in May 2004 are 60-90% higher than corresponding concentrations evident in March 1998. Conversely, the concentrations of t12DCE and 11DCE appear to have remained unchanged over this time. It is not clear from the available data why the concentrations of individual VOCs exhibit such divergent concentration trends, or if the divergent trends are significant with regard to differential migration/transport of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

Several of the compounds detected in the groundwater samples, (12DCE and 11DCE), are probably products of the biodegradation of related parent compounds (PCE and TCE) in the groundwater; detection of c12DCE is almost certainly attributable to biologically mediated reductive dechlorination of PCE (Wilson et al. 1996). However, as shown in the following summary, results for selected indicator parameters indicate that the groundwater geochemistry in this well, especially the oxidation-reduction (REDOX) conditions and levels of dissolved oxygen, is not especially conducive to biotic degradation of chlorinated hydrocarbons.

Geochemical Parameter/Optimum Range (Wilson et al. 1996)	June 2004	November 2004
Nitrate < 1 mg/L	1	1
Iron (II) > 1 mg/L	<0.05*	<0.05*
Sulfate < 20 mg/L	102	102
Dissolved Oxygen < 0.5 ppm	1.63**	0.45**
REDOX < 50 mV	152**	158**
pH >5 and < 9 st. units	7.42**	7.35**
Note: *Result is for total iron; **Field measurement.		

This suggests that active biotic degradation of the VOCs occurs elsewhere, probably at greater depth in the bedrock (Nolichucky Shale). This interpretation is supported by the upward vertical hydraulic gradients indicated by presampling groundwater elevations in the well (see Section 3.0), which suggest upward migration of (dissolved) parent compounds and degradation products via the groundwater flow/contaminant transport pathways intercepted by the monitored interval in the well. Well 56-2C, the deepest (about 77 ft bgs) of the three-well cluster (see Section 3.0), has historically higher VOC concentrations than detected in well 55-2B with decreasing concentrations over time.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A, Bogle, L.K. Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Surface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

MAXIMUM CONCENTRATION: 2003

<5	ND	500 - 5,000	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

56-2C

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID C3
Y-12 GRID EAST COORDINATE: 56,230.51
Y-12 GRID NORTH COORDINATE: 29,884.63
SURFACE ELEVATION: 962.44 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/18/83 PAIRED/CLUSTERED WITH: 56-2A 56-2B
TAG DEPTH (measured): 77.03 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 964.94 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	69.3	893.14
BOTTOM (filter pack or open hole):	77.3	885.14
MIDPOINT (filter pack or open hole):	73.3	889.14
PUMP INTAKE:	74.70	887.74
WATER LEVEL (average):	7.10	955.34

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	6		
CONVENTIONAL SAMPLING METHOD:	1 samples	03/13/97	03/13/97
LOW-FLOW SAMPLING METHOD:	5 samples	03/24/98	11/18/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/29/03	.	11/18/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.67 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	6	4,549 µg/L	05/22/00	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 56-2C

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during August 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 69.3 to 77.3 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with wells 56-2A and 56-2B near the southwest corner of Bldg. 9201-4 in the central part of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the mercury investigation at Y-12, six groundwater samples have been collected from the well, with the conventional sampling method used in March 1997 and the low-flow sampling method used between March 1998 and November 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Conasauga Group (Nolichucky Shale). Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations. Also, the presampling groundwater elevations in this well and the two wells with which it is clustered (56-2A and 56-2B) indicate upward hydraulic gradients from the deeper bedrock (56-2C) to the shallow bedrock interval (55-2B) and downward vertical gradients from the water table interval (55-2A) to the shallow bedrock interval.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sulfate-enriched sodium-bicarbonate groundwater generally characterized by:

- very high TDS (>1,000 mg/L);
- pH of 8.1 – 8.7 (field measurements);
- high levels of chloride (>20 mg/L) and sulfate (>40 mg/L);
- low molar proportions of calcium, magnesium, and potassium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability formations of the Conasauga Group (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow bedrock wells (i.e., <100 ft bgs) completed in these formations yield calcium-magnesium-bicarbonate groundwater, but a fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs (in BCV west of Y-12). The sodium-dominated geochemistry of the groundwater is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater. In areas where the low-permeability formations underlie the industrial sections of Y-12, the geochemical transitions appear to occur at shallower depths, possibly because of long-term pumpage of groundwater from building basement sumps (DOE 1998).

It is not clear if the unusually high chloride and sulfate concentrations typical of the groundwater samples reflect natural geochemical characteristics or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well. Additionally, although the groundwater contains a mixture of dissolved chlorinated hydrocarbons (see Section 5.3) and elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995), the most recent monitoring data suggest that the geochemical characteristics of the groundwater, particularly the REDOX conditions, are not especially conducive to biotic degradation of VOCs (Table 1).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate was detected in four of the groundwater samples, with the highest concentration (1.37 mg/L in May 2003) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, the following VOCs were detected in each of the groundwater samples (Table 2): PCE, TCE, 12DCE (c12DCE), and VC. The source of the VOCs has not been confirmed, but may be related to historical production and machining operations in Bldgs. 9201-4 and 9201-5 (DOE 1998). Considering the upward vertical hydraulic gradients noted in Section 3, it is possible that DNAPL deeper in the bedrock may be a source of the VOCs.

The principal compounds in the groundwater samples are PCE, TCE, and 12DCE, which were detected in each sample, with maximum historical concentrations above 2,500 μg/L, 1,000 μg/L, and 700 μg/L, respectively (Table 2). Secondary compounds are t12DCE, 11DCE, and VC with maximum historical concentrations below 40 μg/L. Note that the most recent sampling results show that the concentrations of PCE, TCE, c12DCE, and VC remain above respective MCLs (Table 2).

Natural biodegradation of PCE and TCE may explain the presence of c12DCE (biodegradation product) in the groundwater samples from this well, with the VC concentrations suggesting the strongly reducing (methanogenic) conditions necessary to transform 12DCE to VC (Chapelle 1996). However, as noted in Section 4.0, results for several geochemical indicator parameters (e.g., REDOX) are substantially outside the respective optimum range for biotic degradation of chlorinated hydrocarbons. Considering the very high PCE concentrations and the upward hydraulic gradient indicated by presampling groundwater elevations (see Section 3.0), perhaps the monitored interval in the well intercepts groundwater flow/transport pathways for dissolved VOCs moving upward from a source (DNAPL) deeper in the bedrock where conditions are better suited for biodegradation.

Natural biodegradation may explain the generally decreasing VOC concentration trend evident for the well (Figure 1) as well as the unusually high levels of chloride in the well; chloride may accumulate during biologically mediated reductive dechlorination of PCE and related degradation compounds (Hinchee et al. 1995).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Only the groundwater sample collected in March 1997 had gross beta activity above the applicable MDA and corresponding CE, and the result (7.8 pCi/L) is significantly below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds*. Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well 56-2C: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2003	November 2003
Nitrate < 1 mg/L	1.37	1.03
Iron (II) > 1 mg/L	<0.01*	0.109*
Sulfate < 20 mg/L	46.4	41.5
Dissolved Oxygen < 0.5 ppm	7.3**	3.31**
REDOX < 50 mV	164**	172**
pH >5 and < 9 st. units	8.25**	8.63**
Note: *Results are for total iron; **Field measurement.		

Table 2. Well 56-2C: summary of VOC results

Sampling Date	VOC Concentration (µg/L)					
	PCE	TCE	c12DCE	t12DCE	11DCE	VC
03/13/97	2,700	650	280	.	.	37
03/24/98	1,400	380	180	4 J	7	6
05/22/00	2,600	1,100	760	10	15	20
10/17/00	1,900	900	730	9	14	17
05/29/03	570	250	180	2 J	3 J	4
11/18/03	460	300	360	5 J	7	6
MCL	5	5	70	100	7	2
Note: "." = Not analyzed; J = Estimated concentration below the analytical reporting limit						

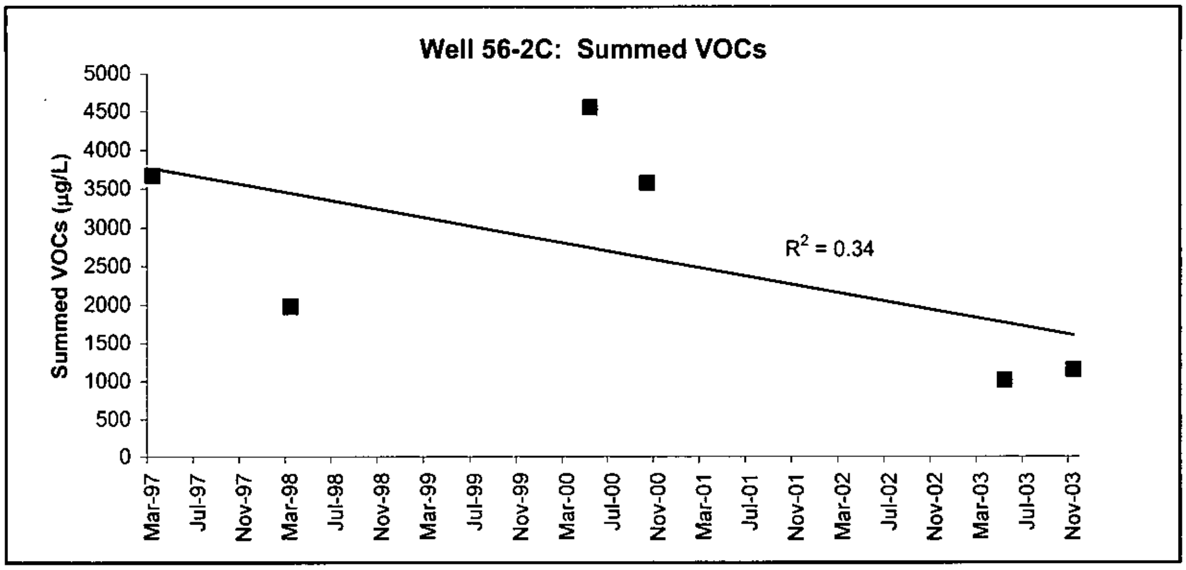

Well 56-2C: Summed VOCs
Summed VOCs (µg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
R2 = 0.34
Mar-97
Jul-97
Nov-97
Mar-98
Jul-98
Nov-98
Mar-99
Jul-99
Nov-99
Mar-00
Jul-00
Nov-00
Mar-01
Jul-01
Nov-01
Mar-02
Jul-02
Nov-02
Mar-03
Jul-03
Nov-03

Figure 1

MAXIMUM CONCENTRATION: 2003

<5	0.015 - 0.03	ND	7.5 - 15	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

59-1A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9202
Y-12 GRID EAST COORDINATE: 59,884.79
Y-12 GRID NORTH COORDINATE: 29,830.55
SURFACE ELEVATION: 945.26 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/09/83 PAIRED/CLUSTERED WITH: 59-1B 59-1C
TAG DEPTH (measured): 13.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 945.95 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.2	940.06
BOTTOM (filter pack or open hole):	13.2	932.06
MIDPOINT (filter pack or open hole):	9.2	936.06
PUMP INTAKE:	11.51	933.75
WATER LEVEL (average):	5.25	940.01

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 3

	Samples	First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	3 samples	03/17/98	10/30/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	.	06/05/03	.	10/30/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 0.25 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 59-1A

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 5.2 to 13.2 ft bgs and constructed with nominal 4.5-inch diameter PVC riser casing and stainless steel well screen. The well is located in the east-central Y-12 area, on the west side of Bldg. 9202, about half way between First Street to the north and Second Street to the south (unless noted otherwise, all directions are in reference to the Y-12 grid). The well is clustered with wells 59-1B and 59-1C.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from the well using the low-flow sampling method in March 1998, June 2003, and October 2003.

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium (maximum = 0.13 mg/L in March 1998) and nickel (maximum = 0.437 mg/L in October 2003) that are most likely attributable to microbiologically-induced corrosion (MIC) of the stainless steel well casing and/or screen. Corrosion of stainless steel may be caused by many different species of bacteria, including iron-related and sulfate-reducing organisms that typically attack the area near welds. Once a colony attaches to the metal it forms a nodule in which to live. The micro-environment within the nodule creates conditions (e.g., acidic pH) that enable the colony to expand and deepen the nodule, which eventually creates a pit or crevice in the metal and facilitates corrosion per the mechanisms described by Driscoll (1986).

The following considerations suggest that elevated concentrations of nickel and chromium in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel (assumed to be Type 304) well screen: (1) there are no known sources of these metals near the well; (2) mobile species of these metals are not typically present in groundwater with the neutral pH evident in the well; (3) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); and (4) indicator parameters (e.g., dissolved oxygen <1 mg/L and pH between 5.5 and 9) are in the optimum range for MIC by sulfate-reducing bacteria (Sarouhan et al. 1998).

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 5.3 ft below ground surface. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6.8 – 7.3;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals, excluding chromium and nickel, that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Each groundwater sample had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.5 mg/L in March 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Each groundwater sample had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0167 mg/L in March 1998) being less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (11 pCi/L in June 2003) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater sample collected in June 2003 (10 pCi/L) is the only result to exceed the applicable MDA and corresponding CE, and this result is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells*. Bechtel National Inc., San Diego, CA.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	<0.015	.	.	.

59-1B

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9202
Y-12 GRID EAST COORDINATE: 59,885.47
Y-12 GRID NORTH COORDINATE: 29,835.10
SURFACE ELEVATION: 945.07 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/11/83 PAIRED/CLUSTERED WITH: 59-1A 59-1C
TAG DEPTH (measured): 36.80 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 945.94 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	28.9	916.17
BOTTOM (filter pack or open hole):	36.9	908.17
MIDPOINT (filter pack or open hole):	32.9	912.17
PUMP INTAKE:	33.63	911.44
WATER LEVEL (average):	4.11	940.96
GEOLOGIC FORMATION:	Nolichucky Shale	
HYDROGEOLOGIC ZONE:	Water Table	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	4		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	4 samples	03/18/98	04/28/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/28/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.51 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 59-1B

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 28.9 to 36.9 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with wells 59-1A and 59-1C in the east-central Y-12 area, on the west side of Bldg. 9202, about half way between First Street to the north and Second Street to the south.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Four groundwater samples were collected from the well between March 1998 and April 2004. The low-flow sampling method was used to obtain each sample.

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium (maximum = 0.201 mg/L in June 2003) and nickel (maximum = 0.28 mg/L in March 1998) that are most likely attributable to microbiologically-induced corrosion (MIC) of the stainless steel well casing and/or screen. Corrosion of stainless steel may be caused by many different species of bacteria, including iron-reducing and sulfate-reducing organisms that typically attack the area near welds. Once a colony attaches to the metal it forms a nodule in which to live. The micro-environment within the nodule creates conditions (e.g., acidic pH) that enable the colony to expand and deepen the nodule, which eventually creates a pit or crevice in the metal and facilitates corrosion per the mechanisms described by Driscoll (1986). The following considerations suggest that elevated concentrations of nickel and chromium in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel (Type 304) well screen: (1) there are no known sources of these metals near the well; (2) mobile species of these metals are not typically present in groundwater with the neutral pH evident in the well; (3) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); and (4) indicator parameters (e.g., dissolved oxygen <1 mg/L and pH between 5.5 and 9) are in the optimum range for MIC by sulfate-reducing bacteria (Sarouhan et al. 1998).

The Y-12 GWPP requested biological testing to assess microbial activity in groundwater at this well in April 2004. The results (shown below) are qualitative bacterial counts of four specific bacteria types that are estimates based on the appearance of the sample after an eight- to ten-day growth period.

Well	Date Sampled	Metals (mg/L)		Bacteria Activity (colony forming units/milliliter)			
		Chromium	Nickel	Heterotrophic Aerobic	Iron-Related	Slime Forming	Sulfate-Reducing
59-1B	04/28/04	0.0335	0.143	100	5,000	>100	1,000

The bacterial counts in this sample confirm that MIC (by iron-related and sulfate-reducing bacteria) is the likely cause of the elevated nickel and chromium concentrations in samples from the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level is about 4 ft bgs. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (327 mg/L – 397 mg/L);
- pH (field measurements) of 6.9 – 7.1;
- unusually high chloride concentrations (>40 mg/L);
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals, excluding nickel and chromium, that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Three groundwater samples had a nitrate concentration above the applicable analytical reporting limit, with the highest concentration (1.17 mg/L in March 1998) being substantially below the MCL for nitrate (10 mg/L). The sample collected from the well in April 2004 was not analyzed for nitrate.

5.2 URANIUM

Each groundwater sample had a uranium concentration above the applicable analytical reporting limit, with the highest concentration (0.0011 mg/L in June 2003) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Results for the three groundwater samples analyzed for VOCs show non-detect values for all compounds. The sample collected from the well in April 2004 was not analyzed for VOCs.

5.4 GROSS ALPHA ACTIVITY

The gross alpha activity reported for the groundwater sample collected in March 1998 (5.5 pCi/L) is the only result to exceed the applicable MDA and corresponding CE, and this result is substantially below the MCL for gross alpha activity (15 pCi/L). The sample collected from the well in April 2004 was not analyzed for gross alpha activity.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE. The sample collected from the well in April 2004 was not analyzed for gross beta activity.

6.0 REFERENCES

Driscoll, F.G. 1986. *Groundwater and Wells.* Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

MAXIMUM CONCENTRATION: 2003

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

59-1C

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9202
Y-12 GRID EAST COORDINATE: 59,881.56
Y-12 GRID NORTH COORDINATE: 29,834.00
SURFACE ELEVATION: 945.12 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/14/83 PAIRED/CLUSTERED WITH: 59-1A 59-1B
TAG DEPTH (measured): 75.46 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 946.12 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	65.9	879.22
BOTTOM (filter pack or open hole):	73.9	871.22
MIDPOINT (filter pack or open hole):	69.9	875.22
PUMP INTAKE:	71.25	873.87
WATER LEVEL (average):	3.99	941.13

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	4		
CONVENTIONAL SAMPLING METHOD:	1 samples	03/19/97	03/19/97
LOW-FLOW SAMPLING METHOD:	3 samples	03/18/98	10/30/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	06/05/03	.	10/30/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.55 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	7 µg/L	03/18/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 59-1C

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well, an NX core hole that was reamed and completed as a monitoring well, was installed during September 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 65.9 to 73.9 ft bgs and is constructed with nominal 4.5-inch diameter PVC (#40) riser casing and stainless steel (Type 304) well screen (0.01 slot wire-wound). The well forms a cluster with wells 59-1A and 59-1B in the east-central Y-12 area, on the west side of Bldg. 9202, about half way between First Street to the north and Second Street to the south.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from the well in March 1997, March 1998, June 2003, and October 2003 using the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 4 ft below ground surface. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 7.6 – 7.7;
- unusually high chloride concentrations (>30 mg/L);
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Three groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.4 mg/L in March 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater sample collected in October 2003 show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime. However, TCE was detected in the groundwater samples collected in March 1997 (0.9 µg/L), March 1998 (7 µg/L), and June 2003 (6 µg/L), with the latter results being slightly above the MCL for TCE (5 µg/L). TCE has not been detected in any of the groundwater samples collected to date from the shallower wells (59-1A and 59-B) clustered with this well.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples have had gross alpha activity above the applicable MDA and the corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

60-1B

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Complex
Y-12 GRID EAST COORDINATE: 60,203.55
Y-12 GRID NORTH COORDINATE: 29,225.44
SURFACE ELEVATION: 929.16 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/09/83 PAIRED/CLUSTERED WITH: 60-1A
TAG DEPTH (measured): 29.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 930.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	21.2	907.96
BOTTOM (filter pack or open hole):	29.2	899.96
MIDPOINT (filter pack or open hole):	25.2	903.96
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	12.45	916.72

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	2 samples	06/11/03	10/13/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	06/11/03	.	10/13/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.61 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 60-1B

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 21.2 to 29.2 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells 60-1A and 60-1C in the southeast-central Y-12 area, on the east side of Bldg. 9201-2, about 200 ft south of Second Street.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from the well in June and October 2003 using the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 12 ft below ground surface. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 7.4 and 7.5;
- unusually high concentrations of sulfate (>50 mg/L);
- low molar proportions of chloride, potassium, and sodium (<15% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	<5	ND	ND

60-2A

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-2
Y-12 GRID EAST COORDINATE: 60,118.44
Y-12 GRID NORTH COORDINATE: 29,096.86
SURFACE ELEVATION: 927.46 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 13.35 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 930.31 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.5	921.96
BOTTOM (filter pack or open hole):	13.5	913.96
MIDPOINT (filter pack or open hole):	9.5	917.96
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	7.28	920.18

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	1 samples	03/20/97	03/20/97
LOW-FLOW SAMPLING METHOD:	2 samples	06/11/03	10/13/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	06/11/03	.	10/13/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.44 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	11.5 µg/L	03/20/97	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL 60-2A

1.0 *INSTALLATION, CONSTRUCTION, AND LOCATION*

This well was installed in 1983 as part of an investigation to identify the subsurface extent of elemental mercury released during historical operations at Y-12 (Rothchild et. al. 1984). The well was completed with a screened monitored interval from 5.5 to 13.5 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot wire-wound). The well is located in the southeast-central Y-12 area, near the southeast corner of Bldg. 9201-2, about 200 ft north of Third Street.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from the well in March 1997, June 2003, and October 2003 using the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 7.3 ft below ground surface.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6.8 – 7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- unusually high total iron concentrations (>5 mg/L); and
- total (unfiltered sample) concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The nitrate concentrations reported for the groundwater samples collected in June and October 2003 were analyzed for nitrate and neither sample had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

The uranium concentration reported for the groundwater sample collected in June 2003 (0.00127 mg/L) exceeds the analytical reporting limit, but is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Low levels of PCE (0.1 μg/L), TCE (1 μg/L), c12DCE (5 μg/L), 11DCE (0.4 μg/L), and VC (3 μg/L) were detected in the groundwater sample collected in March 2003. Note that the VC concentration exceeds the MCL (2 μg/L). A lower concentration of VC (1 μg/L) was detected in the sample collected in June 2003; VOCs were not detected in the groundwater sample collected in October 2003. These compounds are confirmed components of dissolved VOC plumes in the groundwater hydraulically upgradient to the west and northwest of the well.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Rothschild, E.R., R.R. Turner, S.H. Stow, M.A. Bogle, L.K Hyder, O.M. Sealand, and H.J. Wyrick. 1984. *Investigation of Subsurface Mercury at Oak Ridge Y-12 Plant*, ORNL/TM-9092, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	50 - 500	ND	<25

GW-008

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,595.92
Y-12 GRID NORTH COORDINATE: 29,783.05
SURFACE ELEVATION: 962.11 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/21/83 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 26.69 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 965.39 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	13.0	949.11
BOTTOM (filter pack or open hole):	25.5	936.61
MIDPOINT (filter pack or open hole):	19.25	942.86
PUMP INTAKE:	17.72	944.39
WATER LEVEL (average):	12.03	950.08

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	01/26/98	07/07/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/07/04	.	07/07/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.51 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	14	149 µg/L	07/02/02	Indeterminate
GROSS ALPHA (15 pCi/L):	1	44.36 pCi/L	01/06/03	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-008

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1983, completed with a screened monitored interval from 13 to 25.5 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) adjacent to the southwestern disposal plots at the Oil Landfarm. The Oil Landfarm waste disposal plots were used between 1973 and 1982 for biodegradation of about one million gallons of waste oils and machine coolants via landfarming with nutrient-adjusted surface soils during the dry months of each year (April through October). The disposal plots are covered by a low-permeability, mulitlayer cap installed during RCRA closure of the Oil Landfarm in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, a total of 14 groundwater samples have been collected from the well since January 1998, all of which were obtained with the low-flow sampling method.

This well yields groundwater samples with low (<150 mg/L) TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits minor (<4 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-008 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-008 may be primarily westward (parallel with geologic strike) toward discharge areas in a northern tributary of Bear Creek (NT-4) that traverses the western boundary of the Oil Landfarm disposal plots approximately 600 ft west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 57 – 99 mg/L;
- pH of 4.0 – 5.9 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- unusually high (total) iron (>3 mg/L) and manganese (>2 mg/L) concentrations; and
- total concentrations of trace metals (except iron and magnesium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the contaminants present in the groundwater at this well.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations above the analytical reporting limit. Except for the nitrate concentration reported for the sample collected in July 2000 (5.7 mg/L), the nitrate levels are all less than 1 mg/L and substantially below the drinking water MCL for nitrate (10 mg/L). The July 2000 result appears to be an outlier and is a likely sampling/analytical artifact.

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 1): benzene, chloroethane, PCE, TCE, toluene, 11DCA, 11DCE, and c12DCE. The Oil Landfarm is the source of these compounds. Landfarming operations at the site emplaced two distinct plumes of dissolved VOCs in the shallow groundwater system, one originating from the northern disposal plots that is dominated by 111TCA, 11DCA, and 11DCE and one originating from the southern disposal plots that is dominated by PCE, TCE, and 12DCE. Maximum concentrations within the plumes do not indicate the presence of DNAPL in the subsurface at the Oil Landfarm (AJA 1997).

The principal VOCs in the groundwater samples are PCE and c12DCE, with historical maximum concentrations of 75 μg/L and 27 μg/L, respectively. Secondary compounds in the samples are TCE, 11DCA, and 11DCE, each with a historical maximum concentration below 20 μg/L, and benzene, which has been detected at very low (estimated) concentrations in all but two of the samples. Summed concentrations of the VOCs detected in each sample collected since January 1998 are all less than 150 μg/L, which is substantially lower than the summed VOC concentrations indicated by historical characterization data (>700 μg/L; Energy Systems 1990). Nevertheless, the most recent monitoring results show that the PCE, TCE, and 11DCE concentrations remain at or above respective MCLs (Table 1).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample collected since January 1998 shows an increasing long-term trend through July 2002, followed by a generally decreasing trend (Figure 1). Also, some compounds (e.g., PCE) show substantial temporal variations whereas other compounds (e.g., 11DCE) do not. It is not clear from the available data why the concentrations of individual compounds exhibit such divergent temporal variations or if such variations are significant with respect to the overall flux of dissolved VOCs along the shallow groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Four of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (44.36 pCi/L in January 2003) being substantially above the drinking water MCL for gross alpha activity (15 pCi/L). This result is an outlier compared to the other gross alpha values, which are all less than 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Seven of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (43.02 pCi/L in January 2003) being slightly below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). This result is an outlier compared to the other gross beta values, which are all less than 10 pCi/L.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 1997. *Evaluation of Calendar Year 1996 Groundwater and Surface Water Quality Data for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/SUB/97-KDS15V/4, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. (Energy Systems) 1990. *Groundwater Quality Assessment for the Bear Creek Hydrogeologic Regime at the Y-12 Plant, 1989: Data Interpretations and Proposed Modifications,* Y/SUB/90-00206C/1 Part II, prepared for Martin Marietta Energy Systems, Inc. Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-008: summary of VOC results

Sampling Date	Concentration (µg/L)		
	PCE	TCE	c12DCE
01/26/98	10	3 J	17
07/20/98	19	4 J	14
02/08/99	10	3 J	17
07/15/99	7	2 J	15
01/10/00	75	12	24
07/12/00	33	7	18
01/03/01	23	11	20
07/09/01	66	8	18
01/07/02	53	16	21
07/02/02	89	11	27
01/06/03	18	8	21
07/08/03	42	8	23
01/07/04	24	14	24
07/07/04	11	8	22
MCL	5	5	70

Sampling Date	Concentration (µg/L)			
	11DCE	11DCA	Benzene	Other
01/26/98	5	9	2 J	Chloroethane (2 J)
07/20/98	5	8	2 J	.
02/08/99	4 J	9	.	.
07/15/99	3 J	7	1 J	Chloroethane (2 J)
01/10/00	5	11	1 J	.
07/12/00	5	9	2 J	.
01/03/01	6	10	2 J	Toluene (1 J)
07/09/01	5	9	.	.
01/07/02	6	11	1 J	.
07/02/02	7	14	1 J	.
01/06/03	6	11	1 J	.
07/08/03	7	12	1 J	.
01/07/04	7	13	1 J	.
07/07/04	6	12	1 J	.
MCL	7	NA	5	

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

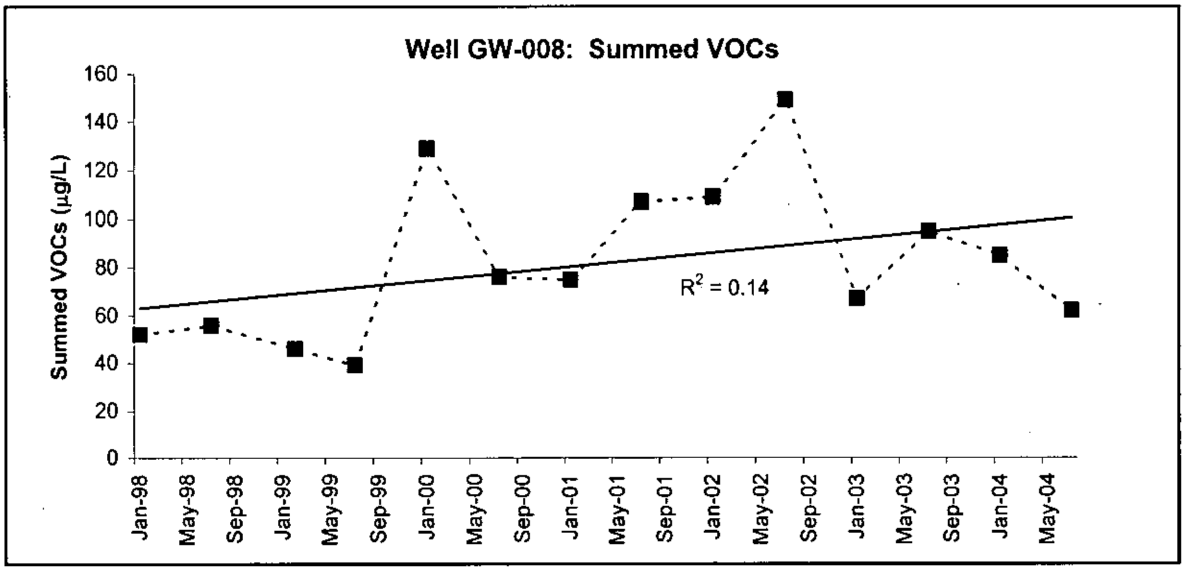


Figure 1

GW-008

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	500 - 5,000	<7.5	ND

GW-014

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 44,308.00
Y-12 GRID NORTH COORDINATE: 29,848.00
SURFACE ELEVATION: 931.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/29/83 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 14.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 934.50 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.0	926.50
BOTTOM (filter pack or open hole):	13.2	918.30
MIDPOINT (filter pack or open hole):	9.1	922.40
PUMP INTAKE:	9.0	922.50
WATER LEVEL (average):	5.11	926.99

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	12		
CONVENTIONAL SAMPLING METHOD:	8 samples	03/14/87	08/04/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/14/02	10/19/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/22/05	.	10/19/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.75 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	5	3503 µg/L	08/04/95	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-014

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1983, completed with a screened monitored interval from 5.0 to 13.2 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) along the eastern border of the Bear Creek Burial Grounds (BCBG) waste management area, approximately 150 ft west of a northern tributary (NT) of Bear Creek (NT-6). The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twelve groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eight samples between March 1987 and August 1995, and the low-flow sampling method used to obtain four samples between March 2002 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 5 ft bgs and exhibits seasonal fluctuations of about 3 ft. Upward hydraulic gradients often are evident in the Nolichucky Shale near the northern tributaries of Bear Creek, which are primary discharge areas for the shallow groundwater flow system, one of which is located approximately 150 ft east of the well (NT-6). Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-014 indicate flow to the south and southeast toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction of groundwater flow in the vicinity of well GW-014 may be primarily eastward (parallel with geologic strike) toward discharge areas in NT-6.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 354 – 524 mg/L;
- pH of 6.3 – 7.5 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- unusually high concentrations of boron (>3 mg/L); and
- total concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant*, *Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the analytical reporting limit.

5.2 URANIUM

All but two of the groundwater samples collected to date have uranium concentrations above the applicable analytical reporting limit, with the highest value (0.008 mg/L in March 1987) being below the drinking water MCL for uranium (0.03 mg/L). The uranium concentrations show a generally decreasing trend, with the most recent results (June and October 2005) being less than 0.002 mg/L.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 1): PCE, TCE, 12DCE, 11DCE, VC, 111TCA, 12DCA, 11DCA, chloroethane, MC, benzene, toluene, total xylene, acetone, chloroform, 2-hexanone, and ethylbenzene. Waste disposal sites within Burial Ground-A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the dissolved VOCs in the shallow groundwater at this well (DOE 1997).

The primary compounds in the groundwater samples are PCE, TCE, 12DCE, VC, and 11DCA, which have respective historical maximum concentrations that exceed 1,000 µg/L (Table 1). Secondary compounds in the samples are 11DCE, 111TCA, chloroethane, and benzene, which have historical maximum concentrations above 100 µg/L. The most recent results (March 2002 to October 2005) show that PCE, TCE, c12DCE, 11DCE, and VC continue to exceed the respective MCLs (Table 1).

The elevated benzene is a distinguishing characteristic of the VOC data for this well. A review of historical data indicates that elevated benzene results have been consistently reported for wells located in areas of Y-12 known to be impacted by historical releases from petroleum fuel underground storage tanks (USTs) and located near the BCBG WMA. Excluding the wells located near USTs, groundwater samples from the following wells at the BCBG WMA had benzene concentrations that exceeded the drinking water MCL (5 µg/L).

Well No.	Depth (ft bgs)	Benzene Concentration (µg/L) / Sampling Date			
		Maximum		Most Recent	
GW-014	13.2	180	11/05/87	4	10/19/05
GW-046	20.3	240	07/09/03	72	07/07/05
GW-068	83.6	51	10/18/05	51	10/18/05
GW-071	219	1,300	06/30/05	1,200	10/20/05
GW-082	34.4	99	08/07/03	ND	10/13/05
GW-117	530	6	11/13/87	ND	09/17/92
GW-118	575	67	11/19/88	1	10/10/93
GW-119	510	20	07/06/88	ND	09/17/92
GW-624	27.2	33	07/15/98	25	10/12/05

Of these, well GW-082 is located on the southwest side of Burial Grounds C-West, and all of the remaining wells are located near Burial Ground A-South: wells GW-014, GW-071, and GW-119 along the eastern boundary; wells GW-117 and GW-118 along the southern boundary; and wells GW-046, GW-068, and GW-624 near the western boundary. Note also the wide range in the total depth of these wells, particularly wells GW-117, GW-118, and GW-119, each of which is artesian. The apparent “clustering” of these wells suggest that benzene is a distinguishing component of the groundwater plume of dissolved VOCs originating from the waste disposal trenches in Burial Ground-A South.

Some of the VOCs in the groundwater samples, particularly c12DCE and VC, are probably present in the groundwater as a consequence of the biotic degradation of PCE and TCE. Also, the dissolved petroleum hydrocarbons (e.g., benzene) in the groundwater may serve as electron donors for biologically mediated dechlorination of PCE and related compounds (Chapelle 1996). However, geochemical characteristics of the groundwater in the well, particularly the REDOX conditions, are not especially conducive to anaerobic biotic degradation (Table 2). Perhaps the monitored interval in the well intercepts groundwater flowpaths that transport dissolved VOCs from source areas where biotic degradation primarily occurs, toward the natural discharge areas for the shallow flow system (i.e., the northern tributaries of Bear Creek that traverse the BCBG WMA).

Summed VOC concentrations show an overall decreasing long-term trend (Figure 1), with similar concentration trends evident for individual compounds (Table 1). Also, the long-term trends for most compounds are dominated by a sharp “spike” in November 1987. The decreasing long-term concentration trends probably reflect reduced flux of VOCs east of the BCBG WMA along the groundwater flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Three of the six groundwater samples collected since March 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the maximum value (5.6 pCi/L in October 2005) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

One of the six groundwater samples collected since March 1990 had gross beta activity above the applicable MDA and corresponding CE, with that result (9.95 pCi/L in March 1990) being substantially less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-014: summary of VOC results

Sampling Date	Concentration (μg/L)			
	PCE	**TCE**	**12DCE**	**c12DCE**
03/14/87	1,040	1,480	3,900	NR
06/26/87	1,100	1,600	4,600	NR
09/29/87	12,600	2,800	4,000	NR
11/05/87	27,000	13,000	30,000	NR
04/20/88	1,500	1,700	5,400	NR
07/05/88	1,300	1,600	17	NR
03/01/90	160	670	2,600	NR
08/04/95	.	410	2,300	NR
03/14/02	21	160	722	720
08/12/02	18	140	972	970
06/22/05	33	250	1,305	1,300
10/19/05	51	280	1,607	1,600
MCL	**5**	**5**	**NA**	**70**
Sampling Date	**Concentration (μg/L)**			
	11DCE	**VC**	**111TCA**	**12DCA**
03/14/87	97	1,070	.	7
06/26/87	200	1,400	2 J	7
09/29/87	110	3,400	10	11
11/05/87	360	.	6	28
04/20/88	150	1,200	.	6
07/05/88	150	920	110	11
03/01/90	120	760	.	.
08/04/95	100	170	.	73
03/14/02	37	75	.	.
08/12/02	25	87	.	.
06/22/05	95	280	.	.
10/19/05	120	370	.	.
MCL	**7**	**2**	**200**	**NA**
Sampling Date	**Concentration (μg/L)**			
	11DCA	**Chloroethane**	**MC**	**Benzene**
03/14/87	530	69	6	26
06/26/87	690	98	9	66
09/29/87	970	110	7	100
11/05/87	1700	.	16	180
04/20/88	600	110	6	31
07/05/88	680	100	8	65
03/01/90	550	.	.	.
08/04/95	450	.	.	.
03/14/02	200	7	.	.
08/12/02	170	8	.	2 J
06/22/05	240	11	.	4 J
10/19/05	370	.	.	4 J
MCL	**NA**	**NA**	**5**	**5**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported

Table 1. Well GW-014: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L)		
	Toluene	Xylenes	Other
03/14/87	2 J	0.8 J	Acetone (40), Chloroform (3 J)
06/26/87	2 J	.	Acetone (14)
09/29/87	2 J	2 J	Chloroform (2 J), 2-Hexanone (2 J)
11/05/87	3 J	6	Chloroform (2 J), 2-Hexanone (210)
04/20/88	0.8 J	.	.
07/05/88	0.8 J	2 J	Ethylbenzene (1 J)
03/01/90	.	.	.
08/04/95	.	.	.
03/14/02	.	.	.
08/12/02	.	.	.
06/22/05	.	.	.
10/19/05	.	.	.
MCL	**1,000**	**10,000**	**.**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

Table 2. Well GW-014: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005	October 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	0.225*	0.156*
Sulfate	< 20 mg/L	7.2	5.6
Dissolved Oxygen	< 0.5 ppm	0.46**	2.69**
REDOX	< 50 mV	108**	62**
pH	>5 and < 9 st. units	7.06**	7.03**

Note: *Results are for total iron; **Field Measurements.

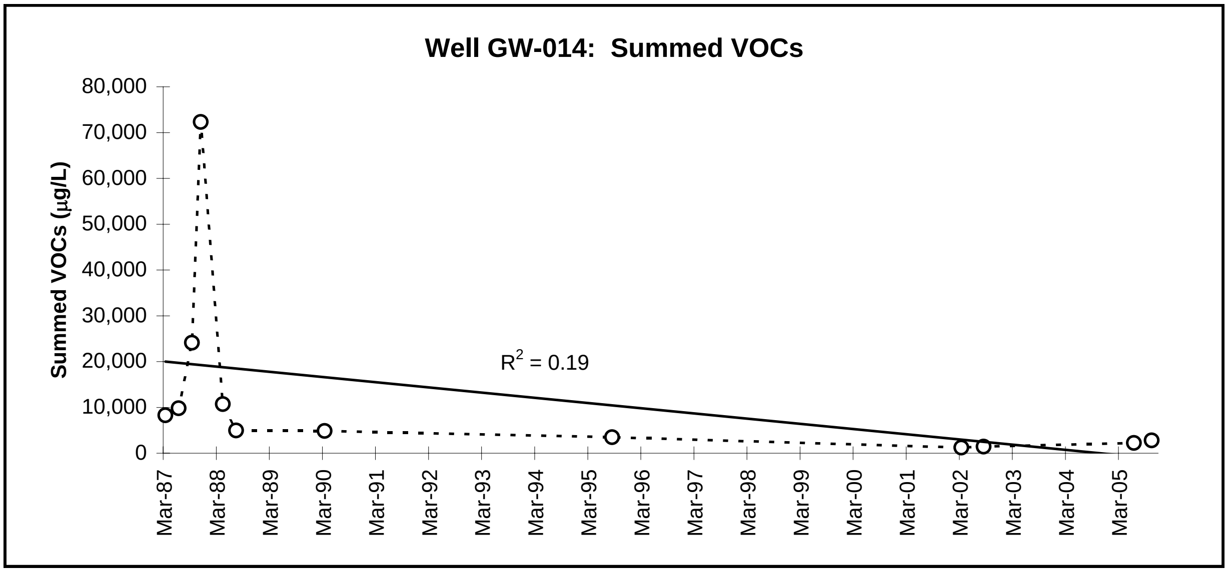

Well GW-014: Summed VOCs
Summed VOCs (µg/L)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
R^2 = 0.19
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mar-05

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	>5,000	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-046

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,283.53
Y-12 GRID NORTH COORDINATE: 29,562.34
SURFACE ELEVATION: 918.13 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/27/83 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 23.85 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 921.17 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.0	913.13
BOTTOM (filter pack or open hole):	20.3	897.83
MIDPOINT (filter pack or open hole):	12.65	905.48
PUMP INTAKE:	11.96	906.17
WATER LEVEL (average):	0.69	917.44

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	11 samples	03/14/87	08/09/95
LOW-FLOW SAMPLING METHOD:	15 samples	01/29/98	07/08/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/06/04	.	07/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.19 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	15	25,382 µg/L	07/19/00	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-046

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1983, completed with a screened monitored interval from 5.0 to 20.3 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) near the central section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between March 1987 and August 1995, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 1 ft bgs and exhibits minor (<5 ft) seasonal fluctuations. Slightly artesian conditions may exist near this well during wetter seasons. Upward hydraulic gradients often are evident in the Nolichucky Shale near the northern tributaries of Bear Creek, which are primary discharge areas for the shallow groundwater flow system, and one of these tributaries (NT-7) traverses the BCBG approximately 150 ft west of the well. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-046 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-046 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-7.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 90 – 280 mg/L;
- pH of 4.4 – 6.0 (field measurements);
- unusually low concentrations of calcium (<20 mg/L) and magnesium (<5 mg/L) along with unusually high concentrations of chloride (>20 mg/L);
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations);
- unusually high concentrations of iron (>3 mg/L) and manganese (>1 mg/L); and
- total concentrations of trace metals (except iron and manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the unusually high chloride concentrations typical of the groundwater samples reflect localized geochemical conditions or contamination from inorganic wastes disposed in the BCBG. Additionally, although the groundwater contains a mixture of dissolved chlorinated hydrocarbons (see Section 5.3) and elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995). The most recent monitoring data suggest that the geochemical characteristics of the groundwater (particularly the REDOX conditions) are not especially conducive to biotic degradation of VOCs (Table 1).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected since August 1995, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (2.7 mg/L in July 2000) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 2): benzene, chloroethane, chloroform, total xylene, MC, PCE, TCE, toluene, TCFM, VC, 11DCA, 12DCA, 11DCE, 12DCE isomers, 111TCA, and 1,1,2-trichloro-1,2,2-trifluoroethane (freon-113). Waste disposal sites within Burial Ground-A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the dissolved VOCs in the shallow groundwater at this well and the DNAPL encountered more than 300 ft bgs in wells located south (down-dip) of BG-A South (DOE 1997).

The primary compounds in the groundwater samples are PCE, TCE, c12DCE, and VC, which were detected in all but one of the samples and have respective historical maximum concentrations that exceed 1,000 μg/L (Table 2). Secondary compounds in the samples are

11DCE, 111TCA, and 11DCA, which also were detected in all but one of the samples and have historical maximum concentrations above 100 µg/L. Benzene, t12DCE, chloroform, chloromethane, and total xylene also have been detected in most of the samples and, excluding suspected outlier results in July 2003 for benzene (240 µg/L) and t12DCE (100 µg/L), the historical maximum concentrations of these compounds are all less than 50 µg/L. Freon-113 and TCFM (freon-11) have been detected in each sample analyzed for these compounds (Table 2), with higher concentrations (>50 µg/L) reported for Freon-113. Methylene chloride and toluene were only detected in a few samples and these results are probably analytical artifacts.

Some of the VOCs in the groundwater samples, particularly c12DCE and VC, are probably present in the groundwater as a consequence of the biotic degradation of related parent compounds (PCE and TCE). Also, the dissolved petroleum hydrocarbons in the groundwater may serve as electron donors for biologically mediated dechlorination of PCE and related compounds (Chapelle 1996). Additionally, the acidic pH of the groundwater samples may be at least partially attributable to abiotic degradation of 111TCA, which chemically degrades to acetic acid (McCarty 1996). However, as noted in Section 4.0, several geochemical characteristics of the groundwater in the well, particularly the REDOX conditions, are not especially conducive to anaerobic biotic degradation. Perhaps the monitored interval in the well intercepts groundwater flowpaths that transport dissolved VOCs from source areas where biotic degradation primarily occurs, toward the natural discharge areas for the shallow flow system (i.e., the northern tributaries of Bear Creek that traverse the BCBG WMA).

Summed VOC concentrations show an indeterminate long-term trend (Figure 1), with diverse concentration trends evident for individual compounds (Table 2). For instance, the benzene concentration trend is clearly skewed by the suspected outlier result obtained in July 2003 (230 µg/L). Also, the long-term concentration trends for several compounds, notably PCE, are dominated by sharp temporal fluctuations; why some compounds exhibit such wide temporal concentrations and others do not is not clear from the available data. Indeterminate long-term trends are evident for other compounds, as illustrated by the concentrations of 12DCA in July 1998 (7 µg/L), July 2000 (2 µg/L), and July 2003 (13 µg/L). It is not clear from the available data if the divergent long-term concentration trends are indicative of corresponding changes in the relative flux of VOCs along the groundwater flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Ten of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum value (10.26 pCi/L in January 1995) being slightly below the drinking water MCL for gross alpha activity (15 pCi/L). However, the historical maximum value is an outlier compared to the other results for gross alpha activity, none of which exceed 3 pCi/L.

5.5 GROSS BETA ACTIVITY

Ten of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (10.78 pCi/L in January 1995) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Nevertheless, the historical maximum value appears to be an outlier compared to the other results for gross beta activity, none of which exceed 6 pCi/L.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons.* Batelle Press, Columbus, OH.

McCarty, P.I. 1996. *Biotic and Abiotic Transformations of Chlorinated hydrocarbons in Groundwater.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-046: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	January 2003	July 2003	January 2004	July 2004
Nitrate < 1 mg/L	1	1.2	0.96	NA
Iron (II) > 1 mg/L	0.0846*	0.0838*	1.33*	0.425*
Sulfate < 20 mg/L	7.3	3.2	4.7	6
Dissolved Oxygen < 0.5 ppm	0.57**	4.71**	7.18**	0.81**
REDOX < 50 mV	229**	139**	30**	207**
pH >5 and < 9 st. units	5.98**	5.35**	5.86**	4.97**
Note: *Results are for total iron; **Field measurement; NA = Not analyzed.				

Table 2. Well GW-046: summary of VOC results

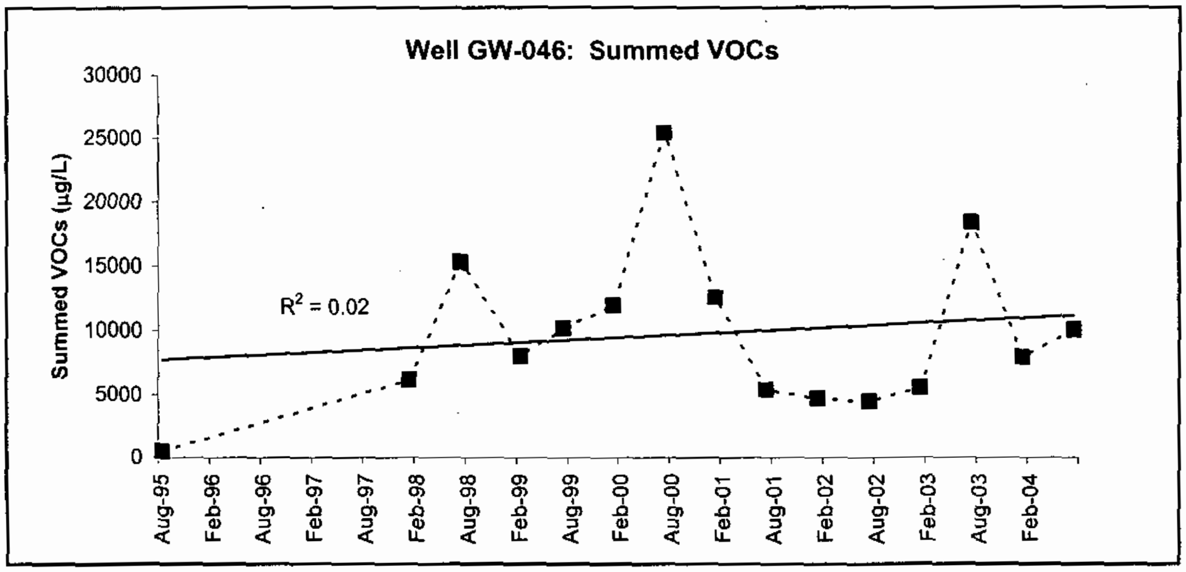
Sampling Date	VOC Concentration (µg/L)					
	PCE	**TCE**	**c12DCE**	**T12DCE**	**11DCE**	**VC**
08/09/95	460	.	NR	NR	.	.
01/28/98	1,000	930	3,400	21	64	450
07/28/98	4.600	3,000	6,400	17	66	760
02/08/99	1,100	1,500	4,400	.	98	550
07/15/99	3,000	2,100	3,900	25	100	630
01/11/00	1,300	2,800	6,200	26	170	760
07/19/00	8,400	4,800	11,000	28	78	760
01/04/01	1,800	2,900	6,400	30	170	640
07/09/01	690	1,200	2,800	20	82	270
01/07/02	500	1,000	2,600	13	83	230
07/02/02	990	980	2,000	11	40	260
01/06/03	920	1,100	2,700	12	78	340
07/09/03	5,100	3,200	7,100	100	190	1,300
01/06/04	1,500	1,400	3,900	27	230	490
07/08/04	2,100	1,700	4,900	34	290	610
MCL	**5**	**5**	**70**	**100**	**7**	**2**

Table 2. (continued)

Sampling Date	VOC Concentration (µg/L)			
	111TCA	12DCA	11DCA	Chloroethane
08/09/95	.	38	.	.
01/28/98	64	3 J	150	12
07/28/98	80	7	230	7
02/08/99	120	.	230	.
07/15/99	120	.	220	.
01/11/00	300	.	250	26
07/19/00	110	5	160	9
01/04/01	260	3 J	240	29
07/09/01	120	2 J	130	6
01/07/02	77	2 J	140	5
07/02/02	32	2 J	73	.
01/06/03	87	4 J	190	5
07/09/03	260	13	730	13
01/06/04	68	6	230	10
07/08/04	77	5	290	13
MCL	**200**	**5**	**NA**	**NA**

Sampling Date	VOC Concentration (µg/L)						
	Chloroform	MC	Benzene	Total Xylene	Toluene	TCFM	Freon-113
08/09/95	.	.	.	.	.	NR	NR
01/28/98	5	4 J	18	6	.	7	NR
07/28/98	9	13	49	8	.	11	NR
02/08/99	.	.	.	NR	.	NR	NR
07/15/99	.	.	42	NR	.	NR	NR
01/11/00	2 J	.	21	5	3 J	NR	NR
07/19/00	4 J	.	25	2 J	.	NR	NR
01/04/01	4 J	.	21	3 J	.	NR	NR
07/09/01	2 J	.	10	2 J	.	NR	NR
01/07/02	2 J	.	10	2 J	.	NR	NR
07/02/02	1 J	.	9	.	.	NR	NR
01/06/03	8	.	47	8	.	NR	NR
07/09/03	33	.	240	28	2 J	NR	NR
01/06/04	8	.	53	8	.	NR	75 J
07/08/04	9	.	63	4 J	.	NR	81
MCL	**NA**	**5**	**5**	**10,000**	**1,000**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = Not reported



Well GW-046: Summed VOCs
Summed VOCs (µg/L)
30000
25000
20000
15000
10000
5000
0
R^2 = 0.02
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	0.03 - 0.3	ND	15 - 150	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-052

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,478.00
Y-12 GRID NORTH COORDINATE: 29,052.00
SURFACE ELEVATION: 903.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/02/83 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 22.04 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 905.70 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.0	899.40
BOTTOM (filter pack or open hole):	19.5	883.90
MIDPOINT (filter pack or open hole):	11.8	891.65
PUMP INTAKE:	17.2	886.20
WATER LEVEL (average):	8.48	894.92

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	7		
CONVENTIONAL SAMPLING METHOD:	5 samples	06/22/90	04/26/93
LOW-FLOW SAMPLING METHOD:	2 samples	03/04/04	08/16/04

SAMPLING DATES FOR CALENDAR YEAR: 2004	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	03/04/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 13.97 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	3	19.8 mg/L	12/15/92	Decreasing
URANIUM (0.03 mg/L):	5	0.089 mg/L	12/15/92	Decreasing
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	6	49.5 pCi/L	12/15/92	Decreasing
GROSS BETA (50 pCi/L):	2	51.44 pCi/L	03/20/91	Decreasing

WELL GW-052

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1983, completed with a screened monitored interval from 4 to 20 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, approximately 200 ft north of the main channel of Bear Creek and between northern tributaries (NT) of the creek (NT-6 and NT-7) that drain sections of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seven groundwater samples have been collected to date, with the conventional sampling method used to collect five samples between June 1990 and April 1993 and the low-flow sampling method used to obtain samples in March and August 2004. The sampling history includes annual and semiannual sampling frequencies and, as indicated by the preceding sampling dates, an extended period (April 1993 – March 2004) when no groundwater samples were collected from the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths and groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). The depth of the well and its location relative to the geologic contact between the Maynardville Limestone and the underlying Nolichucky Shale suggest that the monitored interval is completed near the middle of the Maynardville Limestone.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits unusually large (approximately 14 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-052 indicate a westerly flow direction, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone and the main channel of Bear Creek south of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date indicate that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 184 – 434 mg/L;
- pH (field measurements) of 6.4 – 7.4;
- elevated sulfate concentrations (>20 mg/L) relative to other wells completed at similarly shallow depths in the Maynardville Limestone;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that each of the principal contaminants except VOCs are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), including four samples with concentrations that exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. These former surface impoundments, which are underlain by the Nolichucky Shale approximately 9,500 ft east-northeast of well GW-052, were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. Infiltration from the ponds emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the groundwater, some of which were dissolved from bedrock minerals by the acidic seepage from the ponds. Nitrate is one of the principal inorganic contaminants, is chemically stable and highly mobile in groundwater, and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells in BCV, the extent of nitrate contamination in the Maynardville Limestone west of the former S-3 Ponds, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As shown by the data summarized in Table 1, nitrate concentrations reported for the groundwater samples collected to date show a clearly decreasing trend following the historical maximum concentration in June 1990 (28 mg/L). Also, the historical nitrate results, which were reported for samples obtained with the conventional sampling method, indicate wide temporal fluctuations in nitrate concentrations, although there are insufficient data to evaluate any corresponding relationship with groundwater flow conditions. Conversely, the much lower nitrate concentrations reported for the samples collected in March (2.94 mg/L) and August 2004 (2.9 mg/L), which were obtained with the low-flow sampling method, show much lower levels and suggest minimal temporal variation. The long-term decrease in nitrate concentrations in the shallow groundwater at this well is attributable to the reduced flux of nitrate following closure of the former S-3 Ponds in 1984 and installation of the low-permeability cap in 1989 (DOE 1997).

It is possible that the lower and less variable nitrate concentrations indicated by the most recent groundwater sampling results may be at least partially attributable to the change from the conventional sampling method to the low-flow sampling method. The latter method involves purging the well at a flow rate that this low enough to (<300 milliliters per minute) to minimize drawdown of the water level in the well (<0.1 ft per quarter hour). At five minute intervals after the water-level drawdown has stabilized, field personnel record measurements of selected indicator parameters (e.g., pH) and collect (unfiltered) groundwater samples once the field measurements for each parameter show minimal variation over four consecutive readings. In contrast, under the conventional sampling method, field personnel collect groundwater samples immediately after purging at least three well volumes of groundwater at a pumping rate which may substantially lower the water level in the well (or purge the well dry). Conventional sampling would be expected to induce groundwater inflow from the flowpaths that may not be near the well, whereas low-flow sampling may induce inflow primarily from the groundwater flowpaths located nearest to the well. Assuming advective transport of nitrate via multiple groundwater flowpaths in the water table interval, purging the well in accordance with the conventional sampling method may result in the collection of groundwater samples with higher concentrations of nitrate (and other contaminants) relative to samples obtained with the low-flow sampling method.

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit (Table 1), and results for all but one of the samples exceed the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of well GW-052, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. The CERCLA remedial investigation for BCV identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 4,500 ft east of well GW-052. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and

(3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

Total uranium concentrations reported for the groundwater samples range between the historical maximum value of 0.089 mg/L in December 1992 and the historical minimum value of 0.0262 mg/L in March 2004 (the only result that is less than the MCL). These results reflect a temporally variable but generally decreasing long-term concentration trend. It is unclear from the available data if the temporal fluctuations in uranium levels reflect corresponding short-term variations in groundwater flow conditions and, assuming advective transport in the groundwater, corresponding changes in the relative flux of uranium along the groundwater flowpaths intercepted by the monitored interval in the well. Also, because of the long gap in the sampling history for the well (see Section 2.0), it is not clear if the decreased concentrations of uranium in the shallow groundwater at this well may be directly attributable to the CERCLA remedial action at the BYBY.

Unlike the nitrate results described in Section 5.1, the historical conventional sampling results for total uranium are less clearly distinguished from the recent low-flow sampling results, as illustrated by the similar uranium concentrations detected in the samples collected with the respective method in March 1992 (0.042 mg/L) and August 2004 (0.0467 mg/L). Thus, it is not clear from the available data if the apparent reduction in the concentrations of uranium in the groundwater at this well is an artifact of the change in the groundwater sampling method.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

All of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 2), and all of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (and alpha-emitting daughters) are the source of elevated gross alpha activity in the groundwater at this well, with the most recent (March and August 2004) sampling results confirming the continued presence of U-234 and U-238 in the well (Table 2). The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the shallow groundwater at well GW-052 (DOE 1997). As with total uranium (see Section 5.2), uranium isotopes leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the (limestone) bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

Gross alpha activity values reported for the groundwater samples range between the historical maximum value of 49 pCi/L in December 1992 and the historical minimum value of 16 pCi/L in August 2004. These results reflect a temporally variable but generally decreasing long-term trend for gross alpha activity in the shallow groundwater at this well. This long-term trend generally mirrors the similar trend defined by the sampling results for total uranium and likewise may be attributed to reduced flux of uranium isotopes in response to the CERCLA remedial action at the BYBY during the spring and summer of 2003.

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 2), including results for four samples that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The gross beta activity reported for the sample collected in June 1990 (120 pCi/L) is the historical maximum value for the well. Although uranium isotopes and related daughter products contribute to the gross beta activity in the groundwater at this well, the most recent sampling results (March and August 2004) indicate that Tc-99 also is a source of the beta activity (Table 2). *Technetium-99 is a "signature" component of the contaminant plume* emplaced during historical operation of the former S-3 Ponds because it is the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

The gross beta activity values reported for the groundwater samples have decreased from above 50 pCi/L in the early 1990s to below 20 pCi/L in March and August 2004 (Table 2). This decreasing long-term trend generally mirrors the similar trend defined by the sampling results for gross alpha activity (and total uranium) and likewise may be attributed to reduced flux of uranium isotopes in the Maynardville Limestone (and Bear Creek) as a result of the CERCLA remedial action at the BYBY, along with continued long-term decrease in the relative flux of Tc-99 (and nitrate) evident following closure/capping of the former S-3 Ponds.

6.0 REFERENCES

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-052: summary of results for nitrate and uranium

Sampling Date	Concentration (mg/L)	
	Nitrate (as N)	Total Uranium
06/22/90	28	0.075
03/20/91	12	0.061
12/15/92	19.8	0.089
03/25/93	6.3	0.042
04/26/93	12.06	0.064
03/04/04	2.94	0.0262
08/16/04	2.9	0.0467
MCL	**10**	**0.03**

Table 2. Well GW-052: summary of results for gross alpha activity, uranium isotopes, gross beta activity, and Tc-99

Sampling Date	Concentration (pCi/L)				
	Gross Alpha Activity	U-234	U-238	Gross Beta Activity	Tc-99
06/22/90	40.18	.	.	120.35	.
03/20/91	31.16	.	.	51.44	.
12/15/92	49.5	12.8	25.5	50.8	<CE
03/25/93	20	.	.	30.3	.
04/26/93	32.7	.	.	44.4	.
03/04/04	17	4.9	9	17	19
08/16/04	16	8.4	15	18	19
MCL	**15**	**NA**	**NA**	**50***	**3,470***

Note: * = SDWA screening level for a 4 mrem/yr dose equivalent

MAXIMUM CONCENTRATION: 2005

ND	<0.015	5 - 50	7.5 - 15	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-053

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,086.00
Y-12 GRID NORTH COORDINATE: 29,066.00
SURFACE ELEVATION: 900.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/04/83 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 35.13 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 903.42 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.4	889.10
BOTTOM (filter pack or open hole):	32.8	867.70
MIDPOINT (filter pack or open hole):	22.1	878.40
PUMP INTAKE:	29.1	871.42
WATER LEVEL (average):	5.66	895.46

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	32		
CONVENTIONAL SAMPLING METHOD:	22 samples	06/22/90	09/03/97
LOW-FLOW SAMPLING METHOD:	10 samples	03/11/98	10/17/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/20/05	.	10/17/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.54 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	29	80.4 μg/L	09/26/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-053

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1983, completed with a screened monitored interval from 11.4 to 32.8 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, approximately 500 ft south of the western portion of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). Additionally, the well is located approximately 100 ft north of the main channel of Bear Creek, about 150 ft east of a northern tributaries (NT) of the creek (NT-7) that drains the central section of the BCBG WMA. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-two groundwater samples have been collected to date, with the conventional sampling method used to collect 22 samples between June 1990 and September 1997 and the low-flow sampling method used to obtain ten samples between March 1998 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths and groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits seasonal fluctuations of about 8 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-053 indicate a westerly flow direction, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone and the main channel of Bear Creek south of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date indicate that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 377 – 528 mg/L;
- pH (field measurements) of 6.0 – 7.7;
- low molar proportions of chloride, potassium, sodium, and sulfate (<5% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the 29 groundwater samples collected since March 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Five groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the maximum value (0.9 mg/L in December 1991) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-six groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.008 mg/L in September 1991) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 1): PCE, TCE, 12DCE, 11DCE, VC, 111TCA, 12DCA, 11DCA, chloroethane, benzene, acetone, and 2-butanone. Waste disposal sites within Burial Ground-A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the dissolved VOCs in the shallow groundwater at this well (DOE 1997).

The primary compounds in the groundwater samples are TCE, 12DCE, VC, and 11DCA which were detected in nearly every sample (Table 1). Historical results show that 12DCE, VC, and 11DCA have the highest maximum values (> 20 µg/L) and that VC concentrations have exceeded the MCL (2 µg/L). However, the most recent results (June and October 2005) show that VC is no longer detected and c12DCE concentrations still have the highest values (> 10 µg/L). The secondary compounds (PCE, 11DCE, 111TCA, and 12DCA) have been detected at very low (estimated) levels in less than half of the groundwater samples collected from the well, and PCE is the only secondary VOC that has been detected in the samples collected since September 1992 (Table 1).

Some of the VOCs in the groundwater samples, particularly c12DCE and VC, are probably present in the groundwater as a consequence of the biotic degradation of related parent compounds (PCE and TCE). Although sporadically detected at very low levels, the dissolved benzene in the groundwater may serve as an electron donor for biologically mediated dechlorination of PCE and related compounds (Chapelle 1996). Also, the geochemical characteristics of the groundwater in the well, except for iron concentrations, are conducive to anaerobic biotic degradation (Table 2).

A time-series plot of the summed VOC concentrations shows an overall decreasing long-term trend (Figure 1), which is similar to the long-term trend for all primary VOCs except for TCE (Table 1). The TCE trend shows an indeterminate trend, the significance of this trend is questionable because all of the TCE results are estimated values below the reporting limit. The decreasing long-term concentration trends probably reflect reduced flux of VOCs south of the BCBG WMA along the shallow groundwater flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the maximum value (11 pCi/L in June 2005) being below the drinking water MCL for gross alpha activity (15 pCi/L). However, this result is a suspected outlier because the eight other detected results are less than 5 pCi/L, and the most recent sample (October 2005) was below the MDA.

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE limits, with the maximum value (9.6 pCi/L in September 1991) being substantially less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). All of the gross beta results for the 13 groundwater samples collected since March 1996 have been below the MDA.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-053: summary of VOC results

Sampling Date	Concentration (μg/L)			
	PCE	TCE	12DCE	c12DCE
06/22/90	0.9 J	3 J	26	NR
09/14/90	1 J	3 J	33	NR
12/02/90	.	3 J	27	NR
03/19/91	.	.	20	NR
06/19/91	.	4 J	.	NR
09/26/91	0.9 J	4 J	30	NR
12/22/91	0.9 J	3 J	21	NR
03/29/92	.	2 J	18	NR
06/25/92	.	3 J	24	NR
09/25/92	1 J	4 J	27	NR
03/10/94	.	1 J	10	NR
06/24/94	0.7 J	2 J	15	NR
09/15/94	1 J	3 J	18	NR
12/12/94	1 J	3 J	18	NR
03/28/95	.	2 J	19	NR
06/28/95	.	3 J	16	NR
09/25/95	2 J	3 J	18	NR
12/10/95	1 J	2 J	15	NR
03/26/96	.	2 J	11	NR
08/28/96	.	2 J	14	NR
02/06/97	1 J	3 J	11	11
09/03/97	.	2 J	15	15
03/11/98	2 J	2 J	11	11
09/02/98	2 J	3 J	15	15
03/24/99	.	3 J	13	13
08/26/99	.	3 J	15	15
02/21/00	.	3 J	16	16
08/22/00	.	3 J	15	15
02/12/01	.	4 J	18	18
07/25/01	.	3 J	13	13
06/20/05	.	2 J	10	10
10/17/05	1 J	3 J	11	11
MCL	**5**	**5**	**NA**	**70**

Table 1. Well GW-053: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L)			
	11DCE	**VC**	**111TCA**	**11DCA**
06/22/90	.	21	2 J	13
09/14/90	0.8 J	21	1 J	14
12/02/90	.	11	1 J	11
03/19/91	.	11	.	9
06/19/91	11	17	1 J	21
09/26/91	0.8 J	25	0.9 J	14
12/22/91	.	6	.	10
03/29/92	.	10	.	10
06/25/92	.	25	.	12
09/25/92	.	26	.	14
03/10/94	.	8	.	6
06/24/94	.	11	.	7
09/15/94	.	7	.	8
12/12/94	.	9	.	8
03/28/95	.	10	.	10
06/28/95	.	7	.	8
09/25/95	.	9	.	9
12/10/95	.	6	.	7
03/26/96	.	5	.	6
08/28/96	.	6	.	7
02/06/97	.	6	.	7
09/03/97	.	6	.	7
03/11/98	.	4 J	.	6
09/02/98	.	5 J	.	6
03/24/99	.	5 J	.	6
08/26/99	.	5 J	.	7
02/21/00	.	5 J	.	7
08/22/00	.	3 J	.	6
02/12/01	.	2 J	.	8
07/25/01	.	3	.	6
06/20/05	.	.	.	4 J
10/17/05	.	.	.	4 J
MCL	**7**	**2**	**200**	**NA**

Table 1. Well GW-053: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L) Other Compounds
06/22/90	Acetone (11), Benzene (0.6 J), 12DCA (1 J)
09/14/90	Benzene (0.6 J), Chloroethane (2 J)
12/02/90	Benzene (2 J), MC (3 J), 12DCA (2 J)
03/19/91	.
06/19/91	.
09/26/91	Benzene (0.8 J), Chloroethane (3 J), 12DCA (1 J)
12/22/91	12DCA (1 J)
03/29/92	.
06/25/92	.
09/25/92	Chloroethane (3 J), 12DCA (1 J)
03/10/94	.
06/24/94	.
09/15/94	Acetone (6), 2-Butanone (16)
12/12/94	.
03/28/95	.
06/28/95	.
09/25/95	.
12/10/95	.
03/26/96	.
08/28/96	.
02/06/97	.
09/03/97	.
03/11/98	2-Butanone (2 J)
09/02/98	.
03/24/99	.
08/26/99	.
02/21/00	.
08/22/00	.
02/12/01	.
07/25/01	.
06/20/05	.
10/17/05	.

Note: "." = Not detected; J = Estimated value below analytical reporting limit;
NA = Not applicable; NR = Not reported

Table 2. Well GW-053: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005	October 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	0.327*	0. 605*
Sulfate	< 20 mg/L	11.3	10.1
Dissolved Oxygen	< 0.5 ppm	0.07**	0.1**
REDOX	< 50 mV	37.2**	22**
pH	>5 and < 9 st. units	7.06**	7.03**

Note: *Results are for total iron; **Field Measurements.

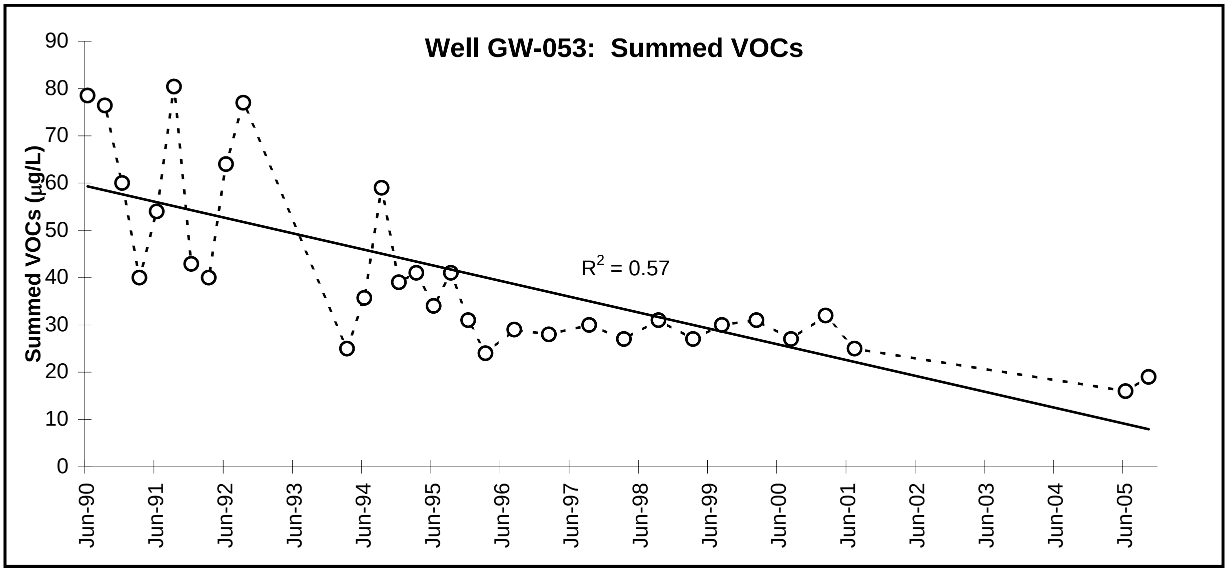

Well GW-053: Summed VOCs
Summed VOCs (µg/L)
90
80
70
60
50
40
30
20
10
0
R^2 = 0.57
Jun-90
Jun-91
Jun-92
Jun-93
Jun-94
Jun-95
Jun-96
Jun-97
Jun-98
Jun-99
Jun-00
Jun-01
Jun-02
Jun-03
Jun-04
Jun-05

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	<0.015	.	.	.

GW-056

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: EXP-A
Y-12 GRID EAST COORDINATE: 41,382.00
Y-12 GRID NORTH COORDINATE: 28,708.00
SURFACE ELEVATION: 886.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/27/84 PAIRED/CLUSTERED WITH: GW-057
TAG DEPTH (measured): 59.21 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 891.49 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	50.4	836.40
BOTTOM (filter pack or open hole):	55.2	831.60
MIDPOINT (filter pack or open hole):	52.8	834.00
PUMP INTAKE:	47.9	838.90
WATER LEVEL (average):	2.77	884.03

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	23 samples	06/09/90	08/19/97
LOW-FLOW SAMPLING METHOD:	8 samples	02/02/98	04/27/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/27/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.6 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	9 µg/L	07/27/98	
GROSS ALPHA (15 pCi/L):	1	18 pCi/L	01/12/00	
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-056

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1985, completed with a screened monitored interval from approximately 50 to 55 ft bgs, and constructed with nominal 2.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) about two miles west of Y-12, near the confluence of the main channel of Bear Creek and a northern tributary (NT) of the creek (NT-8) that drains the western sections of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). This well is a component of Exit Pathway Picket A, which consists of a series of wells (GW-056, GW-057, GW-683, GW-684, and GW-685) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone underlies Bear Creek throughout BCV and the hydrologic interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathways for groundwater and surface water contaminants.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 23 samples between June 1990 and August 1997, and the low-flow sampling method used to obtain 8 samples between February 1998 and April 2004.

Groundwater samples from this well are distinguished by elevated total (unfiltered sample) concentrations of chromium and nickel that are probably attributable to chemical and/or microbiologically-induced corrosion of the stainless steel riser casing and/or well screen (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths and groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits moderate (5 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-056 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields somewhat mineralized, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 364 – 746 mg/L;
- pH (field measurements) of 6.3 – 7.7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and

- total concentrations of trace metals (except chromium and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on data reported for samples collected since February 1991, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nineteen of the groundwater samples had nitrate concentrations above the analytical reporting limit, with all of the results being less than 1 mg/L and substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

All but one of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0081 mg/L in February 1997) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in six groundwater samples collected to date: acetone, chloroform, PCE, TCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and extends several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas, including the BCBG. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downgradient (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm WMA, including the former Hazardous Chemical Disposal Area (HCDA) and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the BCBG. The highest VOC concentrations within the plume exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek south-southwest of Sanitary Landfill I (DOE 1997).

The concentrations of VOCs detected in the groundwater samples from this well are 5 µg/L or less, with TCE and 12DCE being the only compounds detected in more than one of the samples. The highest concentrations were reported for acetone and PCE, with the latter result being equal to the drinking water MCL (5 µg/L). Results for all other compounds are 2 µg/L or less. Also, none of the samples collected since July 1999 contained VOCs.

5.4 GROSS ALPHA ACTIVITY

Seventeen groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (18 pCi/L in January 2000) being slightly above the drinking water MCL for gross alpha activity (15 pCi/L). However, this value appears to be an outlier in comparison with the other results for gross alpha activity, all of which are less than 10 pCi/L, most being less than 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (20 pCi/L in January 2000) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.6 OTHER

As noted in Section 2.0, the groundwater samples from this well typically contain elevated nickel concentrations; 16 of the samples had chromium and/or nickel concentrations above respective UTLs (Table 1), including seven samples with chromium above the federal drinking water MCL (0.1 mg/L) and ten samples with nickel above the state drinking water MCL (0.1 mg/L). Corrosion of the stainless steel well casing and screen in the well is the suspected source of the nickel (and chromium) in the samples because: (1) mobile species of nickel are not typically present in groundwater with the neutral pH evident in the well; (2) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); and (3) microbiological sampling results, summarized below, support the possibility of microbiologically induced corrosion (MIC).

Date Sampled	Bacteria Activity (colony forming units/milliliter)			
	Heterotrophic Aerobic	Iron-Related	Slime Forming	Sulfate-Reducing
04/27/04	500,000	<100	50,000	<1,000

These results, which are based on qualitative bacterial counts estimated from the appearance of the groundwater sample after an eight- to nine-day growth period, confirm substantial microbial activity in the groundwater at this well, including the presence of bacteria (e.g., slime-forming bacteria) that have been documented to cause MIC of stainless steel (Sarouhan et. al. 1998).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

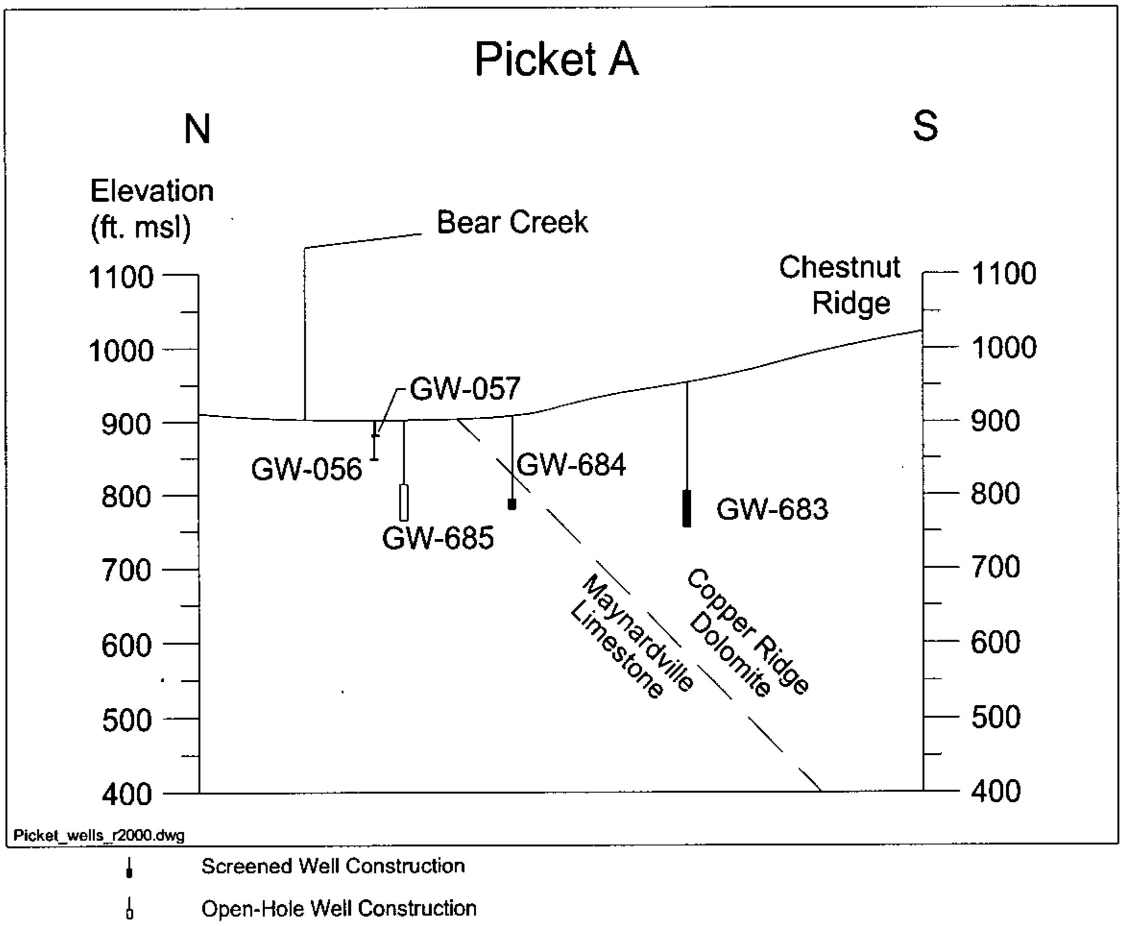
Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-056: summary of chromium and nickel results

Date Sampled	Total Concentration (mg/L)	
	Chromium	Nickel
02/26/91	.	.
05/24/91	.	.
09/15/91	.	.
12/11/91	0.021	0.035
03/13/92	0.013	0.12
06/06/92	0.051	0.026
09/02/92	0.021	0.039
11/23/92	.	0.035
03/04/93	0.01	.
04/22/93	0.23	0.22
07/09/93	0.016	0.031
10/09/93	0.092	0.049
02/26/94	0.036	0.23
09/14/94	.	0.11
03/05/95	0.031	0.064
08/04/95	0.23	0.067
03/14/96	.	0.12
07/23/96	0.1	0.61
02/13/97	.	0.06
08/19/97	0.021	0.07
02/02/98	0.014	0.04
07/27/98	0.0206	0.0662
02/09/99	0.103	0.0997
07/28/99	0.257	0.247
01/12/00	0.169	0.216
07/11/00	0.584	0.292
03/14/01	0.0893	0.0744
04/27/04	0.714	0.361
UTL	**0.029**	**0.06**
MCL	**0.1 (Federal)**	**0.1 (State)**
Notes: "." = Not detected		



Picket A
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-057
GW-056
GW-685
GW-684
GW-683
Maynardville
Limestone
Copper Ridge
Dolomite
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2005

05 - 10	0.03 - 0.3	ND	15 - 150	25 - 50
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-061

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,049.00
Y-12 GRID NORTH COORDINATE: 28,916.00
SURFACE ELEVATION: 901.00 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/21/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 28.09 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 904.60 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	17.5	883.50
BOTTOM (filter pack or open hole):	24.6	876.40
MIDPOINT (filter pack or open hole):	21.1	879.95
PUMP INTAKE:	22.4	878.60
WATER LEVEL (average):	12.29	888.24

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	21 samples	08/10/89	09/21/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/12/02	10/17/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/22/05	.	10/17/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.68 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	11	27.2 mg/L	06/24/92	Indeterminate
URANIUM (0.03 mg/L):	13	0.088 mg/L	09/15/94	Indeterminate
SUMMED VOCs (5 µg/L):	1	14 µg/L	09/15/94	Outlier
GROSS ALPHA (15 pCi/L):	12	42 pCi/L	08/05/02	Indeterminate
GROSS BETA (50 pCi/L):	8	82.9 pCi/L	09/26/91	Indeterminate

WELL GW-061

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 17.5 to 24.6 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, about 650 ft south of the Bear Creek Burial Grounds (BCBG) waste management area (WMA) and about 25 ft south of the main channel of Bear Creek. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected to date, with the conventional sampling method used to collect 21 samples between August 1989 and September 1995 and the low-flow sampling method used to obtain four samples between March 2002 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths and groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). The depth of the well (about 25 ft bgs) and its location relative to Bear Creek (about 25 ft south) and the Maynardville Limestone/Nolichucky Shale geologic contact suggest that the monitored interval is completed directly downdip of Bear Creek near the middle portion of the Maynardville Limestone.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs, with seasonal fluctuations of about 7 ft excluding one measurement (24.3 ft bgs in September 1992) that is a suspected outlier. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-061 indicate a westerly flow direction, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date indicate that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 206 – 476 mg/L;
- pH (field measurements) of 6.7 – 7.5;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- elevated concentrations (maximum > 20 mg/L) of aluminum and iron, related to elevated total suspended solid (>200 mg/L) concentrations in some samples; and
- total (unfiltered sample) concentrations of trace metals (except aluminum, iron, and uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that each of the principal contaminants except VOCs are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), including 13 samples with concentrations that exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. These former surface impoundments, which are underlain by the Nolichucky Shale approximately 9,000 ft east of well GW-061, were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. Infiltration from the ponds emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the groundwater, some of which were dissolved from bedrock minerals by the acidic seepage from the ponds. Nitrate is one of the principal inorganic contaminants, is chemically stable and highly mobile in groundwater, and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells in BCV, the extent of nitrate contamination in the Maynardville Limestone west of the former S-3 Ponds, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek. Because well GW-061 is shallow and located about 25 ft south of the main channel of Bear Creek, the elevated nitrate concentrations in the groundwater samples from the well probably reflect localized inflow of nitrate-contaminated surface water from the creek.

Nitrate concentrations reported for the groundwater samples collected to date range from about 6 mg/L to 27 mg/L (Table 1), with the highest concentrations (> 20 mg/L) reported for samples collected between September 1991 and September 1994. Also, the nitrate concentrations clearly exhibit significant temporal (seasonal) fluctuations, with the lowest levels typically reported for samples collected during seasonally high groundwater flow (winter and spring), and the highest concentrations (including the historical maximum in June 1992) typically reported for samples collected during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (or episodic) "dilution" from recharge of uncontaminated (or less nitrate-contaminated) groundwater via the flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of nitrate concentrations in the groundwater samples shows an indeterminate long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 1). The nitrate results obtained with the low-flow sampling method seemingly exhibit less temporal variability than the conventional sampling results. This may be related to inherent differences in the manner in which each sampling method induces inflow of groundwater into the well. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may induce inflow from water-producing features (and inflow of surface water from Bear Creek) that may not be proximal to the monitored interval. In contrast, low-flow sampling involves purging the well at a flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features near the well.

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit (Table 1), including 17 samples that exceed the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of well GW-061, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. The CERCLA remedial investigation for BCV identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater in the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 5,000 ft east of well GW-061. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

Total uranium concentrations reported for the groundwater samples collected to date range from 0.017 mg/L to 0.088 mg/L (Table 1), with the highest concentrations (> 0.07 mg/L) reported for samples collected between September 1991 and September 1994. The uranium concentrations clearly exhibit significant temporal (seasonal) fluctuations, with the lowest levels typically reported for samples collected during seasonally high groundwater flow (winter and spring), and the highest concentrations (including the historical maximum in September 1994) typically reported for samples collected during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (or episodic) "dilution" from recharge of uncontaminated (or less uranium-contaminated) groundwater during the winter and spring via the flow/transport pathways intercepted by the monitored interval in the well. As with nitrate, the elevated uranium concentrations in the groundwater samples from the well may reflect localized inflow of contaminated surface water from Bear Creek.

A time-series plot of uranium concentrations in the groundwater samples shows an indeterminate long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 2). As with nitrate concentrations (see Section 5.1), the uranium results obtained with the low-flow sampling method seemingly exhibit less temporal variability than the conventional sampling results. This may be related to inherent differences in the manner in which each sampling method induces inflow of groundwater into the well. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may induce inflow from water-producing features (and inflow of surface water from Bear Creek) that may not be proximal to the monitored interval. In contrast, low-flow sampling involves purging the well at a flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features near the well. Note that the uranium concentrations are lower in CY 2005 than in CY 2002 (Figure 2), which may reflect the CERCLA remedial actions completed in May 2003 at the BYBY (described above).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in four groundwater samples: a trace (<1µg/L) of TCE was detected in two samples (September 1991 and June 1994); 12DCE (total) was detected (2 µg/L) in one sample (September 1992); and acetone (6 µg/L) and 2-butanone (8 µg/L) were detected in one sample (September 1994). Acetone and 2-butanone are common laboratory reagents (possible artifacts) and these results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

All of the groundwater samples collected since March 1990 had gross alpha activity above the applicable MDA and corresponding CE (Table 1), and twelve of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (and alpha-emitting daughters) are the source of elevated gross alpha activity in the groundwater at this well, with the most recent (June and October 2005) sampling results confirming the continued presence of U-234 (6.5-6.8 pCi/L) and U-238 (12 pCi/L) in the well. The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the shallow groundwater at well GW-061 (DOE 1997). As with total uranium (see Section 5.2), uranium isotopes leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the (limestone) bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone and the surface water in Bear Creek (DOE 1997). Also, because the monitored interval of well GW-061 is located about 25 ft directly downdip of Bear Creek (see Section 3.0), the elevated gross alpha activity in the groundwater at the well probably reflects localized inflow of contaminated surface water from the creek.

A time-series plot of the gross alpha activity in the groundwater samples collected since March 1990, which is similar to the trend for uranium concentrations (see Section 5.3), shows an indeterminate long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 3). The alpha activities reported for samples collected in the early to mid-1990s exhibit significant temporal (seasonal) fluctuations, with the lowest levels typically reported for samples collected during seasonally high groundwater flow (winter and spring), and the highest concentrations (including the historical maximum in September 1994) typically reported for samples collected during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (or episodic) "dilution" from recharge of less contaminated groundwater (or surface water from Bear Creek) via the flow/transport pathways intercepted by the monitored interval in the well. Note that the alpha activity reported for samples collected in CY 2005 are significantly lower than reported in CY 2002 (Figure 3), which may reflect the CERCLA remedial actions completed in May 2003 at the BYBY (see Section 5.3).

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected since March 1990 had gross beta activity above the applicable MDA and corresponding CE (Table 1), including results for eight samples that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Although uranium isotopes (see Section 5.4) and related daughter products contribute to the gross beta activity in the groundwater at this well, the most recent sampling results (June and October 2005) indicate that Tc-99 (39-40 pCi/L) also is a source of beta activity. Technetium-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds because it is the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Also, because the monitored interval of well GW-061 is located about 25 ft directly downdip of Bear Creek (see Section 3.0), the elevated gross beta activity in the groundwater at the well probably reflects localized inflow of nitrate-contaminated surface water from the creek.

A time-series plot of the gross beta activity in the groundwater samples collected since March 1990 shows an indeterminate long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 3), which is similar to the concentration trends for nitrate, uranium, and gross alpha. As with gross alpha activity, the beta activities reported for samples collected in the early to mid-1990s exhibit significant temporal (seasonal) fluctuations, with the lowest levels typically reported for samples collected during seasonally high groundwater flow (winter and spring), and the highest levels (including the historical maximum in September 1991) typically reported for samples collected during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (or episodic) "dilution" from recharge of less contaminated groundwater (or surface water from Bear Creek) via the flow/transport pathways intercepted by the monitored interval in the well. Note that the beta activity reported for samples collected in CY 2005 are sharply lower than reported in CY 2002 (Figure 3), which may reflect the CERCLA remedial actions completed in May 2003 at the BYBY (see Section 5.3).

6.0 REFERENCES

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-061: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
08/10/89	9	0.033	DQO	DQO
10/09/89	7	0.029	DQO	DQO
12/19/89	5.9	0.027	DQO	DQO
03/12/90	7	0.025	6.88	23.98
06/22/90	9	0.032	12.92	30.73
09/14/90	12	0.041	10.44	37.94
12/02/90	14	0.046	15.95	43.62
03/19/91	7	0.025	12.55	20.24
06/19/91	6	0.025	9.82	16.87
09/26/91	20.1	0.08	27	82.9
12/21/91	12.2	0.034	15.9	45.9
03/27/92	6.9	0.021	6.35	79.8
06/24/92	27.2	0.084	22.9	61.2
09/25/92	23	0.074	18.2	26
03/21/94	10.6	0.04	14.6	26.9
06/24/94	21	0.017	18	57.1
09/15/94	23	0.088	37.1	71.7
12/12/94	8.6	0.029	12.8	36
03/28/95	11	0.04	15.9	38.2
06/28/95	15	0.039	18.5	41.8
09/21/95	18	0.057	20.6	56.2
03/12/02	13.2	0.0642	37	63
08/05/02	8.73	0.0581	42	73
06/22/05	8.57	0.0454	17	41
10/17/05	8.28	0.0476	14	34
MCL	**10**	**0.03**	**15**	**50***

Note: DQO = Result does not meet data quality objectives;
* = SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity).

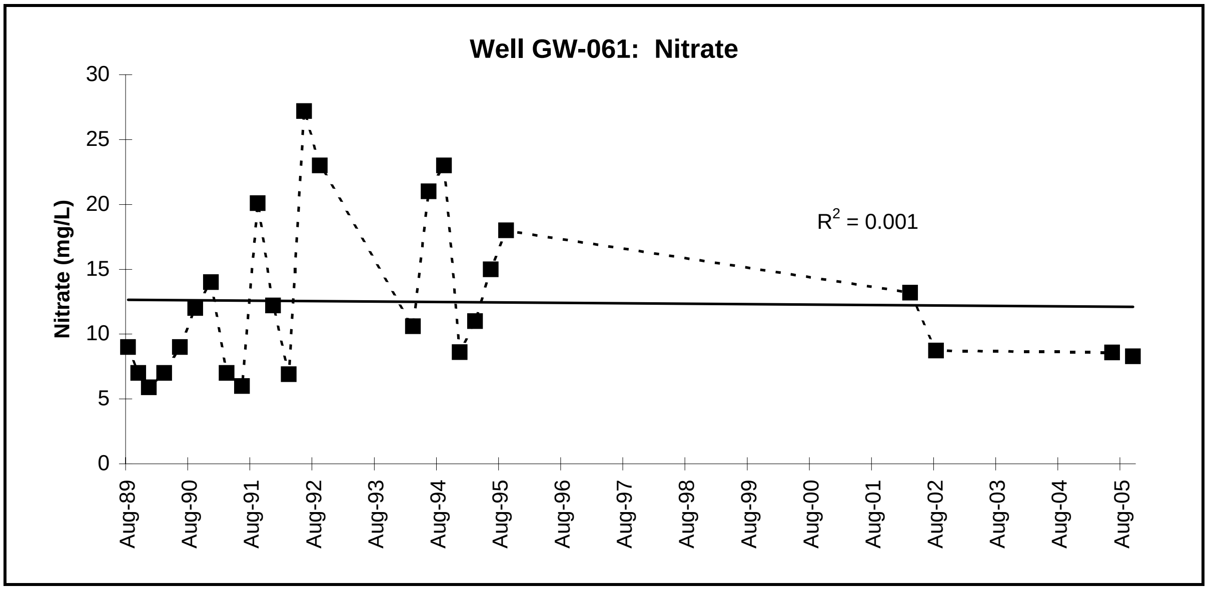


Figure 1

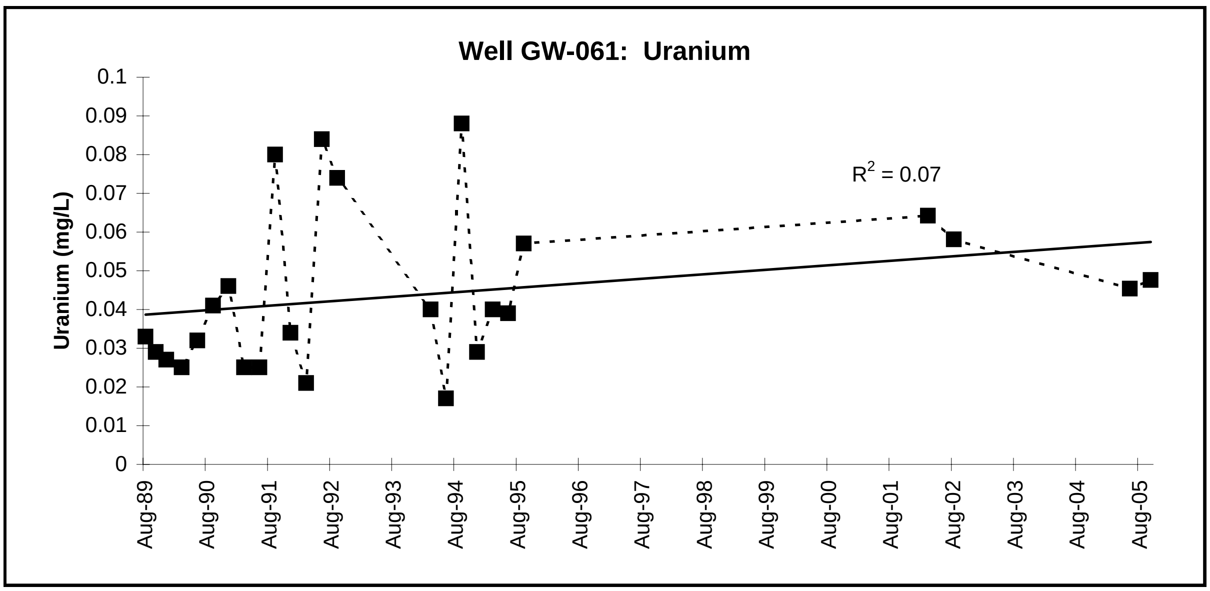


Figure 2

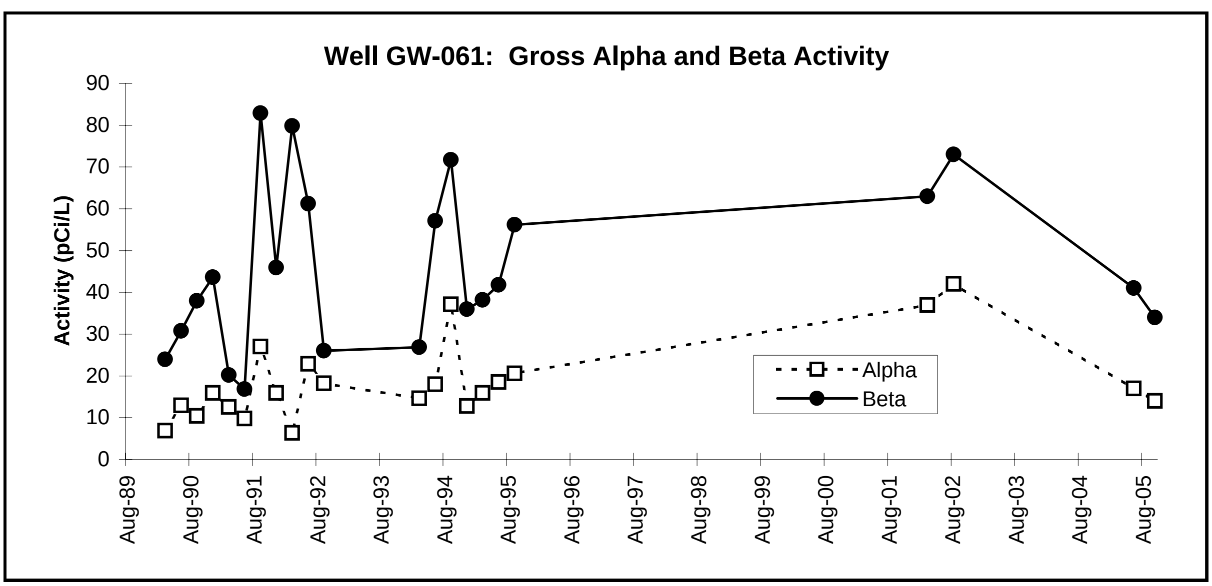


Figure 3

GW-061

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	ND	ND

GW-064

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Oil Landfarm
Y-12 GRID EAST COORDINATE:	49,169.00
Y-12 GRID NORTH COORDINATE:	29,195.00
SURFACE ELEVATION:	979.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	.
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	03/12/84	PAIRED/CLUSTERED WITH:	GW-065
TAG DEPTH (measured):	55.07 ft below top of casing (TOC)		
MEASURING POINT ELEVATION:	982.41 ft above msl	MEASURING POINT:	TOWW
WELL BORE DIAMETER:	4 inches		
WELL CASING MATERIAL:	SS304		
WELL CASING DIAMETER:	2.37 inches (outside diameter)		
WELL SCREEN TYPE:	SS/SW/0.01		
DEDICATED SAMPLING EQUIPMENT:	Well Wizard	Sampling Port No.: .	Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	46.8	932.50
BOTTOM (filter pack or open hole):	52.7	926.60
MIDPOINT (filter pack or open hole):	49.8	929.55
PUMP INTAKE:	51.0	928.31
WATER LEVEL (average):	22.84	957.17
GEOLOGIC FORMATION:	Maynardville Limestone	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	36		
CONVENTIONAL SAMPLING METHOD:	32 samples	11/05/87	08/06/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/06/98	07/26/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/02/05	.	07/26/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	.	
WATER LEVEL FLUCTUATION:	15.22 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	23	148 µg/L	10/30/92	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-064

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 46.8 to 52.7 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is paired with well GW-065 and is located in Bear Creek Valley (BCV) west of Y-12, directly south of the main channel of Bear Creek and approximately 450 ft west (downgradient) of the Rust Spoil Area, which was used from 1975 to 1983 for disposal of construction debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 32 samples between November 1987 and August 1995, and the low-flow sampling method used to obtain four samples between March 1998 and July 2005. Samples were collected on a quarterly frequency between November 1987 and August 1996, with semiannual sampling in 1998 and 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 23 ft bgs and exhibits maximum seasonal water-level fluctuations up to approximately 15 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-064 indicate westerly local flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 176 – 777 mg/L;
- pH of 6.9 – 7.6 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), including 11 samples with concentrations that exceed drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval for the well in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 3,000 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

As shown by the groundwater sampling results summarized in Table 1, nitrate concentrations above the drinking water MCL (10 mg/L) were reported for each sample collected between November 1987 (25 mg/L, the historical maximum value) and January 1990 (11 mg/L). However, all of the samples collected since November 1990 had nitrate concentrations below the MCL (Table 1). Additionally, unlike the nitrate concentrations evident in the groundwater at other wells completed at shallow depths in the Maynardville Limestone wells west of Y-12, the nitrate results for this well do not indicate wide temporal (seasonal) concentration fluctuations, as illustrated by the concentrations evident in March (1.88 mg/L) and August 2005 (2.55 mg/L). This suggests that the monitored interval in the well may not intercept the most permeable flowpaths at shallow depths in the Maynardville Limestone, where nitrate concentrations typically exhibit pronounced temporal fluctuations in response to seasonal (and episodic) recharge/discharge cycles.

A time-series plot of nitrate concentrations detected in the groundwater samples collected to date spans three-year (August 1995 – March 1998) and seven-year (July 1998 – March 2005) periods when no samples were collected from the well, but shows a clearly decreasing long-term concentration trend (Figure 1). The overall decrease from the nitrate concentrations mirrors with the substantially reduced flux of nitrate in the Maynardville Limestone following the closure/capping of the former S-3 Ponds. Also, as indicated by selected data included in the following summary, the increasing time for nitrate levels to decrease by at least 50% indicates that the rate of concentration decrease has slowed considerably and may have reached asymptotic levels in the groundwater at this well.

Sampling Date	Elapsed Time (Days)	Nitrate (mg/L)	Relative % Decrease
07/19/88	.	25	.
11/02/90	837	12	52%
06/23/94	1,379	5.5	54%
07/26/05	4,051	2.55	54%

5.2 URANIUM

Twenty-one groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0098 mg/L in July 1998) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, CTET, chloroform, MC, PCE, TCE, vinyl acetate, 2-hexanone, 12DCE, 11DCA, and 111TCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient of well GW-064, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

Based on frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples collected from well GW-064 to date are TCE and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample collected to date, with a historical maximum concentration of 210 µg/L in November 1987 and concentrations above 100 µg/L reported for more than half of the samples. Additionally, the most recent sampling results (March and August 2005) indicate that the TCE concentrations remain substantially above the drinking water MCL (5 µg/L). The only other VOC that was detected n each sample is 12DCE, although the historical maximum concentration (98 µg/L) is a suspected outlier because all the other results are below 20 µg/L, and the most recent sampling results show estimated concentrations below 5 µg/L (Table 2). Secondary compounds detected in the samples are CTET, chloroform, PCE, and 111TCA, each of which has been detected in more than half of the samples collected to date, although only chloroform and PCE were detected in the samples collected since August 1995, and only PCE was detected in samples collected since July 1998. Aside from a suspected outlier result for PCE (53 µg/L in November 1987), all of the results for these secondary VOCs are less than 10 µg/L and the bulk of the results are estimated concentrations below 5 µg/L (Table 2). The remaining compounds were detected in only a few samples and are probably analytical artifacts.

Review of the VOC data summarized in Table 2 indicates that the concentrations of TCE in the groundwater at this well exhibits significant short-term temporal variability, but the other compounds do not. This is illustrated by the respective TCE and PCE concentrations detected in the groundwater samples collected in August 1992 (100 µg/L and 1 µg/L), October 1992 (130 µg/L and 1 µg/L), and February 1993 (100 µg/L and 1 µg/L). Assuming a heterogeneous mixture of dissolved VOCs in the karst network at shallow depths in the Maynardville Limestone, it is unclear why the concentrations of TCE and PCE do not exhibit concurrent temporal fluctuations. Perhaps the TCE and PCE (and other VOCs) are not well mixed in the groundwater system, but instead occur within separate, discreet transport pathways that are intercepted by the monitored interval in the well. The divergent concentration trends also may reflect differential transport from separate source areas, with decreased flux from the source of TCE (Rust Spoil Area) and comparably more consistent flux of PCE from another upgradient source (e.g., Spoil Area I). Also, the TCE concentrations show a fairly consistent relationship with seasonal groundwater flow conditions, with "peak" concentrations typically evident during seasonally low-flow conditions (summer and fall) and low concentrations evident during seasonally high flow conditions. This relationship suggests that the concentrations of TCE in the groundwater flow/transport pathways intercepted by the monitored interval in this well are influenced by the inflow of uncontaminated (or less TCE-contaminated) recharge during seasonally (and episodically) high flow conditions. Conversely, the concentrations of other VOCs (PCE) do not show any similar apparent correlation with seasonal flow conditions, which again suggests separate sources of the VOCs detected in the groundwater samples from this well.

A time-series plot of TCE concentrations detected in the groundwater samples collected to date incorporates the previously noted gaps in the sampling history for the well and shows a clearly decreasing long-term concentration trend (Figure 2). The overall decrease in TCE levels probably reflects the reduced flux of VOCs in the Maynardville Limestone following the closure/capping of the former S-3 Ponds and long-term natural attenuation of the VOC sources at Spoil Area I and the Rust Spoil Area, both of which were closed without further remedial action (e.g., waste removal or installation of low-permeability cap). Indeed, reduced flux of TCE (and other VOCs) in response to the closure capping of the former S-3 Ponds may account for the approximately 50% concentration decrease evident during the late 1980s and early 1990s. Since then, the rate of concentration decrease appears to have slowed and to be largely controlled by the relative rate of various natural attenuation processes, including the apparent cyclic inflow of uncontaminated (or less-contaminated) recharge.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples collected since February 1991 had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.66 pCi/L in August 1992) being below the MCL for gross alpha activity (15 pCi/L). None of the samples collected since August 1995 had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Twenty groundwater samples collected since February 1991 had gross beta activity above the applicable MDA and corresponding CE, with the highest value (43.7 pCi/L in March 1995) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). None of the samples collected since July 1998 had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-064: summary of nitrate results

Sampling Date	Nitrate (mg/L)
11/05/87	19.7
04/26/88	22
07/18/88	25
09/22/88	24
11/30/88	22
03/07/89	16
05/17/89	17
09/14/89	16
12/07/89	11
01/23/90	11
05/30/90	9
08/18/90	9
11/02/90	12
02/20/91	9
05/17/91	0.73
08/14/91	7
10/23/91	7.23
02/27/92	0.58
06/02/92	6.2
08/29/92	8.2
10/30/92	9.4
02/09/93	8.3
05/12/93	4.7
09/11/93	7.67
10/20/93	9
02/10/94	7.1
06/23/94	5.5
09/01/94	5.4
12/15/94	7.4
03/26/95	5
06/07/95	4.9
08/06/95	5.4
03/06/98	4
07/20/98	3.7
03/02/05	1.88
07/26/05	2.55
MCL	**10**

Table 2. Well GW-064: summary of VOC results

Sampling Date	VOC (µg/L)			
	PCE	TCE	12DCE	111TCA
11/05/87	[53]	210	18	3 J
04/26/88	2 J	160	11	2 J
07/18/88	1 J	160	12	2 J
09/22/88	.	170	13	2 J
11/30/88	2 J	170	13	2 J
03/07/89	1 J	130	10	2 J
05/17/89	1 J	130	7	.
09/14/89	1 J	110	9	2 J
12/07/89	2 J	150	16	2 J
01/23/90	1 J	110	11	1 J
05/30/90	.	110	9	.
08/18/90	.	100	13	.
11/02/90	.	130	[98]	2 J
02/20/91	.	89	9	1 J
05/17/91	.	82	6	0.9 J
08/14/91	.	110	9	1 J
10/23/91	1 J	110	12	1 J
02/27/92	2 J	110	13	1 J
06/02/92	.	110	9	.
08/29/92	1 J	100	9	1 J
10/30/92	1 J	130	10	.
02/09/93	1 J	100	9	1 J
05/12/93	1 J	79	6	0.8 J
09/11/93	1 J	94	7	0.9 J
10/20/93	.	85	6	.
02/10/94	2 J	84	6	0.8 J
06/23/94	1 J	64	5	0.7 J
09/01/94	.	81	6	.
12/15/94	.	78	7	.
03/26/95	1 J	64	7	.
06/07/95	1 J	77	6	.
08/06/95	.	99	11	.
03/06/98	.	54	6	.
07/20/98	1 J	44	4 J	.
03/02/05	.	30	2 J	.
07/26/05	1 J	38	3 J	.
MCL	**5**	**5**	**NA**	**200**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
[ ] = Suspected outlier

Table 2. Well GW-064: summary of VOC results (cont'd)

Sampling Date	VOC (µg/L)		
	CTET	**Chloroform**	**Other**
11/05/87	9	4 J	11DCA(3 J), MC(6), 2-Hexanone(2 J)
04/26/88	6	3 J	.
07/18/88	6	4 J	MC (1 J)
09/22/88	5	4 J	.
11/30/88	6	5	.
03/07/89	5	5	.
05/17/89	5	4 J	Acetone (4 J)
09/14/89	5	5	.
12/07/89	6	5	.
01/23/90	5	4 J	Acetone (30)
05/30/90	.	.	.
08/18/90	4 J	3 J	.
11/02/90	5	4 J	.
02/20/91	4 J	.	.
05/17/91	3 J	.	.
08/14/91	4 J	.	.
10/23/91	3 J	.	.
02/27/92	4 J	4 J	.
06/02/92	3 J	.	.
08/29/92	3 J	.	.
10/30/92	4 J	3 J	.
02/09/93	4 J	3 J	Vinyl acetate (3 J)
05/12/93	2 J	2 J	MC (1 J)
09/11/93	2 J	2 J	.
10/20/93	2 J	2 J	.
02/10/94	2 J	2 J	.
06/23/94	1 J	2 J	.
09/01/94	.	.	.
12/15/94	2 J	2 J	.
03/26/95	1 J	2 J	.
06/07/95	3 J	2 J	.
08/06/95	.	2 J	.
03/06/98	.	1J	.
07/20/98	.	.	.
03/02/05	.	.	c12DCE (2 J)
07/26/05	.	.	c12DCE (3 J)
MCL	**5**	**80***	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
* = MCL is for total trihalomethanes

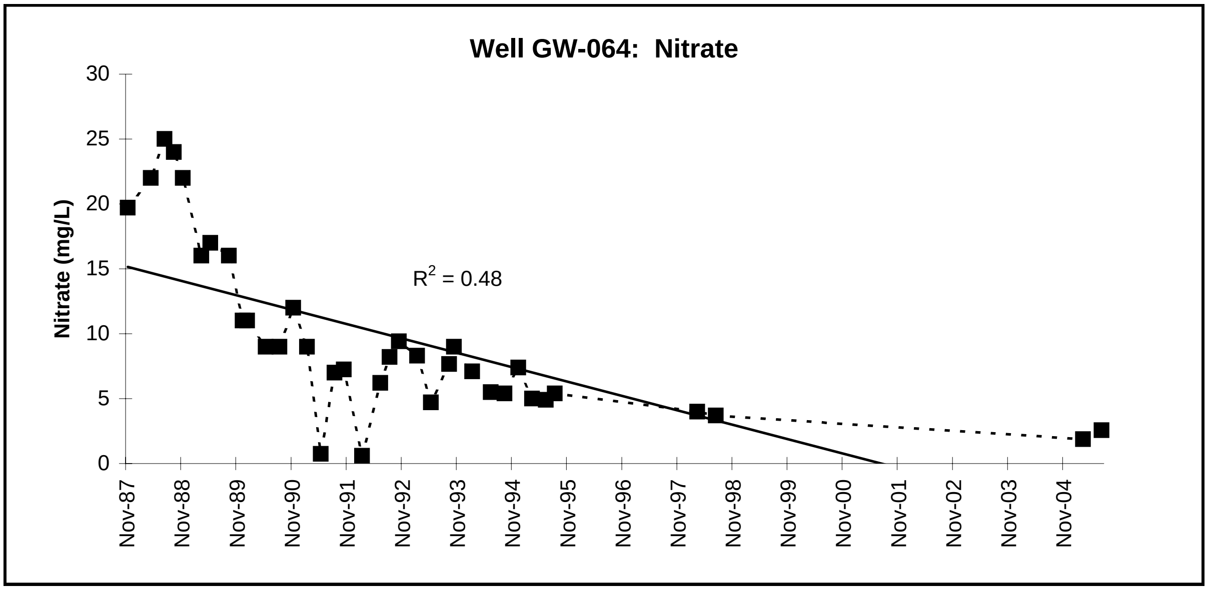


Figure 1

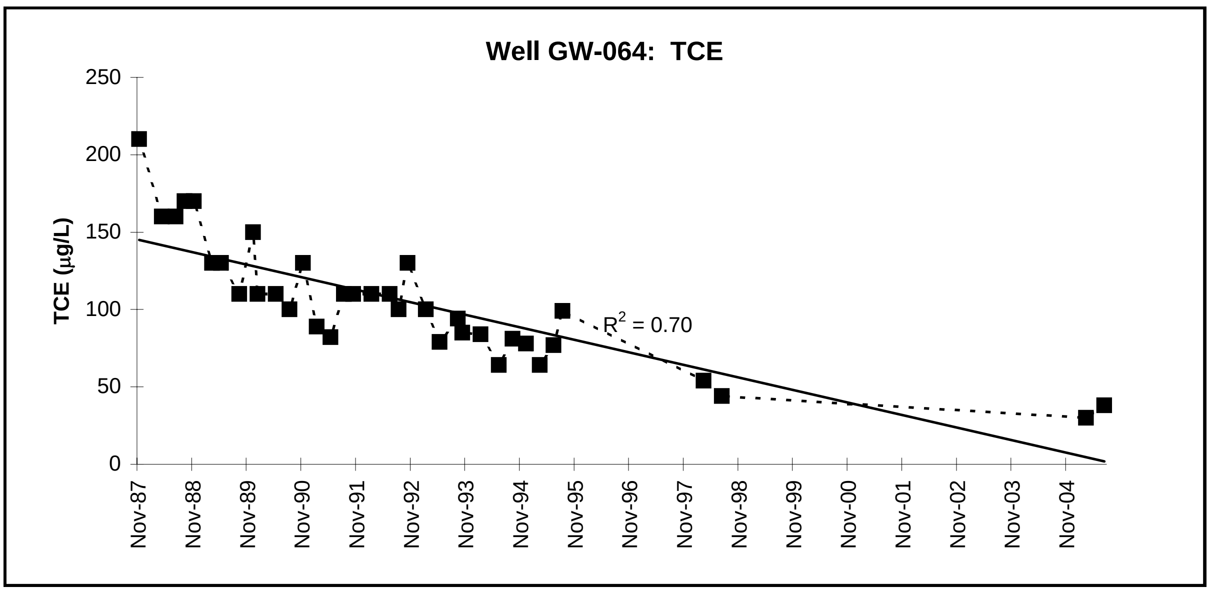


Figure 2

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	ND	<7.5	<25

GW-066

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 48,676.82
Y-12 GRID NORTH COORDINATE: 29,513.36
SURFACE ELEVATION: 959.58 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/24/84 PAIRED/CLUSTERED WITH: GW-067
TAG DEPTH (measured): 59.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 961.63 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	50.0	910.52
BOTTOM (filter pack or open hole):	54.9	905.62
MIDPOINT (filter pack or open hole):	52.5	908.07
PUMP INTAKE:	56.9	903.63
WATER LEVEL (average):	8.85	951.69

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	5		
CONVENTIONAL SAMPLING METHOD:	1 samples	09/27/95	09/27/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/25/02	09/06/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/14/05	.	09/06/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.09 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	3	39 µg/L	09/27/95	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-066

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 50 to 54.9 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is paired with a shallower well (GW-067) and is located in Bear Creek Valley (BCV) next to the main channel of Bear Creek immediately south of the Oil Landfarm waste management area (WMA), approximately one mile west of Y-12. This WMA encompasses the Oil Landfarm (the only RCRA-regulated site in the WMA), the former Boneyard/Burnyard (BYBY) and Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I. All of these facilities are closed, with the Oil Landfarm covered by a low-permeability cap installed during RCRA closure of the site in 1989, and subsurface wastes removed from the BYBY and HCDA during CERCLA remedial actions completed in 2003.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain one sample in September 1995, and the low-flow sampling method used to obtain four samples between March 2002 and September 2005.

Unusually low levels of TDS (<150 mg/L) are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0). Low TDS levels suggest relatively low residence time for the groundwater, which indicates that the monitored interval for the well intercepts highly permeable groundwater flowpaths. However, TDS concentrations were significantly higher (>500 mg/L) in the groundwater samples collected from the well before August 2002. The low TDS levels in the samples collected in March and September 2005 may reflect CERCLA remedial actions at the BYBY, completed in May 2003.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 9 ft bgs and exhibits maximum seasonal fluctuations of approximately 4 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-066 indicate westerly local flow directions, parallel with the direction of geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 107 – 582 mg/L (107 and 142 mg/L in March and September 2005);
- pH of 6.72 – 7.38 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations);
- elevated concentrations (> 2 mg/L) of aluminum and iron, most likely reflecting the elevated suspended solid concentration (e.g., 82 mg/L in March 2005); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Three groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (7.4 mg/L in September 1995) being below the drinking water MCL for nitrate (10 mg/L). Although below the MCL, these nitrate concentrations substantially exceed background levels (<0.028 mg/L) in uncontaminated groundwater in BCV, and indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 3,400 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

5.2 URANIUM

Four groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0097 mg/L in September 1995) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): PCE, TCE, 12DCE (c12DCE), 11DCE, and 11DCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient (east-northeast) of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

As shown in the following data summary, only fairly low concentrations of VOCs have been detected in the groundwater samples collected to date, and no VOCs were detected in the samples collected most recently (March and September 2005).

Sampling Date	**VOC (µg/L)**					
	PCE	**TCE**	**12DCE**	**c12DCE**	**11DCE**	**11DCA**
09/27/95	21	12	3 J	NR	2 J	1 J
03/25/02	8	5 J	2 J	2 J	.	.
08/13/02	6	4 J	.	.	.	.
03/14/05	.	.	.	.	.	.
09/06/05	.	.	.	.	.	.
MCL	**5**	**5**	**NA**	**70**	**7**	**NA**
Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported						

These results suggest that VOCs have been flushed from the groundwater flow/transport pathways intercepted by the monitored interval in the well. This may be a direct consequence of the CERCLA remedial actions ant the BYBY and HCDA, which involved construction of an upgradient subsurface drain to hydraulically isolate the buried wastes; excavation, disposal, and consolidation of wastes above and below the saturated zone; and the reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.4 pCi/L in March 2002) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Two groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.6 pCi/L in September 1995) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee*, Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	500 - 5,000	ND	<25

GW-068

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,377.00
Y-12 GRID NORTH COORDINATE: 29,500.00
SURFACE ELEVATION: 921.20 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/22/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 86.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 924.61 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	70.0	851.20
BOTTOM (filter pack or open hole):	83.6	837.60
MIDPOINT (filter pack or open hole):	76.8	844.40
PUMP INTAKE:	.	.
WATER LEVEL (average):	5.61	916.20

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	10		
CONVENTIONAL SAMPLING METHOD:	8 samples	03/18/87	03/12/90
LOW-FLOW SAMPLING METHOD:	2 samples	06/21/05	10/18/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/21/05	.	10/18/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.2 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	2	2279 µg/L	10/18/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-068

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 70 to 83.6 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) immediately south of the central part of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ten groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eight samples between March 1987 and March 1990, and the low-flow sampling method used to obtain samples in June 2005 and October 2005. This sampling history includes an extended period (15 years) when no groundwater samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits seasonal fluctuations of about 2 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-068 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-068 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-7 (located about 275 ft west of the well).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 322 – 350 mg/L;
- pH of 7.5 – 8 (field measurements);
- low molar proportions of sodium, potassium, chloride and sulfate (<10% of total anions/cations);
- slightly elevated (>0.015 mg/L) lead concentrations; and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Four of the groundwater samples collected to date had nitrate concentrations above the analytical reporting, with the highest value (1.22 mg/L) being substantially below the MCL (10 mg/L). Notably, nitrate concentrations have remained below reporting limits in all of the groundwater samples collected from the well since August 1989.

5.2 URANIUM

Four of the groundwater samples collected to date had uranium concentrations above the analytical reporting, with the highest value (0.003 mg/L) being an order of magnitude below the MCL for uranium (0.03 mg/L). As with nitrate, the uranium concentrations have remained below reporting limits in all of the groundwater samples collected from the well since August 1989.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 2): PCE, TCE, 12DCE, 11DCE, VC, 111TCA, 12DCA, 11DCA, chloroethane, chloroform, MC, acetone, benzene, toluene, total xylene, 2-hexanone, 4-methyl-2-pentanone (4M2P), and CTET. Waste disposal sites within Burial Ground-A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the dissolved VOCs in the shallow groundwater at this well and the DNAPL encountered more than 300 ft bgs in wells located south (down-dip) of BG-A South (DOE 1997).

The primary compounds in the groundwater samples are PCE, TCE, 12DCE, 11DCE, VC, and 11DCA, which have been detected in every sample and have respective historical maximum concentrations that exceed 100 µg/L (Table 1). Secondary compounds in the samples are 111TCA, chloroform, and benzene, which have historical maximum concentrations above 30 µg/L. The most recent results (June and October 2005) show that TCE, c12DCE, 11DCE, VC, and benzene concentrations continue to exceed the respective MCLs (Table 1).

The presence of benzene is a distinguishing characteristic of the VOC data for this well. A review of historical data indicates that elevated benzene results have been consistently reported for wells located in areas of Y-12 known to be impacted by historical releases from petroleum fuel underground storage tanks (USTs) and located near the BCBG WMA. Excluding the wells located near USTs, groundwater samples from the following wells at the BCBG WMA had benzene concentrations that exceeded the drinking water MCL (5 µg/L).

Well No.	Depth (ft bgs)	Benzene Concentration (µg/L) / Sampling Date			
		Maximum		Most Recent	
GW-014	13.2	180	11/05/87	4	10/19/05
GW-046	20.3	240	07/09/03	72	07/07/05
GW-068	83.6	51	10/18/05	51	10/18/05
GW-071	219	1,300	06/30/05	1,200	10/20/05
GW-082	34.4	99	08/07/03	ND	10/13/05
GW-117	530	6	11/13/87	ND	09/17/92
GW-118	575	67	11/19/88	1	10/10/93
GW-119	510	20	07/06/88	ND	09/17/92
GW-624	27.2	33	07/15/98	25	10/12/05

Of these, well GW-082 is located on the southwest side of Burial Grounds C-West, and all of the remaining wells are located near Burial Ground A-South: wells GW-014, GW-071, and GW-119 along the eastern boundary; wells GW-117 and GW-118 along the southern boundary; and wells GW-046, GW-068, and GW-624 near the western boundary. Note also the wide range in the total depth of these wells, particularly wells GW-117, GW-118, and GW-119, each of which is artesian. The apparent “clustering” of these wells suggest that benzene is a distinguishing component of the groundwater plume of dissolved VOCs originating from the waste disposal trenches in Burial Ground-A South.

Some of the VOCs in the groundwater samples, particularly c12DCE and VC, are probably present in the groundwater as a consequence of the biotic degradation of PCE and TCE. Also, the dissolved petroleum hydrocarbons (e.g., benzene) in the groundwater may serve as electron donors for biologically mediated dechlorination of PCE and related compounds (Chapelle 1996). However, some of the geochemical characteristics of the groundwater in the well (e.g., iron and dissolved oxygen levels) are not especially conducive to anaerobic biotic degradation (Table 2). Perhaps the monitored interval in the well intercepts groundwater flowpaths that transport dissolved VOCs from source areas where biotic degradation primarily occurs, toward the natural discharge areas for the shallow flow system (i.e., NT-7 that traverses the BCBG WMA).

A time-series plot of the summed VOC concentrations shows a variable and overall indeterminate long-term trend that encompasses the 15-year (March 1990 – June 2005) gap in the sampling history for the well (Figure 1). Notably, concentrations of PCE and TCE have decreased significantly since March 1990, while concentrations of their degradation products (12DCE and VC) show a significant increase (Table 1). These divergent trends provide additional evidence that biotic degradation of PCE and TCE is ongoing, possibly at areas located upgradient of the well.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected since March 1990 had gross alpha activity above the applicable MDA and corresponding CE. Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

Two of the groundwater samples collected since March 1990 had gross beta activity above the applicable MDA and corresponding CE, with the maximum value (11 pCi/L in October 2005) being substantially less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-068: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	**TCE**	**12DCE**	**c12DCE**	**11DCE**
03/18/87	220	160	420	NR	75
06/29/87	140	330	430	NR	60
09/25/87	140	320	440	NR	81
11/11/87	210	520	550	NR	110
04/19/88	160	590	390	NR	77
06/29/88	170	720	550	NR	110
08/06/89	76	660	390	NR	97
03/12/90	71	490	380	NR	71
06/21/05	2 J	68	762	760	90
10/18/05	2 J	83	1005	1000	160
MCL	**5**	**5**	**NA**	**70**	**7**
Sampling Date	**Concentration (µg/L)**				
	VC	**111TCA**	**11DCA**	**12DCA**	**Chloroform**
03/18/87	120	42	400	2 J	15
06/29/87	70	40	420	2 J	10
09/25/87	150	55	490	2 J	18
11/11/87	220	82	720	4 J	25
04/19/88	230	79	600	.	33
06/29/88	200	96	750	4 J	22
08/06/89	210	32	720	.	12
03/12/90	170	14	510	.	.
06/21/05	270	.	480	.	.
10/18/05	320	.	650	.	.
MCL	**2**	**200**	**NA**	**5**	**80***
Sampling Date	**Concentration (µg/L)**				
	MC	**Acetone**	**Other**		
03/18/87	3 J	5	4M2P (4 J)		
06/29/87	3 J	.	Chloroethane (2 J), 2-Hexanone (1 J)		
09/25/87	2 J	19	.		
11/11/87	2 J	39	.		
04/19/88	6	5	CTET (8)		
06/29/88	6	.	4M2P (10)		
08/06/89	5	130	.		
03/12/90	.	.	.		
06/21/05	.	.	.		
10/18/05	.	.	.		
MCL	**NA**	**NA**	**NA**		

Table 1. Well GW-068: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L)		
	Benzene	Toluene	Xylenes
03/18/87	26	9	3 J
06/29/87	20	3 J	1 J
09/25/87	22	7	.
11/11/87	38	13	.
04/19/88	36	14	6
06/29/88	43	15	6
08/06/89	38	12	6
03/12/90	36	10	.
06/21/05	36	4 J	.
10/18/05	51	5	3 J
MCL	**5**	**1,000**	**10,000**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
NR = Not reported, * = MCL is for total trihalomethanes

Table 2. Well GW-068: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005	October 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	0.491*	0. 55*
Sulfate	< 20 mg/L	5.05	5.32
Dissolved Oxygen	< 0.5 ppm	0.69**	0.94**
REDOX	< 50 mV	86.2**	-92**
pH	>5 and < 9 st. units	8**	7.72**

Note: *Results are for total iron; **Field measurements.

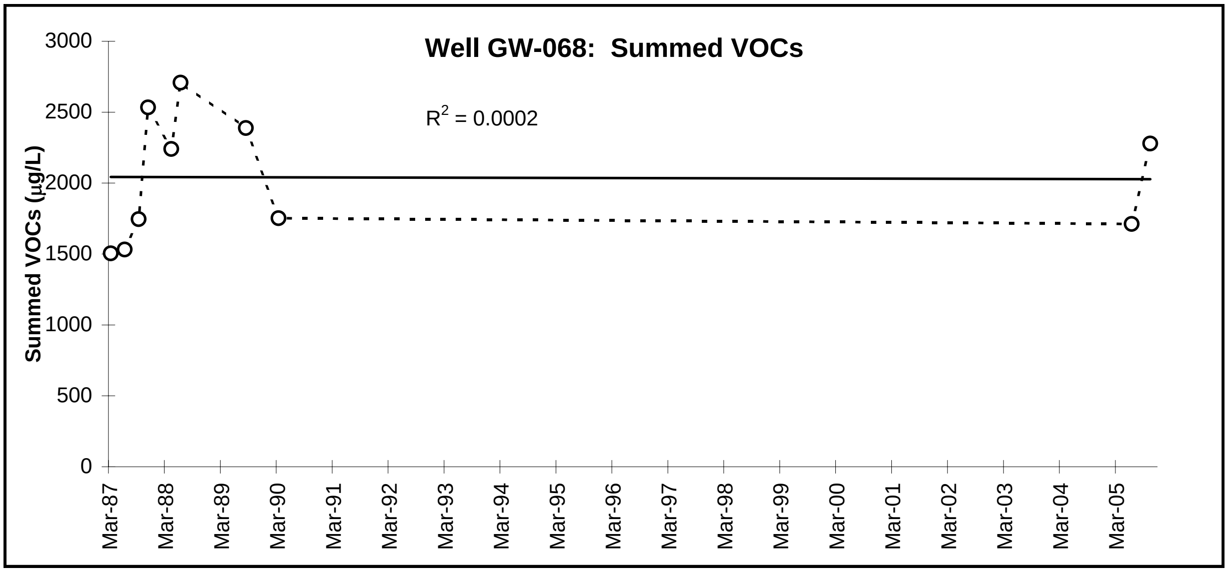

Well GW-068: Summed VOCs
$R^2 = 0.0002$
Summed VOCs (µg/L)
3000
2500
2000
1500
1000
500
0
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mar-05

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	>5,000	7.5 - 15	ND

GW-071

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 44,191.00
Y-12 GRID NORTH COORDINATE: 29,495.00
SURFACE ELEVATION: 925.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/84 PAIRED/CLUSTERED WITH: GW-072
TAG DEPTH (measured): 218.40 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 928.90 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: 0 Port Depth : 0 (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	195.1	730.30
BOTTOM (filter pack or open hole):	219.0	706.40
MIDPOINT (filter pack or open hole):	207.1	718.35
PUMP INTAKE:	208.5	716.90
WATER LEVEL (average):	5.44	920.56

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	13 samples	03/17/87	06/21/91
LOW-FLOW SAMPLING METHOD:	6 samples	03/12/02	10/20/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	.	06/30/05	.	10/20/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.62 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	8	5892 µg/L	06/30/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-071

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 195 to 219 ft bgs, and constructed with nominal 2.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-072 and is located immediately south of the eastern part of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between March 1987 and June 1991, and the low-flow sampling method used to obtain six samples between March 2002 and October 2005. The sampling history includes both quarterly and semiannual sampling frequencies and encompasses an extended period (June 1991 – March 2002) when samples were not collected from the well.

In June 2005, it was determined that the intake for the dedicated sampling pump (Well Wizard™) in the well was at a depth of 133 ft bgs, which is approximately 60 ft above the top of the monitored interval in the well (195 ft bgs). New tubing was used to extend the pump intake to a depth nearer the midpoint of the monitored interval (207 ft bgs), with the samples collected in June and October 2005 being the first obtained with the intake at the new location. Previous groundwater samples collected when the pump intake was so far from the water-producing features intercepted by the monitored interval seem likely to have included "stagnant" water from inside the well casing, particularly the samples collected with the low-flow sampling method. This sampling method involves purging the well at a flow rate that this low enough to (<300 milliliters per minute) to minimize drawdown of the water level in the well (<0.1 ft per quarter hour). At five minute intervals after the water-level drawdown has stabilized, field personnel record measurements of selected indicator parameters (e.g., pH). Groundwater samples are collected once the field measurements for each parameter show minimal variation over four consecutive readings. In contrast, under the conventional sampling method, groundwater samples are collected after at least three well volumes of groundwater have been purged from the well at a pumping rate which may substantially lower the water level in the well. Although the conventional sampling method is more likely than the low-flow method to have induced inflow of groundwater from the water producing feature(s) intercepted by the monitored interval, the samples obtained with this method when the pump intake was 60 ft above the monitored interval also probably included the water from inside the well casing.

Historical data obtained before June 2005 (i.e., when the sampling pump intake was not within the monitored interval) show that the groundwater in the well contains a diverse mixture of chlorinated hydrocarbons and petroleum hydrocarbons. However, as illustrated by the respective maximum concentrations of VOCs detected in samples collected in March/August 2004 and in June/October 2005, summarized below, substantially higher concentrations of most VOCs were detected in the samples obtained after the sampling pump intake was extended to the monitored interval. These findings suggest that all the VOC results obtained may not be representative of the actual concentrations in the groundwater outside the well casing.

COMPOUND	VOC CONCENTRATION (µg/L)		% DIFFERENCE
	2004 Maximum	2005 Maximum	
PCE	540	950	43%
TCE	74	120	38%
c12DCE	31	42	26%
t12DCE	6	3	-100%
11DCE	74	150	51%
VC	3	12	75%
111TCA	240	550	56%
11DCA	2,000	2,600	23%
Chloroethane	18	27	33%
CTET	3	49	94%
Benzene	1,100	1,300	15%
Ethylbenzene	4	4	0%
Toluene	18	30	40%
Xylenes	13	13	0%
Acetone	0	12	100%
Dichlorofluoromethane	10	58	83%
Freon-113	190	390	51%

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 5 ft bgs and exhibits minor seasonal fluctuations (<4 ft). The shallow depth of the static water level in this well suggests nearly artesian flow conditions, which are evident in other wells that intercept the semi-confined groundwater flow/transport pathways at depth in the low-permeability shale formations of the Conasauga Group in BCV. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-071 are typically higher than evident in well GW-072, which is completed at a shallower depth (101 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well (116.6 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.012 – 0.016) from the deeper bedrock interval (GW-071) to the shallow bedrock interval (GW-072).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for groundwater samples collected in June and October 2005 show that the well yields sodium-bicarbonate groundwater generally characterized by:

- TDS of 842 – 970 mg/L;
- pH of 10.1 – 11.5 (field measurements);
- elevated concentrations of chloride (>35 mg/L) compared to other wells completed at similar depths in the Nolichucky Shale;
- low molar proportions of calcium, magnesium, potassium and sulfate (<5% of total anions/cations); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

Considering the upward hydraulic gradients noted in Section 3.0, the elevated levels of chloride in the groundwater at this well potentially reflects upward movement of chloride from the more chloride-enriched groundwater deeper in the bedrock. Also, the elevated chloride levels may be at least partially attributable to the biologically-mediated degradation of chlorinated hydrocarbons in the groundwater (see Section 5.3), which often results in the accumulation of inorganic chloride (Hinchee et al. 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As noted in Section 2.0, the sampling results obtained since June 2005 are considered to be most representative of the groundwater in the well. Accordingly, the following sections are based on these results, which show that VOCs are the principal contaminants present in the groundwater.

5.1 NITRATE

Nitrate was not detected in the groundwater samples collected in June and October 2005.

5.2 URANIUM

The uranium concentration reported for the groundwater sample collected in October 2005 (0.00054 mg/L) slightly exceeds the analytical reporting limit but is several orders of magnitude below the drinking water MCL (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Because the intake of the pump was located above the monitored interval of the well until June 2005, historical VOC data (1987 – 2004) is considered qualitative. These results are presented in

Table 1 for comparison purposes; however the following discussion is based on the most recent and most representative data available.

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected in June and October 2005 (Table 2): acetone, benzene, chloroethane, CTET, ethylbenzene, PCE, TCE, toluene, VC, total xylene, 11DCA, 11DCE, c12DCE, t12DCE, 111TCA, dichlorofluoromethane (DCFM), and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113 (F113). Waste disposal areas within Burial Ground A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the plume of dissolved VOCs in the shallow groundwater at this well (DOE 1997). Waste disposal trenches in Burial Ground A-South also are the suspected source of DNAPL (primarily PCE and TCE) that was encountered at more than 300 ft bgs in a well installed directly south (down-dip) the area (Haase and King 1990). Thus, with DNAPL documented to be present at depth in the bedrock and, as noted in Section 4.0, the upward hydraulic gradients, it is possible that the presence of VOCs in the groundwater at this well reflects the upward migration of the parent compounds (and related degradation products) from DNAPL deeper in the bedrock.

Based on concentration magnitude, the primary VOCs detected in the groundwater samples are benzene, PCE, 11DCA, and 111TCA, each of which has a maximum concentration above 500 µg/L, with the most recent sampling results showing benzene and 11DCA concentrations remain above 1,000 µg/L (Table 2). The results also show that PCE, 111TCA, and benzene concentrations are above applicable drinking water MCLs (11DCA does not have an MCL). Secondary compounds detected n the samples are TCE, 11DCE, and F113, which have maximum concentrations 100 µg/L, and the sampling results show that TCE and 11DCE levels are several orders of magnitude above the drinking water MCLs (5 µg/L and 7 µg/L, respectively). Although the remaining compounds have been detected less frequently and/or at substantially lower levels, with maximum concentrations below 50 µg/L evident for all compounds except DCFM (58 µg/L), the most recent sampling results show that concentrations of CTET and VC exceed respective MCLs (5 µg/L and 2 µg/L).

Many of the VOCs detected in the groundwater samples are probably present in the groundwater as a consequence of biotic degradation (sequential dechlorination) of related parent compounds. Results for pertinent indicator parameters, especially the strongly negative REDOX, suggest that the geochemical conditions in the groundwater at this well are conducive to biotic degradation of chlorinated hydrocarbons (Table 3). Also, the dissolved petroleum hydrocarbons in the groundwater may serve as electron donors for biotic dechlorination (Chapelle 1996). Considering the upward vertical gradients noted in Section 4.0, the high levels of some degradation products, notably 11DCA, may indicate upward migration from the source(s) of related parent compounds deeper in the subsurface.

The groundwater samples from this well, including samples collected before the sampling pump intake was moved into the monitored interval for the well, are distinguished by the very high benzene concentrations. Indeed, groundwater samples with similar levels of benzene (i.e., >1,000 µg/L) were collected only from wells located in areas of Y-12 known to be impacted by historical releases from petroleum fuel underground storage tanks (USTs). Moreover, a review of the historical data indicate that, excluding benzene results for wells located at UST sites and results for other wells (and springs) that are obvious outliers compared to available data for the sampling location, benzene concentrations above the drinking water MCL (5 µg/L) have been reported only for groundwater samples from the following wells, which are all located near the BCBG WMA.

Well No.	Depth (ft bgs)	Benzene Concentration (µg/L) / Sampling Date			
		Maximum		Most Recent	
GW-014	13.2	180	11/05/87	4	10/19/05
GW-046	20.3	240	07/09/03	72	07/07/05
GW-068	83.6	51	10/18/05	51	10/18/05
GW-071	219	1,300	06/30/05	1,200	10/20/05
GW-082	34.4	99	08/07/03	ND	10/13/05
GW-117	530	6	11/13/87	ND	09/17/92
GW-118	575	67	11/19/88	1	10/10/93
GW-119	510	20	07/06/88	ND	09/17/92
GW-624	27.2	33	07/15/98	25	10/12/05

Of these, well GW-082 is located on the southwest side of Burial Ground C-West, and all of the remaining wells are located near Burial Ground A-South: wells GW-014, GW-071, and GW-119 along the eastern boundary; wells GW-117 and GW-118 on the southern boundary; and wells GW-046, GW-068, and GW-624 near the western boundary. Note the wide range in the total depth of these wells, particularly wells GW-117, GW-118, and GW-119, each of which is artesian. The apparent "clustering" of these wells suggest that benzene is a distinguishing component of the groundwater plume of dissolved VOCs originating from the waste disposal trenches in Burial Ground-A South.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the MDA was reported for the groundwater sample collected in October 2005 and this result (10 pCi/L in June 1991) is below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples (June or October 2005) had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Haase, S. and H.L. King. 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant,* Y/TS-629, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant*, *Oak Ridge*, *Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-071: summary of historic (qualitative) VOC results

Sampling Date	Concentration (µg/L)					
	PCE	**TCE**	**12DCE (total)**	**c12DCE**	**11DCE**	**VC**
03/17/87	630	510	36	NR	9	.
06/30/87	1,280	1,020	10	NR	8	.
09/24/87	670	520	34	NR	9	.
11/09/87	1,200	640	15	NR	.	.
04/15/88	850	650	40	NR	8	.
06/30/88	780	580	41	NR	7	.
08/05/89	810	620	29	NR	8	.
02/23/90	570	500	42	NR	11	.
06/27/90	470	410	.	NR	.	.
09/20/90	520	500	47	NR	12	.
12/07/90	590	650	58	NR	13	.
03/24/91	400	410	43	NR	14	.
06/21/91	480	490	42	NR	16	.
03/12/02	320	110	44	35	38	2
08/06/02	390	99	31	25	40	2
03/01/04	330	64	30	24	41	2
08/05/04	540	74	36	31	74	3
MCL	**5**	**5**	**NA**	**70**	**7**	**2**
Sampling Date	**Concentration (µg/L)**					
	111TCA	**11DCA**	**Chloroethane**	**CTET**	**DCFM**	**F113**
03/17/87	5	170	.	.	NR	NR
06/30/87	3 J	180	5	.	NR	NR
09/24/87	3 J	180	3 J	.	NR	NR
11/09/87	2 J	.	.	.	NR	NR
04/15/88	2 J	210	4 J	.	NR	NR
06/30/88	3 J	170	3 J	.	NR	NR
08/05/89	3 J	190	.	.	NR	NR
02/23/90	8	280	.	.	NR	NR
06/27/90	21	400	.	.	NR	NR
09/20/90	30	450	.	.	NR	NR
12/07/90	60	400	.	.	NR	NR
03/24/91	110	430	.	.	NR	NR
06/21/91	330	820	.	.	NR	NR
03/12/02	14	1,780	9	.	.	NR
08/06/02	120	1,600	13	.	3 J	NR
03/01/04	22	1,900	17	3 J	2 J	47
08/05/04	240	2,000	18	.	10	190
MCL	**200**	**NA**	**NA**	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = not reported; NA = not applicable

Table 1. (continued)

Sampling Date	Concentration (µg/L)				
	Acetone	**Benzene**	**Ethylbenzene**	**Toluene**	**Total Xylene**
03/17/87	22	12	1 J	1 J	2 J
06/30/87	10	10	.	.	2 J
09/24/87	16	13	.	.	.
11/09/87	.	11	.	.	3 J
04/15/88	10	14	0.9 J	0.6 J	4 J
06/30/88	.	13	2 J	.	.
08/05/89	.	16	3 J	.	.
02/23/90	.	69	.	.	.
06/27/90	.	120	.	.	.
09/20/90	.	130	.	.	.
12/07/90	.	110	.	.	.
03/24/91	29	130	.	.	.
06/21/91	.	420	.	.	.
03/12/02	48	820	2 J	10	7
08/06/02	.	750	2 J	10	9
03/01/04		820	4 J	12	12
08/05/04	.	1,100	3 J	18	13
MCL	**NA**	**5**	**700**	**1,000**	**10,000**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = not reported; NA = not applicable

Table 2. Well GW-071: summary of VOC results

Sampling Date	Concentration (µg/L)					
	PCE	**TCE**	**c12DCE**	**t12DCE**	**11DCE**	**VC**
06/30/05	950	120	34	3 J	130	.
10/20/05	880	110	42	3 J	150	12
MCL	**5**	**5**	**70**	**100**	**7**	**2**
Sampling Date	**Concentration (µg/L)**					
	111TCA	**11DCA**	**Chloroethane**	**CTET**	**DCFM**	**F113**
06/30/05	550	2,300	15	.	58	390
10/20/05	210	2,600	27	49	.	140
MCL	**200**	**NA**	**NA**	**5**	**NA**	**NA**
Sampling Date	**Concentration (µg/L)**					
	Acetone	**Benzene**	**Ethylbenzene**	**Toluene**	**Total Xylene**	
06/30/05	.	1,300	3 J	27	12	
10/20/05	12	1,200	4 J	30	13	
MCL	**NA**	**5**	**700**	**1,000**	**10,000**	

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = not applicable

Table 3. Well GW-071: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005	October 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	0.304*	0.539*
Sulfate	< 20 mg/L	28	5.36
Dissolved Oxygen	< 0.5 ppm	0.81**	0.87**
REDOX	< 50 mV	-290**	-274**
pH	>5 and < 9 st. units	10.42**	10.41**

Note: *Results are for total iron; **Field measurements.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	50 - 500	ND	ND

GW-072

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 44,159.00
Y-12 GRID NORTH COORDINATE: 29,502.00
SURFACE ELEVATION: 926.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/30/84 PAIRED/CLUSTERED WITH: GW-071
TAG DEPTH (measured): 101.99 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 930.51 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	84.5	841.80
BOTTOM (filter pack or open hole):	98.4	827.90
MIDPOINT (filter pack or open hole):	91.5	834.85
PUMP INTAKE:	93.8	832.51
WATER LEVEL (average):	8.35	918.57

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	15 samples	03/17/87	10/19/05
LOW-FLOW SAMPLING METHOD:	4 samples	03/11/02	10/18/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	.	06/20/05	.	10/18/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 3.86 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	8	397 µg/L	10/19/05	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-072

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 84.5 to 98.4 ft bgs, and constructed with nominal 2.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-071, which is completed at a greater depth (219 ft bgs), and is located immediately south of the eastern part of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between March 1987 and October 2005, and the low-flow sampling method used to obtain four samples between March 2002 and October 2005. The sampling history includes both quarterly and semiannual sampling frequencies and encompasses an extended period (June 1991 – March 2002) when samples were not collected from the well.

An evaluation of the monitoring data available through December 2004 indicated potential bias related to the groundwater sampling method. However, it was not clear if the change in sampling method explained the apparent increase in VOC concentrations or if the higher concentrations are the result of a corresponding increase in the relative flux of VOCs along the flowpaths intercepted by the monitored interval in the well. Results of "paired" sampling performed during June and October 2005, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, apparently confirm the sampling-method bias. As shown by the data summarized in Table 1, there is no distinct difference between the low-flow sampling and conventional sampling results for various geochemical parameters (e.g., pH) or inorganic analytes (e.g., chloride), but the samples obtained with the conventional sampling method had substantially higher summed VOC concentrations than the samples obtained with the low-flow method.

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method may induce greater inflow of VOC-contaminated groundwater than does the low-flow sampling method.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow (<100 ft bgs) bedrock interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits minor seasonal fluctuations (<4 ft). Depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-072 are typically lower than evident in well GW-071, which is completed at a greater depth (219 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well (116.6 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.012 – 0.016) from the deeper bedrock interval (GW-071) to the shallow bedrock interval (GW-072).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields chloride-enriched, sodium-bicarbonate groundwater generally characterized by:

- TDS of 238 – 309 mg/L;
- pH (field measurements) of 9.47 – 10.9;
- elevated concentrations of chloride (>30 mg/L) compared to other wells completed at similar depths in the Nolichucky Shale;
- very low molar proportions of calcium, magnesium, potassium and sulfate (<5% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

Considering the upward vertical gradients noted in Section 4.0, upwelling of chloride-enriched groundwater from deeper in the flow system possibly explains the elevated chloride levels in the shallower groundwater at this well. Also, the elevated chloride levels may be at least partially attributable to the biologically-mediated degradation of chlorinated hydrocarbons in the groundwater (see Section 5.3), which often results in the accumulation of inorganic chloride (Hinchee et al. 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Two of the groundwater samples collected to date had a nitrate concentration above the applicable analytical reporting limit, and the highest result (0.17 mg/L in June 1987) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, and these results (0.001 mg/L in November 1987 and June 1988) are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, benzene, chloroethane, chloroform, MC, PCE, toluene, VC, xylenes, 111TCA, 11DCA, 11DCE, and c12DCE. Waste disposal areas within Burial Ground A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the plume of dissolved VOCs in the shallow groundwater at this well (DOE 1997). Waste disposal trenches in Burial Ground A-South also are the suspected source of DNAPL (primarily PCE and TCE) that was encountered more than 300 ft bgs in a well installed directly south (down-dip) the area (Haase and King 1990).

The primary VOC in the groundwater samples is 11DCA, which has been detected in all but three of the samples collected to date, and has substantially higher concentrations than all other VOCs detected in the samples (Table 2). The next most frequently detected compounds are MC (detected in 11 samples with a maximum concentration of 6 µg/L in November 1987), 11DCE and 12DCE (both detected in six samples, including each of the samples obtained since March 2002). The most recent sampling results show that the concentrations of 11DCE and VC, which was detected only in samples obtained since June 2005, exceed drinking water MCLs (7 µg/L and 2 µg/L, respectively).

As noted in Section 2.0, preliminary indications that VOC concentrations potentially may be biased by the groundwater sampling method are confirmed by the results of “paired” sampling performed in June and October 2005. This is illustrated by the VOC results summarized below, which show substantially higher 11DCA and 11DCE concentrations in samples obtained with the conventional sampling method, but similar concentrations for other compounds detected in samples obtained with either method. As noted in Section 2.0 the conventional sampling method may induce greater inflow of groundwater containing 11DCA than does the low-flow sampling method. However, it is not clear from the available data why the sampling method would significantly influence the concentrations of one compound and not another. Perhaps the VOCs do not extensively intermix in the groundwater, but are separated in discrete flowpaths and become mixed in the well, with the higher concentrations of 11DCA indicating greater inflow from more permeable and/or numerous flowpaths relative to inflow from the flowpaths that contain other VOCs. Also, there may be multiple subsurface sources of the VOCs in the groundwater at this well, and the conventional sampling method may induce greater proportional inflow from the water-producing feature(s) connected to a VOC source dominated by 11DCA.

VOC	Concentration (µg/L)			
	Low-Flow Sampling June 20, 2005	**Conventional Sampling June 21, 2005**	**Low-Flow Sampling October 18, 2005**	**Conventional Sampling October 19, 2005**
PCE	2 J	.	.	.
c12DCE	2 J	5	4 J	10
11DCE	4 J	13	14	23
VC	.	2	2	3
11DCA	75	180	160	350
Chloroethane	1 J	4 J	4 J	6
MC	.	2 J	.	3 J
Benzene	.	1 J	.	2 J

Note: "." = Not detected; J = Estimated value below laboratory reporting limit

Most of the VOCs detected in the groundwater samples are probably present in the groundwater as a consequence of biotic degradation (sequential dechlorination) of related parent compounds. Results for pertinent indicator parameters, especially the strongly negative REDOX, suggest that the geochemical conditions in the groundwater at this well are conducive to biotic degradation of chlorinated hydrocarbons (Table 3), which may explain the relative lack of PCE and 111TCA in the samples relative to their respective degradation products (e.g., 11DCE and 11DCA). Also, the dissolved petroleum hydrocarbons (benzene) in the groundwater may serve as electron donors for biotic dechlorination (Chapelle 1996). Considering the upward vertical gradients noted in Section 4.0, the predominance of degradation products in the shallower groundwater at this well may indicate upward migration from the source(s) of related parent compounds deeper in the subsurface.

As indicated by the preceding discussion, 11DCA dominates the suite of VOCs detected in the groundwater samples, and a time-series plot of the 11DCA results shows a clearly increasing long-term trend (Figure 1), as illustrated by the initial concentration of 6 µg/L in November 1991 and the most recent (conventional sampling) concentration of 350 µg/L in October 2005. Increasing concentration trends are not evident for the other VOCs detected in the groundwater samples, as illustrated by the time-series plot of MC concentrations (Figure 1). All other factors being equal, such divergent trends for individual compounds again suggests that there may be multiple sources of the VOCs in the groundwater flow/transport pathways intercepted by the monitored interval in the well. It also appears that there has been little if any long-term change in the relative flux from the source(s) of some VOCs concurrent, but a substantial increase in the relative flux from the source(s) of 11DCA.

5.4 GROSS ALPHA ACTIVITY

Four of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE, and the highest result (3.66 pCi/L in September 1990) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

Four of the groundwater samples collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE, with the maximum value (5.7 pCi/L in February 1990) being substantially less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Haase, S. and H.L. King. 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant,* Y/TS-629, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-072: Consecutive daily sampling results for summed VOCs and other selected analytes, June and October 2005

Analyte	Units	June 2005		October 2005	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	9.81	9.47	9.83	9.5
REDOX	mV	-167	-150	-193	-168
Dissolved Solids	mg/L	304	302	302	308
Suspended Solids	mg/L	Not detected	Not detected	Not detected	Not detected
Calcium	mg/L	1.76	1.84	1.8	1.72
Chloride	mg/L	32.3	37.6	31.7	32.5
Barium	mg/L	0.205	0.119	0.181	0.135
Iron	mg/L	Not detected	0.112	Not detected	0.0656d
Summed VOCs	μg/L	84	207	178	397

Table 2. Well GW-072: summary of VOC results

Sampling Date	Concentration (μg/L)			
	PCE	12DCE	c12DCE	11DCE
03/17/87	1 J	.	NR	.
06/26/87	1 J	.	NR	.
09/23/87	.	.	NR	.
11/09/87	21	6	NR	.
04/13/88	.	.	NR	.
06/29/88	.	.	NR	.
08/05/89	.	.	NR	.
02/21/90	.	.	NR	.
06/25/90	.	.	NR	.
09/16/90	.	.	NR	.
12/05/90	.	.	NR	.
03/19/91	.	.	NR	.
06/18/91	.	.	NR	.
03/11/02	.	.	NR	2 J
08/06/02	.	2 J	2 J	6
06/20/05	2 J	2 J	2 J	4 J
06/21/05*	.	5	5	13
10/18/05	.	4 J	4 J	8
10/19/05*	.	10	10	23
MCL	**5**	**NA**	**70**	**7**

Table 2. Well GW-072: summary of VOC results (continued)

Sampling Date	Concentration (µg/L)			
	11DCA	**Chloroethane**	**Acetone**	**MC**
03/17/87	.	.	8	2 J
06/26/87	.	.	3	.
09/23/87	.	.	23	.
11/09/87	6	.	41	6
04/13/88	4 J	.	12	2 J
06/29/88	6	.	.	4 J
08/05/89	5	.	.	2 J
02/21/90	6	.	.	.
06/25/90	13	.	7	2 J
09/16/90	20	.	.	3 J
12/05/90	25	.	.	4 J
03/19/91	9	.	.	.
06/18/91	19	.	.	3 J
03/11/02	64	.	.	.
08/06/02	130	4 J	.	.
06/20/05	75	1 J	.	.
06/21/05*	180	4 J	.	2 J
10/18/05	160	4 J	.	.
10/19/05*	350	6	.	3 J
MCL	**5**	**NA**	**NA**	**5**

Sampling Date	OTHER
03/17/87	Toluene (1 J)
06/26/87	Toluene (1 J); 111TCA (0.9 J)
09/23/87	Chloroform (3 J); Xylenes (7)
11/09/87	Chloroform (3 J)
06/21/05*	Benzene (1 J); VC (2)
10/18/05	VC (2)
10/19/05*	Benzene (2 J); VC (3)
MCL	**.**

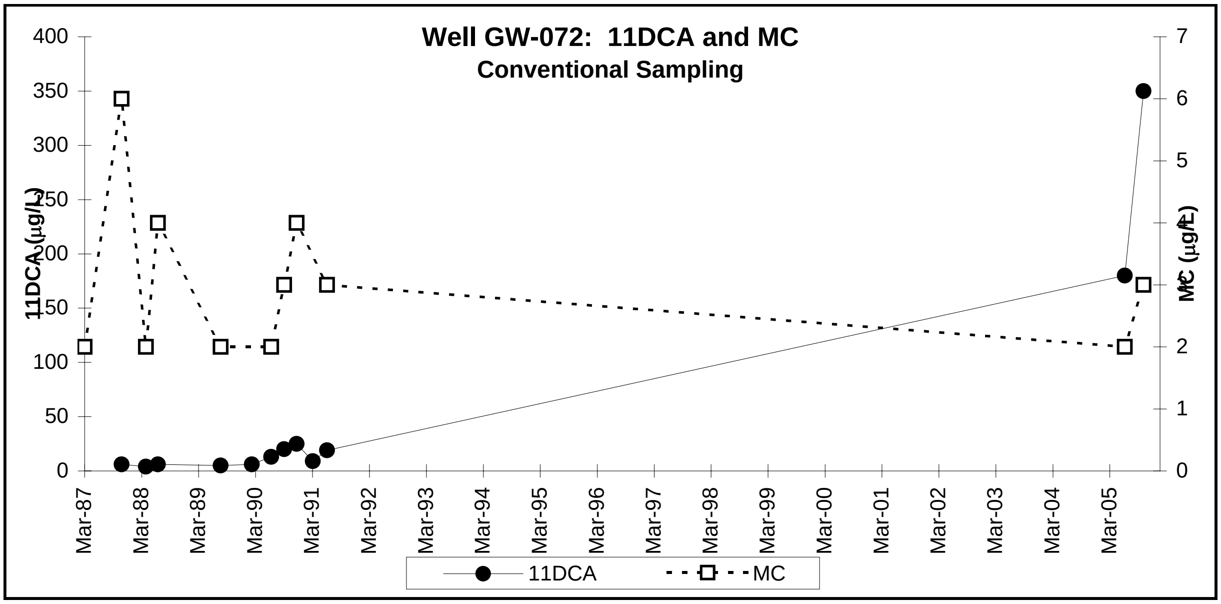
Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
NR = Not reported; * = "paired" sample, conventional method

Table 3. Well GW-072: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005		October 2005	
		LF	Conv.	LF	Conv.
Nitrate	< 1 mg/L	<0.028	<0.028	<0.028	<0.028
Iron (II)	> 1 mg/L	<0.05*	0.112*	<0.05*	0.0656*
Sulfate	< 20 mg/L	1.56	3.92	4.1	4.78
Dissolved Oxygen	< 0.5 ppm	0.91**	.	2.42**	.
REDOX	< 50 mV	-167**	-150**	-193**	-168**
pH	>5 and < 9 st. units	9.81**	9.47**	9.83**	9.5**

Note: LF = Low-flow sampling; Conv. = Conventional Sampling; NM = Not measured

*Results are for total iron; **Field measurements.



Well GW-072: 11DCA and MC
Conventional Sampling
11DCA (µg/L)
MC (µg/L)
400
350
300
250
200
150
100
50
0
7
6
5
4
3
2
1
0
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mar-05
11DCA
MC

Figure 1

MAXIMUM CONCENTRATION: 2004

.	ND	ND	.	.
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-077

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 41,234.00
Y-12 GRID NORTH COORDINATE: 29,729.00
SURFACE ELEVATION: 914.70 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/29/84 PAIRED/CLUSTERED WITH: GW-078
TAG DEPTH (measured): 104.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 919.30 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 3.88 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	87.4	827.30
BOTTOM (filter pack or open hole):	100.3	814.40
MIDPOINT (filter pack or open hole):	93.85	820.85
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	3.18	911.52

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	20		
CONVENTIONAL SAMPLING METHOD:	6 samples	06/13/90	04/09/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/12/98	08/12/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	02/17/04	.	08/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.47 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	16 µg/L	04/09/97	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-077

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 87.4 to 100.3 ft bgs, and constructed with nominal 2.37-inch outside diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-078 and is located on the southern flank of Pine Ridge west of Y-12, about 1,700 ft west of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG encompass several closed former hazardous waste disposal units, including numerous waste disposal trenches that received a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. The various components of the BCBG are covered by low-permeability, multilayer caps installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain six samples between June 1990 and April 1997, and the low-flow sampling method used to obtain fourteen samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Nolichucky Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits moderate fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 168 – 257 mg/L;
- pH (field measurements) of 6.8 – 8.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 17 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Eight groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (3.3 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only one uranium result reported for the sample collected in July 1998 (0.0097 mg/L) has exceeded the analytical reporting limits, and this result is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in three groundwater samples. Relatively low levels of 111TCA were detected in the samples collected in April 1997 (16 µg/L), February 1998 (9 µg/L), and July 1998 (4 µg/L); PCE also was detected in February 1998 (1 µg/L). Neither VOC was detected in subsequent samples.

5.4 GROSS ALPHA ACTIVITY

Gross alpha results reported for the samples collected in February 1998 (1.39 pCi/L) and August 2001 (2.02 pCi/L) exceed the applicable MDA and corresponding CE and are substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (35.75 pCi/L in February 1998) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	.	.

GW-078

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 41,209.00
Y-12 GRID NORTH COORDINATE: 29,730.00
SURFACE ELEVATION: 914.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/30/84 PAIRED/CLUSTERED WITH: GW-077
TAG DEPTH (measured): 23.40 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 918.10 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.7	902.80
BOTTOM (filter pack or open hole):	21.1	893.40
MIDPOINT (filter pack or open hole):	16.4	898.10
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	3.23	911.28

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	20		
CONVENTIONAL SAMPLING METHOD:	6 samples	06/13/90	04/08/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/11/98	08/12/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/17/04	.	08/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 7.28 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-078

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 11.7 to 21.1 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-077 and is located on the southern flank of Pine Ridge west of Y-12, about 1,700 ft west of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG encompass several closed former hazardous waste disposal units, including numerous waste disposal trenches that received a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. The various components of the BCBG are covered by low-permeability, multilayer caps installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain six samples between June 1990 and April 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Nolichucky Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits moderate seasonal fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 144 – 249 mg/L;
- pH (field measurements) of 6.8 – 8.1;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 17 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Five groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (2.2 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the groundwater sample collected in July 1998 (0.0115 mg/L) exceeds the analytical reporting limit, and this result is below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only one groundwater sample: acetone was detected in the sample collected in July 1998 (5 µg/L). This result is probably a sampling or analytical artifact and is an outlier.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the MDA and corresponding CE, with the highest value (2.51 pCi/L in February 1991) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.13 pCi/L in February 1998) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	.	.

GW-079

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 41,616.00
Y-12 GRID NORTH COORDINATE: 30,630.00
SURFACE ELEVATION: 977.20 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/23/84 PAIRED/CLUSTERED WITH: GW-080
TAG DEPTH (measured): 64.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 981.20 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	49.9	927.30
BOTTOM (filter pack or open hole):	64.9	912.30
MIDPOINT (filter pack or open hole):	57.4	919.80
PUMP INTAKE:	61.80	915.40
WATER LEVEL (average):	16.98	960.22
GEOLOGIC FORMATION:	Rogersville Shale	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	19 samples	05/31/90	09/05/97
LOW-FLOW SAMPLING METHOD:	15 samples	02/12/98	08/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/17/04	.	08/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.9 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-079

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 49.9 to 64.9 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-080 and is located on the southern flank of Pine Ridge west of Y-12, about 1,500 ft west of the northernmost section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG encompass several closed former hazardous waste disposal units, including numerous waste disposal trenches that received a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. The various components of the BCBG are covered by low-permeability, multilayer caps installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between May 1990 and September 1997, and the low-flow sampling method used to obtain 15 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Rogersville Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits moderate seasonal fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 202 mg/L;
- pH (field measurements) of 6.9 – 8.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 30 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Six groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (1.8 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the groundwater sample collected in August 2003 (0.00571 mg/L) exceeds the analytical reporting limit, and this result is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.79 pCi/L in July 1996) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Ten groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.95 pCi/L in January 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	.	.

GW-080

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 41,621.00
Y-12 GRID NORTH COORDINATE: 30,622.00
SURFACE ELEVATION: 977.10 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/24/84 PAIRED/CLUSTERED WITH: GW-079
TAG DEPTH (measured): 33.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 981.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	20.8	956.30
BOTTOM (filter pack or open hole):	29.7	947.40
MIDPOINT (filter pack or open hole):	25.25	951.85
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	19.00	958.10

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	39		
CONVENTIONAL SAMPLING METHOD:	24 samples	05/31/90	09/05/97
LOW-FLOW SAMPLING METHOD:	15 samples	02/11/98	08/12/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/17/04	.	08/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 7.94 pre-sampling measurements (ft)
TDS: L (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	431 mg/L	02/03/99	Outlier
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	670.9 µg/L	09/05/97	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-080

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 20.8 to 29.7 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-079 on the southern flank of Pine Ridge west of Y-12, about 1,500 ft west of the northernmost section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG encompass several closed former hazardous waste disposal units, including numerous waste disposal trenches, which are covered by low-permeability, mulitlayer caps installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 24 samples between May 1990 and September 1997, and the low-flow sampling method used to obtain 15 samples between February 1998 and August 2004.

The well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Rogersville Shale). The average static groundwater level in the well is 19 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 68 – 182 mg/L;
- pH (field measurements) of 5.4 – 8.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- unusually high total iron concentrations (>8 mg/L); and
- total (unfiltered sample) concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion

5.1 NITRATE

Eight samples had nitrate concentrations above the analytical reporting limit. Aside from the nitrate concentration reported for the sample collected in February 1999 (431 mg/L), which is most likely a sampling or analytical artifact, the highest value (3 mg/L in August 2000) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the sample collected in June 1994 (0.001 mg/L) exceeds the analytical reporting limit, and this result is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in six of the 35 groundwater samples collected from the well since January 1991. A trace of 4-methyl-2-pentanone (1 μg/L) was detected in the groundwater sample collected in September 1991. Four consecutive groundwater samples had 111TCA: September 1997 (630 μg/L), February 1998 (30 μg/L), July 1998 (10 μg/L), and February 1999 (2 μg/L). The sample collected in September 1997 also contained a trace of PCE (0.9 μg/L). Aside from a trace of chloromethane (3 μg/L) detected in the sample collected in August 2000, VOCs have not been detected in the groundwater samples collected from the well since February 1999.

5.4 GROSS ALPHA ACTIVITY

Thirteen of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.64 pCi/L in March 1995) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seventeen of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (40.33 pCi/L in July 1998) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). However, this result is probably an outlier because the other gross beta results are much lower (11.9 pCi/L in July 1996 is the next highest).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	ND	500 - 5,000	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-082

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,090.25
Y-12 GRID NORTH COORDINATE: 30,433.80
SURFACE ELEVATION: 960.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/17/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 38.45 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 964.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	24.1	936.42
BOTTOM (filter pack or open hole):	34.4	926.12
MIDPOINT (filter pack or open hole):	29.25	931.27
PUMP INTAKE:	31.52	929.00
WATER LEVEL (average):	17.18	943.34

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	43		
CONVENTIONAL SAMPLING METHOD:	32 samples	03/23/87	08/07/03
LOW-FLOW SAMPLING METHOD:	11 samples	06/18/98	08/05/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/01/04	.	08/05/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: X
WATER LEVEL FLUCTUATION: 2.3 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	26	4,788 µg/L	08/07/03	Increasing
GROSS ALPHA (15 pCi/L):	1	22.5 pCi/L	03/27/92	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-082

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1984, completed with a screened monitored interval from 24.1 to 34.4 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) about halfway between the fork in a northern tributary of Bear Creek (NT-8) that drains the western and northwestern sections of Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous former hazardous and nonhazardous waste disposal areas that received a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 32 samples between March 1987 and August 2003, and the low-flow sampling method used to obtain 11 samples between June 1998 and August 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially lower contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during February and August 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm a sampling-method bias. However, as shown by the data summarized in Table 1, the samples obtained with the conventional method have substantially higher VOC concentrations instead of substantially lower concentrations, as indicated by the study. The significant difference between the two sampling method results noted in the study probably reflects an increase in contaminant flux during the time period spanning the change in methods. Note that the groundwater samples obtained with each sampling method have similar geochemical characteristics (Table 1).

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of VOC-contaminated groundwater into the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maryville Limestone (Conasauga Group). The bulk of the groundwater flow in the Maryville Limestone occurs within a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Maryville Limestone and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits relatively minor (<2 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-082 indicate south and southwesterly flow down the southern flank of Pine Ridge. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-082 may be primarily westward (parallel with geologic strike) toward discharge areas in the upper reaches of a northern tributary of Bear Creek (NT-8) on the northwest boundary of the BCBG waste management area approximately 300 ft west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 178 – 822 mg/L, excluding suspected outliers in September 1990 (44 mg/L) and August 2003 (955 mg/L);
- pH of 5.0 – 7.9 (field measurements);
- chloride concentrations above 100 mg/L;
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations);
- unusually high concentrations of boron (>20 mg/L), barium (>1 mg/L), and manganese (>1 mg/L); and
- total concentrations of trace metals (except barium, boron, and manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from inorganic wastes disposed in the BCBG. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). As illustrated by the most recent sampling results summarized in Table 2, the geochemical characteristics of the groundwater (particularly the REDOX conditions) appear to be conducive to biotic degradation of VOCs (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations at or above the applicable reporting limit were detected in the groundwater samples collected in February 2001 (0.0726 mg/L) and December 2002 (0.0802 mg/L) and both of these results are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Uranium concentrations at or above the applicable reporting limit were detected in the groundwater samples collected in June 1991 (0.001 mg/L), July 1998 (0.0109 mg/L), and February 2001 (0.00646 mg/L); these results reflect background levels that are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the each groundwater sample (Table 3): benzene, chloroethane, total xylene, PCE, TCE, VC, 11DCA, 11DCE, 12DCE (c12DCE), and 111TCA. These compounds are all components of a plume of dissolved VOCs in the shallow groundwater downgradient of the waste disposal sites within Burial Ground-C West, with mobile components of the plume being transported toward natural groundwater discharge areas in the northern tributaries of Bear Creek west of the BCBG (DOE 1997). Many of the compounds, particularly c12DCE and VC may be present as a direct consequence of the natural biotic degradation of related parent compounds (e.g., PCE and TCE) disposed in BG-C West. The geochemical characteristics of the groundwater appear to be conducive to biodegradation of chlorinated hydrocarbons (see Section 4.0), with the strongly negative REDOX conditions and low levels of dissolved oxygen (Table 2) suggesting the strongly reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC (Chapelle 1996).

The primary compounds in the groundwater samples are 12DCE (c12DCE), 11DCA, and VC, with historical maximum concentrations exceeding 1,000 μg/L for 12DCE and 11DCA, and exceeding 100 μg/L for VC (Table 2). The initial detection of VC (December 1991) and 11DCA (April 1997) and subsequent increasing concentration of both VOCs suggests a staggered "breakthrough" of components of the dissolved VOC plume. Also, the most recent (low-flow sampling) results show that the concentrations of c12DCE and VC remain at least an order-of-magnitude above respective drinking water MCLs (Table 2). Secondary compounds in the groundwater samples are benzene, chloroethane, 11DCE, and 111TCA. Historical maximum concentrations for these VOCs are all less than 100 μg/L, with the most recent sampling results showing concentrations of none of these compounds are above applicable MCLs. In contrast to the primary and secondary VOCs in the samples, PCE, TCE, and total xylene have only been detected in one sample each and all these results are estimated values below 5 μg/L.

As noted in Section 2.0, results of "paired" sampling in CY 2003 show that the conventional sampling method obtains groundwater samples with substantially higher VOC concentrations than groundwater samples obtained with the low-flow sampling method. Conventional sampling may yield samples with higher VOC concentrations because the more aggressive purging (see Section 2.0) may induce greater flow of contaminated groundwater into the well from primary contaminant flowpaths that are further from the well. However, there are substantial differences between the conventional and low-flow sampling results for individual VOCs, with the largest concentration differences evident for 11DCA and the smallest differences evident for chloroethane (Table 4).

Respective time-series plots of summed VOC concentrations reported for samples obtained with the conventional sampling method and low-flow sampling method (Figure 1) suggest increasing long-term concentration trends. The conventional sampling results show summed VOC concentrations steadily increased from 71 μg/L in March 1991 to 263 μg/L in April 1997 and dropped to 163 μg/L in August 1997, with an order-of-magnitude concentration increase indicated by conventional sampling VOC results obtained in February 2003 (4,325 μg/L) and August 2003 (4,786 μg/L). The low-flow sampling data likewise indicate an order-of-magnitude increase in summed VOC concentrations between July 1998 (185 μg/L) and February 2002 (3,104 μg/L), followed by a generally decreasing trend through August 2004 (745 μg/L). Increases in the summed VOC concentrations indicated by both conventional and low-flow sampling data are primarily attributable to substantially higher concentrations of 12DCE and 11DCA (Table 3). These trends probably reflect an overall increase in the relative flux of these compounds in the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, the recent decreasing trend suggests that a "pulse" of dissolved VOCs may have been intercepted by the monitored interval of the well.

5.4 GROSS ALPHA ACTIVITY

Two of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.75 pCi/L in December 1995) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.9 pCi/L in August 2004) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

McCarty, P.I. 1996. *Biotic and Abiotic Transformations of Chlorinated hydrocarbons in Groundwater.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-082: Consecutive daily sampling results for summed VOCs and other selected analytes, February and August 2003

Analyte	Units	February 2003		August 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	6.96	6.96	6.71	6.95
Dissolved Oxygen	ppm	0.01	0.81	0.47	1.41
REDOX	mV	-117	-45	-51	-49
Dissolved Solids	mg/L	717	758	677	955
Suspended Solids	mg/L	Not detected	Not detected	Not detected.	2
Calcium	mg/L	156	169	145	184
Chloride	mg/L	3.05	2.86	2.28	2.17
Barium	mg/L	1.11	1.23	0.89	1.18
Boron	mg/L	19.2	21.2	15.1	22.6
Summed VOCs	ug/L	2,883	4,325	1,218	4,788

Table 2. Well GW-082: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		Low-Flow Sampling		Conventional Sampling	
		February 2003	August 2003	February 2003	August 2003
Nitrate	<1 mg/L	<0.02	<0.02	<0.02	<0.02
Iron (II)	>1 mg/L	0.59	0.52	0.709	0.892
Sulfate	<20 mg/L	5.16	5.96	4.82	4.77
Dissolved Oxygen	<0.5 ppm	0.01*	0.47*	0.81*	1.41*
REDOX	<50 mV	-117*	-51*	-45*	-49*
pH	>5 and <9 st. units	6.96*	6.71*	6.96*	6.95*

Note: * Field measurement

Table 3. Well GW-082: summary of VOC results

Sampling Date	VOC Concentration (µg/L)					
	PCE	TCE	12DCE (Total)	c12DCE	11DCE	VC
Conventional Sampling						
03/09/91	.	.	72	NR	.	.
06/11/91	.	.	51	NR	.	.
09/25/91	.	.	.	NR	.	.
12/21/91	.	2 J	27	NR	.	5
03/27/92	.	.	22	NR	.	8
06/24/92	.	.	.	NR	.	6
09/27/92	.	.	19	NR	.	6
12/11/92	.	.	19	NR	.	13
03/10/93	.	.	41	NR	.	30
04/21/93	.	.	50	NR	.	31
07/25/93	.	.	29	NR	.	8
10/18/93	.	.	23	NR	.	13
04/15/97	.	.	200	NR	.	53
08/29/97	.	.	130	NR	.	32
02/06/03	.	.	1,800	1,800	63	360
08/07/03	.	.	1,900	1,900	95	430
Low-Flow Sampling						
06/18/98	.	.	320	320	.	58
10/20/98	.	.	160	160	.	19
03/04/99	.	.	380	380	8	150
02/13/01	.	.	640	640	9	190
07/26/01	.	.	840	840	27	240
02/12/02	3 J	.	1,100	1,100	43	290
07/29/02	.	.	820	820	22	200
02/05/03	.	.	1,200	1,200	53	240
08/06/03	.	.	630	630	17	160
03/01/04	.	.	520	520	.	120
08/05/04	.	.	560	560	1 J	110
MCL	**5**	**5**	**NA**	**70**	**7**	**2**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported

Table 3 (continued)

Sampling Date	VOC Concentration (µg/L)				
	111TCA	11DCA	Benzene	Chloroethane	Total Xylene
Conventional Sampling					
03/09/91	.	.	.	.	.
06/11/91	.	.	.	.	.
09/25/91	0.4 J	.	.	.	.
12/21/91	.	.	.	.	1 J
03/27/92	.	.	.	.	.
06/24/92	.	.	.	.	.
09/27/92	.	.	.	.	.
12/11/92	.	.	.	.	.
03/10/93	.	.	.	.	.
04/21/93	.	.	.	.	.
07/25/93	.	.	.	.	.
10/18/93	.	.	.	.	.
04/15/97	.	3 J	.	7	.
08/29/97	.	.	.	.	.
02/06/03	15	2,000	66	21	.
08/07/03	30	2,200	99	31	.
Low-Flow Sampling					
06/18/98	.	3 J	.	15	.
10/20/98	.	1 J	.	5	.
03/04/99	.	410	6	12	.
02/13/01	.	360	8	28	.
07/26/01	7	1,200	31	18	.
02/12/02	6	1,600	45	17	.
07/29/02	4 J	730	22	25	.
02/05/03	12	1,300	55	23	.
08/06/03	5	360	18	28	.
03/01/04	.	32	.	32	.
08/05/04	.	44	1 J	29	.
MCL	**200**	**NA**	**5**	**NA**	**10,000**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported

Table 4. Well GW-082: comparison of conventional and low-flow sampling results for VOCs

VOC	VOC Concentration (µg/L)					
	February 2000			August 2000		
	Low-Flow Sampling	Conventional Sampling	% Change	Low-Flow Sampling	Conventional Sampling	% Change
Benzene	55	66	+ 20%	18	99	+ 450%
Chloroethane	23	21	- 9%	28	31	+ 11%
c12DCE	1,200	1,800	+ 50%	630	1,900	+ 202%
VC	240	360	+ 50%	160	430	+ 169%
11DCE	53	63	+ 19%	17	95	+ 459%
11DCA	1,300	2,000	+ 54%	360	2,200	+ 511%

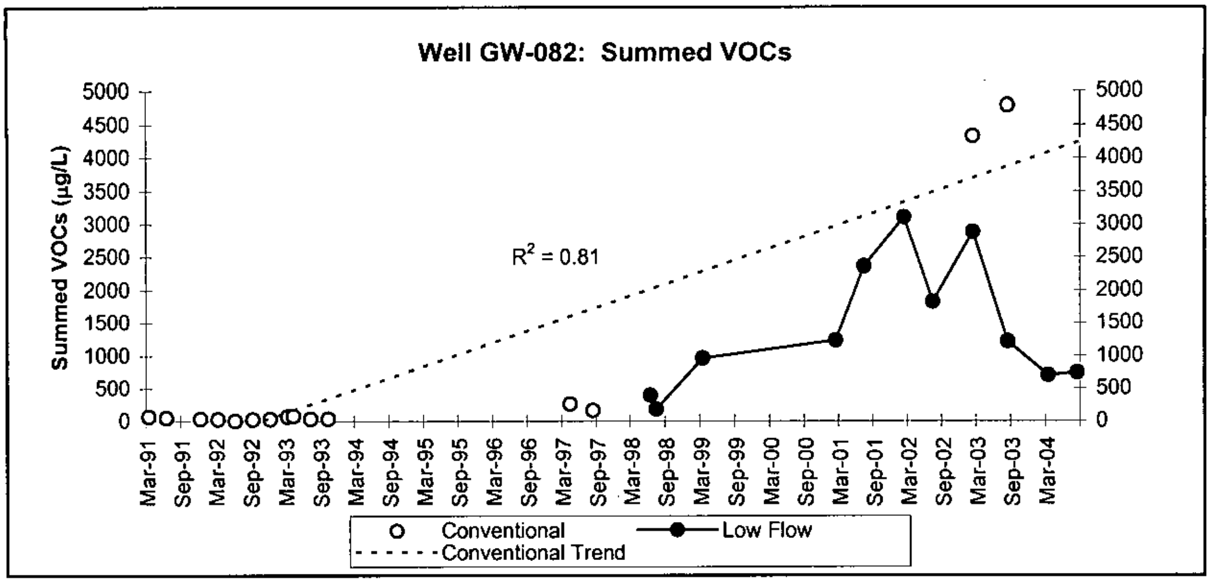

Well GW-082: Summed VOCs
Summed VOCs (µg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
R^2 = 0.81
Mar-91
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Conventional
Low Flow
Conventional Trend

Figure 1

MAXIMUM CONCENTRATION: 2004

100 - 1,000	ND	ND	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-085

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 49,058.00
Y-12 GRID NORTH COORDINATE: 30,003.00
SURFACE ELEVATION: 979.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/22/84 PAIRED/CLUSTERED WITH: GW-086
TAG DEPTH (measured): 62.34 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 983.57 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 4 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	48.4	931.40
BOTTOM (filter pack or open hole):	58.8	921.00
MIDPOINT (filter pack or open hole):	53.6	926.20
PUMP INTAKE:	51.23	928.57
WATER LEVEL (average):	10.4	969.4

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	48		
CONVENTIONAL SAMPLING METHOD:	34 samples	11/05/87	09/17/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/03/98	08/03/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	.	08/03/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.86 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	35	313 mg/L	10/22/93	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	28 µg/L	06/24/94	Decreasing
GROSS ALPHA (15 pCi/L):	4	44.1 pCi/L	08/30/92	Decreasing
GROSS BETA (50 pCi/L):	30	320 pCi/L	02/12/03	Increasing

WELL GW-085

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1984, completed with a screened monitored interval from 48.4 to 58.8 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-086 and is located in Bear Creek Valley (BCV) west of Y-12, on the east side of the Oil Landfarm waste management area (WMA), about 500 ft west of a northern tributary (NT) of Bear Creek (NT-2), several of which trend northeast-southwest across the southern flank of Pine Ridge west of Y-12 and are numbered in ascending order downstream from the headwaters of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-eight groundwater samples have been collected from the well, with the conventional sampling method used to obtain 34 samples between November 1987 and September 1997 and the low-flow sampling method used to obtain 14 samples between March 1998 and August 2004.

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits seasonal fluctuations up to 5 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-085 are typically higher than evident in well GW-086, which is completed at shallower depths (30 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well (28 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.01 – 0.04) from the shallow bedrock interval (GW-085) to the water table interval (GW-086).

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-085 indicate southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 390 – 2,020;
- pH of 6.4 – 7.5 (field measurements);
- elevated concentrations of inorganic contaminants, particularly barium (>1 mg/L) and nitrate (>100 mg/L), the latter of which dominates the ion chemistry of the samples and are the likely source of the unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for samples collected in February 1993 (RPD = -77.8%), February 1994 (RPD = -32.1%), and June 1995 (RPD = 51.7%);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except barium and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the monitoring data reported for the groundwater samples collected since February 1990, nitrate and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for each groundwater sample, with all but four samples having concentrations above 100 mg/L, including 15 samples with concentrations above 300 mg/L (Table 1). The source of the nitrate is the former S-3 Ponds, which are located about 3,000 ft directly east of the well near the headwaters of Bear Creek at the west end of Y-12, and are four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplaced an extensive plume of groundwater contamination containing a heterogeneous mixture of inorganic, organic, and radiological contaminants. Some of the inorganic contaminants (e.g., nitrate and uranium) were entrained in the nitric acidic wastes and others (e.g., barium and strontium) were dissolved from bedrock minerals. Nitrate is the primary inorganic contaminant in the plume and, based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) relatively rapid, westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel flowpaths, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997).

As noted previously, nitrate concentrations reported for most of the groundwater samples exceed 100 mg/L (Table 1), with 17 results exceeding 200 mg/L (Table 1). Note that the historical maximum nitrate concentration (2,139 mg/L in February 1993) and historical minimum nitrate concentration (17 mg/L in June 1995) are considered qualitative because of the ion charge-balance errors for these samples (see Section 4.0); both results also appear to be outliers compared to the nitrate concentrations reported for the other groundwater samples. Additionally, the nitrate concentrations exhibit a wide range of temporal fluctuations, but do not show a consistent relationship with groundwater flow conditions, as illustrated by temporal "peak" concentrations reported for samples obtained during both seasonally high and low flow conditions (Figure 1). These results are representative of concentrations in the shallow groundwater flow system in the Nolichucky Shale west of NT-2, which, as noted previously, is a discharge area for nitrate-contaminated groundwater from the shallow flow system. Elevated nitrate concentrations in groundwater at this well also show that the leading western edge of the nitrate plume in the Nolichucky Shale west of the former S-3 Ponds occurs somewhere west of the well toward NT-3 (DOE 1997).

A time-series plot of the nitrate concentrations detected in the groundwater samples (excluding the results considered qualitative because of ion charge-balance errors) shows a generally indeterminate trend dominated by what appear to be long-term concentration cycles (Figure 1). Nitrate concentrations generally increased between May 1990 (115 mg/L) and October 1993 (312.6 mg/L), subsequently decrease through March 1998 (43 mg/L), increased again through February 2002 (244 mg/L), and again decreased through August 2004 (70.7 mg/L), which is the lowest concentration reported since August 1998 (58 mg/L). This nitrate concentration trend potentially reflects a sequence of cyclic "pulses" in the relative flux of nitrate via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

Eleven groundwater samples had total uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00201 mg/L in February 2001) being and order-of-magnitude below the MCL for uranium (0.03 mg/L). Uranium is one of the primary components of the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. The low concentrations of uranium in the groundwater at this well, in contrast to the very high nitrate levels, illustrate the significantly greater attenuation of uranium relative to nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected only in five of the groundwater samples, with chloroform detected in three samples, bromodichloromethane detected in two samples, and acetone detected in one sample.

5.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with results for samples collected February 1992 (32.4 pCi/L), August 1992 (44.1 pCi/L), October 1992 (15.9 pCi/L), and February 1993 (17.3 pCi/L) exceeding the MCL for gross alpha activity (15 pCi/L). These results may be sampling or analytical artifacts, possibly related to analytical interference from the high TDS of the (unfiltered) groundwater samples. Also, seven samples collected between June 1994 and October 1995 were analyzed for U-234 and U-238, which are alpha-emitting radionuclides most likely to be present in the groundwater. Aside from a suspected outlier reported for the sample collected in June 1995 (U-234 of 219 pCi/L), only two results exceed the MDA and corresponding CE, and both of these are less than 1 pCi/L.

5.5 GROSS BETA ACTIVITY

Each groundwater sample had gross beta activity above the applicable MDA and corresponding CE, with results for more than 80% (33) of the samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in Table 1, Tc-99 was detected (i.e., >MDA and CE) in the twelve samples analyzed for this beta-emitting radionuclide, with the highest values reported for the samples collected in October 1993 (331 pCi/L) and August 2001 (370 pCi/L). Note that all the Tc-99 results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale west of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate, with primarily westward strike-parallel transport in the water table and bedrock intervals toward discharge areas in NT-1 and NT-2 (DOE 1997).

Results for gross beta activity reported for the groundwater samples show a fairly wide range between the historical minimum value (24.6 pCi/L in October 1991) and historical maximum value (320 pCi/L in February 2003), which may be at least partially attributable to analytical interferences related to the high TDS of the samples. As with nitrate concentrations in the samples, gross beta activity also does not exhibit a consistent relationship with groundwater flow conditions, with temporal "peak" concentrations reported for samples obtained during both seasonally high and low flow conditions. In any case, elevated gross beta activity in the groundwater at this well reflects the transport of Tc-99 in the shallow flow system in the Nolichucky Shale west of NT-2 (DOE 1997).

A time-series plot of the gross beta activity reported for the groundwater samples shows a generally increasing long term trend through February 2003 (320 pCi/L), the historical maximum value for the well, followed by a decreasing trend through August 2004 (80 pCi/L), which is the lowest value reported since March 1999 (48 pCi/L) (Figure 2). Also, although the gross beta results show substantially wider temporal variability, the results suggest long-term concentration cycles corresponding with those indicated by the nitrate data. Like the nitrate concentrations, the gross beta activity potentially reflects a series of cyclic "pulses" in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-085: summary of results for nitrate, gross beta activity, and Tc-99

Sampling Date	Concentration		
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)	Tc-99 (pCi/L)
02/02/90	145	41.76	.
05/22/90	208	59.43	.
08/08/90	127	64.6	.
10/24/90	261	62.64	.
01/26/91	157	69.36	.
05/09/91	115	72.08	.
08/13/91	124	89.39	.
10/15/91	161.4	24.6	.
02/25/92	154	75.2	.
06/03/92	219	51.7	.
08/30/92	227	62.6	.
10/30/92	251	38	.
02/11/93	(2,139)	120	.
05/12/93	240	144	.
09/14/93	304	116	.
10/22/93	312.6	77.6	.
02/11/94	115	67.9	331
06/24/94	176	71.5	291
09/07/94	210	142	273
12/15/94	206	102	255
03/26/95	180	119	234
06/08/95	(17)	37.6	212
08/06/95	220	141	194
10/25/95	191	134	234
03/25/96	184	100	257
08/20/96	144	95.6	219
03/04/97	70.2	38	.
09/17/97	63	38	.
03/03/98	43	31	.
08/31/98	58	33	.
03/18/99	103	48	.
08/31/99	133.9	93	.
02/29/00	186	120	.
09/08/00	227	200	.
02/05/01	224	200	270
08/01/01	219	180	370
02/18/02	244	240	.
07/31/02	233	220	.
02/12/03	224	320	.
08/11/03	195	170	.
02/23/04	120	120	.
08/03/04	70.7	80	.
MCL	**10**	**50***	**3,790***

Note: "."= Not analyzed; () = Result considered qualitative because of ion charge-balance error; * SWDA screening level for a 4 millirem per year dose equivalent

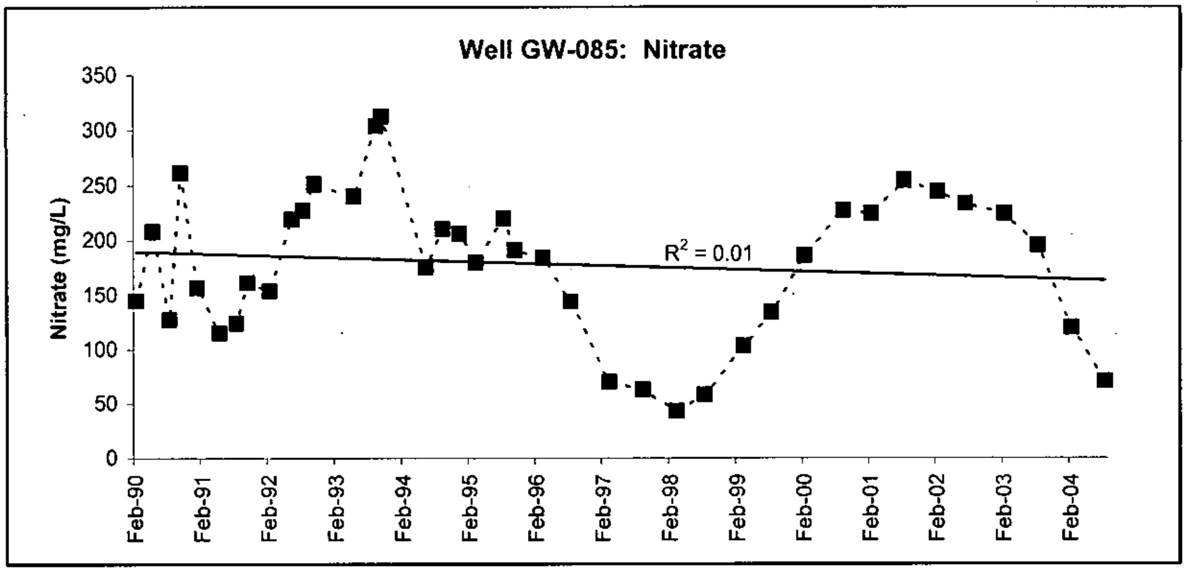


Figure 1

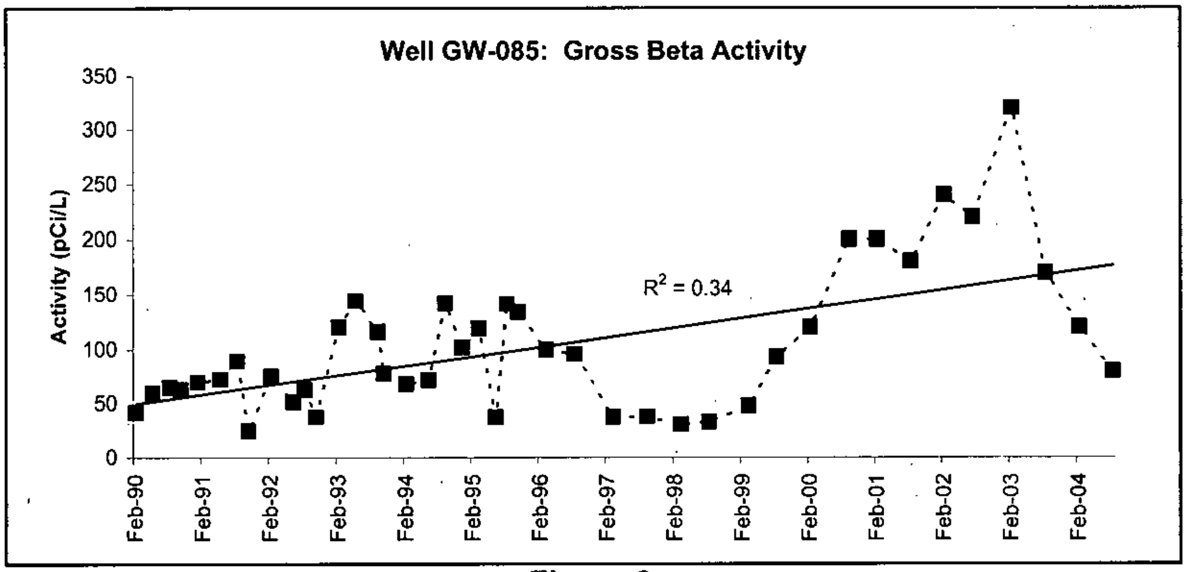


Figure 2

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	<5	ND	ND

GW-097

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 46,959.00
Y-12 GRID NORTH COORDINATE: 29,459.00
SURFACE ELEVATION: 941.90 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/11/84 PAIRED/CLUSTERED WITH: GW-098 GW-120
TAG DEPTH (measured): 23.86 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 945.41 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	9.3	932.60
BOTTOM (filter pack or open hole):	19.2	922.70
MIDPOINT (filter pack or open hole):	14.3	927.65
PUMP INTAKE:	.	.
WATER LEVEL (average):	7.54	935.08

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	13 samples	03/17/87	01/29/90
LOW-FLOW SAMPLING METHOD:	4 samples	06/17/98	08/29/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/08/05	.	08/29/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.15 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	2	11 µg/L	07/15/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-097

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1984, completed with a screened monitored interval from 9.3 to 19.2 ft bgs, and constructed with nominal 2.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-098 and GW-120, and is located in Bear Creek Valley (BCV) adjacent to the southwestern disposal plots at the Oil Landfarm, approximately 350 ft north of the main channel of Bear Creek and 150 ft east of a northern tributary of the creek (NT-4) that drains the western portion of the Oil Landfarm waste management area (WMA). The Oil Landfarm consisted of waste disposal plots that were used between 1973 and 1982 for biodegradation of about one million gallons of waste oils and machine coolants via landfarming with nutrient-adjusted surface soils during the dry months of each year (April through October). The disposal plots are covered by a low-permeability, multilayer cap installed during RCRA closure of the Oil Landfarm in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between March 1987 and January 1990, and the low-flow sampling method used to obtain four samples between June 1998 and August 2005. The sampling history includes both quarterly and semiannual sampling frequencies and encompasses extended periods (January 1990 – June 1998 and July 1998 – March 2005) when no samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in Nolichucky Shale (the Conasauga Group), which trends northeast-southwest through BCV, dips to the southeast at 45º - 55º, and directly underlies many of the primary sources of groundwater contamination west of Y-12. The bulk of the groundwater flow in the Nolichucky Shale occurs within the water table interval, a highly permeable zone that typically occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek. These tributaries traverse from northeast to southwest across the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

The static water level in the well occurs at an average depth of about 8 ft bgs and exhibits maximum seasonal fluctuations of approximately 2 ft. Moreover, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-097 are typically higher than evident in well GW-098, which is completed at a greater depth (104 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well (76 ft), the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.017 –0.061) from the water table interval (GW-097) to the shallow bedrock interval (GW-098).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-097 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-097 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-4, which traverses the western boundary of the Oil Landfarm WMA approximately 150 ft west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-bicarbonate groundwater generally characterized by:

- TDS of 608 – 655 mg/L;
- pH of 6.43 – 6.9 (field measurements);
- low concentrations of magnesium (<10 mg/L) and elevated levels of chloride (>25 mg/L) and sulfate (>25 mg/L) compared to other wells completed at similar depth in the Nolichucky Shale;
- low molar proportions of potassium and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear from the available data why the magnesium concentrations are so low. Additionally, the elevated sulfate and chloride concentrations may reflect natural geochemical characteristics in the Nolichucky Shale, or may be the result of contamination from one or more sources hydraulically upgradient of the well. Also, considering that the groundwater contains a mixture of chlorinated hydrocarbons (see Section 5.3), elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Only one of the groundwater samples collected to date had a nitrate concentration above the applicable analytical reporting limit, and this result (0.0791 mg/L in March 2005) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Nine groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0228 mg/L in July 1998) being below the MCL for uranium (0.03 mg/L). However, this result is a suspected outlier because the other uranium results are at or below 0.005 mg/L.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 1): acetone, benzene, chloroethane, chloroform, ethylbenzene (ETB), methylene chloride, PCE, TCE, toluene, xylene, 11DCA, 12DCE (c12DCE), 111TCA, and 4-methyl-2-pentanone (4M2P). Note, however, that no VOCs were detected in the sample collected most recently (August 2005). Nevertheless, the detection of VOCs in the previous samples indicates that the monitored interval for the well intercepts groundwater flow/transport pathways followed by mobile components of the subsurface contaminant plume emplaced during historical operation of the former Oil Landfarm. Waste disposal operations at the site emplaced two distinct plumes of dissolved VOCs in the shallow groundwater, one originating from the northern disposal plots that is dominated by 111TCA, 11DCA, and 11DCE and one originating from the southern disposal plots that is dominated by PCE, TCE, and 12DCE. Maximum concentrations within the plumes do not indicate the presence of DNAPL in the subsurface at the Oil Landfarm (DOE 1997). Considering the location of the well relative to the Oil Landfarm disposal plots and the preferred strike-parallel direction of groundwater flow in the Nolichucky Shale, the (former) presence of dissolved VOCs in the well indicates primarily westward groundwater transport toward discharge areas in NT-4.

Based on frequency of detection and concentration magnitude, principal VOCs detected in the groundwater samples collected to date are 12DCE (c12DCE) and 11DCA (Table 1). At least one of these VOCs was detected in all but one of the samples, with historical maximum concentrations of 27 µg/L for 12DCE and 13 µg/L for 11DCA. Secondary compounds in the samples are chloroethane and methylene chloride, one or both of which was detected in each sample collected between March 1987 and September 1989, but not in any of the samples collected since then, and most of these results are less than 10 µg/L. Each of the remaining compounds was detected in no more than three of the samples collected to date and the bulk of these results are estimated values below 5 µg/L (Table 1). Moreover, no VOCs were detected in the sample collected most recently (August 2005).

The apparent dominance of 12DCE and 11DCA in the groundwater samples potentially reflects the biologically mediated degradation (sequential dechlorination) of respective parent compounds (PCE and 111TCA) in the groundwater. Additionally, dissolved hydrocarbons (e.g., benzene) in the groundwater may serve as electron donors necessary for co-metabolic transformation of the chlorinated hydrocarbons (McCarty 1996). However, as illustrated by the data summarized in Table 2, results for several indicator parameters suggest that selected geochemical characteristics of the groundwater at this well generally are not within the optimum range for biotic degradation of chlorinated hydrocarbons. The REDOX conditions, for instance, do not suggest the strongly reducing (methanogenic) conditions necessary to transform 12DCE to VC (Chapelle 1996). Perhaps the monitored interval for the well intercepts groundwater flow/transport pathways for degradation products migrating hydraulically downgradient of the source area(s) where geochemical conditions promote more effective biotic dechlorination. This too may explain the infrequent detection of parent compounds (PCE and 111TCA) as well as 12DCE and 11DCA degradation products (VC and chloroethane) in the groundwater samples from this well.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample collected to date shows an overall decreasing trend dominated by a "peak" concentration in November 1987 (80 µg/L) and the gaps in the sampling history for the well (Figure 1). Also, as illustrated by the selected sampling results included in the following summary, summed VOC concentrations initially decreased fairly rapidly, but subsequently the rate of decease slowed considerably.

Sampling Date	**Elapsed Time (Days)**	**Summed VOCs (mg/L)**	**Relative % Decrease**
03/17/87	.	53	.
04/25/88	548	23	52%
03/08/05	3,590	11	54%

The initial, more rapid decrease probably mirrors the substantially reduced flux of VOCs in the Nolichucky Shale following installation of the low-permeability cap over the Oil Landfarm. The much slower, subsequent decrease in VOC concentrations suggest long-term natural attenuation in the shallow flow system, including flushing of residual contamination by seasonal (and episodic) recharge/discharge cycles. In any case, the decrease in the concentrations of VOCs in the well suggests a corresponding decrease in the discharge of VOC-contaminated groundwater into NT-4.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE. This result (1.42 pCi/L in January 1990) is well below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.22 pCi/L in June 1998) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-097: summary of VOC results

Sampling Date	VOC (µg/L)			
	12DCE	**11DCA**	**Chloroethane**	**Methylene Chloride**
03/17/87	14	14	10	2 J
06/22/87	10	12	10	4 J
09/10/87	20	12	7	3 J
11/03/87	27	17	19	6
04/25/88	9	13	.	3 J
07/13/88	9	12	8	.
09/15/88	.	15	8	.
11/22/88	8	11	.	0.4 J
03/21/89	8	13	9	.
07/27/89	6	10	8	.
09/14/89	6	10	7	.
12/08/89	6	10	.	.
01/29/90	6	9	.	.
06/17/98	2 J	4 J	.	.
07/15/98	3 J	3 J	.	.
03/08/05	1 J	1 J	.	.
08/29/05	.	.	.	.
MCL	70*	NA	70	5

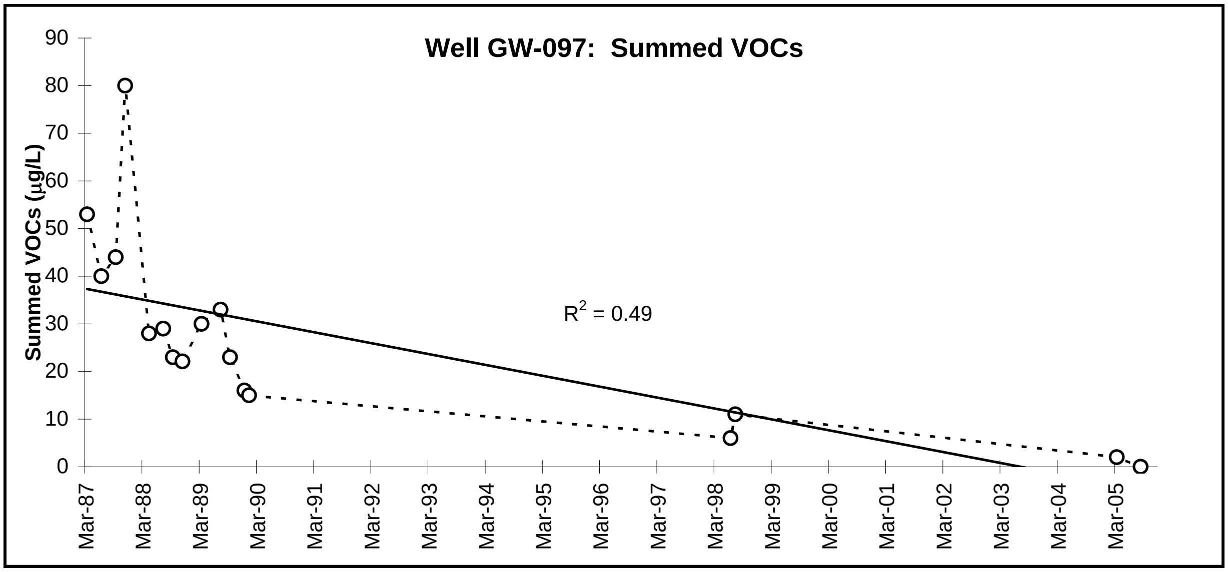
Sampling Date	OTHER VOCs (µg/L)
03/17/87	Acetone (5), Benzene (1 J), PCE (3 J), Toluene (1 J), VC (2), Xylene (1 J)
06/22/87	Toluene (1 J)
09/10/87	Chloroform (2 J)
11/03/87	Acetone (6), TCE (2 J), 4M2P (3 J)
04/25/88	ETB (2 J), Xylene (1 J)
11/22/88	Benzene (0.4 J), Chloroform (0.5 J), ETB (0.9 J), Toluene (0.4 J), TCE (0.5 J)
07/27/89	Acetone (9)
07/15/98	PCE (3 J), 111TCA (2 J)
03/08/05	c12DCE (1 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
* MCL is for c12DCE

Table 2. Well GW-097: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	August 2005
Nitrate	mg/L	<1	0.0791	<0.028
Iron (II)	mg/L	>1	0.125*	0.329*
Sulfate	mg/L	<20	23.5	28.1
Dissolved Oxygen	ppm	<0.5	0.05**	2.72**
REDOX	mV	<50	113**	34**
pH	st. units	>5 and < 9	6.43**	6.49**

Note: *Results are for total iron; **Field measurement.



Well GW-097: Summed VOCs
Summed VOCs (μg/L)
90
80
70
60
50
40
30
20
10
0
R2 = 0.49
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mar-05

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	<0.015	5 - 50	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-098

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 46,959.00
Y-12 GRID NORTH COORDINATE: 29,452.00
SURFACE ELEVATION: 942.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/21/84 PAIRED/CLUSTERED WITH: GW-097 GW-120
TAG DEPTH (measured): 105.65 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 945.95 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	76.6	865.80
BOTTOM (filter pack or open hole):	104.0	838.40
MIDPOINT (filter pack or open hole):	90.3	852.10
PUMP INTAKE:	96.45	845.95
WATER LEVEL (average):	9.45	932.95

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	13 samples	03/17/87	01/30/90
LOW-FLOW SAMPLING METHOD:	4 samples	03/13/01	08/03/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/19/04	.	08/03/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.69 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	4	25 μg/L	02/19/04	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-098

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1984, completed with a screened monitored interval from 77 to 104 ft bgs, and constructed with nominal 4.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-097 and GW-120 and is located in Bear Creek Valley (BCV) adjacent to the southwestern disposal plots at the Oil Landfarm, about 350 ft north of the main channel of Bear Creek and 150 ft east of a northern tributary (NT) of the creek (NT-4) that drains the western portion of the Oil Landfarm waste management area (WMA). The Oil Landfarm waste disposal plots were used between 1973 and 1982 for biodegradation of about one million gallons of waste oils and machine coolants via landfarming with nutrient-adjusted surface soils during the dry months of each year (April through October). The disposal plots are covered by a low-permeability, multilayer cap installed during RCRA closure of the Oil Landfarm in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Aside from sampling performed as part of the initial groundwater contamination investigations in BCV during the early 1980s, a total of 17 groundwater samples have been collected from the well since January 1998. The conventional sampling method was used to obtain 13 samples between March 1987 and January 1990, and the low-flow sampling method used to obtain four samples between March 2001 and August 2004. The sampling history includes both quarterly and semiannual sampling frequencies and encompasses an extended period (January 1990 – March 2001) when samples were not collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits minor (<5 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-098 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-098 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-4, which traverses the western boundary of the Oil Landfarm WMA approximately 150 ft west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields moderately mineralized, chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 582 – 922 mg/L;
- pH of 6.44 – 6.9 (field measurements);
- chloride concentrations above 100 mg/L;
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the contaminants present in the groundwater at this well.

5.1 NITRATE

Only one of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, and that result (0.1 mg/L in March 1989) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Total uranium concentrations at or above the applicable analytical reporting limit were reported for ten of the groundwater samples collected to date, with the highest value (0.00213 mg/L in March 2001) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 1): acetone, benzene, chloroethane, chloroform (CLF), ethylbenzene (ETB), methylene chloride (MC), PCE, TCE, toluene (TOL), xylene, 11DCA, 11DCE, 12DCE (c12DCE), 111TCA, and 4-methyl-2-pentanone (4M2P). The Oil Landfarm is the source of these compounds. Landfarming operations at the site emplaced two distinct plumes of dissolved VOCs in the shallow groundwater, one originating from the northern disposal plots that is dominated by 111TCA, 11DCA, and 11DCE and one originating from the southern disposal plots that is dominated by PCE, TCE, and 12DCE. Maximum concentrations within the plumes do not indicate the presence of DNAPL in the subsurface at the Oil Landfarm (AJA 1997).

Based on frequency of detection and concentration magnitude, principal VOCs in the groundwater samples are 12DCE (c12DCE) and TCE, one or both of which were detected in each sample collected to date, with historical maximum concentrations of 30 μg/L and 13 μg/L, respectively (Table 1). Secondary compounds in the samples are 11DCA, 11DCE, and 111TCA, at least one of which was detected in each sample, with historical maximum concentrations of 6 μg/L, 6 μg/L, and 2 μg/L, respectively. All of the other VOCs, including PCE and several petroleum hydrocarbons, were detected infrequently in samples collected during the late 1980s, with the highest concentrations reported for acetone (8 μg/L). Also, the most recent sampling results (February and August 2004) show that TCE concentrations remain at or above the drinking water MCL (Table 1).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample collected to date shows an overall decreasing trend (Figure 1). The summed VOC concentrations show an increasing trend between March 1987 (33 μg/L) and January 1990 (62 μg/L) dominated by wide temporal fluctuations and much lower concentrations evident after the 11-year gap in the sampling history for the well (Figure 1). Long- and short-term changes in summed VOC concentrations are primarily attributable to corresponding changes in the levels of 12DCE; whereas results for other compounds show minimal long- or short-term variation, as illustrated by the 11DCA concentrations detected in the samples collected in March 1987 (3 μg/L), April 1988 (3 μg/L), March 2001 (2 μg/L), and February 2004 (2 μg/L). The increasing summed VOC concentrations (before 1990) generally precede installation of the low-permeability cap at the site, with the decreasing summed concentrations evident thereafter reflecting an overall reduction in the flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. The divergent concentration trends for individual compounds may be a function of the differences in the relative mobility of each compound in the groundwater.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 1997. *Evaluation of Calendar Year 1996 Groundwater and Surface Water Quality Data for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/SUB/97-KDS15V/4, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

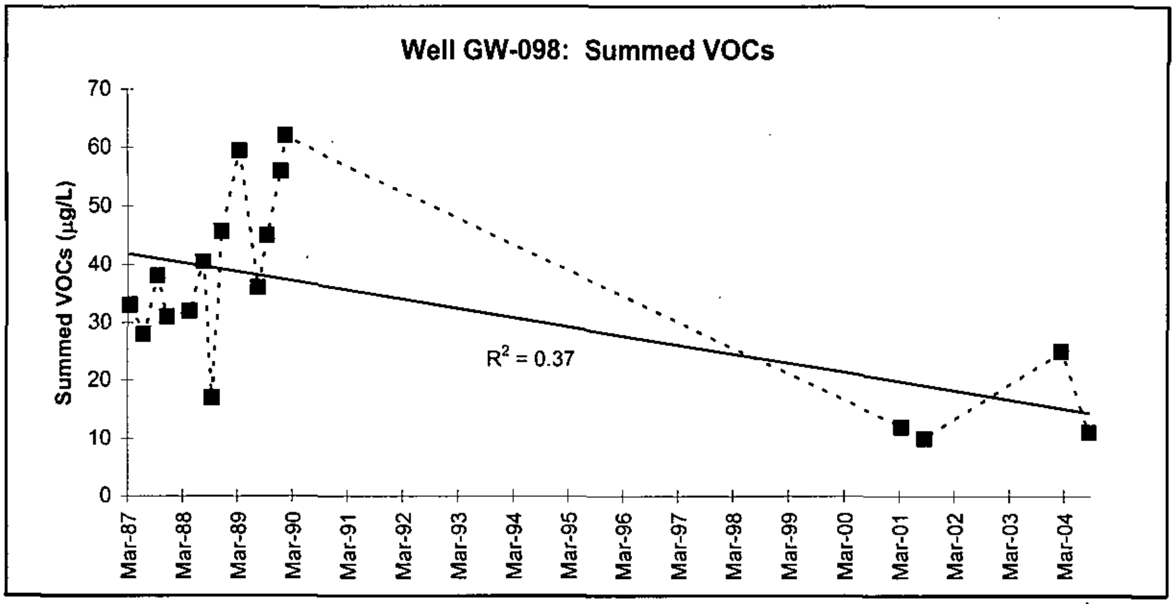
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-098: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	TCE	11DCE	12DCE	c12DCE
03/17/87	2 J	6	2 J	8	NR
06/29/87	.	6	3 J	8	NR
09/04/87	.	7	1 J	8	NR
11/03/87	.	.	.	22	NR
04/25/88	.	6	.	7	NR
07/07/88	0.9	10	3 J	19	NR
09/23/88	.	8	2 J	.	NR
11/22/88	1 J	10	3 J	22	NR
03/18/89	1 J	12	4 J	30	NR
07/27/89	.	8	2 J	21	NR
09/26/89	.	9	2 J	29	NR
12/19/89	1 J	9	3 J	32	NR
01/30/90	.	9	3 J	35	NR
03/13/01	.	5	.	5	5
08/08/01	.	3 J	.	5	5
02/19/04	.	13	6	4 J	4 J
08/03/04	.	5	2 J	4 J	4 J
MCL	5	5	7	NA	70

Sampling Date	Concentration (µg/L)		
	111TCA	11DCA	Other
03/17/87	1 J	3 J	Acetone (8), MC (1 J), TOL (1 J), Xylene (1 J)
06/29/87	1 J	2 J	Acetone (3 J), Chloroethane (3 J), MC (2 J)
09/04/87	.	3 J	Acetone (8 J), Chloroethane (3 J), CLF (3 J), MC (4 J)
11/03/87	2 J	5	CLF (2 J)
04/25/88	1 J	3 J	MC (1 J), TOL (1 J), Xylene (1 J), 4M2P (2 J)
07/07/88	2 J	4 J	MC (1 J), TOL (0.6 J)
09/23/88	1 J	3 J	MC (3 J)
11/22/88	2 J	5	Benzene (0.2 J), CLF (0.6 J), ETB (0.8 J), MC (0.7 J),
03/18/89	2 J	6	TOL (0.4 J)
07/27/89	1 J	4 J	Chloroethane (4 J), TOL (0.4 J)
09/26/89	1 J	4 J	.
12/19/89	2 J	4 J	.
01/30/90	2 J	5	Acetone (5 J)
03/13/01	.	2 J	Acetone (8)
08/08/01	.	2 J	.
02/19/04	.	2 J	.
08/03/04	.	.	.
MCL	200	NA	

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported



Well GW-098: Summed VOCs
Summed VOCs (µg/L)
70
60
50
40
30
20
10
0
R^2 = 0.37
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	<0.015	ND	ND	ND

GW-100

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 50,957.00
Y-12 GRID NORTH COORDINATE: 29,759.00
SURFACE ELEVATION: 984.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/12/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 17.87 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 987.40 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	3.8	980.80
BOTTOM (filter pack or open hole):	20.7	963.90
MIDPOINT (filter pack or open hole):	12.3	972.35
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	3.11	981.49

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	01/22/86	09/06/95
LOW-FLOW SAMPLING METHOD:	2 samples	03/04/04	08/17/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/04/04	.	08/17/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.42 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	3	190 mg/L	09/06/95	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-100

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1984, completed with a screened monitored interval from 4 to 21 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, on the north side of Bear Creek approximately 1,100 ft west-southwest of the former S-3 Ponds. This site consists of four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplace a large heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains one of the primary sources of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between January 1986 and September 1995, and the low-flow sampling method used to obtain samples in March and August 2004. The sampling history includes both quarterly and semiannual sampling frequencies and encompasses two large gaps when samples were not collected from the well: January 1990 – September 1995 and October 1995 –March 2004.

High total dissolved solids (TDS) is a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and a direct consequence of contamination associated with historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). Based on the depth of the well and its location relative to the (projected) geologic contact between the Maynardville Limestone and the underlying Nolichucky Shale, the monitored interval in the well potentially intercepts groundwater flow/transport pathways within the highly permeable zone near the bottom of the formation.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits minor seasonal fluctuations (<2 ft). Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the well indicate flow to the west, parallel with geologic strike of the Maynardville Limestone and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields slightly acidic, chloride- and nitrate-enriched (contaminated) calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,160 – 2,508 mg/L;
- pH (field measurements) of 6.63 – 6.9;
- elevated concentrations of chloride and nitrate (e.g., 314 mg/L and 51.3 mg/L, respectively, in August 2004);
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations);
- elevated concentrations of several trace metals, notably chromium and nickel; and
- total concentrations of trace metals (except chromium and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, only nitrate is a contaminant in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations reported for all of the groundwater samples collected to date exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds. Nitrate is a principal component of the contaminant plume that originates from the site, and it enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells in the Maynardville Limestone in BCV west of Y-12, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater indicate: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) than the deeper bedrock and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations reported for the groundwater samples collected to date range from about 50 mg/L to over 450 mg/L (Table 1), with the highest concentrations reported for samples collected before January 1990. The most recent sampling results (March and August 2004) are similar to the historical minimum value (52 mg/L in January 1986), although this historic result appears to be an outlier compared to the other results obtained before January 1990 (Table 1). Unlike other wells that yield nitrate-contaminated groundwater from the Maynardville Limestone, the nitrate results for this well do not appear to exhibit strong seasonal fluctuations or display any consistent relationship with groundwater flow conditions, as illustrated by the temporal peak concentrations reported for samples collected during seasonally high flow (e.g., 438 mg/L in February 1989) and seasonally low flow (e.g., 457 mg/L in September 1988). A time-series plot of the nitrate data for the well reflects the varying sampling frequency and the substantial gaps in the sampling history for the well (see Section 2.0), but shows a clearly decreasing long-term trend (Figure 1). The decreasing trend coincides with installation of the low-permeability cap at the former S-3 Ponds during RCRA closure of the site in 1988, and reflects the substantial reduction in the relative flux of nitrate along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

Thirteen of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), including results for three samples that exceed the drinking water MCL for uranium (0.03 mg/L): 0.23 mg/L in January1986, 0.053 mg/L in May 1986, and 0.074 mg/L in November 1987. Although below the MCL, many of the uranium results exceed the applicable UTL (0.004 mg/L). Elevated levels of uranium in the groundwater samples from this well result from downgradient migration/transport of uranium from the contaminant plume emplaced during historical operation of the former S-3 Ponds. Uranium was entrained in the nitric acid wastes disposed at the site and is a primary component of the S-3 Ponds contaminant plume. The extent of uranium migration/transport from the plume is largely controlled by the pH of the groundwater. Within the acidic groundwater near the former surface impoundments, uranium is probably present as uranyl cations that tend to form complexes with a wide variety of inorganic anions (Fetter 1993). Under the more neutral pH typical of groundwater in the Maynardville Limestone, uranyl cations may complex with carbonate dissolved from the bedrock, which greatly increases the mobility of uranium.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results for common laboratory reagents (e.g., methylene chloride), none of the groundwater samples collected since January 1990 contained VOCs.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE. Gross alpha activity results reported for previous samples are qualitative (the sample-specific MDA and CE are not available).

5.5 GROSS BETA ACTIVITY

One of the groundwater samples collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE (4.88 pCi/L in September 1995). Gross beta activity results reported for previous samples are qualitative (the sample-specific MDA and CE are not available). The lack of elevated gross beta activity in the groundwater at this well is somewhat surprising because Tc-99, a primary component of the S-3 Ponds contaminant plume, is a beta-emitting radionuclide that is highly mobile in groundwater and is present in the wells that are hydraulically upgradient (east-northeast) and downgradient (west-southwest) of the well. Moreover, the samples collected most recently (March and August 2004) were analyzed for Tc-99 and both results are below the respective MDA for each sample. These results are consistent with the low levels of gross beta activity and shows that, for reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-100: summary of results for nitrate and uranium

Sampling Date	Concentration (mg/L)	
	Nitrate (as N)	**Total Uranium**
01/22/86	52	0.23
05/29/86	345	0.053
03/09/87	386	0.008
06/10/87	429	0.003
10/06/87	259	0.01
11/24/87	216	0.074
09/02/88	457	0.008
11/07/88	294	<0.001
02/25/89	438	0.007
05/15/89	432	0.004
09/13/89	358	<0.001
12/04/89	348	0.003
01/19/90	388	0.001
09/06/95	190	0.0015
03/04/04	54.3	<0.0005
08/17/04	51.3	0.00138
MCL	**10**	**0.03**

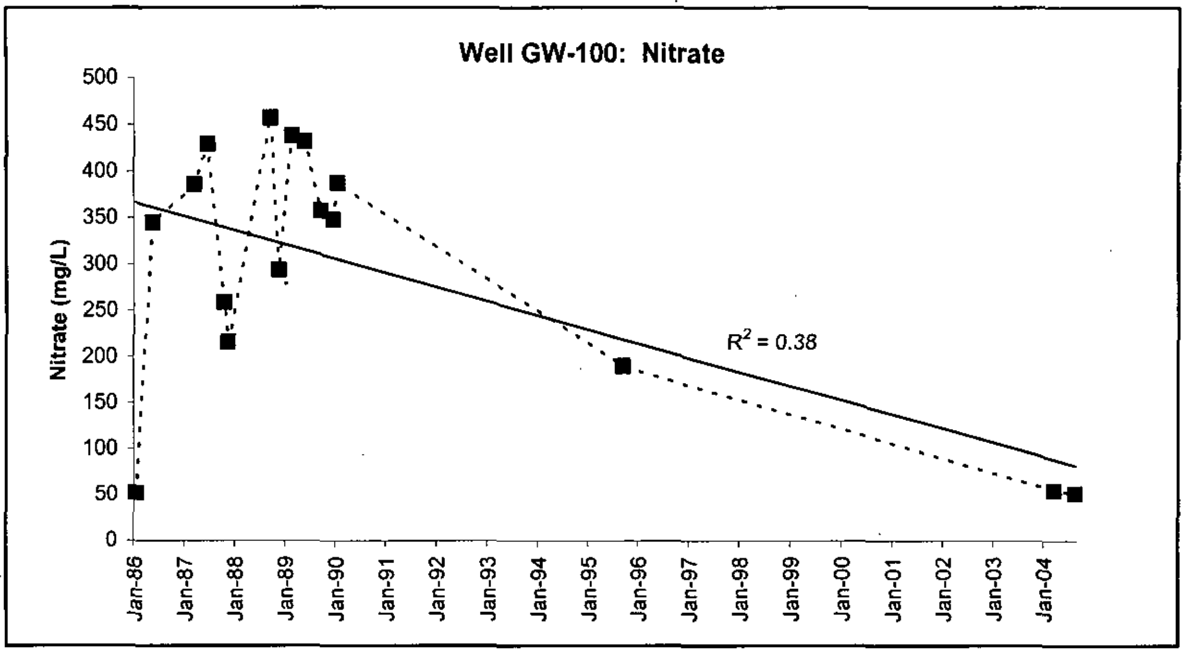

Well GW-100: Nitrate
Nitrate (mg/L)
500
450
400
350
300
250
200
150
100
50
0
$R^2 = 0.38$
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04

Figure 1

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-101

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,844.00
Y-12 GRID NORTH COORDINATE: 30,241.00
SURFACE ELEVATION: 1,005.10 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/12/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 19.18 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,007.40 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	10.1	995.00
BOTTOM (filter pack or open hole):	17.5	987.60
MIDPOINT (filter pack or open hole):	13.8	991.30
PUMP INTAKE:	15.7	989.40
WATER LEVEL (average):	6.13	998.98

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	9		
CONVENTIONAL SAMPLING METHOD:	7 samples	01/23/86	04/14/91
LOW-FLOW SAMPLING METHOD:	2 samples	03/08/04	08/18/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/08/04	.	08/18/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.71 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	3	2510 mg/L	01/12/91	Decreasing
URANIUM (0.03 mg/L):	2	0.045 mg/L	04/14/91	Decreasing
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	1	23.41 pCi/L	01/12/91	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-101

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1984, completed with a screened monitored interval from about 10 to about 18 ft bgs, and constructed with nominal 2.5-inch diameter PVC riser casing and well screen (0.01 slot spiral-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, approximately 150 ft directly west of the former S-3 Ponds and 350 ft southeast of a northern tributary (NT) of Bear Creek (NT-1). The S-3 Ponds were four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplaced a large heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains one of the primary sources of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nine groundwater samples have been collected from the well, with the conventional sampling method used to obtain seven samples between January 1986 and April 1991 and the low-flow sampling method used to obtain samples in March and August 2004. The sampling history includes a generally semiannual sampling frequency and, as indicated by the preceding sampling dates, an extended period (April 1991 – March 2004) when no groundwater samples were collected from the well.

High total dissolved solids (TDS) is a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and a direct consequence of contamination associated with historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the upper part of the Nolichucky Shale (Conasauga Group). The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops beneath the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits minor (<2 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-101 indicate flow to the west-southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, groundwater near well GW-101 probably flows primarily to the west toward discharge areas in NT-1.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater that has been substantially impacted by inorganic contaminants (e.g., nitrate) emplaced in the subsurface upgradient of the well during historical operation of the former S-3 Ponds. However, the geochemical characteristics indicated by the analytical results reported for samples collected between January 1986 and April 1991 differ substantially from the geochemical characteristics indicated by the analytical results reported for the samples collected most recently (March and August 2004). The first group of samples, which were obtained with the conventional sampling method, are characterized by extremely high TDS (>10,000 mg/L) attributable to the very high levels of nitrate (>5,000 mg/L) and other ions (e.g., calcium >3,000 mg/L), along with very high total concentrations of several trace metals, including aluminum (>25 mg/L), barium (>10 mg/L), iron (>30 mg/L), manganese (>5 mg/L), and strontium (>20 mg/L). In contrast, the samples collected most recently, which were obtained using the low-flow sampling method, had substantially lower TDS (919 mg/L in March 2004 and 1,000 mg/L in August 2004) corresponding with the much lower concentrations of nitrate (e.g., 61.2 mg/L in March 2004 and 84.2 mg/L in August 2004) and other ions. Concentrations of trace metals in the samples collected most recently also are substantially lower than historical levels (e.g., barium = 0.707 mg/L in August 2004), but remain above background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate is the primary contaminant present at elevated levels in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), with concentrations above 1,000 mg/L reported for each of the samples collected between January 1986 (3,613 mg/L) and April 1991 (1,423 mg/L). Note that the latter result is qualitative because of an unacceptably high charge balance error (-50.1%), as determined by the percent difference between the summed millequivalent concentrations of the primary anions and cations. The source of the nitrate is the contaminant plume emplaced during historical operations of the former S-3 Ponds. Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from this site. Based on the existing network of monitoring wells in the Nolichucky Shale in BCV west of Y-12, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) transport/migration in the unconsolidated zone (water table interval) directly south toward the headwaters of Bear Creek; (2) westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; (3) vertically migration parallel with geologic dip, driven by the greater density of the highly mineralized and acidic wastewater, and (4) substantially slower migration deeper in the bedrock via much longer strike-parallel flowpaths, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997).

A time-series plot of the nitrate concentrations shows a clearly decreasing trend (Figure 1). As noted previously and illustrated by the data in Table 1, the nitrate concentrations detected in the groundwater samples collected in March and August 2004 are substantially lower than historical levels, although both results show that the nitrate levels in the shallow groundwater at this well remain substantially above the drinking water MCL for nitrate (10 mg/L). For instance, the nitrate concentration reported for the groundwater sample collected in March 2004 (61.2 mg/L) reflects a 97% decrease from the nitrate level evident in January 1991 (2,510 mg/L). Other wells completed at shallow depths in the Nolichucky Shale downgradient of the former S-3 Ponds likewise show lower nitrate concentrations than indicated by historical data for the wells. The reduced levels of nitrate in groundwater at these wells are primarily attributable to the substantially reduced flux of nitrate (and other contaminants) in the shallow groundwater flow system that occurred in response to the closure of the S-3 Ponds in 1984 and the installation of the low-permeability cap in 1988 (DOE 1997).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit (Table 1), with concentrations that exceed the drinking water MCL for uranium (0.03 mg/L) reported for all but the most recently collected samples, which are almost an order-of-magnitude below the MCL. As noted previously, historical data show that the groundwater in this well and elsewhere immediately downgradient of the former S-3 Ponds contains elevated concentrations of several trace metals, some of which were entrained in the wastes disposed at the site (e.g., uranium) and others were dissolved from minerals in the residuum and bedrock (Nolichucky Shale) underlying the site (e.g., barium). The uranium in the groundwater probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Thus, the distribution of elevated uranium concentrations in the Nolichucky Shale near the former S-3 Ponds is largely confined to the low-pH groundwater within about 500 ft of the site (DOE 1997).

A time-series plot of the uranium concentrations in each sample from the well shows a clearly decreasing concentration trend (Figure 2). As illustrated by the data summarized in Table 1, total uranium concentrations reported to date show a reduction of about 53% between January 1986 (0.096 mg/L) and April 1991 (0.045 mg/L) and a further reduction of more than 90% through March (0.0032 mg/L) and August 2004 (0.00367 mg/L). The substantial concentration decrease indicated by the most recent sampling results, as with the nitrate concentrations reported for these samples, is primarily attributable to the substantially reduced flux of contaminants in the shallow groundwater flow system in response to the closure of the S-3 Ponds.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, none of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for four of the groundwater samples collected since May 1990 (Table 1), and each of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L). However, none of the gross alpha activity results obtained since January 1991 exceed the applicable MDA and/or the associated CE. Additionally, the gross alpha activity reported for the groundwater samples collected before May 1990 do not meet data quality objectives (DQOs) because the sample-specific MDA and corresponding CE are not available for these samples. Historical results for gross alpha activity probably inaccurate because of analytical interferences associated with the very high TDS in these (unfiltered) samples. Also, low levels of gross alpha activity in the groundwater at this well are supported by the radiological analyses of the samples collected in March and August 2004, which show very low levels (<4 pCi/L) of U-234 and U-238, which are alpha-particle emitting radionuclides and confirmed components of the groundwater contaminant plume originating from the former S-3 Ponds.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for three of the groundwater samples collected since May 1990 (Table 1). Each of these results is below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). As with gross alpha activity, the results for gross beta activity reported for groundwater samples collected before May 1990 do not meet applicable DQOs, and the historical results probably incorporate analytical interferences associated with the high TDS in the samples. Relatively low levels of gross beta activity in the groundwater at this well are supported by the results of radiological analyses of the samples collected in March and August 2004, which show values below the respective MDA for Tc-99, a beta-particle emitting radionuclide and a "signature" component of the groundwater contaminant plume originating from the former S-3 Ponds. Based on the existing network of monitoring wells in Nolichucky Shale west of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate, with transport in the water table interval south toward Bear Creek and more westward (strike-parallel) transport in the bedrock intervals toward discharge areas in NT-1 and NT-2 (DOE 1997). Considering that the most recent sampling results show that nitrate concentrations in the groundwater at this well remain above 50 mg/L, the lack of Tc-99 in the groundwater is somewhat surprising. Thus, it is possible that the Tc-99 results are inaccurate because of analytical interferences associated with the very high TDS in these samples.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-101: summary of results for nitrate, uranium, gross alpha, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Total Uranium (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
01/23/86	3,613	0.096	[188]	[60]
05/29/86	5,216	0.07	[110]	[34]
05/16/90	1,780	0.059	33.89	44.71
07/30/90	2,400	0.062	48.81	< CE
10/15/90	2,420	0.043	205.09	< CE
01/12/91	2,510	0.044	23.41	43.72
04/14/91	[1,423]	0.045	< CE	41.52
03/08/04	61.2	0.0032	<MDA	<MDA
08/18/04	84.2	0.00367	<MDA	<MDA
MCL	**10**	**0.03**	**15**	**50***

Note: [ ] = Result considered qualitative because of unacceptable ion charge-balance error (nitrate) or MDA and CE not reported (alpha/beta); * = SDWA screening level for a 4 mrem/yr *dose equivalent*

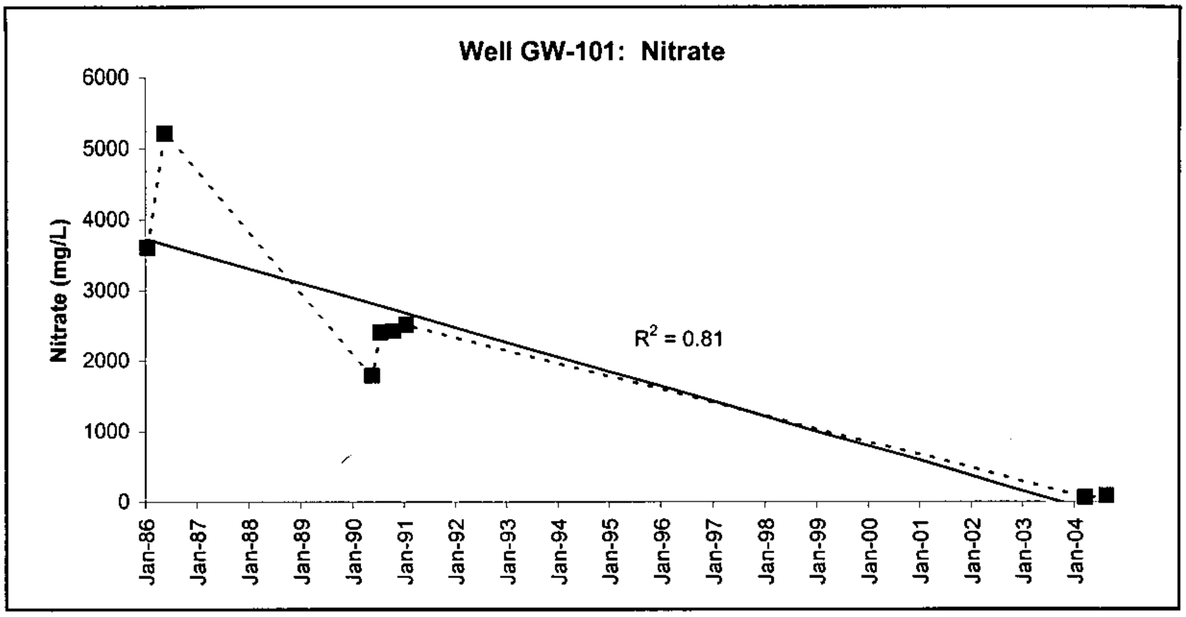


Figure 1

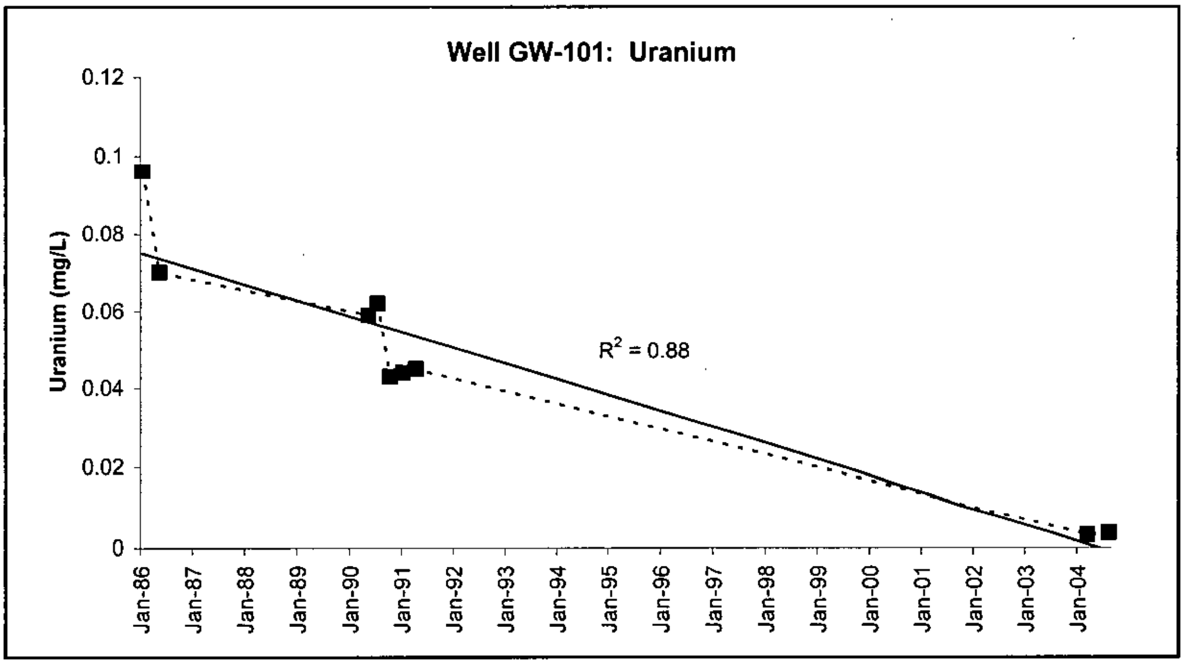


Figure 2

MAXIMUM CONCENTRATION: 2003

100 - 1,000	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-105

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,833.00
Y-12 GRID NORTH COORDINATE: 30,417.00
SURFACE ELEVATION: 1,014.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/18/84 PAIRED/CLUSTERED WITH: GW-106
TAG DEPTH (measured): 19.40 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,018.20 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	9.5	1004.80
BOTTOM (filter pack or open hole):	17.0	997.30
MIDPOINT (filter pack or open hole):	13.25	1001.05
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	4.92	1009.39

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	15 samples	01/24/86	01/19/90
LOW-FLOW SAMPLING METHOD:	2 samples	05/08/03	10/02/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/08/03	.	10/02/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.33 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	755 mg/L	10/02/03	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-105

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1984, completed with a screened monitored interval from 9.5 to 17 ft bgs, and constructed with nominal 2.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with well GW-106 and is located in Bear Creek Valley (BCV) near the west end of Y-12, at the Rust Garage (RG) about 250 ft east-southeast of the former S-3 Ponds. The RG once housed several petroleum fuel underground storage tanks (USTs) and associated service lines and dispenser, a fuel unloading station, and drum storage area for used oil (DOE 1998). Located directly west of the RG, the former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well, with the conventional sampling method used to obtain 15 samples between January 1986 and January 1990, and the low-flow sampling method used to obtain samples in June and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 5 ft bgs and exhibits minimal (<2 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-105 than well GW-106, which is completed at a greater depth (75 ft bgs) in the Nolichucky Shale. Based on the distance (51 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005 - 0.01) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-105 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 2,690 – 6,070 mg/L;
- pH of 6.5 – 7.1 (field measurements);
- high concentrations of nitrate (>500 mg/L);
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- elevated total concentrations of several trace metals, particularly barium (>2 mg/L) and strontium (>1 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate is the principal contaminant present in the groundwater at this well.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 350 mg/L, with concentrations above 1,000 mg/L reported for all but five of the samples, including the samples collected most recently (Table 1). The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, 9201-4, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

The highest nitrate concentrations, including the historical maximum concentration (2,619 mg/L in January 1986), were reported for groundwater samples collected before installation of the low-permeability cap at the former S-3 Ponds. Nevertheless, comparably high nitrate concentrations (>1,000 mg/L) also were reported for samples obtained after installation of the cap (e.g., 1,840 mg/L in September 1989). These results are believed to be representative of nitrate concentrations in the short-term migration/transport pathways at shallow depths in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998). Also, considering the upward vertical hydraulic gradients indicated by presampling groundwater elevations (see Section 3.0), the concentrations of nitrate (and other contaminants) in the shallow groundwater at this well may at least partially reflect influx from deeper in the bedrock.

A time-series plot of the nitrate concentrations in the groundwater samples spans the 13-year gap in the sampling history for the well, but the data suggests a possible decreasing long-term trend (Figure 1), with the nitrate concentration evident in March 2003 (350 mg/L) being the lowest reported for the well. Moreover, as illustrated by the barium and strontium data summarized in Table 1, concentration decreases also are evident for other inorganic contaminants in the groundwater samples. Concurrently decreasing concentrations of nitrate and other inorganic compounds suggest a corresponding reduction in the relative flux of contaminants. Reduced flux of contaminants via the shallow groundwater flow/transport pathways intercepted by the monitored interval in the well suggest that the center of mass of the contaminant plume in the Nolichucky Shale east of the former S-3 Ponds lies to the east (parallel with geologic strike) of this well and is continuing to slowly move eastward (DOE 1998).

5.2 URANIUM

Total uranium concentrations at or above the applicable analytical reporting limit were detected in fourteen of the groundwater samples, with the highest concentration (0.014 mg/L in March 1987) being less than the MCL (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

No VOCs were detected in the groundwater samples collected from well GW-105 during CY 2003.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater samples obtained before January 1991, which includes all but two of the samples from this well, are considered qualitative because the applicable MDA and corresponding CE are not available for these samples. Also, the most recent (May and October 2003) sampling results for gross alpha activity are below the applicable MDA, although each of these samples has an unusually high MDA (23 pCi/L and 200 pCi/L, respectively). The MDAs may be an artifact of the high TDS in the samples, which may cause significant analytical interferences for gross alpha activity. Consequently, filtered groundwater samples from this well may be best suited for radiological analyses.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater samples obtained before January 1991, which includes all but two of the samples from this well, are considered qualitative because the applicable MDA and corresponding CE are not available for these samples. Also, the most recent (May and October 2003) sampling results for gross beta activity are below the applicable MDA, although each of these samples has an unusually high MDA (97 pCi/L and 810 pCi/L, respectively). The MDAs may be an artifact of the high TDS in the samples, which may cause analytical interferences for gross beta activity. Consequently, filtered groundwater samples from this well may be best suited for radiological analyses.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-105: summary of results for selected inorganic contaminants

Sampling Date	Concentration (mg/L)		
	Nitrate (as N)	Barium	Strontium
01/24/86	2,619	15	4.4
05/30/86	605	4.9	1.6
03/10/87	1,942	15.8	.
06/10/87	1,921	19.2	.
10/05/87	1,208	11.4	.
11/19/87	1,106	6.36	2.6
04/04/88	2,140	14	.
06/21/88	2,310	25	.
09/06/88	1,010	9.09	.
11/09/88	1,100	7	.
02/22/89	514	3	.
05/17/89	1,720	12	.
09/13/89	1,840	11	.
12/04/89	1,080	5.2	.
01/19/90	921	5	.
05/08/03	350	2.94	1.23
10/02/03	755	5.97	2.38
MCL	**10**	**2**	**NA**

Note: "." = Not detected; NA = Not applicable

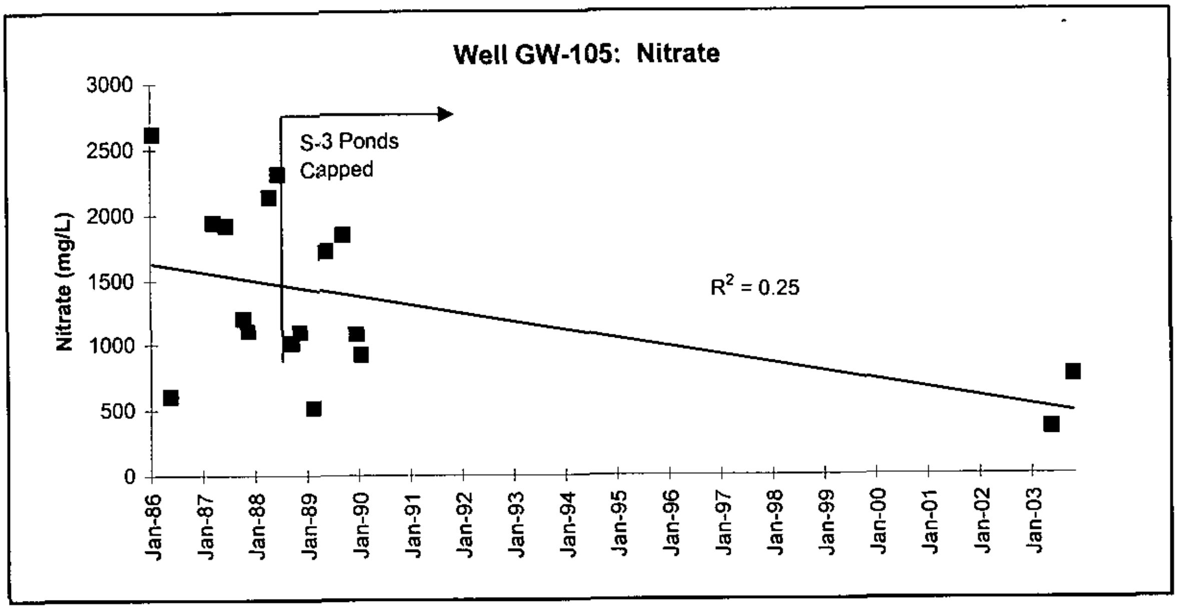

Well GW-105: Nitrate
Nitrate (mg/L)
3000
2500
2000
1500
1000
500
0
S-3 Ponds
Capped
R^2 = 0.25
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03

Figure 1

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
100 - 1,000	<0.015	ND	ND	ND

GW-106

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,843.00
Y-12 GRID NORTH COORDINATE: 30,418.00
SURFACE ELEVATION: 1,014.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/26/84 PAIRED/CLUSTERED WITH: GW-105
TAG DEPTH (measured): 74.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,017.30 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	53.3	961.20
BOTTOM (filter pack or open hole):	75.0	939.50
MIDPOINT (filter pack or open hole):	64.15	950.35
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	1.47	1013.03

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	15 samples	01/24/86	01/16/90
LOW-FLOW SAMPLING METHOD:	2 samples	05/08/03	10/02/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/08/03	.	10/02/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 0.58 pre-sampling measurements (ft)
TDS: H (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	740 mg/L	05/08/03	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-106

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1984, completed with a screened monitored interval from 53 to 75 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with well GW-105 and is located in Bear Creek Valley (BCV) near the west end of Y-12, at the Rust Garage (RG) about 250 ft east-southeast of the former S-3 Ponds. The RG once housed several petroleum fuel underground storage tanks (USTs) and associated service lines and dispenser, a fuel unloading station, and drum storage area for used oil (DOE 1998). Located directly west of the RG, the former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well, with the conventional sampling method used to obtain 15 samples between January 1986 and January 1990, and the low-flow sampling method used to obtain samples in June and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 1.5 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are higher in well GW-106 than well GW-105, which is completed at a shallower depth (17 ft bgs) in the Nolichucky Shale. Based on the distance (51 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005 - 0.01) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-106 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 2,425 - 4,850 mg/L;
- pH of 6.9 – 7.1 (field measurements);
- high concentrations of nitrate (>500 mg/L);
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- elevated total concentrations of several trace metals, particularly barium (>4 mg/L) and strontium (>20 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 400 mg/L, with concentrations above 1,000 mg/L reported for six of the samples (Table 1). The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, 9201-4, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

The highest nitrate concentrations, including the historical maximum concentration (3,190 mg/L in September 1988), were reported for groundwater samples collected before installation of the low-permeability cap over the former S-3 Ponds. Also, the most recent sampling results show nitrate concentrations (e.g., 740 mg/L in May 2003) that are about 30% lower than the nitrate levels evident shortly before installation of the cap (e.g., 1,172 mg/L in September 1987), but are about 50 to 80% higher than nitrate concentrations evident shortly after installation of the cap (e.g., 400 mg/L in December 1989). Additionally, the nitrate result reported for the sample collected in January 1990 (706 mg/L) is considered qualitative because of the ion charge balance error for the sample (i.e., relative percent difference between respective summed millequivalent concentrations of the major cations and anions exceeds 20%). The nitrate results for this well are believed to be representative of concentrations in the long-term, strike-parallel groundwater flow/transport pathways at depth in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998).

A time-series plot of nitrate concentrations in the groundwater samples (excluding the qualitative result noted above) spans the 13-year gap in the sampling history for the well and shows a fairly indeterminate long term concentration trend (Figure 1). The trend suggests sharply lower flux of nitrate following installation of the low-permeability cap at the former S-3 Ponds, but minimal changes in the relative flux of nitrate since then. Similarly indeterminate concentration trends also are evident for other inorganic contaminants in the groundwater samples, as illustrated by the barium results summarized in Table 1, and likewise suggest minimal changes in the relative flux of inorganic contaminants via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

Total uranium concentrations at or above the applicable analytical reporting limit were detected in thirteen of the groundwater samples, with the highest concentration (0.013 mg/L in March 1988) being less than the MCL (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Aside from sporadic (false positive) results for common laboratory reagents (e.g., acetone), none of the VOCs that are confirmed groundwater contaminants at Y-12 were detected in the groundwater samples.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater samples obtained before January 1991, which includes all but two of the samples from this well, are considered qualitative because the applicable MDA and corresponding CE are not available for these samples. Also, the most recent (May and October 2003) sampling results for gross alpha activity are below the applicable MDA, although each of these samples has an unusually high MDA (68 pCi/L and 230 pCi/L, respectively). The MDAs may be an artifact of the high TDS in the samples, which may cause significant analytical interferences for gross alpha activity. Consequently, filtered groundwater samples from this well may be best suited for radiological analyses.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater samples obtained before January 1991, which includes all but two of the samples from this well, are considered qualitative because the applicable MDA and corresponding CE are not available for these samples. Also, the most recent (May and October 2003) sampling results for gross alpha activity are below the applicable MDA, although each of these samples has an unusually high MDA (210 pCi/L and 610 pCi/L, respectively). The MDAs may be an artifact of the high TDS in the samples, which may cause analytical interferences for gross beta activity. Consequently, filtered groundwater samples from this well may be best suited for radiological analyses.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

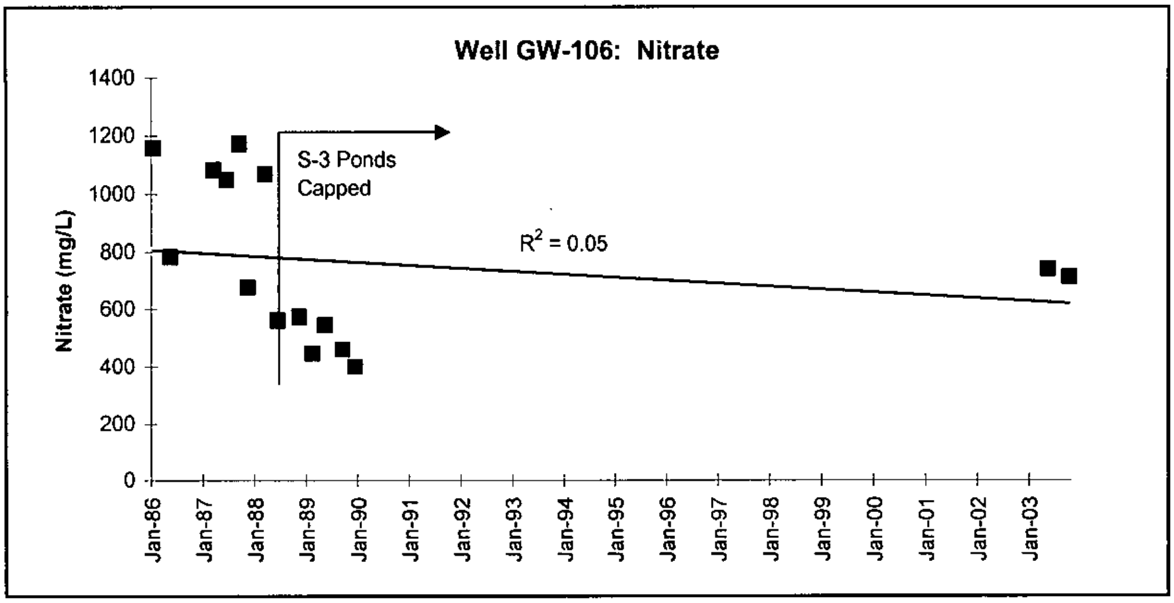
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-106: summary of results for selected inorganic contaminants

Sampling Date	Concentration (mg/L)	
	Nitrate (as N)	Barium
01/24/86	1,158	3.2
05/30/86	783	2
03/10/87	1,084	5.1
06/10/87	1,050	2.97
09/30/87	1,172	2.01
11/18/87	676	1.7
03/30/88	1,070	2.61
06/18/88	561	1.7
09/02/88	3,190	1.3
11/08/88	574	1.5
02/21/89	447	1.3
05/17/89	545	1.1
09/12/89	461	0.91
12/01/89	400	0.89
01/16/90	(706)	0.78
05/08/03	740	4.42
10/02/03	712	3.59
MCL	**10**	**2**

Note: "." = Not detected; ( ) = Qualitative result



Well GW-106: Nitrate
1400
1200
1000
800
600
400
200
0
Nitrate (mg/L)
S-3 Ponds Capped
$R^2 = 0.05$
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03

Figure 1

MAXIMUM CONCENTRATION: 2004

>1,000	0.015 - 0.03	50 - 500	150 - 1,500	>5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-108

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,207.00
Y-12 GRID NORTH COORDINATE: 30,070.00
SURFACE ELEVATION: 995.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/26/84 PAIRED/CLUSTERED WITH: GW-107 GW-109
TAG DEPTH (measured): 58.30 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 999.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	41.0	954.80
BOTTOM (filter pack or open hole):	58.6	937.20
MIDPOINT (filter pack or open hole):	49.8	946.00
PUMP INTAKE:	49.80	946.00
WATER LEVEL (average):	4.58	991.22

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	20 samples	01/29/86	08/11/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/16/98	07/08/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/07/04	.	07/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.78 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	17	13,300 mg/L	07/18/00	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	18	358 µg/L	07/18/00	Indeterminate
GROSS ALPHA (15 pCi/L):	8	1,334.57 pCi/L	01/07/03	Indeterminate
GROSS BETA (50 pCi/L):	18	14,510.59 pCi/L	01/07/03	Increasing

Results (since 1991) > Screening Level

WELL GW-108

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1984, completed with a screened monitored interval from 41 to 58.6 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-107 and GW-109 and is located in Bear Creek Valley (BCV) near the west end of Y-12, about 800 ft southeast of the former S-3 Ponds. The former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well, with the conventional sampling method used to obtain 20 samples between January 1986 and August 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

Extremely high levels of TDS and fairly low pH are distinguishing characteristics of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 5 ft bgs and exhibits minimal (<2 ft) seasonal fluctuations. Also, groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-108 than in wells GW-107 and GW-109, which are completed at shallower (14 ft bgs) and deeper (128 ft bgs) depths, respectively, in the Nolichucky Shale. Based on the distance between the monitored interval midpoints (elevation) in each well, the contemporaneous groundwater elevations indicate an upward vertical hydraulic gradient (0.046) from the deeper bedrock (GW-109) to the shallow bedrock interval (GW-108) and a downward vertical gradient (0.002) from the water table interval (GW-107) to the shallow bedrock interval.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-108 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in

directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 29,000 – 86,400 mg/L;
- pH of 5.01 – 6.03 (field measurements);
- very high concentrations (>10,000 mg/L) of calcium and nitrate, the latter of which is the likely source of the unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for the sample collected in August 1997 (RPD = -34.1%);
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- elevated total concentrations of several trace metals, particularly barium (>80 mg/L) and strontium (>30 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the groundwater samples collected from the well since June 1995, the principal contaminants present in the groundwater at this well are nitrate, VOCs, and gross beta activity.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 8,500 mg/L, with concentrations above 10,000 mg/L reported for most of the samples (Table 1). The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

Very high nitrate concentrations (and TDS) are characteristic of the groundwater samples from this well, most of which had concentrations above 10,000 mg/L. The historical maximum nitrate value (19,700 mg/L in August 1997) is qualitative because the ion-charge balance error (see Section 4.0), and the next highest result was 13,300 mg/L (July 2000). These results are believed to be representative of nitrate concentrations in the short-term migration/transport pathways at shallow depths in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998). Also, considering the upward vertical hydraulic gradients indicated by presampling groundwater elevations (see Section 3.0), the concentrations of nitrate (and other contaminants) in the shallow groundwater at this well may at least partially reflect influx from deeper in the bedrock.

A time-series plot of the nitrate concentrations in the groundwater samples, excluding the qualitative result (August 1997), shows a generally decreasing long-term trend (Figure 1), with a series of cyclical "peak" nitrate levels evident in February 1999 (11,800 mg/L), July 2000 (13,300 mg/L), January 2003 (10,400 mg/L). The deceasing long-term trend suggests an overall decrease in the relative flux of nitrate via the groundwater flowpaths intercepted by the monitoring interval in the well, which may indicate a corresponding reduction in the flux of nitrate from the deeper bedrock intervals. The cyclical peak concentrations potentially reflect temporal variations in the relative efficiency of natural attenuation processes that influence nitrate levels in the groundwater.

5.2 URANIUM

Total uranium concentrations at or above the applicable analytical reporting limit were detected in 13 of the groundwater samples (Table 1), with the highest concentration (0.0205 mg/L in January 2001) being less than the MCL (0.03 mg/L). The contaminant plume emplaced in the Nolichucky Shale during historical operation of the former S-3 Ponds is the most likely source of the uranium. Considering the acidic pH of the samples from the well (see Section 4.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). The concentrations of uranium in the groundwater at this well, in contrast to the very high nitrate levels, illustrate the significantly greater attenuation of uranium relative to nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected from the well (Table 2): acetone, benzene, bromoform, bromomethane, chloroform, chloromethane, methylene chloride (MC), PCE, TCE, and 11DCE. These compounds are components of the contaminant plume originating from the former S 3-Ponds. Compared to other components of the Eastern S-3 Ponds Plume (e.g., nitrate), the relatively low concentrations of VOCs in the shallow groundwater at well GW-108 primarily reflects the substantially smaller volume of organic wastes disposed at the site (DOE 1998).

The primary VOCs in the groundwater samples are MC, chloroform, chloromethane, and bromomethane, which have the maximum concentrations of 69 μg/L, 38 μg/L, 79 μg/L, and 170 μg/L, respectively (Table 2). However, the maximum chloromethane and bromomethane concentrations are potential outliers that were reported for the sample collected in July 2000; excluding these results, the concentrations of these VOCs are less than 30 μg/L. Most recent samples show that MC concentrations remains substantially above the MCL (5 μg/L). Secondary VOCs in the groundwater samples are acetone, with concentrations above 10 μg/L reported for the most recent samples (e.g., 18 μg/L in July 2004), along with low concentrations (estimated values below 5 μg/L) of PCE, TCE, bromoform, and benzene.

A time-series plot of the summed concentration of VOCs detected in each groundwater sample (excluding the outliers mentioned above) shows an indeterminate trend (Figure 2). The significance of this trend is questionable because sampling results obtained between June 1995 and March 1998 contain several false positive results for chloroform and acetone (Table 2), which lowered the summed VOC concentration value for these samples and skews the long-term concentration trend.

5.4 GROSS ALPHA ACTIVITY

Eight of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), all of which exceed the MCL (15 pCi/L). However, one of these results (1,335 pCi/L in January 2003) is a suspected outlier because the other results are significantly lower (146 pCi/L to 700 pCi/L). Analytical results for samples obtained in CY 1996 (November), CY 2000 (January), and CY 2002 (January and July) show that uranium isotopes (U-234 and U-238) are a source of gross alpha activity in the groundwater. All of the results for U-234 (ranging from 13.1-18.47 pCi/L) and U-238 (ranging from 5.19 – 6.22 pCi/L) were above the applicable MDA and CE; however, the consistently low results for these isotopes do not support the high gross alpha activity reported for samples from the well. The inconsistent detection and widely variable results for gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0).

5.5 GROSS BETA ACTIVITY

Each groundwater sample from the well had gross beta activity of at least 7,500 pCi/L, which is significantly above the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in Table 1, Tc-99 was detected (i.e., >MDA and CE) in all of the samples analyzed for this beta-emitting radionuclide, with the highest value (30,625 pCi/L) reported for the most recent sample (July 2003).

A time-series plot of the gross beta activity in each sample shows a generally increasing long-term trend (Figure 3), although the most recent data suggest a modest decrease in gross beta activity between January 2003 (14,510 pCi/L) and August 2004 (12,100 pCi/L). The generally increasing long-term trend potentially reflects a corresponding increase in the overall flux of Tc-99 within the strike-parallel groundwater flowpaths in the Nolichucky Shale east of the S-3 Ponds. However, the increasing trend for Tc-99 contrasts with the decreasing trend for nitrate, which seems unusual considering that both contaminants are stable and highly mobile in the groundwater system. Such divergent concentration trends probably reflect the complex hydrochemical dynamics within the contaminant plume originating from the S-3 Ponds. For example, nitrate concentrations within the plume may be reduced by natural attenuation processes which do not affect Tc-99. The divergent concentration trends also may correspond with differences in the history of nitrate and Tc-99 waste disposal at the former S-3 Ponds. The site regularly received nitrate wastes (via pipeline from process buildings in Y-12), but got only periodic shipments of wastes containing Tc-99. This may have emplaced a series of Tc-99 "slugs" within the more continuous stream of nitric-acid wastes. Thus, the increasing Tc-99 activity evident in well GW-108 may reflect a temporal flux increase corresponding to one or more "slugs" of Tc-99 wastes migrating eastward along strike-parallel groundwater flowpaths in the Nolichucky Shale.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-108: summary of results for nitrate, gross alpha activity, gross beta activity

Sampling Date	Concentration				
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tc-99 (pCi/L)
06/28/95	10,000	0.015	< CE	9,500	.
11/04/96	10,900	0.016	700	5,690	8,690
03/04/97	10,500	0.015	<MDA	8,000	18,000
08/11/97	(19,700)	0.015	<MDA	13,000	14,000
03/16/98	11,800	0.02	<MDA	10,000	21,000
07/28/98	10,700	0.0186	<MDA	14,000	22,000
02/15/99	11,800	.	<MDA	7,676.32	25,100
07/27/99	9,880	.	<MDA	10,745.91	24,151.47
01/11/00	8,980	.	333.3	8,642.12	18,117.58
07/18/00	13,300	.	<MDA	9,025.39	19,241.93
01/04/01	11,800	0.0205	429	10,237.68	26,405.81
07/11/01	10,300	.	153.95	11,400	26,900
01/08/02	9,360	0.0181	<MDA	7,954.49	29,525.35
07/09/02	9,280	0.0157	146.63	11,532.61	26,872.71
01/07/03	10,400	0.015	[1,334.57]	14,510.59	28,222.66
07/10/03	9,820	0.0153	<MDA	13,862.58	30,624.69
01/07/04	8,940	0.0144	551.02	12,612.67	27,087.53
07/08/04	9,520	0.0197	137.25	12,100.94	30,004.76
MCL	**10**	**0.03**	**15**	**50***	**3,790***

Note: ( ) = Result considered qualitative because of ion-charge balance error; [ ] = Suspected outlier; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-108: summary of VOC results

Date Sampled	Concentration (µg/L)				
	MC	Chloroform	Chloromethane	Bromoform	Bromomethane
06/28/95	38	22	.	1 J	.
11/04/96	53	FP	.	.	.
03/04/97	48	29	.	2 J	1
08/11/97	38	22	.	2 J	.
03/16/98	51	29	.	3J	.
07/28/98	51	30	.	3 J	.
02/15/99	54	38	.	3 J	.
07/27/99	45	30	.	3 J	.
01/11/00	53	28	.	3 J	4
07/18/00	63	37	[79]	3 J	[170]
01/04/01	FP	36	23	4 J	29
07/11/01	FP	31	13	3 J	22
01/08/02	FP	29	.	4 J	.
07/09/02	69	32	.	5 J	14
01/07/03	50	36	22	4 J	22
07/10/03	FP	36	21	3 J	19
01/07/04	.	34	21	3 J	24
07/09/04	51	31	.	5	8
MCL	**5**	**80***	**NA**	**80***	**NA**
Date Sampled	**Concentration (µg/L)**				
	PCE	**TCE**	**Benzene**	**Acetone**	**11DCE**
06/28/95	.	2 J	.	35	.
11/04/96	.	.	.	32	.
03/04/97	.	FP	.	FP	.
08/11/97	.	2 J	.	FP	.
03/16/98	1 J	3 J	.	FP	.
07/28/98	.	3 J	.	19	.
02/15/99	.	2 J	2 J	18	.
07/27/99	1 J	3 J	.	.	.
01/11/00	.	2 J	.	.	.
07/18/00	2 J	4 J	.	.	.
01/04/01	1 J	3 J	.	.	.
07/11/01	1 J	3 J	.	.	1 J
01/08/02	1 J	3 J	.	.	.
07/09/02	2 J	3 J	.	18	.
01/07/03	3 J	4 J	.	.	.
07/10/03	2 J	4 J	1 J	.	.
01/07/04	3 J	4 J	1 J	10	.
07/08/04	3 J	3 J	1 J	18	.
MCL	**5**	**5**	**5**	**NA**	**7**

Note: "." = Not detected; FP=false positive result; J = Estimated value below the analytical reporting limit; [ ] = suspected outlier; NA = Not applicable; * = MCL for total trihalomethanes (chloroform + bromoform)

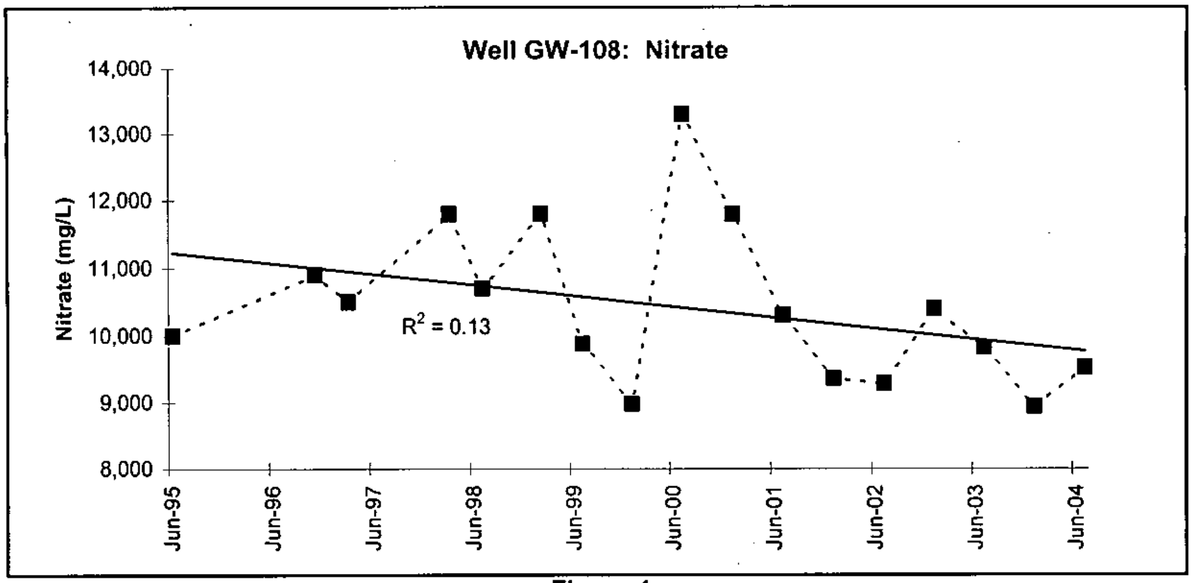


Figure 1

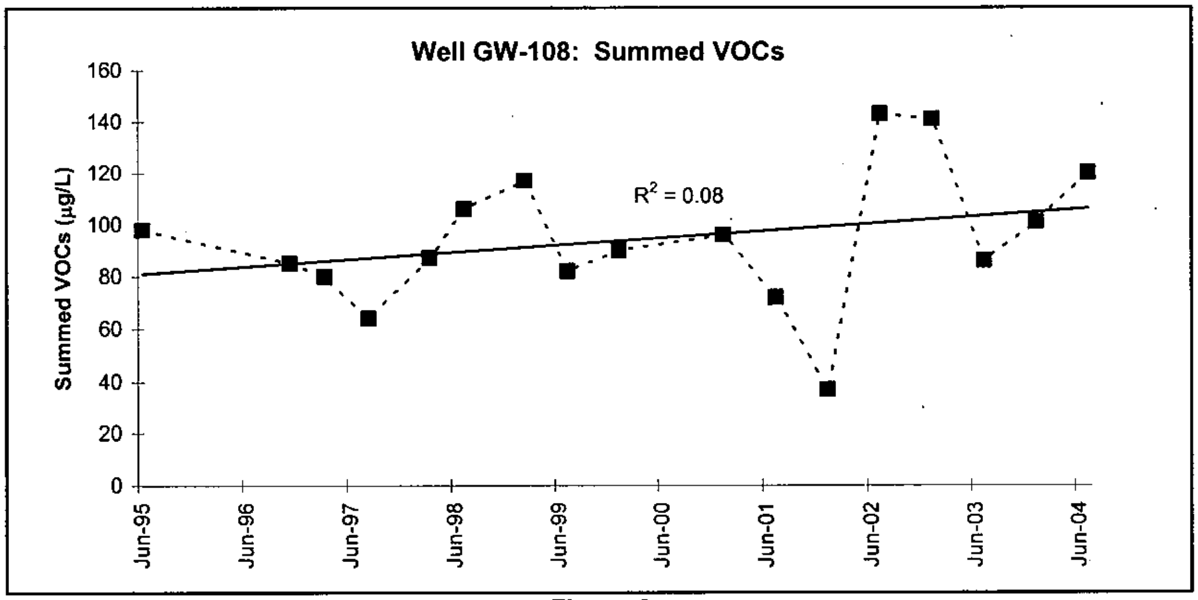


Figure 2

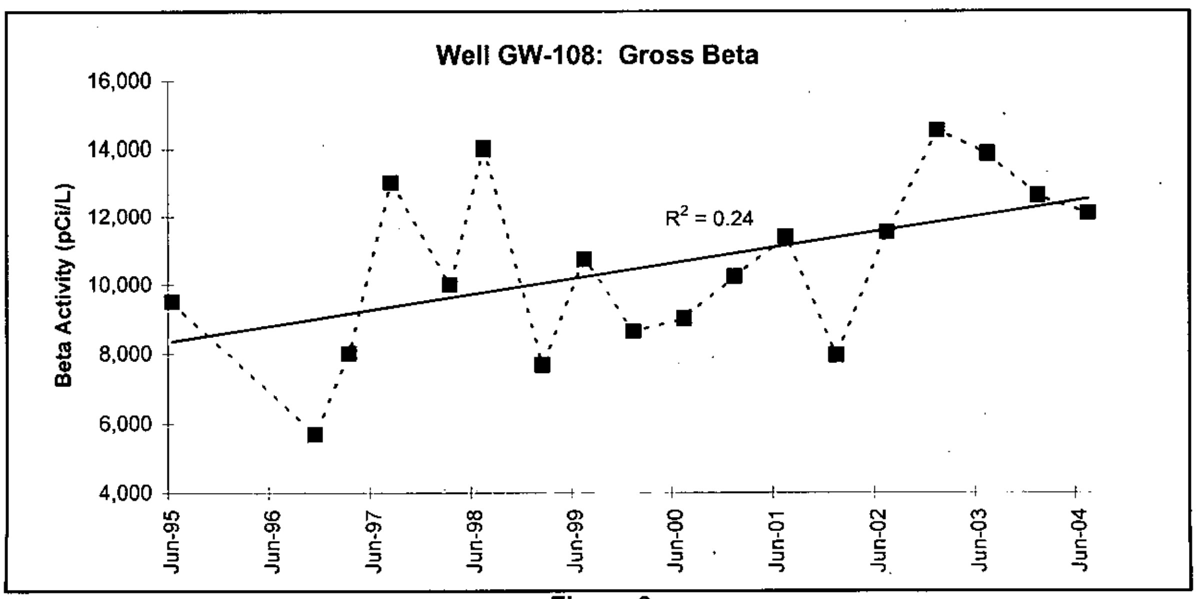


Figure 3

MAXIMUM CONCENTRATION: 2003

>1,000	0.015 - 0.03	50 - 500	ND	>5,000
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-109

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,207.00
Y-12 GRID NORTH COORDINATE: 30,056.00
SURFACE ELEVATION: 995.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/27/84 PAIRED/CLUSTERED WITH: GW-107 GW-108
TAG DEPTH (measured): 125.45 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 998.20 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	96.6	898.70
BOTTOM (filter pack or open hole):	128.5	866.80
MIDPOINT (filter pack or open hole):	112.55	882.75
PUMP INTAKE:	113.70	881.60
WATER LEVEL (average):	1.96	993.34

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	22		
CONVENTIONAL SAMPLING METHOD:	16 samples	01/29/86	06/29/95
LOW-FLOW SAMPLING METHOD:	6 samples	09/02/99	10/06/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/14/03	.	10/06/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.77 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	6	10,400 mg/L	10/06/03	Indeterminate
URANIUM (0.03 mg/L):	1	0.032 mg/L	06/29/95	Anomalous Result
SUMMED VOCs (5 µg/L):	6	521 µg/L	06/29/95	Decreasing
GROSS ALPHA (15 pCi/L):	1	122 pCi/L	06/29/95	Anomalous Result
GROSS BETA (50 pCi/L):	6	19,000 pCi/L	10/06/03	Increasing

WELL GW-109

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1984, completed with a screened monitored interval from 96.6 to 128.5 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-107 and GW-108 and is located in Bear Creek Valley (BCV) near the west end of Y-12, about 800 ft southeast of the former S-3 Ponds. The former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-two groundwater samples have been collected from the well, with the conventional sampling method used to obtain 16 samples between January 1986 and June 1995, and the low-flow sampling method used to obtain six samples between September 1999 and October 2003.

Extremely high levels of TDS and slightly low pH are distinguishing characteristics of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 2 ft bgs and exhibits minimal (<2 ft) seasonal fluctuations. Also, groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are higher in well GW-109 than in wells GW-107 and GW-108, which are completed at shallower depths (14 ft bgs and 58 ft bgs, respectively) in the Nolichucky Shale. Based on the distance between the monitored interval midpoints (elevation) in each well, the contemporaneous groundwater elevations indicate an upward vertical hydraulic gradient (0.046) from the deeper bedrock (GW-109) to the shallow bedrock interval (GW-108) and a downward vertical gradient (0.002) from the water table interval (GW-107) to the shallow bedrock interval.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-109 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in

directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 49,800 – 57,598 mg/L;
- pH of 5.39 – 5.84 (field measurements);
- very high concentrations (>10,000 mg/L) of nitrate and calcium;
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- elevated total concentrations of several trace metals, particularly barium (>80 mg/L) and strontium (>60 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995). Furthermore, concentrations of cadmium (> 1 mg/L) and mercury (> 0.01 mg/L) significantly exceed applicable MCLs (0.005 mg/L and 0.002 mg/L, respectively).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the six groundwater samples collected from the well since June 1995, the principal contaminants present in the groundwater at this well are nitrate, VOCs, and gross beta activity.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 8,000 mg/L, with a concentration above 10,000 mg/L reported for the most recent sample (Table 1). The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants (e.g., cadmium) within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is a primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. Chemically stable and mobile in groundwater, nitrate effectively traces the principal groundwater flow/transport pathways for other similarly mobile contaminants, with the distribution of nitrate in the groundwater suggesting: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 up to 4,000 ft from the former S-3 Ponds (DOE 1998).

Very high nitrate concentrations (and TDS) are characteristic of the groundwater samples from this well, all of which had concentrations above 8,000 mg/L. These results are believed to be representative of nitrate concentrations in the migration/transport pathways at intermediate depths in the Nolichucky Shale east of the former S-3 Ponds (DOE 1998). The concentration levels of most inorganic contaminants (nitrate, barium, strontium, uranium) are fairly similar in contemporaneous samples from wells GW-109 and GW-108; however, cadmium and mercury concentrations are significantly above respective MCLs in samples from well GW-109 (see Section 3.0) and are not detected in samples from well GW-108. The elevated concentrations of these heavy metals in samples from well GW-109 may reflect density driven migration to greater depths beneath the former S-3 Ponds.

A time-series plot of the nitrate concentrations in the groundwater samples shows a fluctuating and generally indeterminate long-term trend (Figure 1), with higher concentrations evident during seasonally low flow conditions (October). The significance of this trend is questionable because the minimum (8,700 mg/L) and maximum (10,800 mg/L) concentrations were both reported for samples collected during CY 2003, which are within the range of nitrate concentrations reported for the eight samples collected from the well during CY 1986 and CY 1987 (8,620 – 11,199 mg/L). The fairly stable nitrate concentrations probably reflect lower groundwater flux at greater depths in the Nolichucky Shale (see Section 3.0)

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were detected in all of the groundwater samples (Table 1), with the highest concentration (0.032 mg/L in June 1995) slightly above the MCL for uranium (0.03 mg/L). The contaminant plume emplaced in the Nolichucky Shale during historical operation of the former S-3 Ponds is the most likely source of the uranium. Considering the acidic pH of the samples from the well (see Section 4.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). The concentrations of uranium in the groundwater at this well, in contrast to the very high nitrate levels, illustrate the significantly greater attenuation of uranium relative to nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected from the well (Table 2): acetone, bromoform, chloroform, methylene chloride (MC), toluene, PCE, TCE, 12DCE, and 11DCE. These compounds are components of the contaminant plume originating from the former S-3 Ponds. Compared to other components of the Eastern S-3 Ponds Plume (e.g., nitrate), the relatively low concentrations of VOCs in the shallow groundwater at well GW-109 primarily reflects the substantially smaller volume of organic wastes disposed at the site (DOE 1998).

The primary VOCs in the groundwater samples are PCE, MC, chloroform, and acetone, which have the maximum concentrations of 180 μg/L, 35 μg/L, 19 μg/L, and 24 μg/L, respectively (Table 2). Most recent samples show that PCE and MC concentrations remain substantially above the applicable MCL (5 μg/L for both). Note that PCE concentrations are significantly higher in samples from GW-109 than in shallower well GW-108 (similar to cadmium and mercury concentrations, see Section 5.1), which may reflect density driven migration to greater depths beneath the S-3 Site because PCE is dense and not very soluble in water. Secondary VOCs in the groundwater samples are 12DCE, 11DCE, bromoform, and toluene. None of these compounds were detected in samples collected from the well during CY 2000, and the CY 2003 results for these compounds are either estimated values below 5 μg/L (11DCE, bromoform, and toluene) or not detected (12DCE).

A time-series plot of the summed concentration of VOCs detected in each groundwater sample shows a clearly decreasing trend (Figure 2), which may be skewed by the high acetone result (240 µg/L) reported for the initial sample (June 1995). The concentrations of all compounds have decreased between June 1995 and May 2003 (Table 2), more significantly for acetone (94%) than for PCE (11%). Acetone is significantly less dense and more soluble in groundwater than PCE (Fetter 1994), and the upward vertical hydraulic gradient (see Section 3.0) may at least partially explain the rapid concentration decrease for acetone.

5.4 GROSS ALPHA ACTIVITY

Only one of the groundwater samples from well GW-109 had gross alpha activity above the applicable MDA and corresponding CE (Table 1), which also exceeds the MCL (15 pCi/L). The inconsistent detection of gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0), and the elevated result (122 pCi/L) reported for the June 1995 sample is a suspected outlier.

5.5 GROSS BETA ACTIVITY

Each groundwater sample from the well had gross beta activity exceeding 7,500 pCi/L, which is significantly above the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in Table 1, Tc-99 was detected at very high levels (~20,000 pCi/L) in both of the samples (May and October 2000) analyzed for this beta-emitting radionuclide.

A time-series plot of the gross beta activity in each sample shows a generally increasing trend (Figure 3). This potentially reflects a corresponding increase in the overall flux of Tc-99 within the strike-parallel groundwater flowpaths in the Nolichucky Shale east of the S-3 Ponds. The increasing trend for Tc-99 contrasts with the indeterminate trend for nitrate, which seems unusual considering that both contaminants are stable and highly mobile in the groundwater system. The difference between the concentration trends probably reflect the complex hydrochemical dynamics within the contaminant plume originating from the S-3 Ponds. For example, nitrate concentrations within the plume may be reduced by attenuation processes that do not affect Tc-99. The differing concentration trends also may correspond with differences in the history of nitrate and Tc-99 waste disposal at the former S-3 Ponds. The site regularly received nitrate wastes (via pipeline from process buildings in Y-12), but got only periodic shipments of wastes containing Tc-99. This may have emplaced a series of Tc-99 "slugs" within the more continuous stream of nitric-acid wastes. Thus, the increasing beta activity evident in well GW-109 may reflect a temporal flux increase corresponding to one or more "slugs" of Tc-99 wastes migrating eastward along strike-parallel groundwater flowpaths in the Nolichucky Shale.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Fetter, C.W. 1994. *Applied Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-109: summary of results for nitrate, gross alpha activity, gross beta activity

Sampling Date	Concentration				
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tc-99 (pCi/L)
06/29/95	8,850	0.032	[122]	7,300	.
09/02/99	9,180	0.0169	<MDA	11,000	.
05/25/00	9,090	0.0118	< CE	7,300	21,000
10/19/00	9,520	0.00948	<MDA	7,400	20,000
05/14/03	8,750	0.0174	<MDA	16,000	.
10/06/03	10,400	0.0205	<MDA	19,000	.
MCL	**10**	**0.03**	**15**	**50***	**3,790***

Note: [ ] = Suspected outlier; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-109: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	TCE	MC	Chloroform	Acetone	Bromoform
06/29/95	180	6	35	19	240	8
09/02/99	170	6	15	14	63	4 J
06/08/00	170	5	20	14	90	.
10/19/00	140	4 J	19	12	38	.
05/14/03	160	4 J	22	13	14	3 J
10/06/03	150	3 J	19	13	15	3 J
MCL	**5**	**5**	**5**	**80***	**NA**	**80 ***

Note: "." = Not detected; J = Estimated value below the analytical reporting limit;
NA = Not applicable; * = MCL for total trihalomethanes (chloroform + bromoform)

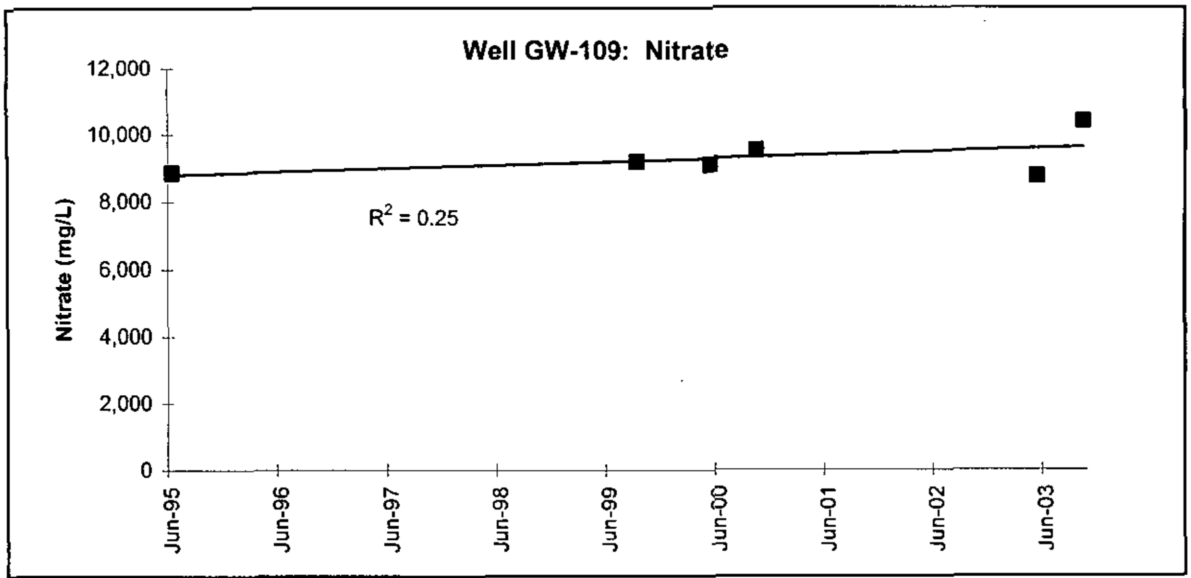


Figure 1

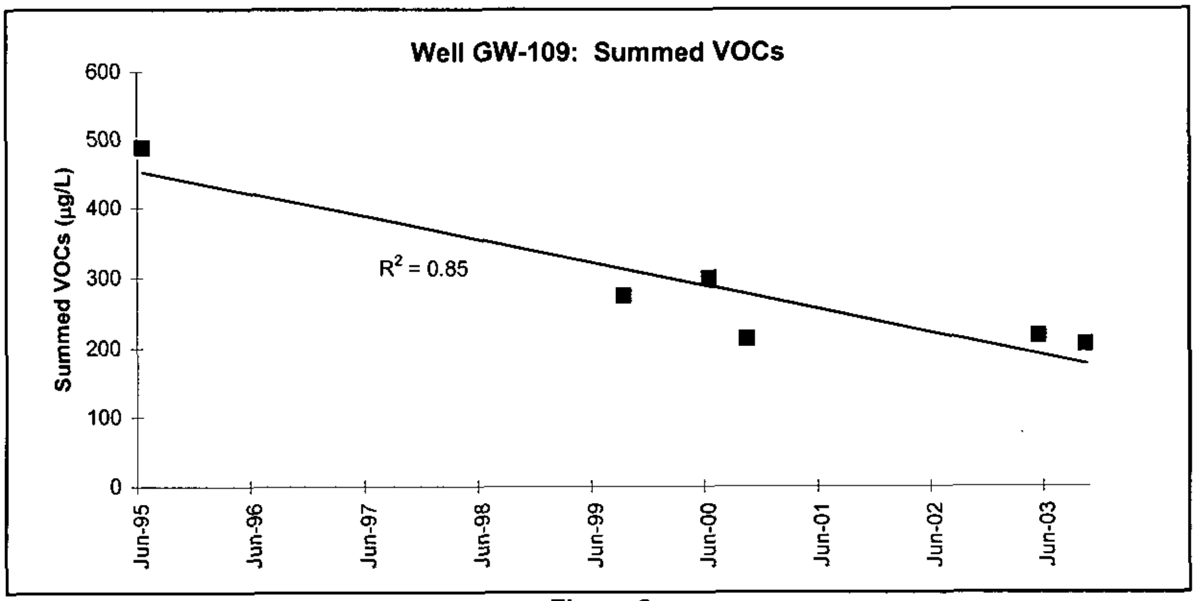


Figure 2

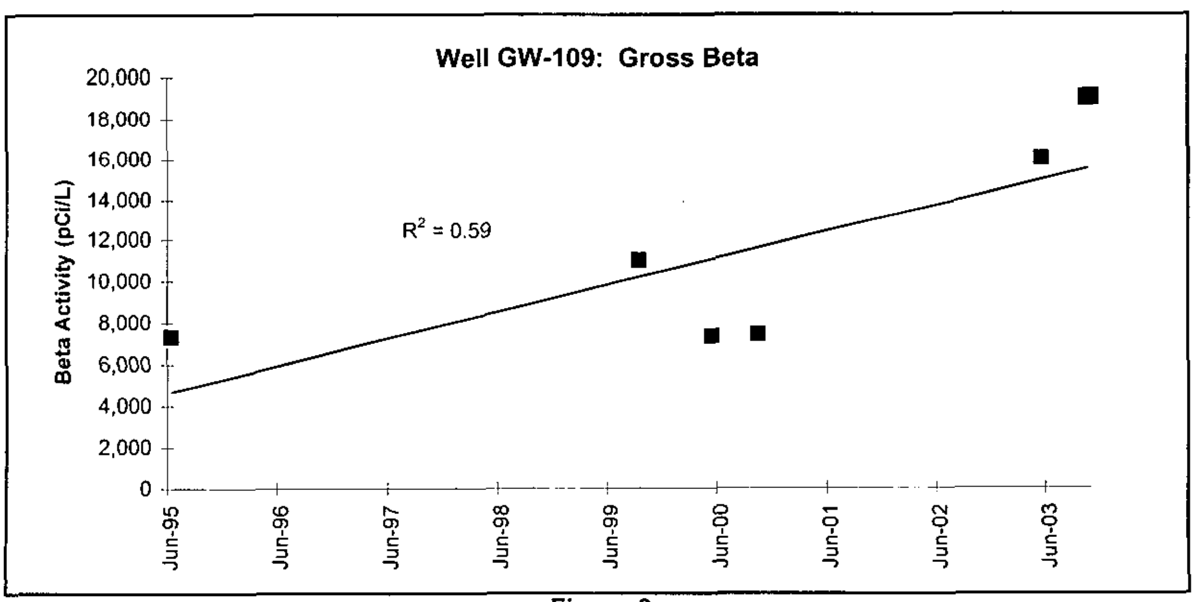


Figure 3

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-115

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,684.99
Y-12 GRID NORTH COORDINATE: 31,073.48
SURFACE ELEVATION: 1,051.92 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/01/84 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 54.49 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,055.01 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	37.6	1014.32
BOTTOM (filter pack or open hole):	53.0	998.92
MIDPOINT (filter pack or open hole):	45.3	1006.62
PUMP INTAKE:	46.91	1005.01
WATER LEVEL (average):	7.35	1044.57

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	52		
CONVENTIONAL SAMPLING METHOD:	38 samples	03/09/87	08/11/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/15/98	01/06/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/06/04	.	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.31 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	2	148 μg/L	07/12/00	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-115

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1984, completed with a screened monitored interval from 37.6 to 53.0 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley north of Bear Creek Valley Road near the west end of Y-12 and is hydraulically upgradient of all known sources of groundwater contamination at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-two groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 38 samples between March 1987 and August 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and January 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits moderate seasonal fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 222 – 391 mg/L;
- pH (field measurements) of 6.2 – 7.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 34 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (1.6 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the analytical reporting limit, and both results (0.001 mg/L in September 1993 and August 1994) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in four groundwater samples: acetone (25 μg/L) in July 1991, MC (2 μg/L) in September 1993, acetone (140 μg/L) and benzene (8 μg/L) in July 2000, and chloromethane (1 μg/L) in July 2001. These results are probably analytical artifacts because the well is located upgradient of all potential sources of VOCS.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.59 pCi/L in July 2003) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Sixteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.3 pCi/L in October 1991) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
100 - 1,000	<0.015	ND	ND	<25

GW-122

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,806.70
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,004.15 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/25/85 PAIRED/CLUSTERED WITH: GW-123
TAG DEPTH (measured): 145.28 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,007.20 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.79 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	92.0	912.15
BOTTOM (filter pack or open hole):	142.0	862.15
MIDPOINT (filter pack or open hole):	117.0	887.15
PUMP INTAKE:	131.9	872.20
WATER LEVEL (average):	11.99	992.16

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	21		
CONVENTIONAL SAMPLING METHOD:	19 samples	12/12/86	04/13/91
LOW-FLOW SAMPLING METHOD:	2 samples	03/30/05	08/24/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/30/05	.	08/24/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.78 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	3	667 mg/L	01/12/91	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-122

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1985, completed with an open-hole monitored interval from 92 to 142 ft bgs, and constructed with nominal 4.5-inch diameter steel (SF25) riser casing. The well is paired with deeper well GW-123 (572 ft bgs), and is located in Bear Creek Valley (BCV) approximately 400 ft southwest of the former S-3 Ponds. Located near the western end of Y-12 and north of the headwaters of Bear Creek, the S-3 Ponds consist of four contiguous, unlined surface impoundments that were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in accordance with applicable RCRA regulations in 1988. Closure included removal of liquid wastes and stabilization of sludge remaining in each pond, which were then filled and covered with a multilayer low-permeability cap and completed with an asphalt-paved parking lot in 1989. Historical operation of the S-3 Ponds created a large mound in the water table that dissipated after the site was closed and capped, and emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between December 1986 and April 1991, and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes a quarterly sampling frequency followed by a 14-year period (April 1991 – March 2005) when no samples were collected from the well.

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and are a direct consequence of contamination associated with historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100-300 ft bgs) bedrock interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º - 55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. (Note that the well is located within the outcrop area of the Maynardville Limestone). The bulk of the groundwater flow in the Nolichucky Shale occurs in a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock). Also, the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the formation from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 12 ft bgs and exhibits maximum seasonal fluctuations less than 10 ft. The direction of groundwater flow near the well, as indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, is primarily westward, parallel with geologic strike (i.e., bedding-plane fractures) in the Nolichucky Shale.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields highly mineralized, nitrate-contaminated, sodium- and chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,990 – 4,836 mg/L;
- pH (field measurements) of 6.42 – 6.8;
- high concentrations of nitrate (>200 mg/L), sodium (>95 mg/L), and chloride (>85 mg/L);
- low molar proportions of potassium and sulfate (<5% of total anions/cations);
- elevated concentrations of barium (>2 mg/L), boron (>0.4 mg/L), and strontium (>10 mg/L); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of the carbonate bedrock underlying the former S-3 Ponds by the many years of acidic seepage from the site, in addition to inorganic constituents entrained in the wastes disposed at the site, accounts for the TDS and extremely high concentrations of some trace metals, particularly barium and strontium, in the groundwater at this well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected to date, nitrate is the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eighteen of the groundwater samples collected to date were analyzed for nitrate (Table 1) and all of these results exceed the drinking water MCL for nitrate (10 mg/L). The elevated nitrate concentrations indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Nitrate is a primary component of the contaminant plume, is chemically stable and highly mobile in groundwater, and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Additionally, the greater density of the highly mineralized acidic wastewater disposed at the site promoted density-driven vertical migration via strike- and dip-parallel flowpaths in the Nolichucky Shale.

As noted previously, all of the groundwater samples had nitrate concentrations above the MCL, with the historical maximum concentration (1,400 mg/L) reported for the sample collected in November 1988 (Table 1). However, this result is considered qualitative because the ion charge-balance error calculated for the sample (-25.2%), which expresses the percent difference between the summed millequivalent concentrations of primary anions and cations in the groundwater, exceeds the DQO (+/-20%). Similarly, the historical minimum nitrate concentration (210 mg/L in April 1991) also is qualitative because of the charge balance error (38.7%). Charge balance errors for both samples are probably related to the nitrate concentrations.

Nitrate results reported for the groundwater samples collected before April 1991 range from 600 to 1,000 mg/L, but the most recent results are significantly lower (Table 1). A time-series plot of the nitrate results (excluding the qualitative results described above) shows a clearly decreasing long-term concentration trend dominated by wide short-term fluctuations (Figure 1). The overall decrease from the nitrate concentrations evident in groundwater samples collected from the well during the late-1980s reflects the substantially reduced flux of nitrate in the Nolichucky Shale in response to the closure of the former S-3 Ponds in 1988 and installation of the low-permeability cap at the site in 1989.

5.2 URANIUM

Thirteen groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the highest value (0.012 mg/L in November 1988) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results (available since January 1991) and low levels (<10 µg/L) of several common laboratory reagents (e.g., chloroform, MC, toluene, xylene, and acetone) that were detected in samples collected before December 1989, a trace of PCE was detected in one sample from the well (1 µg/L in January 1991). However, no VOCs were detected in the samples collected in March and August 2005.

5.4 GROSS ALPHA ACTIVITY

Two of the eight groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (12.18 pCi/L in July 1990) being below the MCL for gross alpha activity (15 pCi/L). None of the samples collected since July 1990 had gross alpha activity above the applicable MDA and/or CE.

5.5 GROSS BETA ACTIVITY

Four of the eight groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE, including one value (53.65 pCi/L in January 1990) exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The most recent results show that gross beta levels are substantially below the screening level (16 pCi/L in March 2005 and <MDA in August 2005).

6.0 REFERENCES

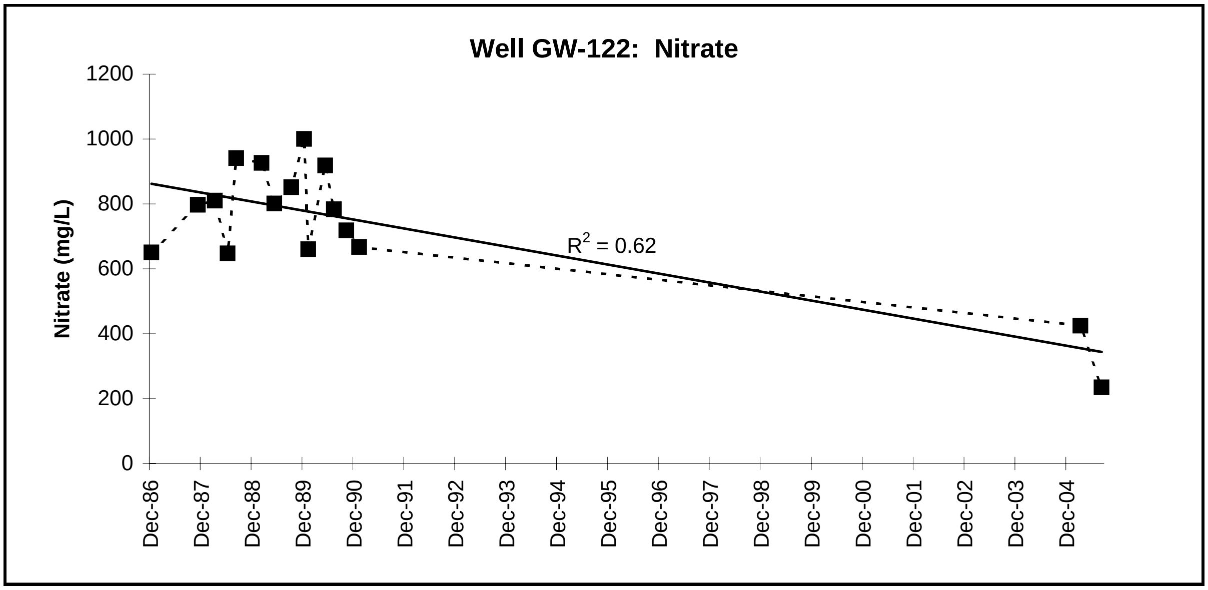
HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-122: summary of results for nitrate and total uranium

Sampling Date	Nitrate (mg/L)	Total Uranium (mg/L)
12/12/86	650	0.001
03/09/87	.	0.005
06/15/87	.	0.003
10/05/87	.	0.004
11/20/87	797	<0.001
03/29/88	810	<0.001
06/20/88	647	0.001
08/29/88	941	<0.001
11/04/88	[1,440]	0.012
02/22/89	926	<0.001
05/17/89	801	<0.001
09/14/89	851	<0.001
12/06/89	1,000	<0.001
01/16/90	660	<0.001
05/16/90	918	0.001
07/30/90	783	0.001
10/15/90	718	0.001
01/12/91	667	0.001
04/13/91	[210]	0.001
03/30/05	425	0.00132
08/24/05	234	0.00152
MCL	**10**	**0.03**

Note: "." = Not analyzed; [ ] = Result considered qualitative because of ion charge balance



Well GW-122: Nitrate
Nitrate (mg/L)
1200
1000
800
600
400
200
0
R2 = 0.62
Dec-86
Dec-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04

Figure 1

MAXIMUM CONCENTRATION: 2003

ND	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-123

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,794.20
Y-12 GRID NORTH COORDINATE: 29,741.70
SURFACE ELEVATION: 1,004.43 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/25/85 PAIRED/CLUSTERED WITH: GW-122
TAG DEPTH (measured): 574.79 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,007.45 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	522.0	482.43
BOTTOM (filter pack or open hole):	572.0	432.43
MIDPOINT (filter pack or open hole):	547	457.43
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	17.61	986.82

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	23 samples	12/23/86	09/08/92
LOW-FLOW SAMPLING METHOD:	2 samples	02/03/03	08/04/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	02/03/03	.	08/04/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 55.48 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	37 µg/L	03/23/92	Indeterminate
GROSS ALPHA (15 pCi/L):	1	21.5 pCi/L	03/23/92	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-123

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1985, completed with an open-hole monitored interval from 522 to 572 ft bgs, and constructed with 4.5-inch diameter steel riser casing. The well forms a cluster with well GW-122 and is located in Bear Creek Valley west of Y-12, about 500 ft southwest (hydraulically downgradient) of the former S-3 Ponds, which are a major source of groundwater contamination in Bear Creek Valley. Located at the headwaters of Bear Creek, the S-3 Ponds consisted of four unlined surface impoundments, each with a 2.5 million gallon capacity, that were used between 1951 and 1984 for the disposal of acidic, radioactive liquid wastes generated primarily at Y-12. The S-3 Ponds were covered with a multi-layer, low permeability cap (including asphalt paving) during RCRA closure of the site in 1988.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 23 samples between December 1986 and September 1992, and the low-flow sampling method used to obtain samples in February and August 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (>400 ft bgs) in the Conasauga Group (Nolichucky Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 18 ft bgs and exhibits unusually wide (>50 ft) fluctuations. Excluding the very low groundwater elevations evident in May 1991 (949.45 ft above msl) and May 1992 (950.45 ft above msl), however, groundwater elevations in the well have fluctuated less than 15 ft (Figure 1).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sodium-chloride-bicarbonate groundwater generally characterized by:

- high TDS (>800 mg/L);
- pH (field measurements) of 6.2 – 10.8;
- low molar proportions of calcium, magnesium, potassium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for nine groundwater samples collected from the well since January 1991.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for seven groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime. A trace concentration (0.5 μg/L) of benzene was detected in the samples collected in July 1991 and October 1991, with a similar concentration of toluene (0.9 μg/L) also reported for the sample collected in July 1991. Toluene also was detected in October 1991 but this result is a false positive.

5.4 GROSS ALPHA ACTIVITY

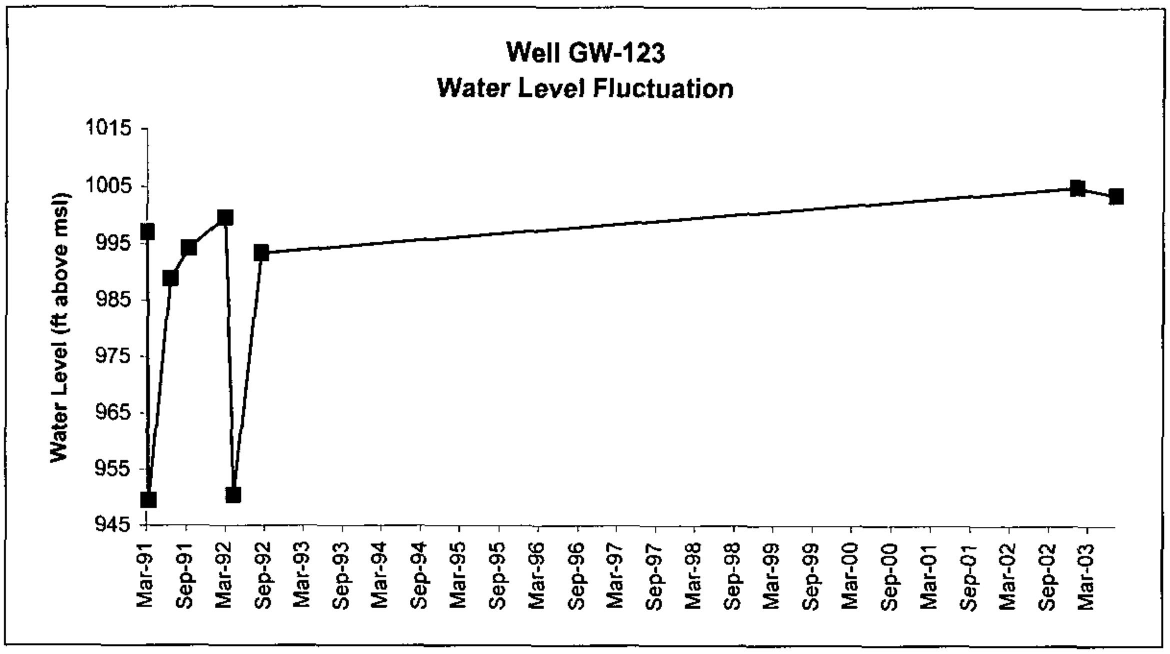
Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater samples collected in March 1992 (21.5 pCi/L) and October 2001 (1.41 pCi/L). Accurate measurement of gross alpha activity may be limited by the high level of TDS in the groundwater samples from this well.

5.5 GROSS BETA ACTIVITY

Six of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE. These results show gross beta activity near 10 pCi/L through each quarter of 1991, followed by a sharp spike in March 1992 (36.1 pCi/L) and subsequent a decrease below the MDA in February and August 2003. Accurate measurement of gross beta activity may be limited by the high level of TDS in the groundwater samples from this well.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.



Well GW-123
Water Level Fluctuation
Water Level (ft above msl)
1015
1005
995
985
975
965
955
945
Mar-91
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	<0.015	ND	7.5 - 15	50 - 500

GW-124

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,223.20
Y-12 GRID NORTH COORDINATE: 29,655.70
SURFACE ELEVATION: 1,003.98 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/23/85 PAIRED/CLUSTERED WITH: GW-125
TAG DEPTH (measured): 153.44 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,006.85 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	100.0	903.98
BOTTOM (filter pack or open hole):	150.0	853.98
MIDPOINT (filter pack or open hole):	125.0	878.98
PUMP INTAKE:	144.9	859.06
WATER LEVEL (average):	15.45	988.61

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	15 samples	12/06/86	09/16/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/19/01	08/23/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/23/05	.	08/23/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.06 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	5	51 mg/L	09/16/95	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	4	177 pCi/L	09/16/95	Decreasing

WELL GW-124

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1985 and was completed with an open-hole monitored interval from 100 to 150 ft bgs and nominal 4.5-inch diameter steel (SF25) riser casing. The well is paired with deep well GW-125 (552 ft bgs), and is located in Bear Creek Valley (BCV) west of Y-12, approximately 400 ft south of the former S-3 Ponds. Located near the western end of Y-12 and north of the headwaters of Bear Creek, the S-3 Ponds consist of four contiguous, unlined surface impoundments that were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in accordance with applicable RCRA regulations in 1988. Closure included removal of liquid wastes and stabilization of sludge remaining in each pond, which were then filled and covered with a multilayer low-permeability cap and completed with an asphalt-paved parking lot in 1989. Historical operation of the S-3 Ponds created a large mound in the water table that dissipated after the site was closed and capped, and emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between December 1986 and September 1995, and the low-flow sampling method used to obtain four samples between March 2001 and August 2005. The sampling history includes a quarterly sampling frequency followed by 6-year (September 1995 – March 2001) and 4-year (August 2001 – March 2005) periods when no samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100-300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of approximately 15.5 ft bgs and exhibits seasonal fluctuations up to 8 ft. Directions of groundwater flow near the well, as indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, are primarily westward, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 530 – 1,786 mg/L;
- pH (field measurements) of 6.4 – 6.97;
- elevated concentrations of sulfate (>60 mg/L), chloride (>30 mg/L), and nitrate (>10 mg/L) relative to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of sodium & potassium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of the carbonate bedrock underlying the former S-3 Ponds by the many years of acidic seepage from the site, in addition to inorganic constituents entrained in the wastes disposed at the site, accounts for the TDS and elevated concentrations of inorganic compounds (e.g., nitrate) in the groundwater at this well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected to date, nitrate and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Sixteen of the groundwater samples collected to date were analyzed for nitrate (Table 1), and all of these results show nitrate concentrations above the drinking water MCL (10 mg/L). The elevated nitrate concentrations indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants emplaced during historical operation of the former S-3 Ponds. Nitrate is a primary component of the contaminant plume, is chemically stable and highly mobile in groundwater, and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Nitrate probably enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997).

As noted previously, all of the groundwater samples had nitrate concentrations above the MCL, with the highest concentration (1,510 mg/L) reported for the sample collected in June 1988 (Table 1). However, this result is considered qualitative because the ion charge-balance error calculated for the sample (-62.6%), as expressed by the percent difference between the summed millequivalent concentrations of primary anions and cations in the groundwater, exceeds the DQO (+/-20%) for the Y-12 GWPP. Similarly, two unusually low nitrate concentrations (26 mg/L in November 1988 and 17 mg/L in March 1989) also are qualitative because of the ion charge balance errors (54.1% and 37.4%, respectively).

A time-series plot of the nitrate concentrations (excluding the qualitative results described above) shows a generally decreasing long-term concentration trend which began abruptly after the sample collected in August 1988 (Figure 1). The overall decrease from the nitrate concentrations evident in the late-1980s undoubtedly reflects the substantially reduced flux of nitrate in the

Maynardville Limestone in response to the closure of the former S-3 Ponds in 1988 and installation of the low-permeability cap at the site in 1989.

5.2 URANIUM

Eighteen groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the highest value (0.008 mg/L in December 1986) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive VOC results and low levels (<10 µg/L) of several common laboratory reagents (e.g., chloroform, MC, toluene, xylene, and acetone) detected in a few groundwater samples collected before March 1989, one or more of the following VOCs were detected in all but three of the samples collected to date: PCE, TCE, 12DCE, and/or chloroform (Table 2). These VOCs are confirmed components of the contaminant plume emplaced during historical operation of the former S-3 Ponds, but are typically present in the groundwater at substantially lower concentrations compared to other components of the plume (e.g., nitrate). This is because wastewaters that contained chlorinated solvents and other organic chemicals were not extensively disposed at the site (DOE 1997).

Based on concentration levels, the primary compounds in groundwater at this well are PCE and TCE (Table 2). The historical maximum value for PCE (21 µg/L in June 1987) and TCE (12 µg/L in October and November 1987) exceed the respective drinking water MCL (5 µg/L for both). Only PCE has been detected at a very low level (2 µg/L) since September 1995, and no VOCs were detected in the samples collected most recently (March and August 2005). The present lack of VOCs in the groundwater at this well generally mirrors the sharply reduced levels of nitrate in the well and likewise reflect the substantially reduced flux of VOCs (and other similarly mobile contaminants) via the groundwater flow/transport pathways intercepted by the monitored interval in the well as a direct consequence of closure of the former S-3 Ponds in 1988 and installation of the low-permeability cap at the site in 1989.

5.4 GROSS ALPHA ACTIVITY

Three of the six groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the highest value (8.17 pCi/L in January 1990) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE (Table 1). Additionally, all but one result exceeds the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is most likely Tc-99, which was detected in the groundwater samples collected in March 2005 (61 pCi/L) and August 2005 (82 pCi/L). Note that Tc-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate, which reflects their common source and their similar transport characteristics in the groundwater.

A time-series plot of the results for gross beta activity obtained since January 1990 shows a decreasing long-term trend (Figure 2). As with nitrate and VOC concentrations, this decreasing beta activity trend probably reflects the substantially reduced flux of Tc-99 in the Maynardville Limestone in response to the closure of the former S-3 Ponds in 1988 and installation of the low-permeability cap at the site in 1989.

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-124: summary of results for nitrate, total uranium, gross alpha, and gross beta

Sampling Date	Nitrate (mg/L)	Total Uranium (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
12/06/86	343	0.008	DQO	DQO
03/19/87	.	0.007	DQO	DQO
06/16/87	.	0.003	DQO	DQO
10/01/87	.	<0.001	DQO	DQO
11/16/87	346	0.006	DQO	DQO
03/30/88	335	0.005	DQO	DQO
06/21/88	[1,510]	0.003	DQO	DQO
08/27/88	339	0.006	DQO	DQO
11/05/88	[26]	0.004	DQO	DQO
03/06/89	[17]	0.001	DQO	DQO
05/15/89	176	0.006	DQO	DQO
09/05/89	212	0.006	DQO	DQO
12/05/89	184	0.005	DQO	DQO
01/15/90	160	0.002	8.17	556.37
09/16/95	51	0.0038	<CE	177
03/19/01	12.5	0.00534	<MDA	64
08/09/01	25.6	0.0048	7.5	110
03/23/05	11.9	0.00443	8.1	47
08/23/05	17.5	0.00448	<MDA	61
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not analyzed; [ ] = result considered qualitative because of charge balance; DQO = result does not meet data quality objectives; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent

Table 2. Well GW-124: summary of VOC results

Sampling Date	VOC (µg/L)			
	PCE	**TCE**	**12DCE**	**Chloroform**
12/06/86	8	7	.	.
03/19/87	13	7	5	2 J
06/16/87	21	10	10	5
10/01/87	18	12	7	6
11/16/87	19	12	13	3 J
03/30/88	14	8	6	3 J
06/21/88	17	9	8	3 J
08/27/88	17	9	.	3 J
11/05/88	20	10	7	3 J
03/06/89	14	5	4 J	2 J
05/15/89	16	7	.	2 J
09/05/89	19	9	7	2 J
12/05/89	17	7	9	2 J
01/15/90	15	6	7	2 J
09/16/95	1 J	.	.	1 J
03/19/01	.	.	.	.
08/09/01	2 J	.	.	.
03/23/05	.	.	.	.
08/23/05	.	.	.	.
MCL	**5**	**5**	**NA**	**80***

Sampling Date	OTHER COMPOUNDS
03/19/87	Acetone (8), Methylene chloride (2 J), Toluene (1 J), 111TCA (1 J)
06/16/87	Acetone (4 J), Toluene (1 J), Xylenes (1 J)
10/01/87	Methylene chloride (1 J), Toluene (1 J), 111TCA (2 J)
06/21/88	Methylene chloride (2 J)
08/27/88	Vinyl acetate (1 J)
03/06/89	Toluene (0.3 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
NR = Not reported, * MCL is for total trihalomethanes

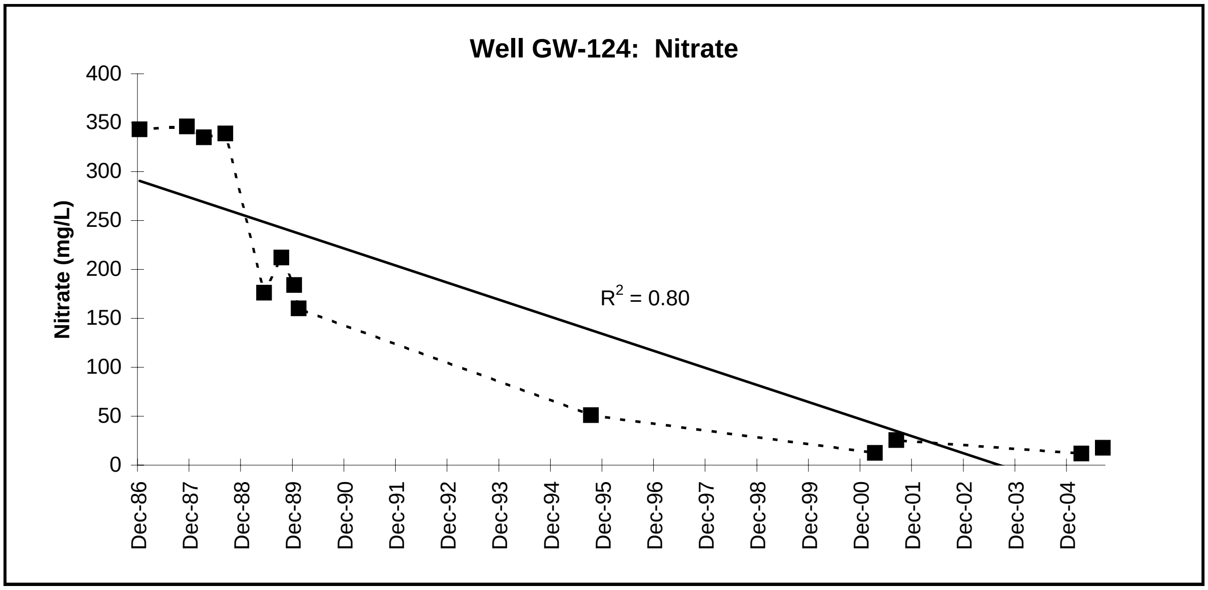


Figure 1

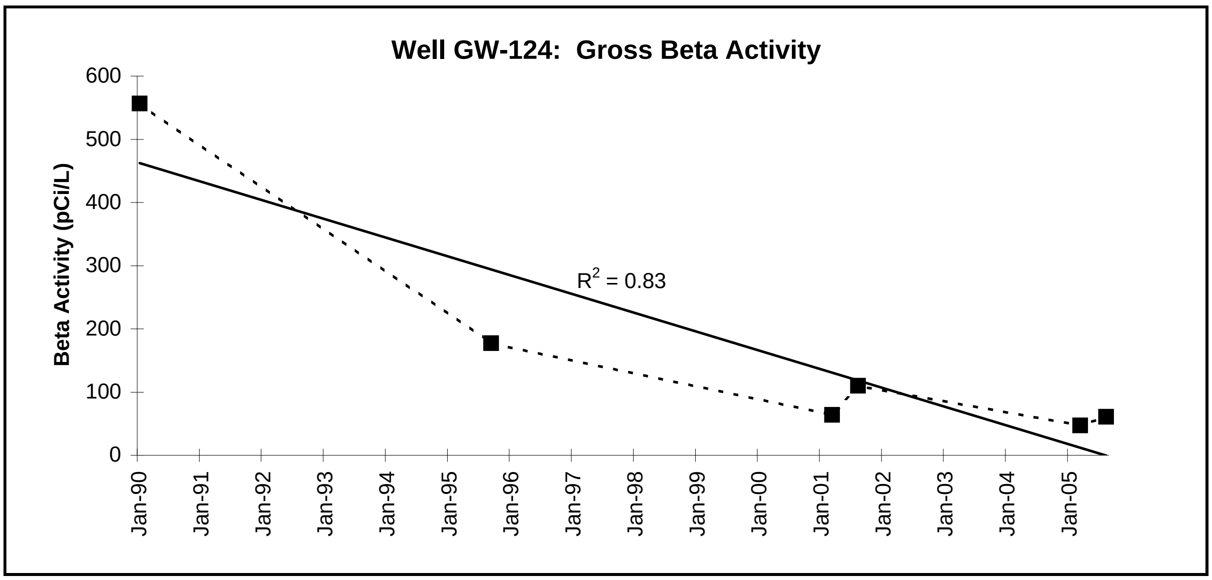


Figure 2

MAXIMUM CONCENTRATION: 2005

<5	0.015 - 0.03	ND	7.5 - 15	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-127

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,828.00
Y-12 GRID NORTH COORDINATE: 29,850.00
SURFACE ELEVATION: 1,003.67 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 26.52 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.90 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.5 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	14.0	989.67
BOTTOM (filter pack or open hole):	24.0	979.67
MIDPOINT (filter pack or open hole):	19.0	984.67
PUMP INTAKE:	22.3	981.40
WATER LEVEL (average):	13.31	990.37

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	12		
CONVENTIONAL SAMPLING METHOD:	10 samples	12/12/86	01/18/90
LOW-FLOW SAMPLING METHOD:	2 samples	06/22/05	10/24/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/22/05	.	10/24/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.61 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-127

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed with a screened monitored interval from 14 to 24 ft bgs, and constructed with nominal 2-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located in Bear Creek Valley (BCV) west of Y-12, approximately 300 ft west-southwest of the former S-3 Ponds and 100 ft north of the main channel of Bear Creek. Located near the western end of Y-12 and north of the headwaters of Bear Creek, the S-3 Ponds consist of four contiguous, unlined surface impoundments that were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in accordance with applicable RCRA regulations in 1988. Closure included removal of liquid wastes and stabilization of sludge remaining in each pond, which were then filled and covered with a multilayer low-permeability cap and completed with an asphalt-paved parking lot in 1989. Historical operation of the S-3 Ponds created a large mound in the water table that dissipated after the site was closed and capped, and emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twelve groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 10 samples between December 1986 and January 1990, and the low-flow sampling method used to obtain two samples between June and October 2005. The sampling history includes a quarterly sampling frequency followed by a 15-year period (January 1990 – June 2005); when no groundwater samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º-55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for contaminant migration in BCV. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Moreover, the highly acidic wastes from the former S-3 Ponds dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 13 ft bgs and exhibits minor (<3 ft) seasonal fluctuations. Directions of groundwater flow near the well, as indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, indicate components of flow to the west, parallel with the trend (strike) of bedding in Nolichucky Shale, and to the south-south west, across geologic-strike toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic flow via strike-parallel flowpaths (i.e., bedding-plane fractures) oriented in directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths, and dissolution of carbonate strata by the acidic seepage locally enhanced strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater that is generally characterized by:

- TDS of 521 –932 mg/L;
- pH (field measurements) of 6.58 – 7.1;
- high concentrations of sodium (>40 mg/L), chloride (>30 mg/L), and sulfate (>50 mg/L);
- low concentrations of potassium (below detection limits); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants have been present in the groundwater at this well, but none have been detected at levels that exceed drinking water MCLs in samples collected since January 1990.

5.1 NITRATE

Eleven groundwater samples collected to date had nitrate concentrations at or above the applicable reporting limit (Table 1), including three samples with concentrations that exceed the drinking water MCL for nitrate (10 mg/L). The historical maximum nitrate concentration (63.4 mg/L) was reported for the sample collected in December 1986, with lower levels (<15 mg/L) reported for all subsequent samples. Moreover, nitrate concentrations have been below the MCL in the all of the samples collected since August 1988, and the nitrate was not detected (i.e., <0.028 mg/L reporting limit) in the sample collected most recently (October 2005). Considering that the well is only 300 ft from the former S-3 Ponds, where nitrate concentrations in the shallow groundwater exceed 1,000 mg/L, the relatively low nitrate concentrations in the well suggest that the monitored interval does not intercept groundwater flow/transport pathways that are extensively connected with the contaminant plume emplaced during historical operation of the site. Nitrate is a principal component of the plume, is stable and highly mobile in groundwater, and is believed to effectively trace the primary flowpaths for other similarly mobile components from the former S-3 Ponds. Thus, the present lack of nitrate in the groundwater from this well mirrors the substantially reduced flux of nitrate (and other similarly mobile contaminants) that occurred in the shallow groundwater flow system after the site was closed and capped in the late 1980s.

5.2 URANIUM

All groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), including 10 concentrations that exceeded the MCL for uranium (0.03 mg/L). The historical maximum uranium concentration (0.885 mg/L) was reported for the sample collected in December 1986. Uranium concentrations decreased by about 50% from December 1986 through January 1990 (0.434 mg/L), and are below the MCL in June and October 2005 (Table 1). As with the nitrate concentrations in the groundwater from the well, the elevated uranium levels indicated by the historical sampling results suggest that the monitored interval for the well intercepts the groundwater flow/transport pathways that are hydraulically connected with the contaminant plume emplace during historical operation of the former S-3 Ponds. Uranium was entrained in the nitric-acid wastes disposed at the site and is a primary component of the plume. In the acidic groundwater nearest the site, uranium is probably present as uranyl cations, which are prone to pH sensitive sorption reactions (Fetter 1993). Considering that the infiltration of acidic wastes was discontinued in 1984 and the site has been covered by a low-permeability cap since 1989, subsequent recharge/discharge cycles have substantially buffered the acidic pH of the groundwater such that the more neutral pH now evident in the well promotes attenuation (sorption) of the uranyl cations. Additionally, as with nitrate, the closure and capping of the former S-3 Ponds substantially reduced the relative flux of uranium in the shallow groundwater flow system downgradient of the site.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results (screened in samples collected since January 1991) and very low levels (<5 µg/L) of several common laboratory reagents (e.g., acetone) detected in samples collected before May 1989, two VOCs (PCE and chloroform) have been detected in at least three samples collected from the well to date (Table 2). Both of these VOCs are minor components of the contaminant plume originating from the former S-3 Ponds. Compared to the inorganic components of the plume, particularly nitrate, VOCs are present at substantially lower concentrations, primarily because the related wastes (e.g., chlorinated solvents) were not extensively disposed at the former S-3 Ponds (DOE 1997).

The historical maximum value for PCE (42 µg/L in August 1988) exceeds the drinking water MCL (5 µg/L), but only trace levels (3 µg/L or less) were detected in subsequent samples (March, May, and December 1999, and January 1990). Moreover, no VOCs were detected in the samples collected in June and October 2005. The lack of VOCs in the groundwater from the well again reflects the substantially reduced flux of contaminants in the shallow groundwater flow system that occurred after the former S-3 Ponds were closed and capped.

5.4 GROSS ALPHA ACTIVITY

All three of the groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE (Table 1), including one concentration (267 pCi/L in January 1990) that exceeded the MCL for gross alpha activity (15 pCi/L). No gross alpha activity has been detected at concentrations that exceeded the MCL since January 1990, which is supported by the isotopic uranium results reported for the samples collected in June and October 2005, which show low levels (<10 pCi/L) of U-234 and U-238 (Table 1).

5.5 GROSS BETA ACTIVITY

Two of the three groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE (Table 1), including one value (308 pCi/L in January 1990) exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The groundwater samples collected in June and October 2005 had gross beta activity below the SDWA screening level. Also, radiological analyses of the samples collected in June and October 2005 suggests that the source of the gross beta activity may be Tc-99 (Table 1), a beta-particle emitting radionuclide that is a principal component of the contaminant plume from the former S-3 Ponds.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant*, *Oak Ridge*, *Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-127: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	**Total Uranium**	**Gross Alpha**	**Gross Beta**	**Tc-99**	**U-234**	**U-238**
12/12/86	63.4	0.885	DQO	DQO	.	.	.
04/05/88	14.3	0.72	DQO	DQO	.	.	.
06/14/88	9.1	0.368	DQO	DQO	.	.	.
08/27/88	12	0.447	DQO	DQO	.	.	.
11/07/88	9.4	0.002	DQO	DQO	.	.	.
03/03/89	6	0.44	DQO	DQO	.	.	.
05/16/89	5	0.517	DQO	DQO	.	.	.
09/13/89	7	0.593	DQO	DQO	.	.	.
12/05/89	7	0.417	DQO	DQO	.	.	.
01/18/90	6	0.434	267	308	.	.	.
06/22/05	0.136	0.0299	12	<MDA	<MDA	4.7	8.1
10/24/05	<0.028	0.0196	7.8	15	24	3.9	5.3
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: "." = Not analyzed; DQO = result does not meet data quality objectives; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	<5	ND	ND

GW-133-01

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 01 Port Depth : 552 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	08/16/99	08/23/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/23/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 01

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 01 being 552 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 01 yields groundwater from the deep bedrock (Rogersville Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Rogersville Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 01 yields highly mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 1,120 – 1,190 mg/L;
- pH (field measurements) of 7.67 – 8.09;
- fluoride concentrations near 5 mg/L (e.g., 4.91 mg/L in August 2004);

- low molar proportions of calcium, chloride, magnesium, potassium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Rogersville Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

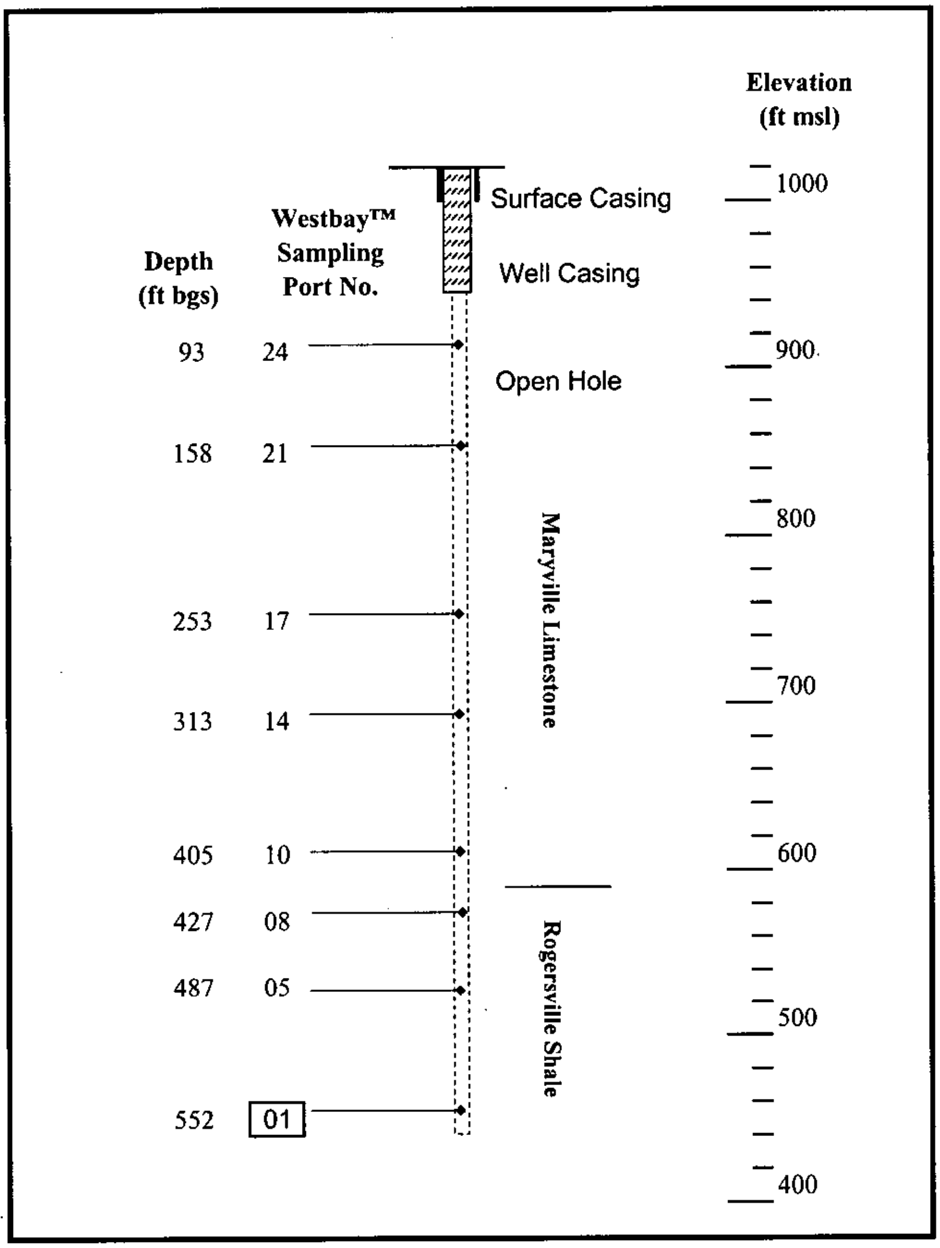

Elevation
(ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™
Sampling
Port No.
Depth
(ft bgs)
93
24
158
21
253
17
313
14
405
10
427
08
487
05
552
01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-133-05

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 05 Port Depth : 487 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/17/99	08/23/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/23/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 05

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 05 being 487 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 05 yields groundwater from the deep bedrock (Rogersville Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Rogersville Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 05 yields mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 657 – 664 mg/L;
- pH (field measurements) of 8.47 – 8.69;
- fluoride concentrations above 2 mg/L (e.g., 2.16 mg/L in August 2004);
- low molar proportions of calcium, chloride, magnesium, potassium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Rogersville Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

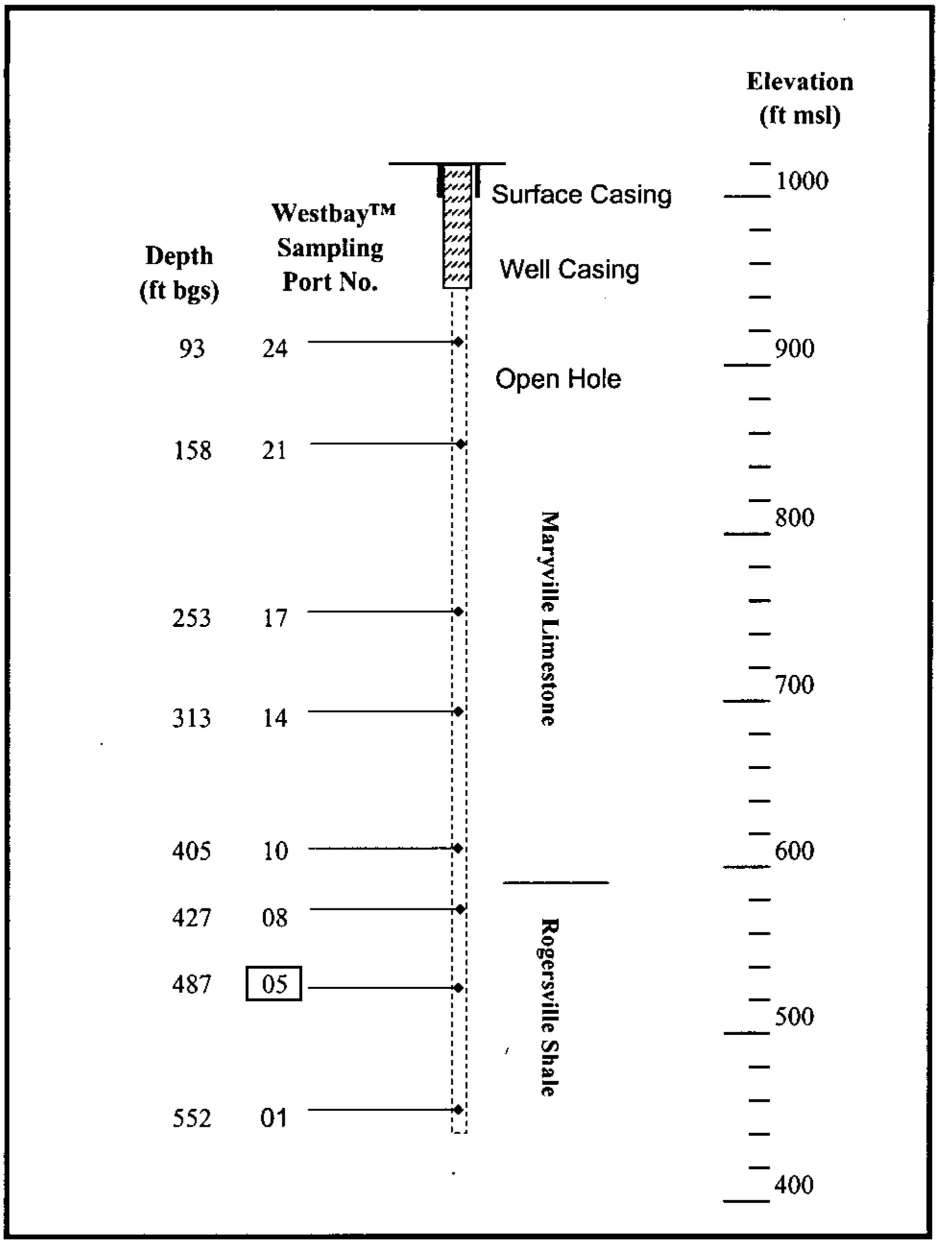

Elevation (ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Depth (ft bgs)
Westbay™ Sampling Port No.
93
24
158
21
253
17
313
14
405
10
427
08
487
05
552
01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-08

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 08 Port Depth : 427 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/17/99	08/23/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	.	08/23/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	13 μg/L	08/17/99	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 08

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 08 being 427 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 08 yields groundwater from the deep bedrock (Rogersville Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Rogersville Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 08 yields mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 551 – 555 mg/L;
- pH (field measurements) of 8.11 – 8.51;
- low molar proportions of calcium, chloride, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Rogersville Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Low concentrations of the following petroleum hydrocarbons were detected in the groundwater sample collected in August 1999: ethylbenzene (8 μg/L), toluene (2 μg/L), and styrene (3 μg/L). The well is hydraulically upgradient of all known sources of groundwater contamination located near the west end of Y-12, including contamination attributed to historical leaks of petroleum fuel from underground storage tanks formerly located at the Rust Garage Area southeast of the well. It is possible that the presence of these VOCs in the groundwater sample reflects the localized, residual contamination associated in some way with the drilling of the original core hole in which the well was constructed. These compounds were not detected in the August 2004 sample from the port.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

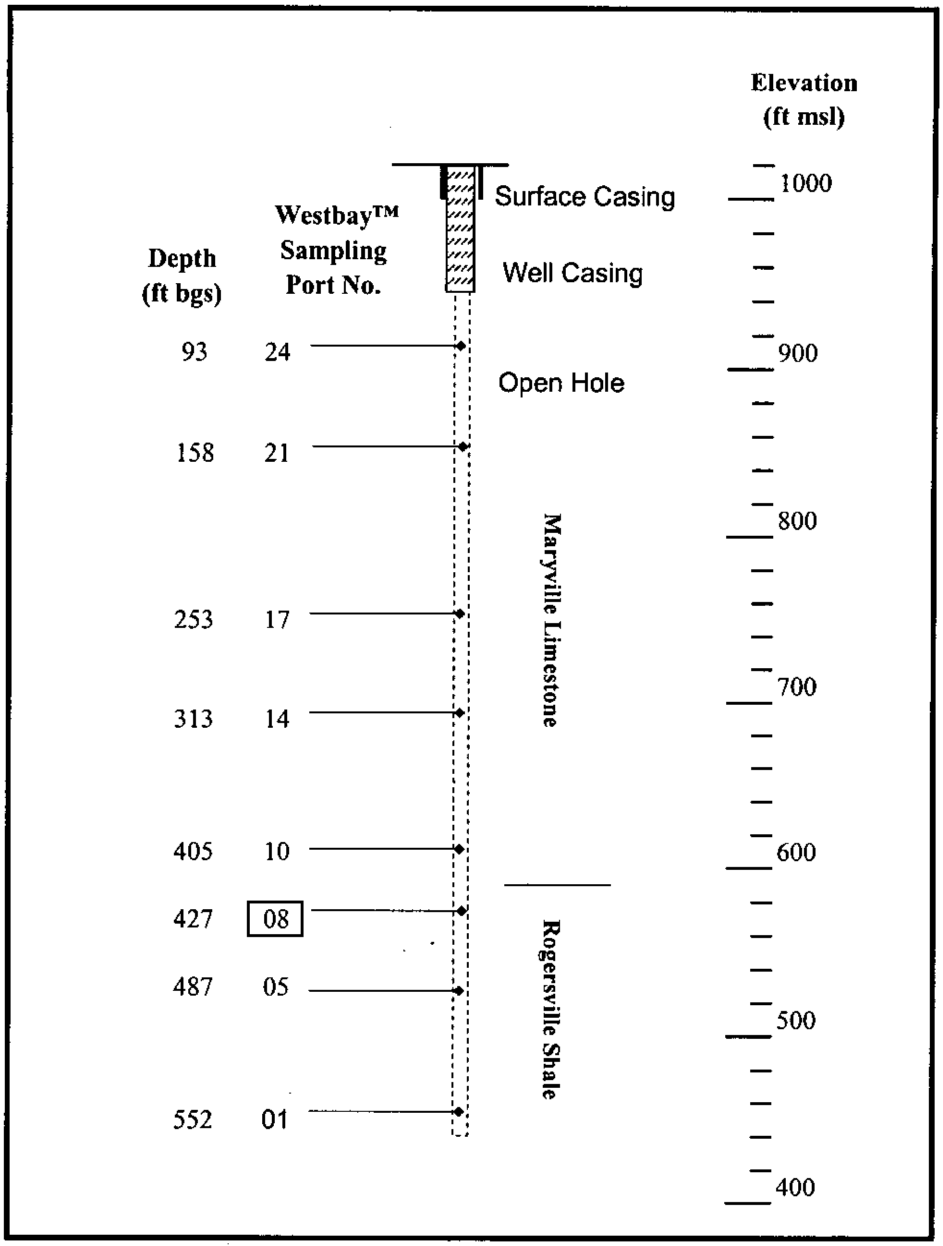
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Elevation (ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Depth (ft bgs)
Westbay™ Sampling Port No.
93 24
158 21
253 17
313 14
405 10
427 08
487 05
552 01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-10

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 10 Port Depth : 405 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/18/99	08/24/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/24/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 10

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 10 being 405 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 10 yields groundwater from the deep bedrock (Rogersville Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Rogersville Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 10 yields mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 658 – 717 mg/L;
- pH (field measurements) of 8.18 – 8.44;
- fluoride concentrations above 2 mg/L (e.g., 2.78 mg/L in August 2004);
- low molar proportions of calcium, chloride, magnesium, potassium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA, which is consistent with the gross beta result for this sample.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

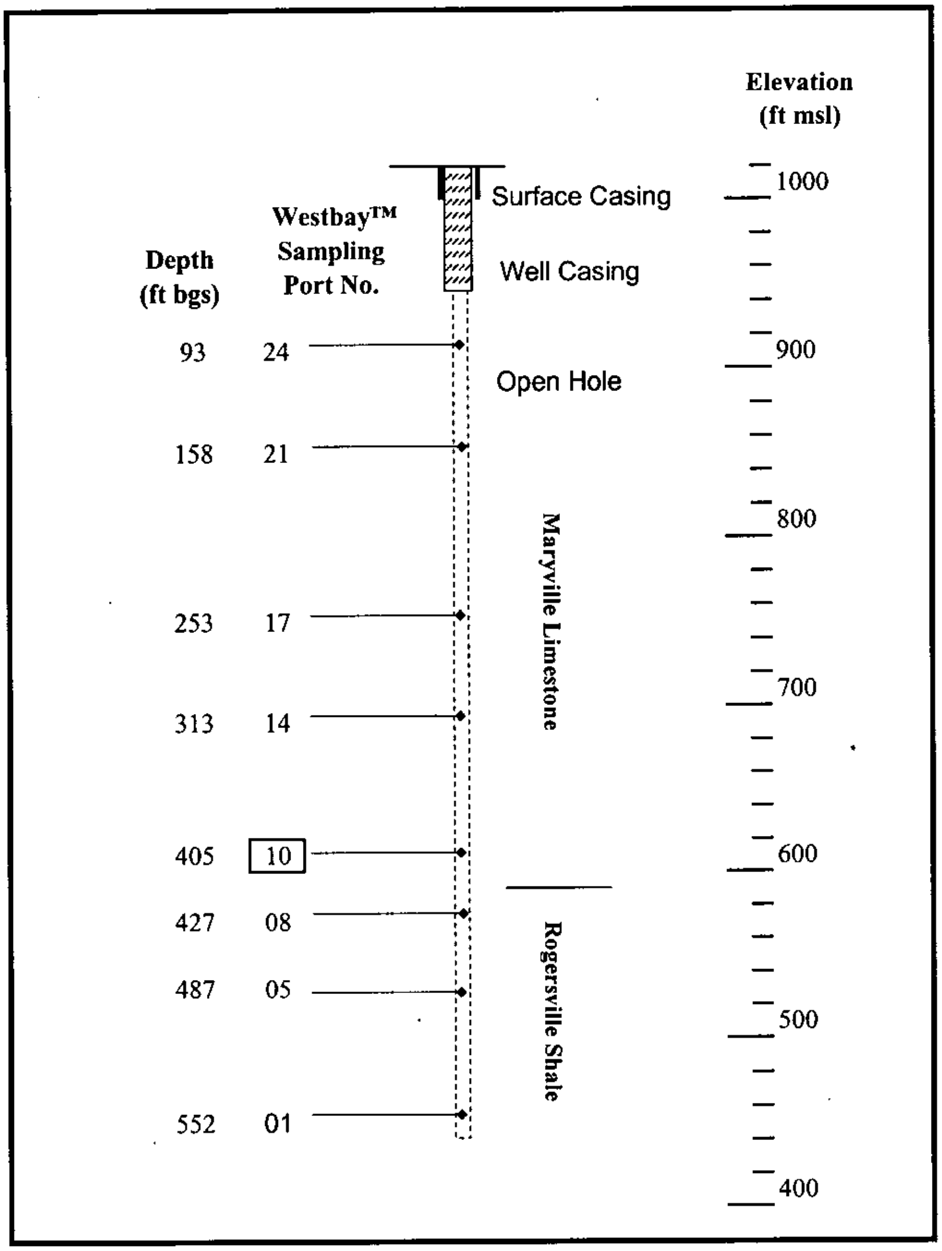

Elevation
(ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™
Sampling
Port No.
Depth
(ft bgs)
93 24
158 21
253 17
313 14
405 10
427 08
487 05
552 01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-14

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 14 Port Depth : 313 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/18/99	08/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	.	08/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	7 µg/L	08/26/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 14

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 14 being 313 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 14 yields groundwater from the intermediate depth bedrock (Maryville Limestone) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Maryville Limestone) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 14 yields moderately mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 718 – 746 mg/L;
- pH (field measurements) of 8.4 – 8.51;
- fluoride concentrations above 2 mg/L (e.g., 3.12 mg/L in August 2004);

- low molar proportions of calcium, chloride, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

One of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit, and this result (0.00137 mg/L in August 1999) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Low (estimated) concentrations of the following petroleum hydrocarbons were detected in the groundwater samples: benzene (3 μg/L in August 1999 and 4 μg/L in August 2004), ethylbenzene (1 μg/L in August 1999 and 2 μg/L in August 2004), and styrene (1 μg/L in August 1999 and August 2004). The well is hydraulically upgradient of all known sources of groundwater contamination located near the west end of Y-12, including contamination attributed to historical leaks of petroleum fuel from underground storage tanks formerly located at the Rust Garage Area southeast of the well.

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. However, the sample collected in August 2004 was analyzed for Tc-99 (a beta-particle emitter) and the reported Tc-99 concentration (40 pCi/L) exceeds both the applicable MDA (13 pCi/L) and the corresponding CE (8.6 pCi/L). Note that Tc-99 is at least partially volatilized during sample preparation for analysis of gross beta activity, so the level of Tc-99 is typically higher (if present in the sample) than the gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

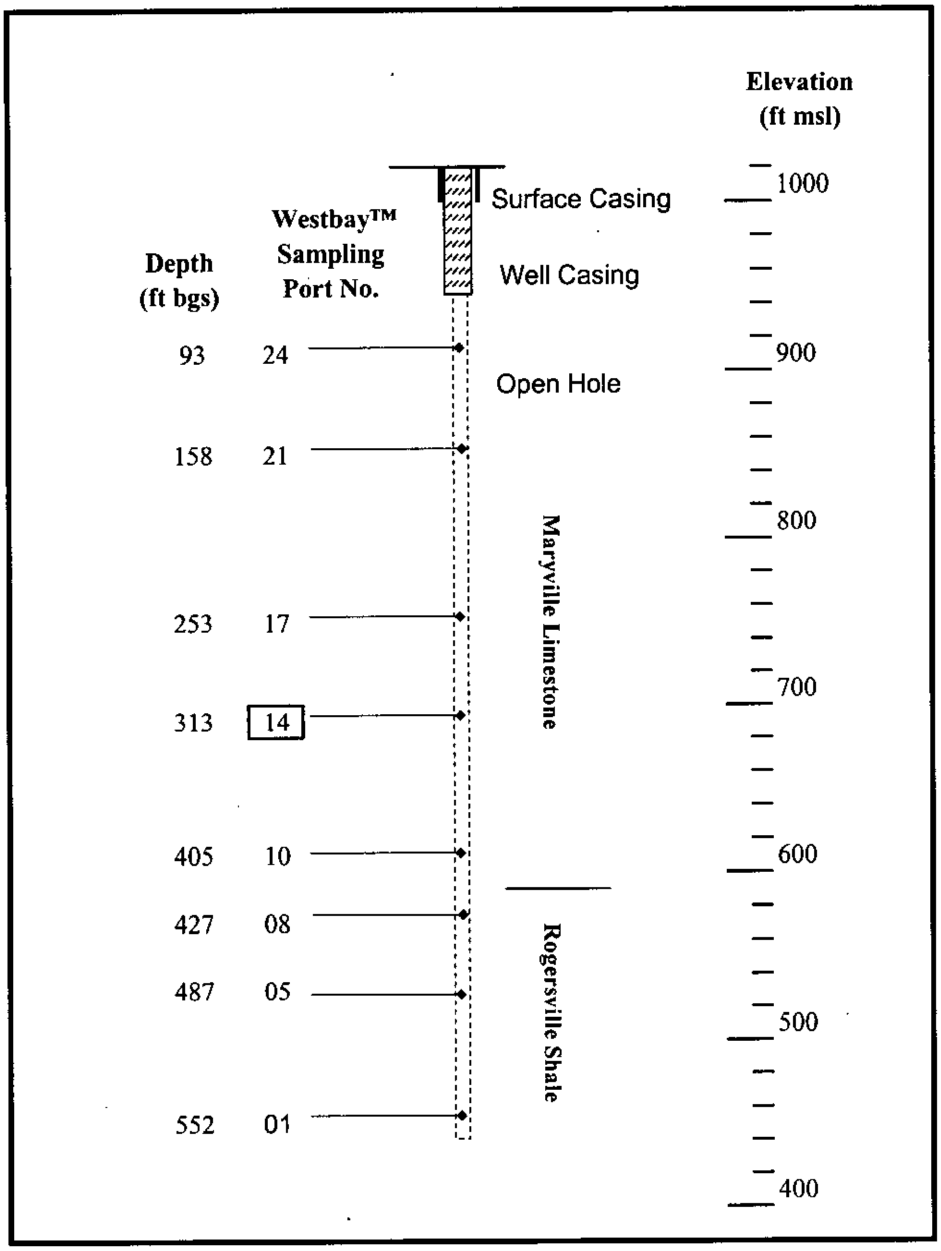
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Elevation (ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™ Sampling Port No.
Depth (ft bgs)
93 24
158 21
253 17
313 14
405 10
427 08
487 05
552 01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-17

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 17 Port Depth : 253 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/18/99	08/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	.	08/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 17

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 17 being 253 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 17 yields groundwater from the bedrock (Maryville Limestone) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Maryville Limestone) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 17 yields mineralized sodium-bicarbonate groundwater generally characterized by:

- TDS of 620 – 672 mg/L;
- pH (field measurements) of 8.49 – 8.7;
- fluoride concentrations above 2 mg/L (e.g., 2.98 mg/L in August 2004);
- low molar proportions of calcium, chloride, magnesium, potassium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of benzene (1 μg/L) was detected in the groundwater sample collected in August 1999. The well is hydraulically upgradient of all known sources of groundwater contamination located near the west end of Y-12, including contamination attributed to historical leaks of petroleum fuel from underground storage tanks formerly located at the Rust Garage Area southeast of the well. It is possible that the presence of benzene in the groundwater sample reflects the localized, residual contamination associated in some way with the drilling of the original core hole in which the well was constructed.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

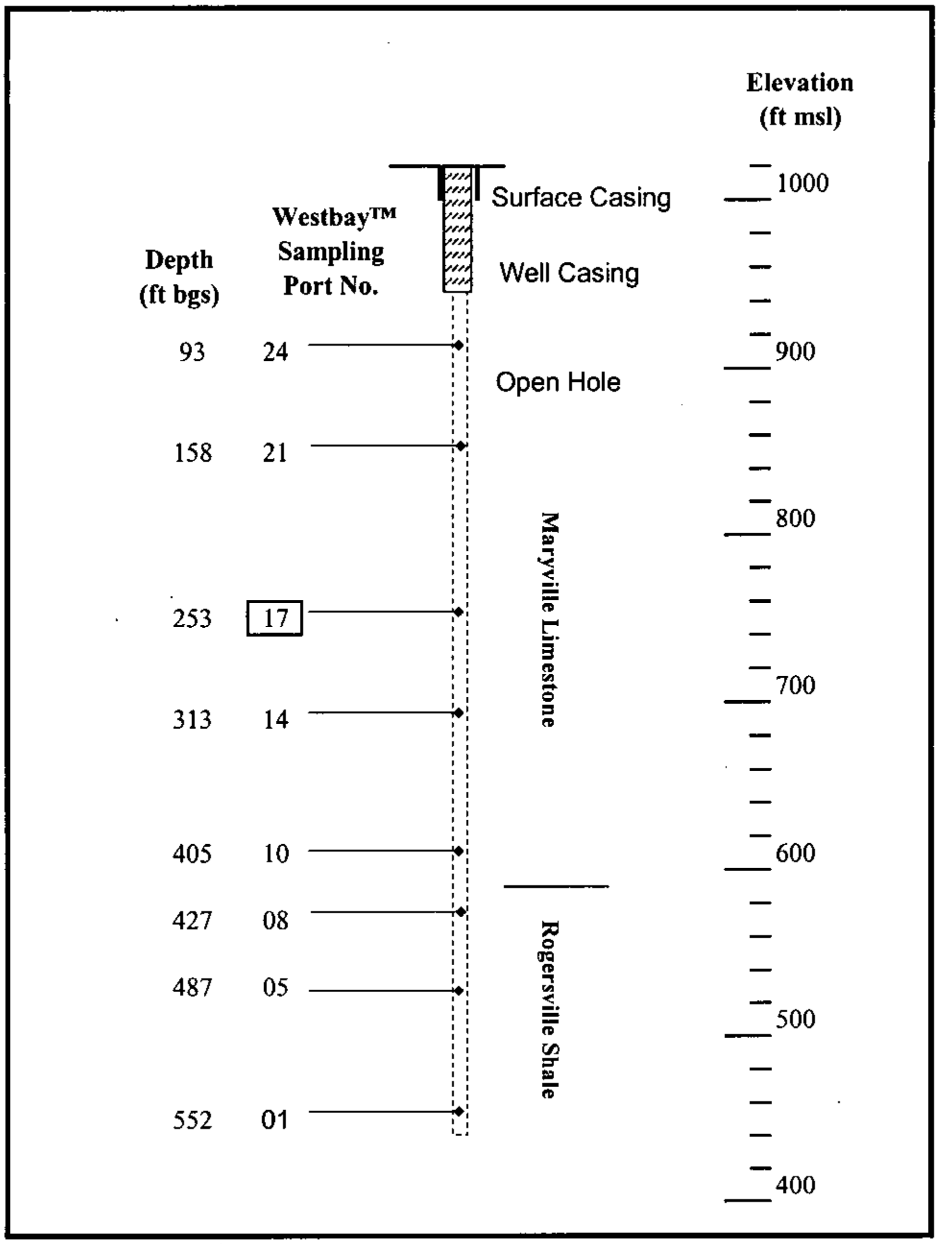

Elevation
(ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™
Sampling
Port No.
Depth
(ft bgs)
93 24
158 21
253 17
313 14
405 10
427 08
487 05
552 01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-21

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 21 Port Depth : 158 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/19/99	08/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	.	08/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-133
Sampling Port 21

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 21 being 158 ft bgs (Figure 1). Only three samples have been collected from this port, one in August 1999 and two (duplicate) in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 21 yields groundwater from the intermediate depth bedrock (Maryville Limestone) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Maryville Limestone) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 21 yields sodium-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 295 – 355 mg/L;
- pH (field measurements) of 7.84 – 7.87;
- sodium concentrations above 50 mg/L (e.g., 66.4 mg/L in August 2004);

- low molar proportions of chloride, fluoride, potassium, and sulfate (<10% of total anions/cations);
- total strontium concentrations that typically exceed 1 mg/L (e.g., 1.66 mg/L in August 2004); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

A combination of several natural geochemical processes probably account for the high strontium concentrations in the groundwater samples from this port, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of 111TCA (1 μg/L) was detected in the groundwater sample collected in August 1999. The well is hydraulically upgradient of all known sources of groundwater contamination located near the west end of Y-12, where there are several contaminant plumes that contain a variety of dissolved VOCs, including 111TCA.

5.4 GROSS ALPHA ACTIVITY

None of groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Additionally, the sample collected in August 2004 was analyzed for Tc-99; the analytical result is below the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

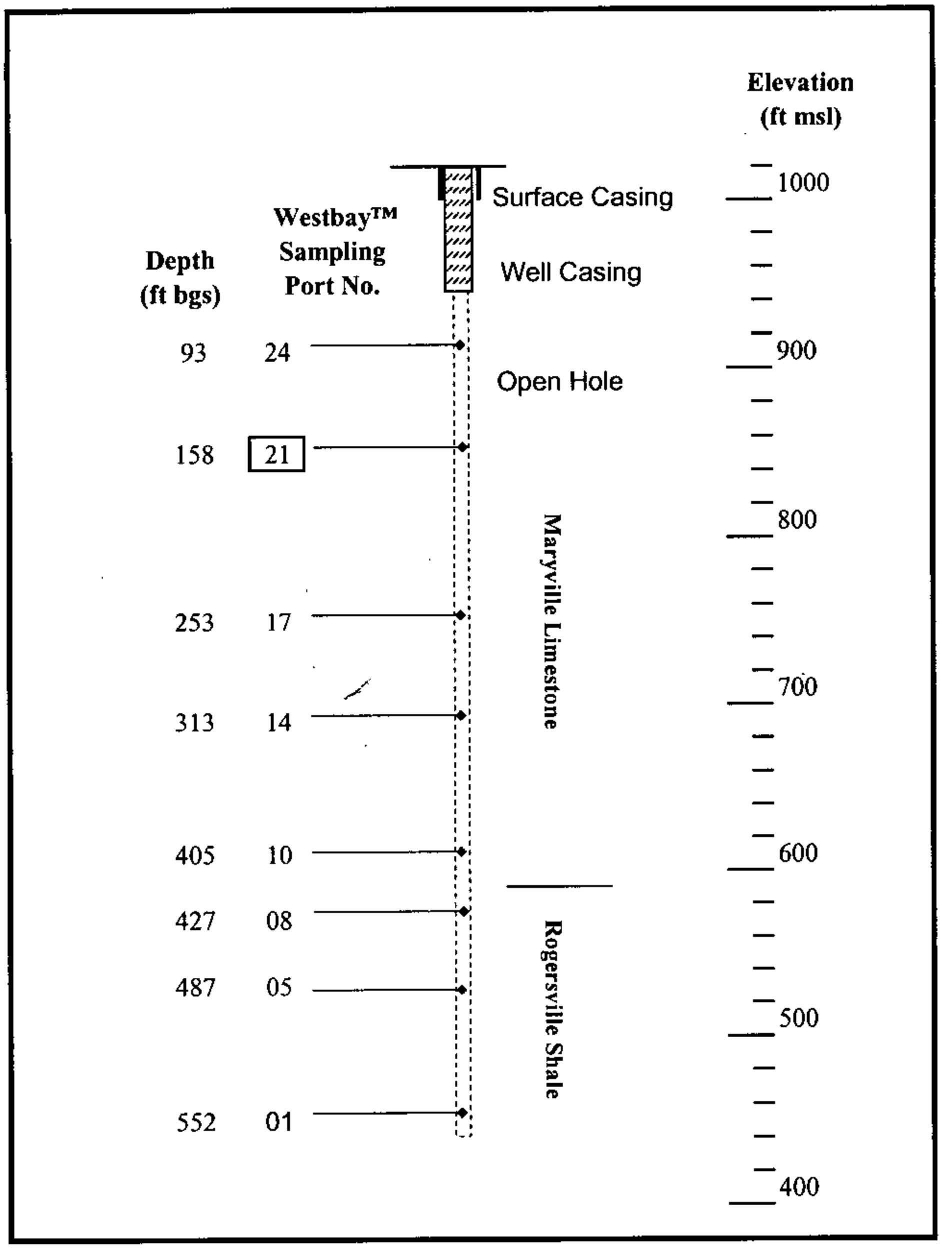

Elevation (ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™ Sampling Port No.
Depth (ft bgs)
93 24
158 21
253 17
313 14
405 10
427 08
487 05
552 01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	<5	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-133-24

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,637.00
Y-12 GRID NORTH COORDINATE: 30,659.00
SURFACE ELEVATION: 1,022.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,025.86 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 24 Port Depth : 93 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	08/19/99	08/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	270 pCi/L	08/19/99	Indeterminate
GROSS BETA (50 pCi/L):	1	56 pCi/L	08/19/99	Indeterminate

WELL GW-133
Sampling Port 24

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 200 ft northeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 55 to 599 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from eight sampling ports, with port 24 being 93 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 24 yields groundwater from the shallow bedrock (Maryville Limestone) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Maryville Limestone) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which trend southwest across the southern flank of Pine Ridge and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a more permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 24 yields sodium-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 291 – 299 mg/L;
- pH (field measurements) of 7.29 – 7.55;
- sodium concentrations above 40 mg/L (e.g., 44.9 mg/L in August 2004);

- low molar proportions of chloride, fluoride, potassium, and sulfate (<10% of total anions/cations);
- total strontium concentrations that typically exceed 1 mg/L (e.g., 1.66 mg/L in August 2004); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Low (estimated) concentrations of carbon tetrachloride (2 μg/L), styrene (2 μg/L), and 111TCA (1 μg/L) were detected in the groundwater sample collected in August 1999 and the sample collected in August 2004 had a trace (1 μg/L) of styrene. The well is hydraulically upgradient of all known sources of groundwater contamination located near the west end of Y-12, where there are several contaminant plumes that contain a variety of dissolved VOCs, including carbon tetrachloride, 111TCA, and petroleum hydrocarbons (e.g., styrene).

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater sample collected in August 1999 (270 pCi/L) exceeds the applicable MDA and corresponding CE and is more than 10 times the drinking water MCL for gross alpha activity (15 pCi/L). In contrast, the gross alpha activity reported for the sample collected in August 2004 does not exceed the MDA.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater sample collected in August 1999 (56 pCi/L) exceeds the applicable MDA and corresponding CE and is slightly above the Safe Drinking Water Act screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). In contrast, the gross beta activity reported for the sample collected in August 2004 does not exceed the MDA. Moreover, the sample collected in August 2004 was analyzed for Tc-99; which is a beta-emitting radionuclide and a principal component of the groundwater contaminant plume that originates from former S-3 Ponds, and the analytical result for Tc-99 does not exceed the MDA.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

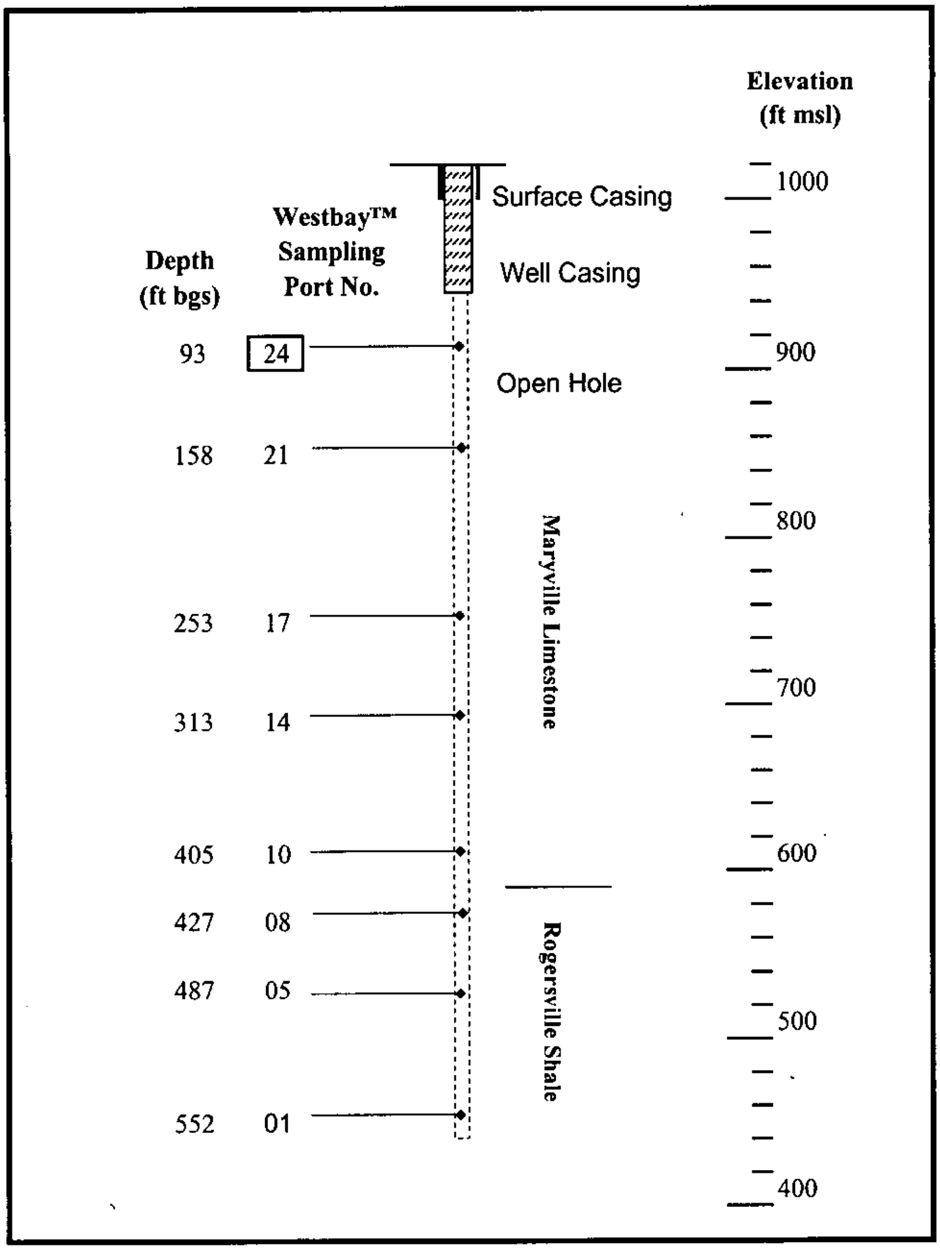

Elevation (ft msl)
1000
900
800
700
600
500
400
Surface Casing
Well Casing
Open Hole
Westbay™ Sampling Port No.
Depth (ft bgs)
93
24
158
21
253
17
313
14
405
10
427
08
487
05
552
01
Maryville Limestone
Rogersville Shale

Figure 1

MAXIMUM CONCENTRATION: 2004

100 - 1,000	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-05

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 05 Port Depth : 740 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	. samples	08/03/99	08/08/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	1,173 mg/L	08/03/99	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 05

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 05 being 740 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 05 yields groundwater from the deep bedrock (Maryville Limestone) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Maryville Limestone) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 05 yields highly mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS of 8,510 – 9,200 mg/L;
- pH (field measurements) of 7.2 – 7.22;
- high concentrations of nitrate (e.g., 860 mg/L in August 2004);
- low molar proportions of calcium, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of barium (>2 mg/L), lithium (>1 mg/L), and strontium (>8 mg/L); and
- total (unfiltered sample) concentrations of trace metals (except barium, lithium, and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance

limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

Elevated trace metal concentrations are attributable to natural geochemical processes at depth, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite ($BaSO_4$) and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater samples collected in August 1999 and August 2004 had nitrate concentrations of 1,173 mg/L and 860 mg/L, respectively. These nitrate results potentially reflect a generally decreasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from sampling port 05 showing that the plume extends at least 750 ft bgs. Moreover, the nitrate concentrations reported for all sampling ports more than 300 ft bgs are substantially higher than evident for sampling ports at shallower depths (Figure 1) because seasonal recharge/discharge cycles more effectively flush nitrate (and other contaminants) from the shallow groundwater flow system (DOE 1997). The elevated nitrate concentrations at depth reflect downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater (Toran and Saunders 1992) and the hydraulic head created by site operations.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.00154 mg/L) and August 2004 (0.00274 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L). Along with nitrate, uranium is a principal component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Thus, the low (background) levels of uranium in the groundwater from sampling port 05 reflect the substantially lower mobility and greater attenuation of uranium relative to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of benzene (1 μg/L) was detected in the groundwater sample collected in August 1999 and was not detected in the sample collected in August 2004. Benzene is not a major component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

The gross alpha activity result reported for each groundwater sample collected to date does not exceed the applicable MDA.

5.5 GROSS BETA ACTIVITY

The gross beta activity result reported for each groundwater sample collected to date does not exceed the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is surprising because the distribution of Tc-99 typically mirrors that of nitrate (see Section 5.1). For reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the interval monitored by this port.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

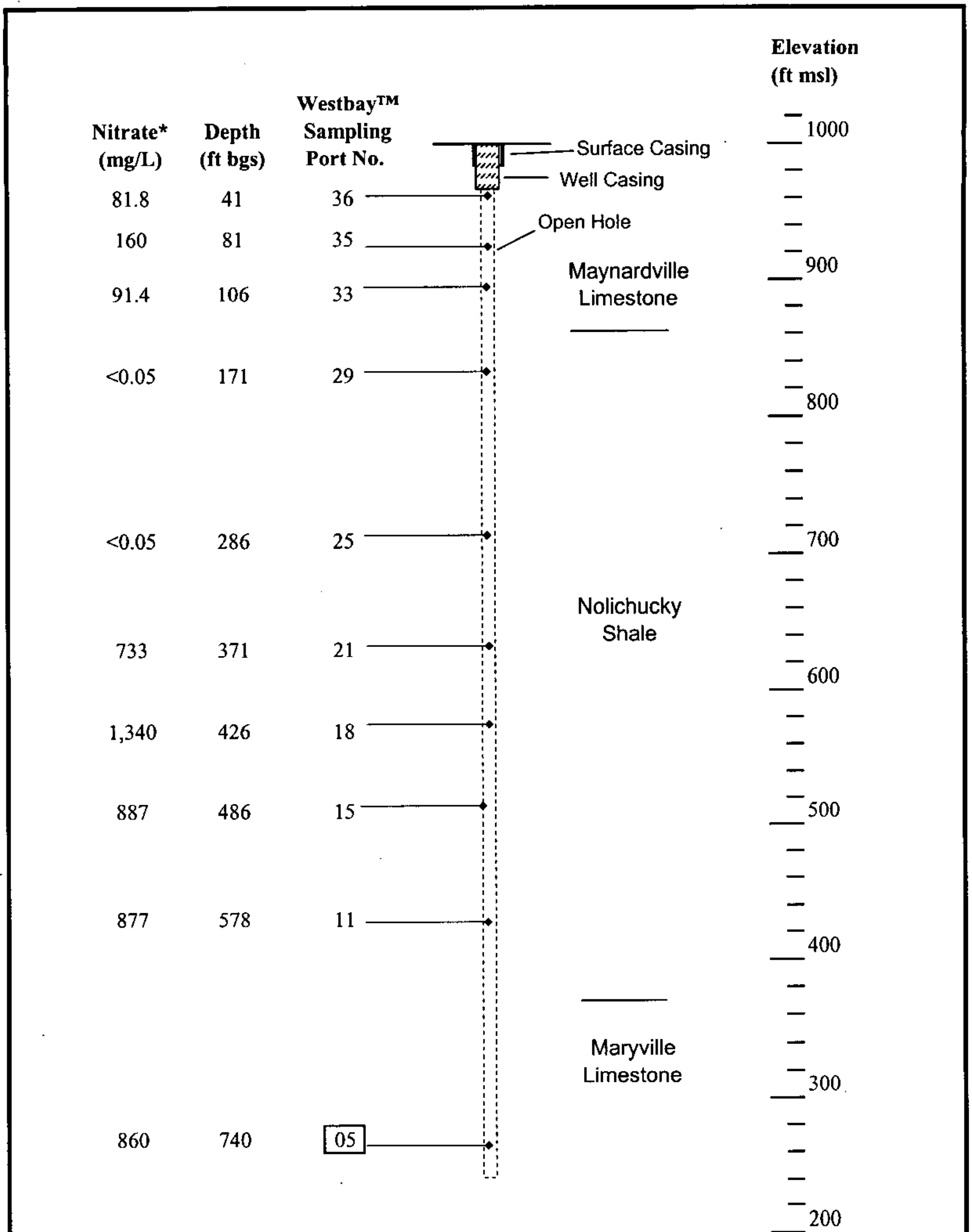
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
100 - 1,000	<0.015	ND	ND	ND

GW-134-11

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 11 Port Depth : 578 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 3

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	08/04/99	08/08/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	877 mg/L	08/08/04	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 11

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 11 being 578 ft bgs (Figure 1). Three samples have been collected from this port, two in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 11 yields groundwater from the deep bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 11 yields highly mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS of 2,640 – 6,330 mg/L;
- pH (field measurements) of 7.6 – 7.77;
- extremely high concentrations nitrate (e.g., 877 mg/L in August 2004);
- low molar proportions of calcium, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of strontium (>3 mg/L); and

- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Maryville Limestone) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater. Elevated strontium concentrations are attributable to natural geochemical processes at depth, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations of 237 mg/L and 877 mg/L were reported for the groundwater samples collected in August 1999 and August 2004, respectively. These nitrate results potentially reflect a generally increasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Moreover, the nitrate concentrations reported for all sampling ports more than 300 ft bgs are substantially higher than evident for sampling ports at shallower depths (Figure 1) because seasonal recharge/discharge cycles more effectively flush nitrate (and other contaminants) from the shallow groundwater flow system (DOE 1997). The elevated nitrate concentrations at depth reflect downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater (Toran and Saunders 1992) and the hydraulic head created by site operations.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.00157 mg/L) and August 2004 (0.00248 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L). Along with nitrate, uranium is a principal component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Thus, the low (background) levels of uranium in the groundwater from sampling port 11 reflect the substantially lower mobility and greater attenuation of uranium relative to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of carbon disulfide (2 μg/L) was detected in one of the groundwater samples collected in August 1999. This compound is not a major component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

The gross alpha activity result reported for each groundwater sample collected to date does not exceed the applicable MDA.

5.5 GROSS BETA ACTIVITY

The gross beta activity result reported for each groundwater sample collected to date does not exceed the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is surprising because the distribution of Tc-99 typically mirrors that of nitrate (see Section 5.1). For reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the interval monitored by this port.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

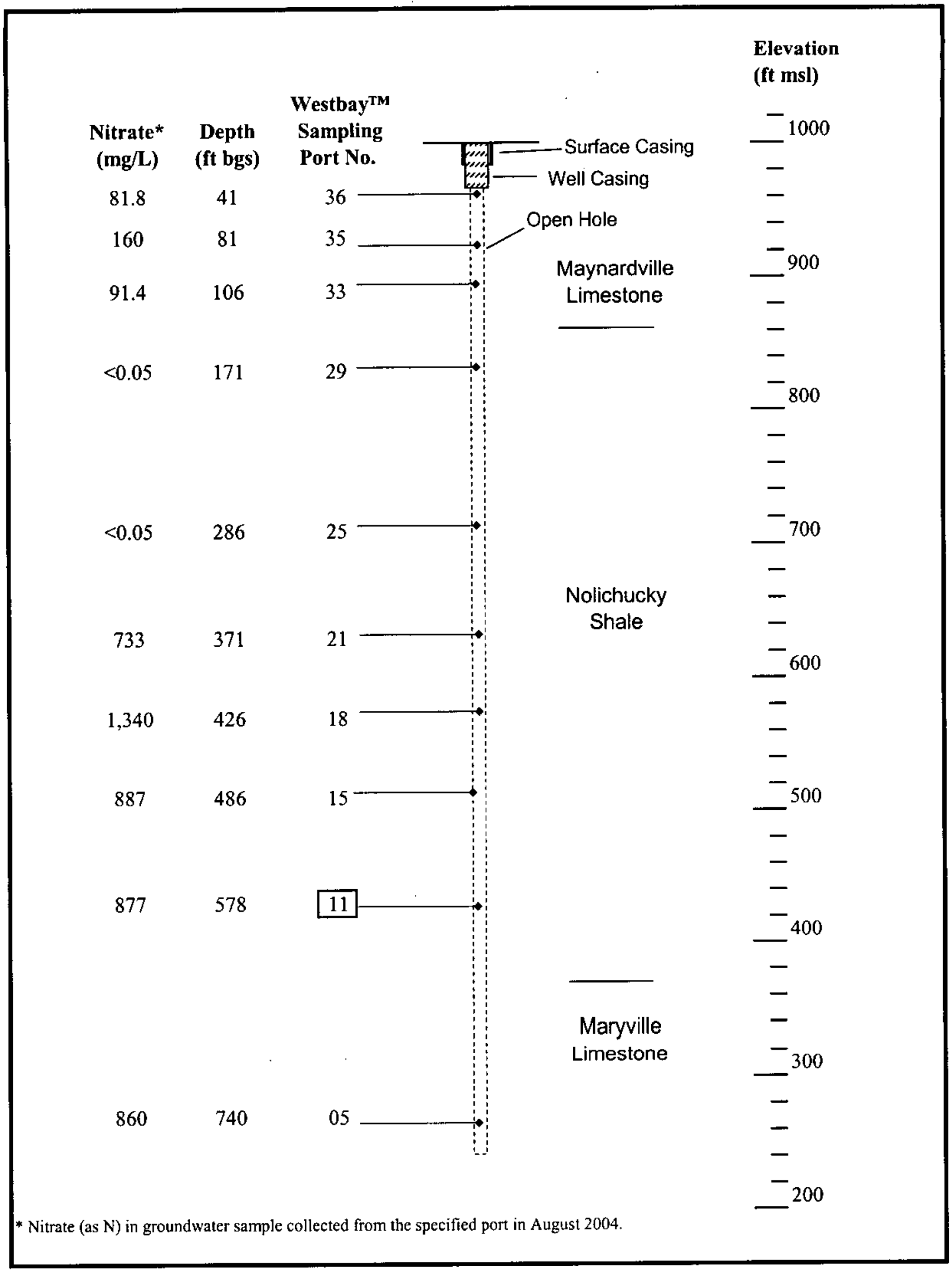
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant*, Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Elevation (ft msl)
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

100 - 1,000	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-15

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 15 Port Depth : 486 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	4		
CONVENTIONAL SAMPLING METHOD:	. samples	03/13/96	08/09/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	.	08/09/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	1	887 mg/L	08/09/04	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 15

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 15 being 486 ft bgs (Figure 1). Four samples have been collected from this port, one in March 1996, two in August 1999, and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 15 yields groundwater from the deep bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 15 yields highly mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS of 6,460 – 16,500 mg/L;
- pH (field measurements) of 6.83 – 7.22;
- extremely high concentrations nitrate (e.g., 887 mg/L in August 2004);
- low molar proportions of calcium, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of strontium (>3 mg/L); and

- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater. Elevated strontium concentrations are attributable to natural geochemical processes at depth, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations of 3,987 mg/L and 887 mg/L were reported for the groundwater samples collected in August 1999 and August 2004, respectively. These nitrate results potentially reflect a decreasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Moreover, the nitrate concentrations reported for all sampling ports more than 300 ft bgs are substantially higher than evident for sampling ports at shallower depths (Figure 1) because seasonal recharge/discharge cycles more effectively flush nitrate (and other contaminants) from the shallow groundwater flow system (DOE 1997). The elevated nitrate concentrations at depth reflect downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater (Toran and Saunders 1992) and the hydraulic head created by site operations.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.0018 mg/L) and August 2004 (0.00277 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L). Along with nitrate, uranium is a principal component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Thus, the low (background) levels of uranium in the groundwater from sampling port 15 reflect the substantially lower mobility and greater attenuation of uranium relative to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

The gross alpha activity result reported for each groundwater sample collected to date does not exceed the applicable MDA.

5.5 GROSS BETA ACTIVITY

The gross beta activity result reported for each groundwater sample collected to date does not exceed the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is surprising because the distribution of Tc-99 typically mirrors that of nitrate (see Section 5.1). For reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the interval monitored by this port.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

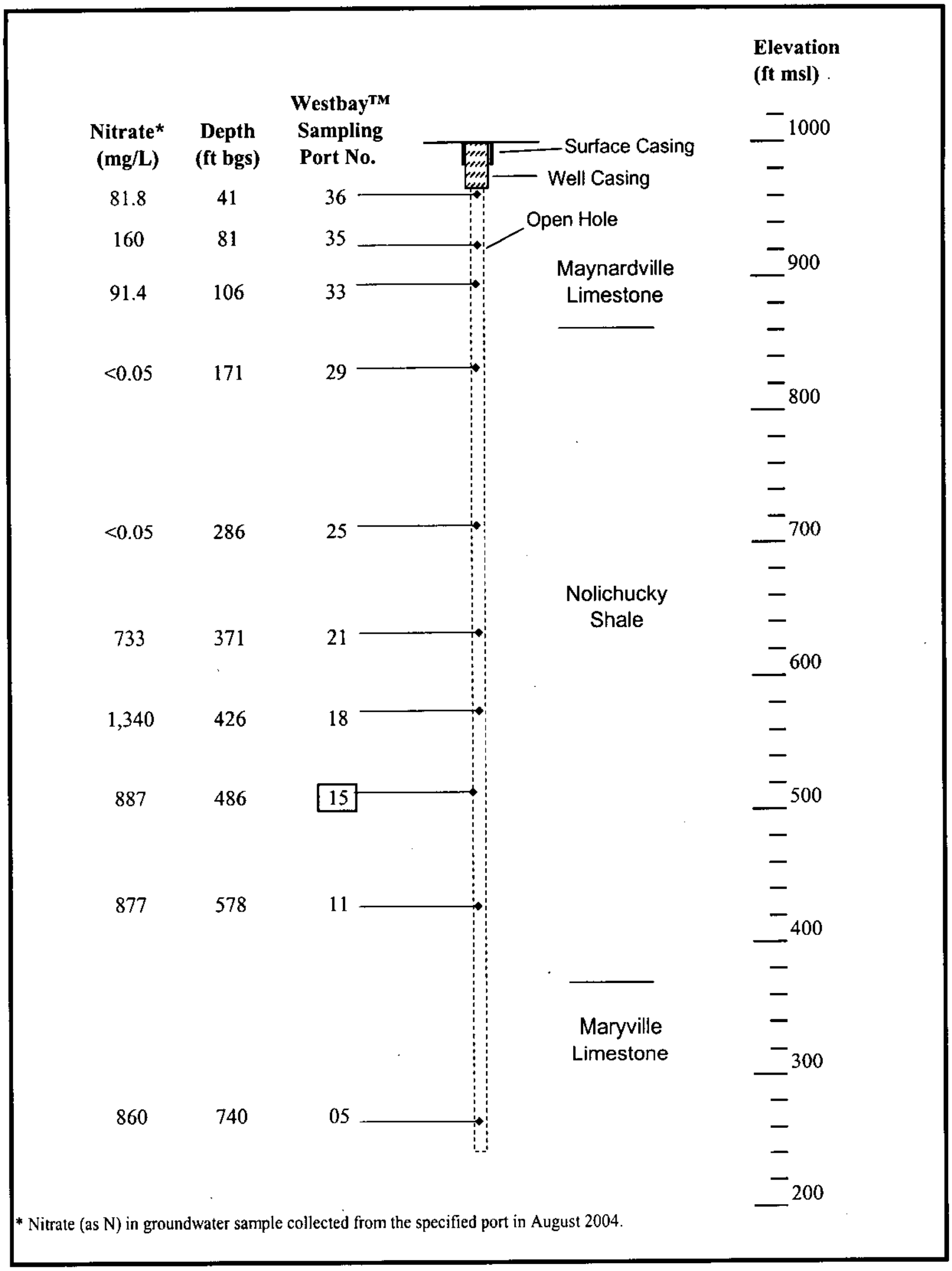

Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Elevation (ft msl)
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

>1,000	<0.015	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-134-18

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 18 Port Depth : 426 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	. samples	08/04/99	08/10/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	.	08/10/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	2,333 mg/L	08/04/99	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 18

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 18 being 426 ft bgs (Figure 1). Three samples have been collected from this port, two in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 18 yields groundwater from the deep bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 18 yields highly mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS of 4,880 – 12,700 mg/L;
- pH (field measurements) of 7.14 – 7.37;
- extremely high concentrations nitrate (e.g., 1,340 mg/L in August 2004);
- low molar proportions of calcium, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of barium (>2 mg/L), lithium (>1 mg/L), and strontium (>4 mg/L); and

- total (unfiltered sample) concentrations of trace metals (except barium, lithium, and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

Elevated trace metal concentrations are attributable to natural geochemical processes at depth, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite ($BaSO_4$) and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations of 2,333 mg/L and 1,340 mg/L were reported for the groundwater samples collected in August 1999 and August 2004, respectively. These nitrate results potentially reflect a decreasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Moreover, the nitrate concentrations reported for all sampling ports more than 300 ft bgs are substantially higher than evident for sampling ports at shallower depths (Figure 1) because seasonal recharge/discharge cycles more effectively flush nitrate (and other contaminants) from the shallow groundwater flow system (DOE 1997). The elevated nitrate concentrations at depth reflect downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater (Toran and Saunders 1992) and the hydraulic head created by site operations.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.00284 mg/L) and August 2004 (0.00224 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L). Along with nitrate, uranium is a principal component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Thus, the low (background) levels of uranium in the groundwater from sampling port 18 reflect the substantially lower mobility and greater attenuation of uranium relative to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of styrene (3 μg/L) was detected in the groundwater sample collected in August 1999. Styrene is not a major component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is surprising because the distribution of Tc-99 typically mirrors that of nitrate (see Section 5.1). For reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the interval monitored by this port.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

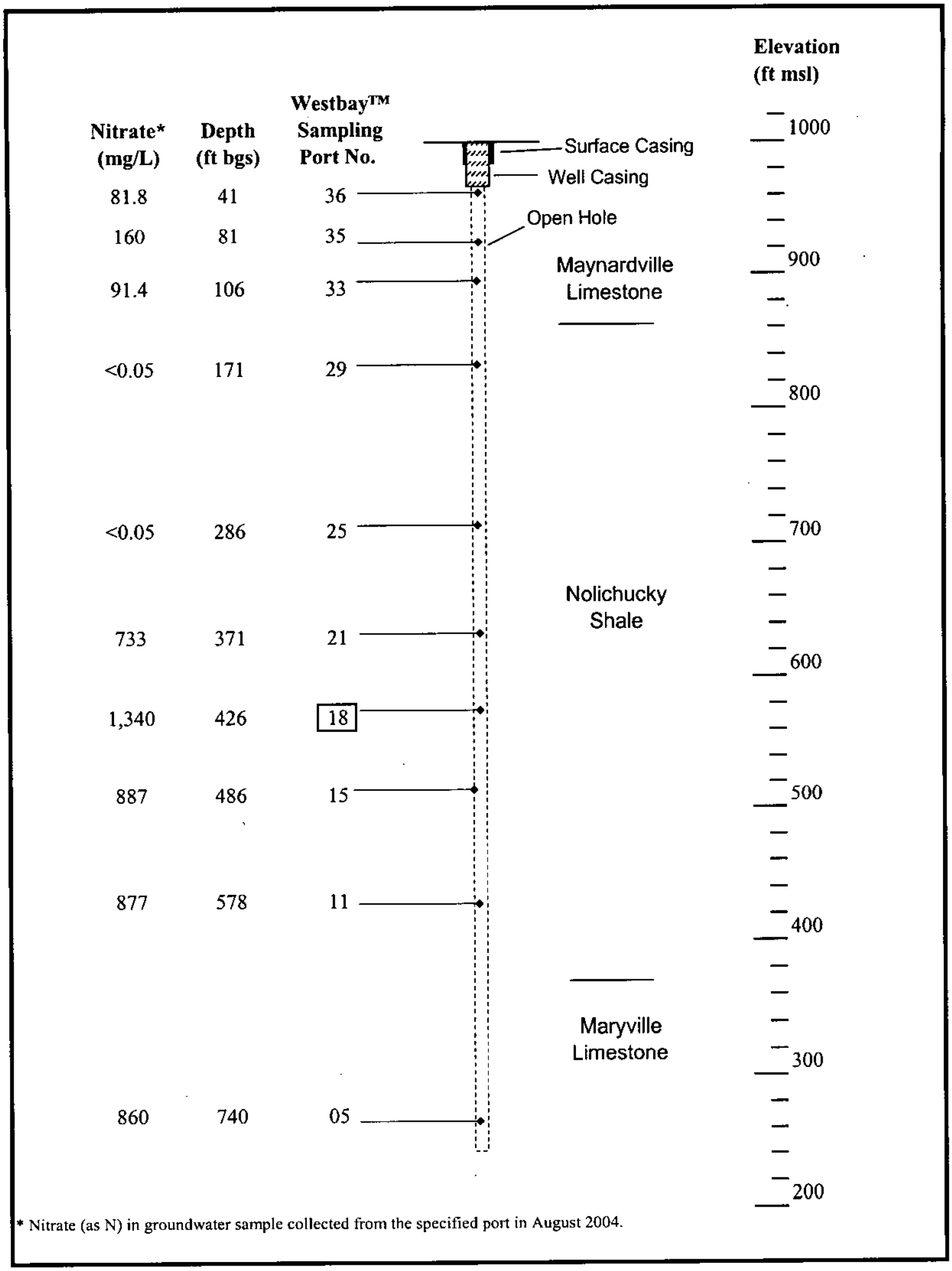
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Elevation
(ft msl)
Westbay™
Nitrate* Depth Sampling
(mg/L) (ft bgs) Port No.
Surface Casing
Well Casing
Open Hole
Maynardville
Limestone
Nolichucky
Shale
Maryville
Limestone
1000
900
800
700
600
500
400
300
200
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

100 - 1,000	<0.015	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-134-21

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 21 Port Depth : 371 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	. samples	08/05/99	08/10/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/10/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

TDS: H (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	818.2 mg/L	08/05/99	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 21

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (Haase and King 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 21 being 371 ft bgs (Figure 1). Three samples have been collected from this port to date, two in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 21 yields groundwater from the deep bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 21 yields highly mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS of 5,620 – 6,370 mg/L;
- pH (field measurements) of 7.7 – 7.8;
- high concentrations of nitrate (e.g., 733 mg/L in August 2004);
- low molar proportions of calcium, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of strontium (>2 mg/L); and

- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater. Elevated strontium concentrations are attributable to natural geochemical processes at depth, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater samples collected in August 1999 and August 2004 had nitrate concentrations of 818 mg/L and 733 mg/L, respectively. The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Moreover, the nitrate concentrations reported for all sampling ports more than 300 ft bgs (e.g., port 21) are substantially higher than evident for sampling ports at shallower depths (Figure 1) because seasonal recharge/discharge cycles more effectively flush nitrate (and other contaminants) from the shallow groundwater flow system (DOE 1997). The elevated nitrate concentrations at depth reflect downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater (Toran and Saunders 1992) and the hydraulic head created by site operations.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.00235 mg/L) and August 2004 (0.0023 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L). Along with nitrate, uranium is a principal component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Thus, the low (background) levels of uranium in the groundwater from sampling port 21 reflect the substantially lower mobility and greater attenuation of uranium relative to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is surprising because the distribution of Tc-99 typically mirrors that of nitrate (see Section 5.1). For reasons not readily apparent from the available data, Tc-99 is not transported via the groundwater flow/transport pathways intercepted by the interval monitored by this port.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant*, Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee*, Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

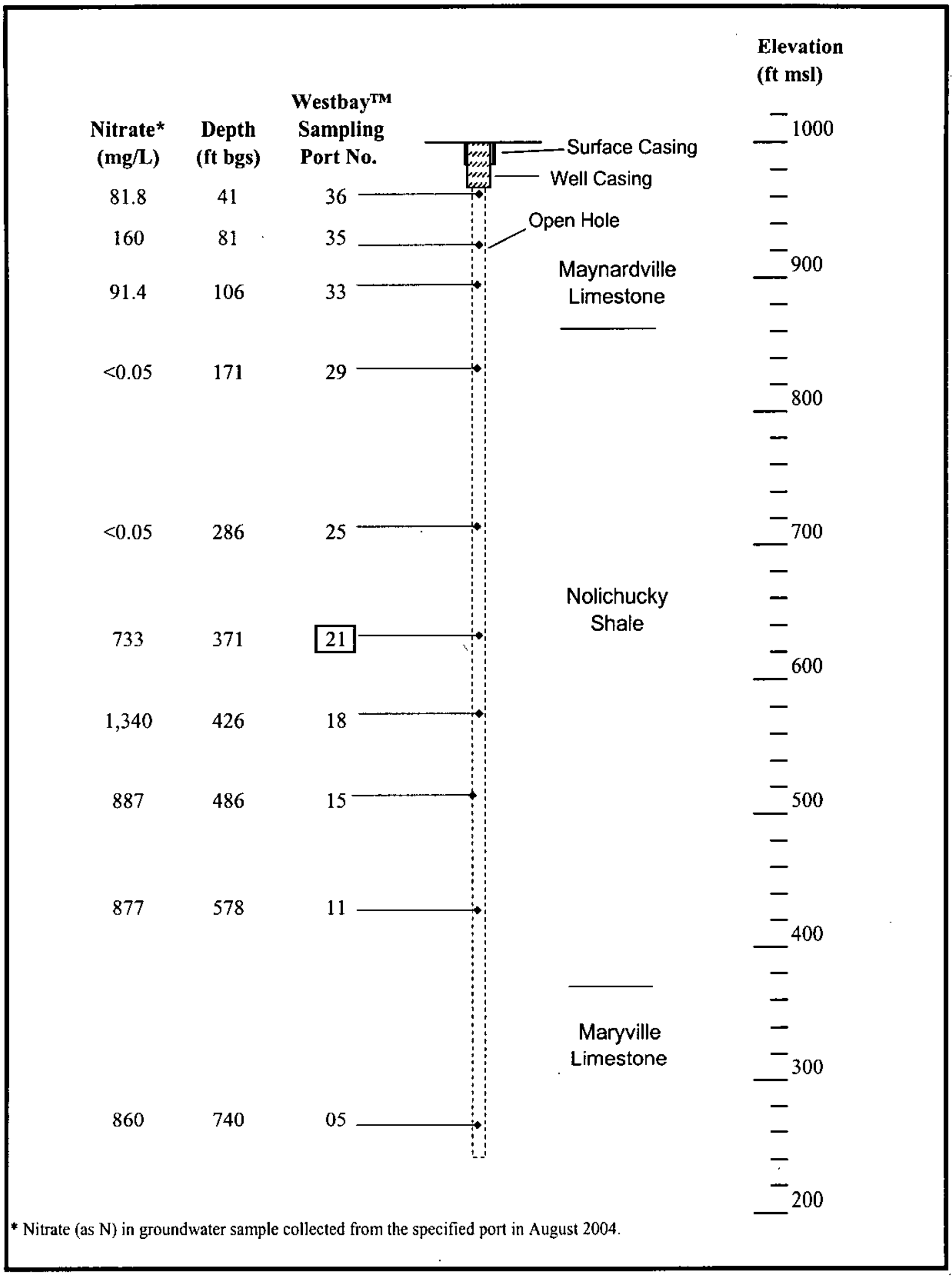

Elevation (ft msl)
Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-25

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 25 Port Depth : 286 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.
GEOLOGIC FORMATION:	Nolichucky Shale	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/10/99	08/10/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/10/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 25

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 25 being 286 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 25 yields groundwater from the intermediate depth bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 25 yields sodium-bicarbonate groundwater generally characterized by:

- TDS of 918 and 929 mg/L;
- pH (field measurements) of 8.9;
- unusually high carbonate alkalinity (e.g., 59.8 mg/L in August 2004);
- low molar proportions of calcium, chloride, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of boron (>1 mg/L); and

- total (unfiltered sample) concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater sample collected in August 1999 had a nitrate concentration of 0.05331 mg/L, and nitrate was not detected in August 2004. The low level of nitrate is particularly surprising in light of the proximity of well GW-134 to the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

Compared to the substantially higher nitrate concentrations reported for sampling ports that are shallower (e.g., port 33) and deeper (e.g., port 21) in the well (Figure 1), the background levels of nitrate evident in the groundwater samples from port 25 potentially indicate significant lithologic and/or stratigraphic control on down-dip migration/transport of the mobile components of the S-3 Ponds contaminant plume. Sampling port 25 also may yield groundwater from a low-yield (matrix) interval in the bedrock that is not well connected to the fractures which transmit the nitrate-contaminated groundwater.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting limit were reported for the groundwater samples collected in August 1999 (0.00235 mg/L) and August 2004 (0.0023 mg/L). Both of these results are substantially less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of styrene (1 µg/L) was detected in the groundwater sample collected in August 1999. Styrene is not a major component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

The gross alpha activity result reported for each groundwater sample collected to date does not exceed the applicable MDA.

5.5 GROSS BETA ACTIVITY

The gross beta activity result reported for each groundwater sample collected to date does not exceed the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

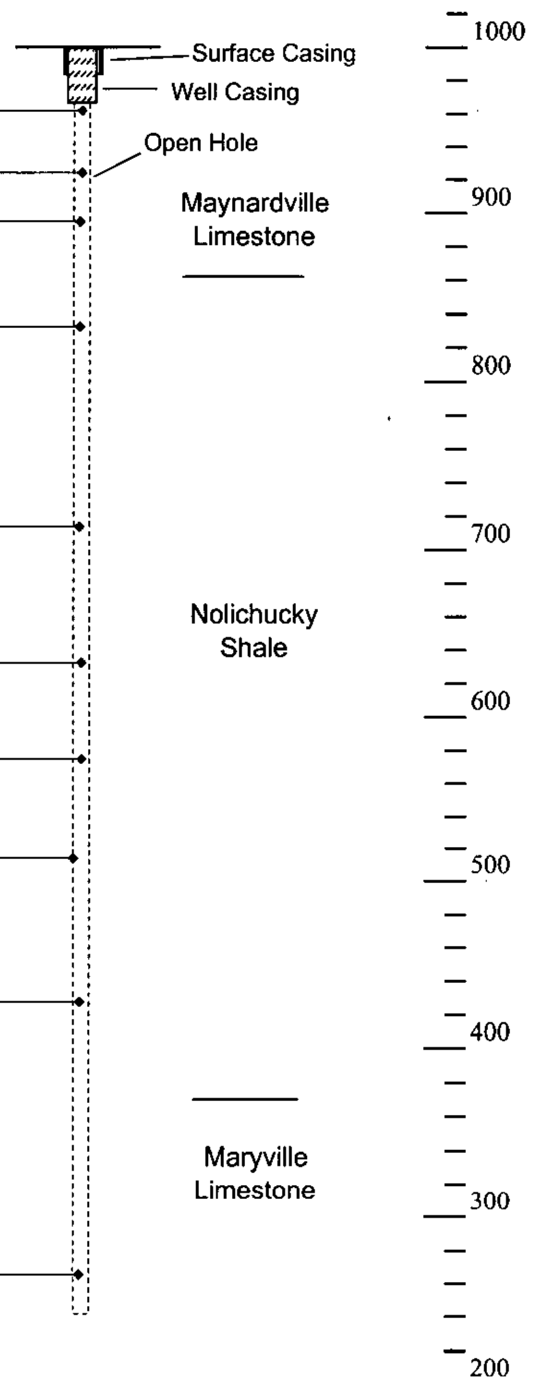
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Nitrate* (mg/L)	Depth (ft bgs)	Westbay™ Sampling Port No.
81.8	41	36
160	81	35
91.4	106	33
<0.05	171	29
<0.05	286	25
733	371	21
1,340	426	18
887	486	15
877	578	11
860	740	05

* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	<5	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-29

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 29 Port Depth : 171 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/11/99	08/11/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-134
Sampling Port 29

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (Haase and King 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 29 being 171 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 29 yields groundwater from the intermediate depth bedrock (Nolichucky Shale) interval in the Conasauga Group formations that subcrop along the southern flank of Pine Ridge and dip to the southeast below the Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the low-permeability formations (e.g., Nolichucky Shale) occurs within a highly conductive zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of decreased fracture frequency, reduced fracture aperture, and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs via flowpaths oriented parallel with geologic strike (e.g., bedding plane fractures).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 29 yields sodium-bicarbonate groundwater generally characterized by:

- TDS of 410 and 478 mg/L;
- pH (field measurements) of 8.7 and 9.05;
- low molar proportions of calcium, chloride, fluoride, magnesium, potassium, and sulfate (<10% of total anions/cations);
- elevated levels of boron (>1 mg/L); and
- total (unfiltered sample) concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock (>300 ft bgs) is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater sample collected in August 1999 had a nitrate concentration of 0.05376 mg/L, and nitrate was not detected in August 2004. The low level of nitrate is particularly surprising in light of the proximity of well GW-134 to the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

Compared to the substantially higher nitrate concentrations reported for sampling ports that are shallower (e.g., port 33) and deeper (e.g., port 21) in the well (Figure 1), the background levels of nitrate evident in the groundwater samples from port 29 potentially indicate significant lithologic and/or stratigraphic control on down-dip migration/transport of the mobile components of the S-3 Ponds contaminant plume. Sampling port 29 also may yield groundwater from a low-yield (matrix) interval in the bedrock that is not well connected to the fractures which transmit the nitrate-contaminated groundwater.

5.2 URANIUM

A total uranium concentration above the applicable analytical reporting limit was reported for the groundwater sample collected in August 1999 (0.000721 mg/L) and this result is substantially less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of styrene (1 µg/L) was detected in the groundwater sample collected in August 2004. Styrene is not a major component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

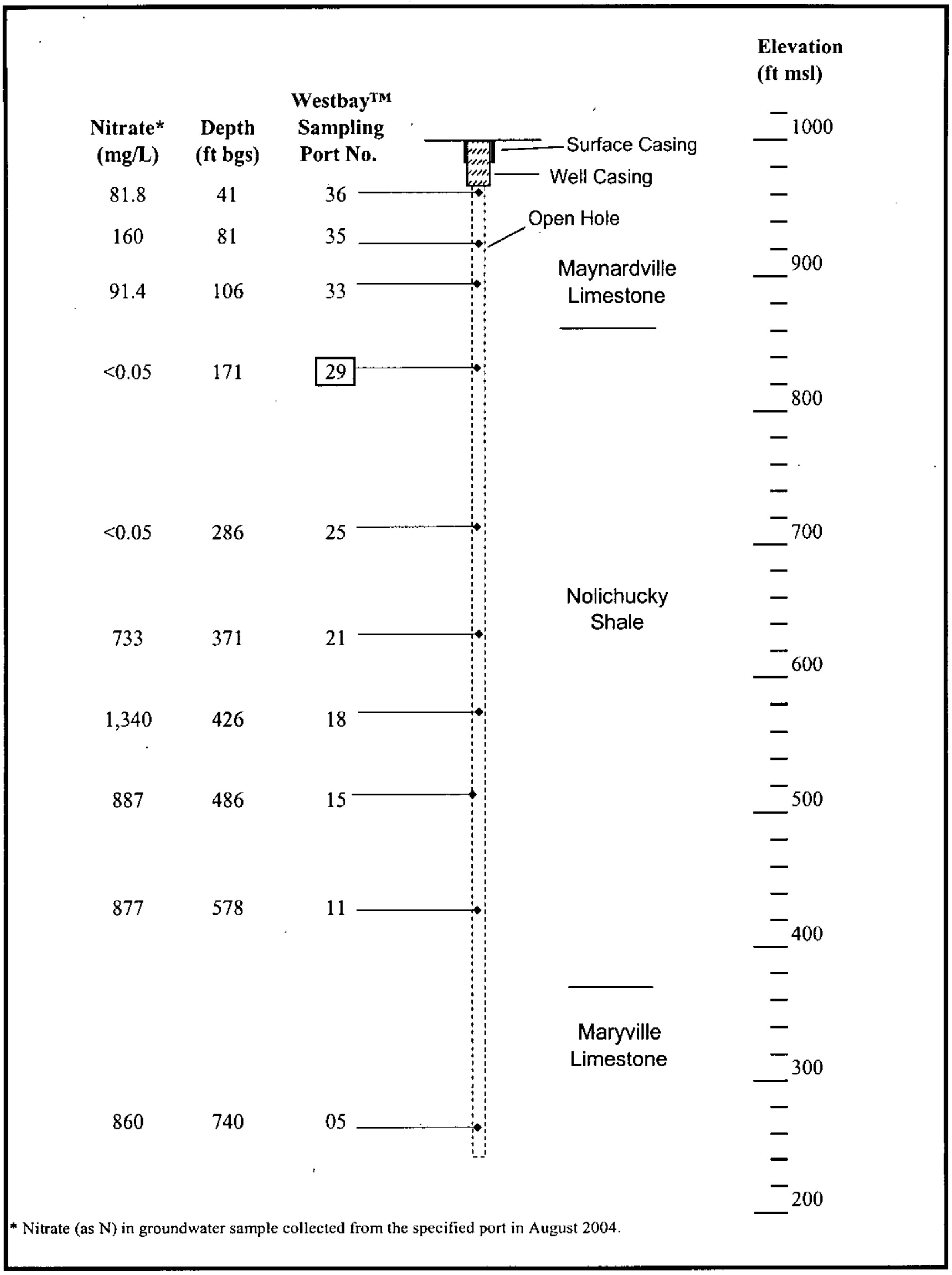
King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Elevation (ft msl)
Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

MAXIMUM CONCENTRATION: 2004

10 - 100	ND	5 - 50	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-33

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 33 Port Depth : 106 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/11/99	08/11/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	214.5 mg/L	08/11/99	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	2	57 μg/L	08/11/99	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	2	210 pCi/L	08/11/99	Indeterminate

WELL GW-134
Sampling Port 33

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 33 being 106 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 33 yields groundwater from the shallow bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 33 yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 929 and 1,560 mg/L;
- pH (field measurements) of 7.2 and 7.45;
- nitrate concentrations above 50 mg/L;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater samples collected in August 1999 and August 2004 had nitrate concentrations of 214.5 mg/L and 91.4 mg/L, respectively. These nitrate results, which substantially exceed the drinking water MCL for nitrate (10 mg/L), suggest a decreasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Additionally, compared to the nitrate concentrations reported for all the sampling ports more than 300 ft bgs (Figure 1), the substantially lower nitrate levels in the groundwater samples from port 33 illustrate how seasonal recharge/discharge cycles more effectively flush contaminants from the shallow flow system (DOE 1997).

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

The following VOCs were detected in each of the groundwater samples collected to date: PCE, TCE, c12DCE, and chloroform. As shown in the following data summary, the highest concentrations were reported in August 1999 for TCE (30 μg/L) and c12DCE (14 μg/L), both of which may be present as a result of the degradation of the parent compound (PCE), with the concentrations of PCE and TCE being above the respective MCLs (5 μg/L).

Date Sampled	Concentration (µg/L)			
	PCE	TCE	c12DCE	Chloroform
08/11/99	10	30	14	3 J
08/11/04	8	4 J	5 J	1 J
MCL	5	5	70	Not applicable
Note: J = Estimated value below the analytical reporting limit				

All of the VOCs detected in the groundwater samples collected to date are confirmed components of the contaminant plume that originates from the former S-3 Ponds, and their presence in the groundwater from this sampling port indicates vertical (down-dip) transport/migration for at least 100 ft bgs. Nevertheless, compared to the nitrate concentrations in the groundwater samples from this well, the relatively low concentrations of VOCs reflect the much lower volume of organic wastes disposed at the site and the greater attenuation of these compounds relative to that of nitrate (DOE 1997). Additionally, PCE concentrations reported for sampling port 35, which is only 25 ft shallower in the Maynardville Limestone, are much higher than evident in port 36 (Figure 2). As with the similar disparity in the nitrate concentrations in the groundwater from these ports, the difference between PCE levels in each port potentially reflect the strong influence on groundwater flow/contaminant migration exerted by lithologic and/or stratigraphic features in the Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

The groundwater samples collected in August 1999 and August 2004 had gross beta activity of 210 pCi/L and 130 pCi/L, respectively. Both results are substantially above the Safe Drinking Water Act (SDWA) screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). In addition to gross beta activity, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Although the Tc-99 result for this sample (270 pCi/L) is substantially below the SDWA screening level for Tc-99 (3,790 pCi/L), the result confirms that Tc-99 is the primary source of gross beta activity in the groundwater samples from this port. Like nitrate and chlorinated hydrocarbons, the presence of Tc-99 in the water-producing feature(s) providing inflow to sampling port 33 reflect the density-driven vertical (down-dip) migration of the more mobile components of the contaminant plume.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

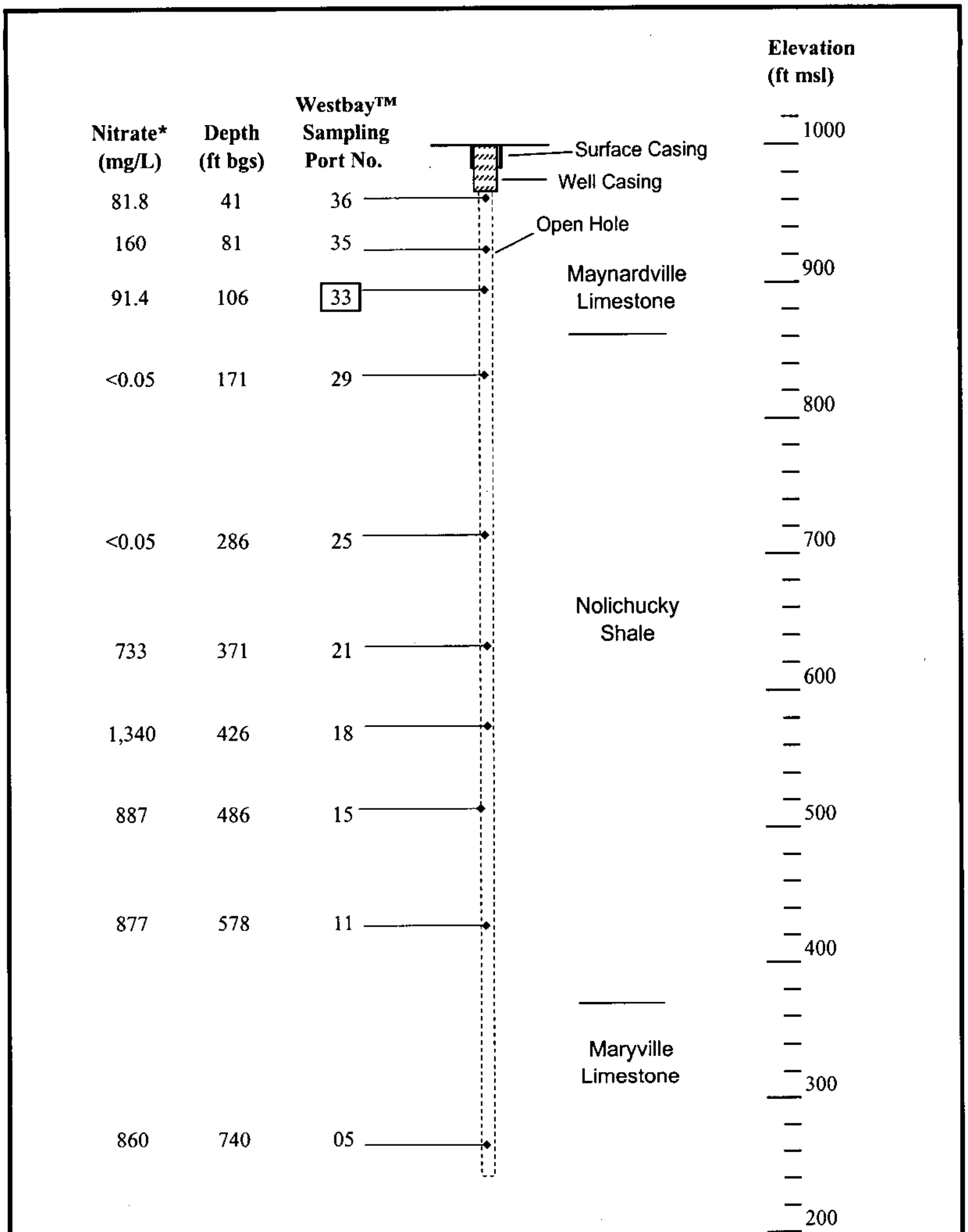
Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

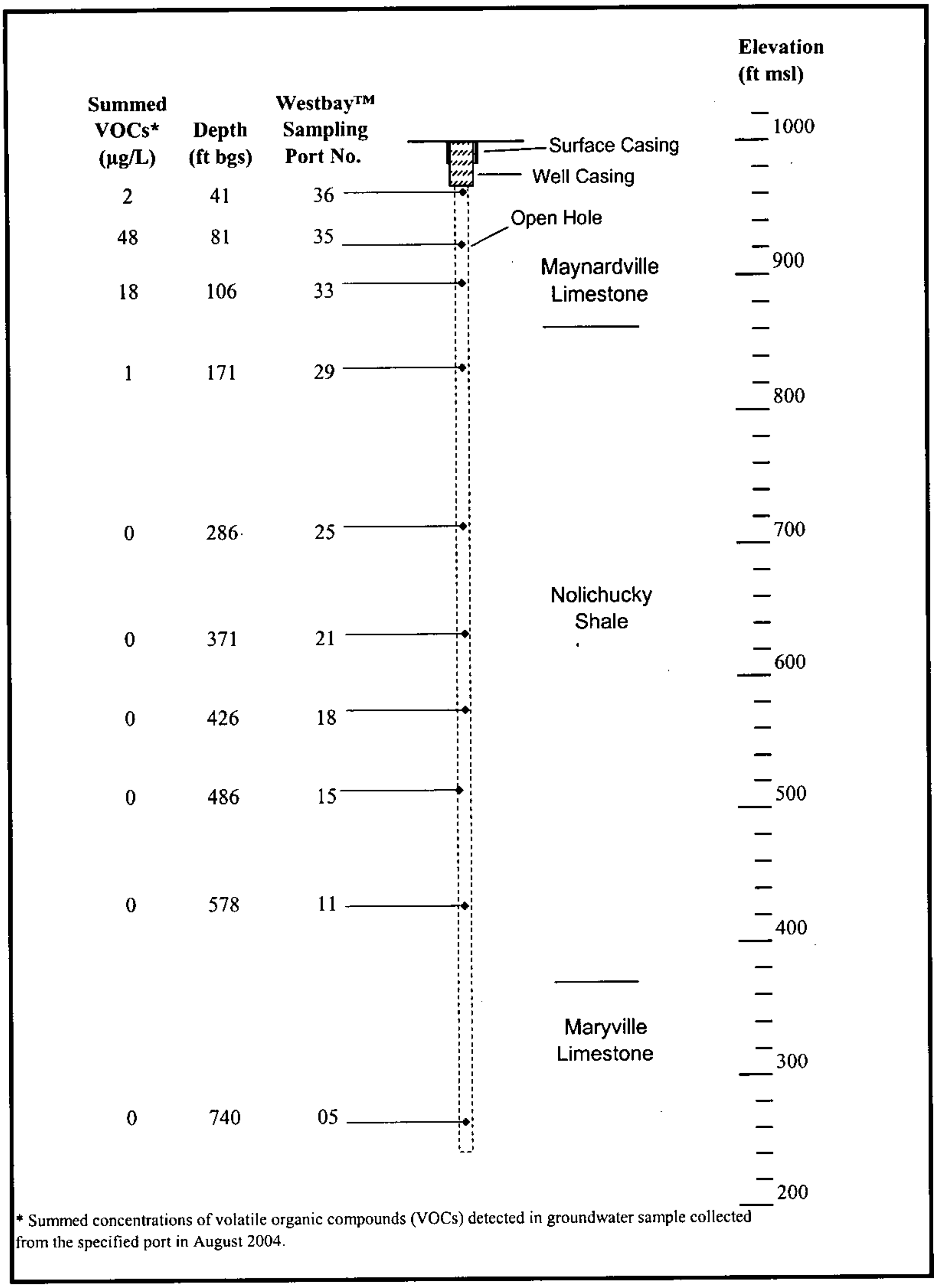

Summed VOCs* (µg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Elevation (ft msl)
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
2 41 36
48 81 35
18 106 33
1 171 29
0 286 25
0 371 21
0 426 18
0 486 15
0 578 11
0 740 05
1000
900
800
700
600
500
400
300
200
* Summed concentrations of volatile organic compounds (VOCs) detected in groundwater sample collected from the specified port in August 2004.

Figure 2

MAXIMUM CONCENTRATION: 2004

100 - 1,000	ND	5 - 50	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-35

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 35 Port Depth : 81 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/11/99	08/11/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	290.5 mg/L	08/11/99	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	48 µg/L	08/11/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	2	330 pCi/L	08/11/99	Indeterminate

WELL GW-134
Sampling Port 35

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 35 being 81 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 35 yields groundwater from the shallow bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 35 yields nitrate-contaminated, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,540 and 2,180 mg/L;
- pH (field measurements) of 7.0 and 7.25;
- nitrate concentrations above 100 mg/L;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations);

- elevated total (unfiltered sample) concentrations of strontium (>1 mg/L); and
- total concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated strontium concentrations may be attributable to natural geochemical processes at depth in the Maynardville Limestone, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite ($BaSO_4$) and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater samples collected in August 1999 and August 2004 had nitrate concentrations of 290.5 mg/L and 160 mg/L, respectively. These nitrate results, which substantially exceed the drinking water MCL for nitrate (10 mg/L), suggest a decreasing long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend laterally at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Additionally, compared to the nitrate concentrations reported for all the sampling ports more than 300 ft bgs (Figure 1), the substantially lower nitrate levels in the groundwater samples from port 35 illustrate how seasonal recharge/discharge cycles more effectively flush contaminants from the shallow flow system (DOE 1997). Moreover, the nitrate concentrations reported for sampling port 35 are significantly higher than the nitrate levels evident in groundwater from sampling port 36, which is only 15 ft shallower in the Maynardville Limestone than port 35 (Figure 1). This suggests that there are significant lithologic and/or stratigraphic controls on the migration/transport of the mobile components of the S-3 Ponds contaminant plume.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

The following VOCs were detected in each of the groundwater samples collected to date: PCE, TCE, c12DCE, 11DCE, and chloroform. Each of these compounds except 11DCE was detected in each groundwater sample. As shown in the following data summary, the highest concentrations were reported for PCE, TCE, and c12DCE, with the concentrations of PCE and TCE being above the respective MCLs (5 µg/L).

Date Sampled	**Concentration (µg/L)**				
	PCE	**TCE**	**c12DCE**	**111DCE**	**Chloroform**
08/11/99	11	19	13	.	3 J
08/11/04	15	16	10	2 J	2 J
MCL	5	5	70	7	Not applicable
Note: "." = Not detected; J = Estimated value below the analytical reporting limit					

All of the VOCs detected in the groundwater samples collected to date are confirmed components of the contaminant plume that originates from the former S-3 Ponds, and their presence in the groundwater from this sampling port indicates vertical (down-dip) transport/migration for at least 100 ft bgs. Nevertheless, compared to the nitrate concentrations in the groundwater samples from this sampling port, the relatively low concentrations of VOCs reflect the much lower volume of organic wastes disposed at the site and the greater attenuation of these compounds relative to that of nitrate (DOE 1997). Additionally, PCE concentrations reported for sampling port 36 (40 ft shallower) and for sampling port 33 (25 ft deeper) in the Maynardville Limestone are much lower than evident in port 35 (Figure 2). As with the similar disparity between nitrate concentrations in the groundwater samples from these ports, the difference between PCE levels potentially reflect the strong influence on groundwater flow/contaminant migration exerted by lithologic and/or stratigraphic features in the Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA and CE.

5.5 GROSS BETA ACTIVITY

The groundwater samples collected in August 1999 and August 2004 had gross beta activity of 330 pCi/L and 220 pCi/L, respectively. Both results are substantially above the Safe Drinking Water Act (SDWA) screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). In addition to gross beta activity, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Although the Tc-99 result for this sample (370 pCi/L) is substantially below the SDWA screening level for Tc-99 (3,790 pCi/L), the result confirms that Tc-99 is the primary source of gross beta activity in the groundwater samples from this port. Like nitrate and PCE, the presence of Tc-99 in the water-producing feature(s) providing inflow to sampling port 35 reflects the southward (across strike and down-dip) migration of the mobile components of the S-3 Ponds contaminant plume.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes. (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

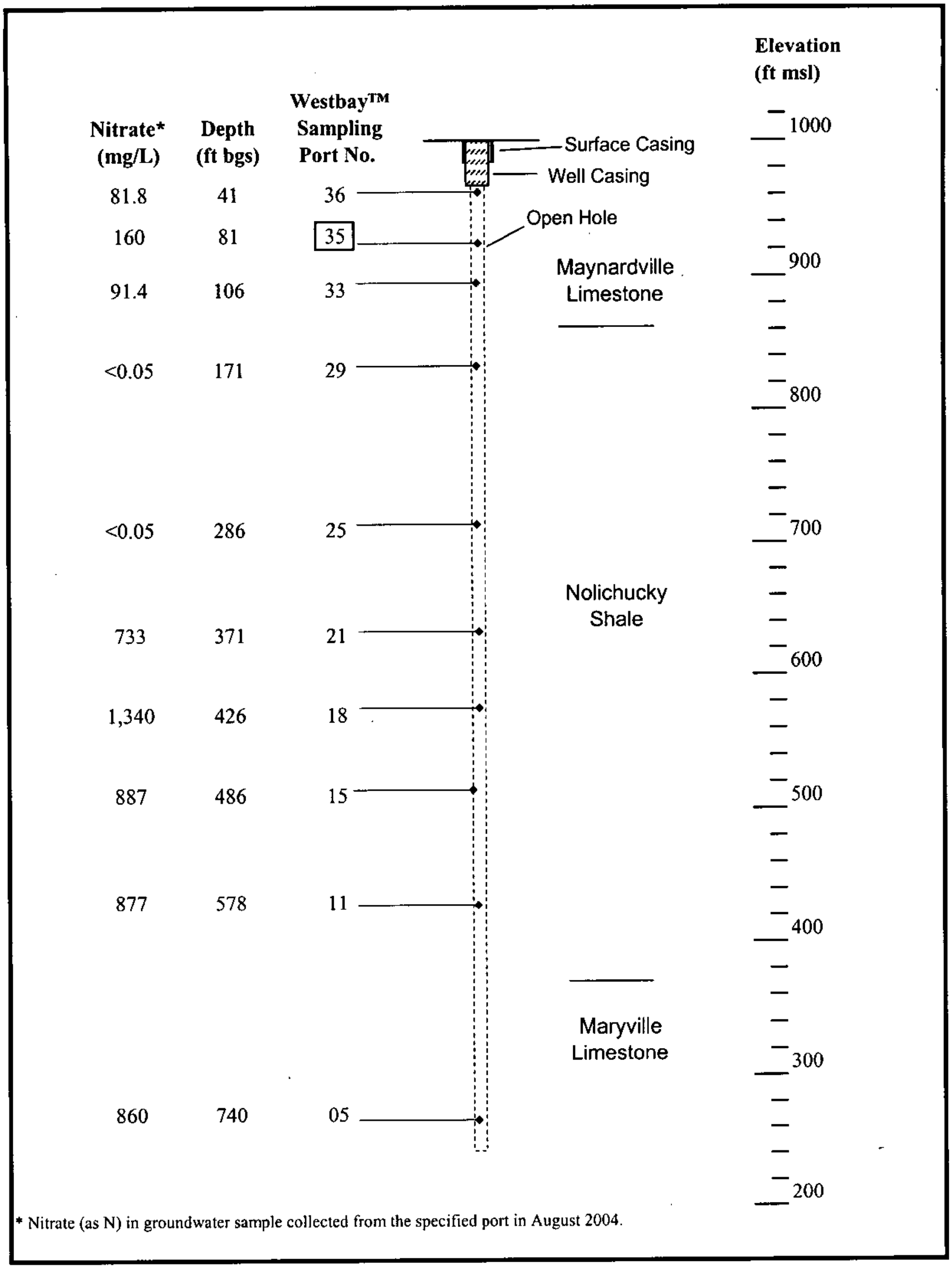
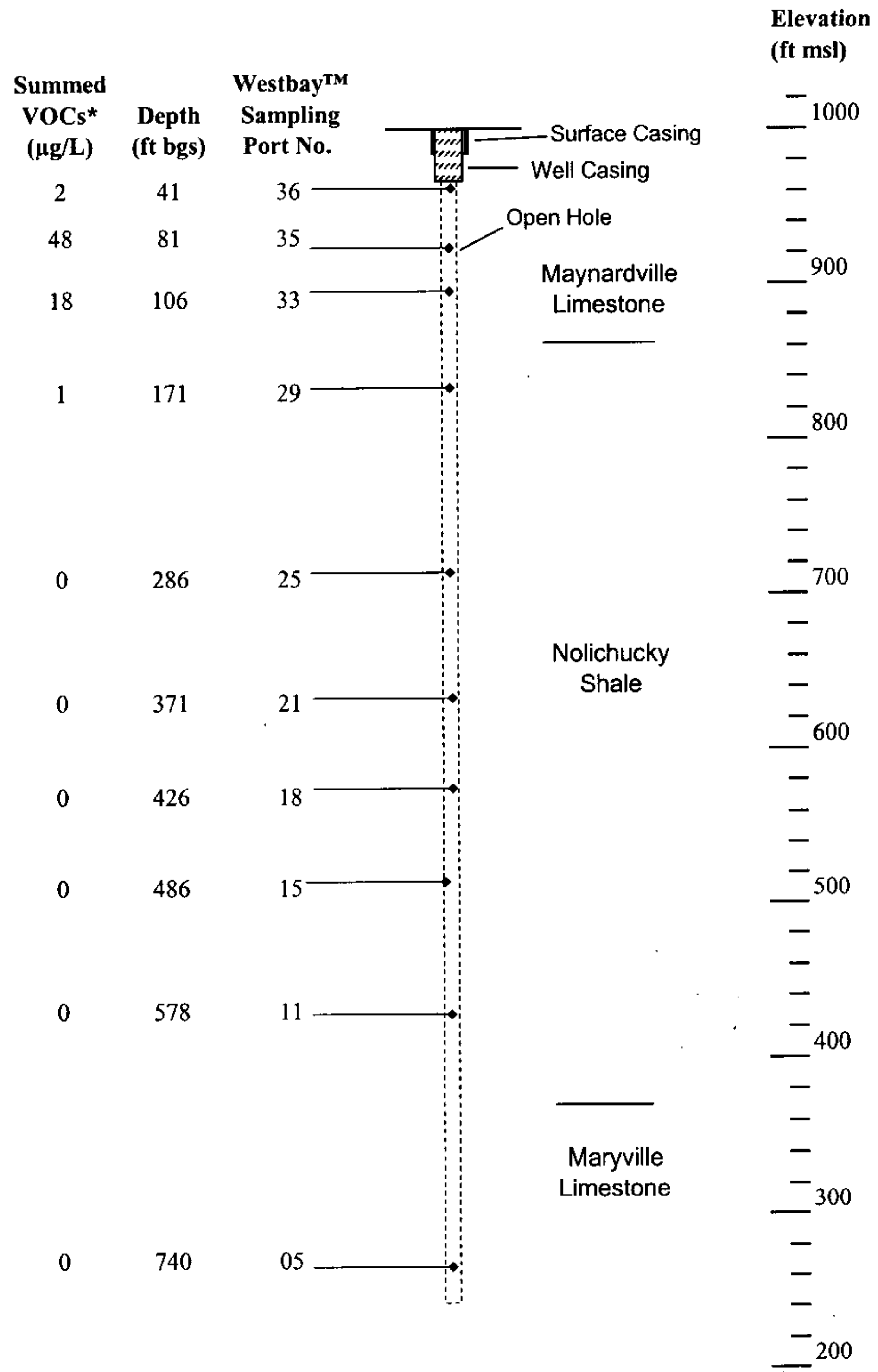

Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Elevation (ft msl)
Surface Casing
Well Casing
Open Hole
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1



* Summed concentrations of volatile organic compounds (VOCs) detected in groundwater sample collected from the specified port in August 2004.

Figure 2

MAXIMUM CONCENTRATION: 2004

10 - 100	ND	<5	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-134-36

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,533.00
Y-12 GRID NORTH COORDINATE: 29,741.00
SURFACE ELEVATION: 1,002.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/12/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,005.63 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 36 Port Depth : 41 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	08/11/99	08/11/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	81.8 mg/L	08/11/04	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	1	130 pCi/L	08/11/04	Indeterminate

WELL GW-134
Sampling Port 36

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located in Bear Creek Valley (BCV) near the west end of Y-12, approximately 450 ft southeast of the former S-3 Ponds. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 35 to 842 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 36 being 41 ft bgs (Figure 1). Only two samples have been collected from this port, one in August 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 36 yields groundwater from the shallow bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 36 yields nitrate-contaminated, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 791 and 982 mg/L;
- pH (field measurements) of 7.2 and 7.45;
- nitrate concentrations above 50 mg/L;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

The groundwater samples collected in August 1999 and August 2004 had nitrate concentrations of 72.98 mg/L and 81.8 mg/L, respectively. These nitrate results, which substantially exceed the drinking water MCL for nitrate (10 mg/L), suggest an indeterminate long-term concentration trend.

The source of the nitrate is the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds, which were four contiguous, unlined surface impoundments used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric-acid wastes generated at Y-12. The ponds also received periodic shipments of Tc-99 wastes generated at the DOE Savannah River Plant. During RCRA closure of the site in 1988, the ponds were backfilled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot). Operation of the ponds emplaced a contaminant plume containing a heterogeneous mix of inorganic, organic, and radiological contaminants. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic component of the plume and, based on available data from the network of existing monitoring wells, elevated concentrations (>10 mg/L) of nitrate extend at least 5,000 ft east-southeast and west-southwest (parallel with geologic strike) of the former S-3 Ponds, and approximately 1,000 ft south-southwest (across geologic strike) toward the main channel of Bear Creek (DOE 1997). The elongated geometry of the plume reflects the preferred strike-parallel direction of groundwater flow/contaminant transport in BCV.

The gradational decrease in bulk permeability and groundwater flux that occurs with depth (see Section 3.0) has generally limited the vertical (down-dip) extent of the S-3 Ponds contaminant plume, with the very high nitrate concentrations (>1,000 mg/L) evident for the groundwater samples from the deepest sampling port in well GW-134 (sampling port 5) showing that the plume extends at least 750 ft bgs. Additionally, compared to the nitrate concentrations reported for all the sampling ports more than 300 ft bgs (Figure 1), the substantially lower nitrate levels in the groundwater samples from port 36 illustrate how seasonal recharge/discharge cycles more effectively flush contaminants from the shallow flow system (DOE 1997). Moreover, the nitrate concentrations reported for sampling port 36 are significantly (>50%) lower than the nitrate levels evident in groundwater from sampling port 35, which is only 15 ft deeper in the Maynardville Limestone than port 36 (Figure 1). This suggests that there are significant lithologic and/or stratigraphic controls on the migration/transport of the mobile components of the S-3 Ponds contaminant plume.

5.2 URANIUM

None of the groundwater samples collected to date had a total uranium concentration above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

A low (estimated) concentration of PCE (2 µg/L) was detected in the groundwater sample collected in August 2004. This compound is one of the primary organic components of the S-3 Ponds contaminant plume, and their presence in the shallow groundwater from this sampling port reflects the southward (down-dip) transport toward the headwaters of Bear Creek. Compared to the nitrate concentrations in the groundwater samples from this sampling port, the low concentrations of PCE reflects the much lower volume of organic wastes disposed at the site and the greater attenuation of these compounds relative to that of nitrate (DOE 1997). Additionally, PCE concentrations reported for sampling port 35, which is 40 ft deeper in the Maynardville Limestone, are much higher than evident in port 36 (Figure 2). As with the similar disparity in the nitrate concentrations in the groundwater from these ports, the difference between PCE levels in each port potentially reflect the strong influence on groundwater flow/contaminant migration exerted by lithologic and/or stratigraphic features in the Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA was reported for the groundwater sample collected in August 2004, and this result (4.8 pCi/L) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

The groundwater samples collected in August 1999 and August 2004 had gross beta activity of 32 pCi/L and 130 pCi/L, respectively. These results suggest an increasing concentration trend, with the latter value being substantially above the Safe Drinking Water Act (SDWA) screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). In addition to gross beta activity, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. Although the Tc-99 result for this sample (230 pCi/L) is substantially below the SDWA screening level for Tc-99 (3,790 pCi/L), the result confirms that Tc-99 is the primary source of gross beta activity in the groundwater samples from this port. Like nitrate and PCE, the presence of Tc-99 in the water-producing feature(s) providing inflow to sampling port 36 reflects the southward (across strike and down-dip) migration of the mobile components of the S-3 Ponds contaminant plume.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

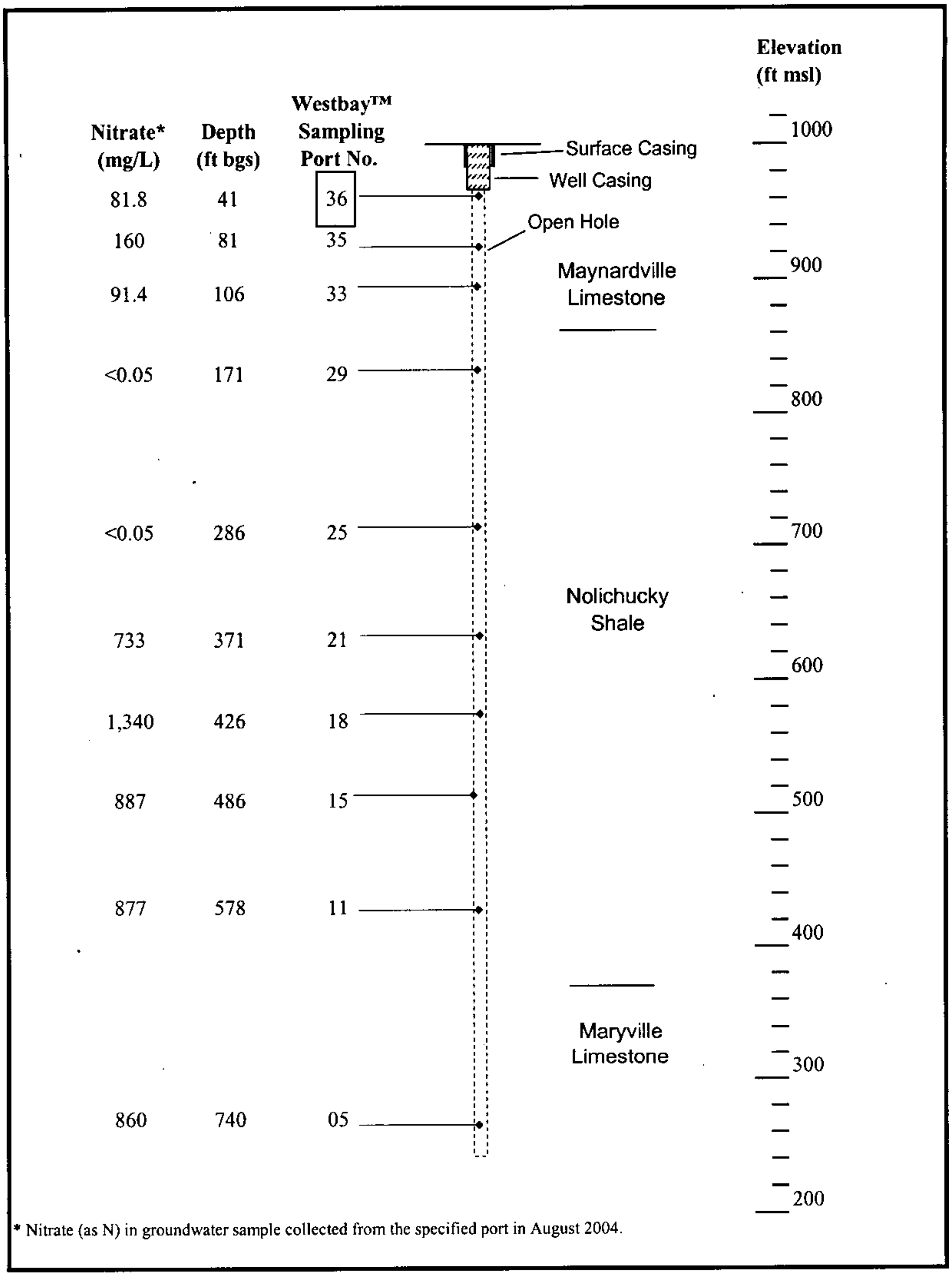

Elevation (ft msl)
Nitrate* (mg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Surface Casing
Well Casing
Open Hole
81.8 41 36
160 81 35
91.4 106 33
<0.05 171 29
<0.05 286 25
733 371 21
1,340 426 18
887 486 15
877 578 11
860 740 05
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
1000
900
800
700
600
500
400
300
200
* Nitrate (as N) in groundwater sample collected from the specified port in August 2004.

Figure 1

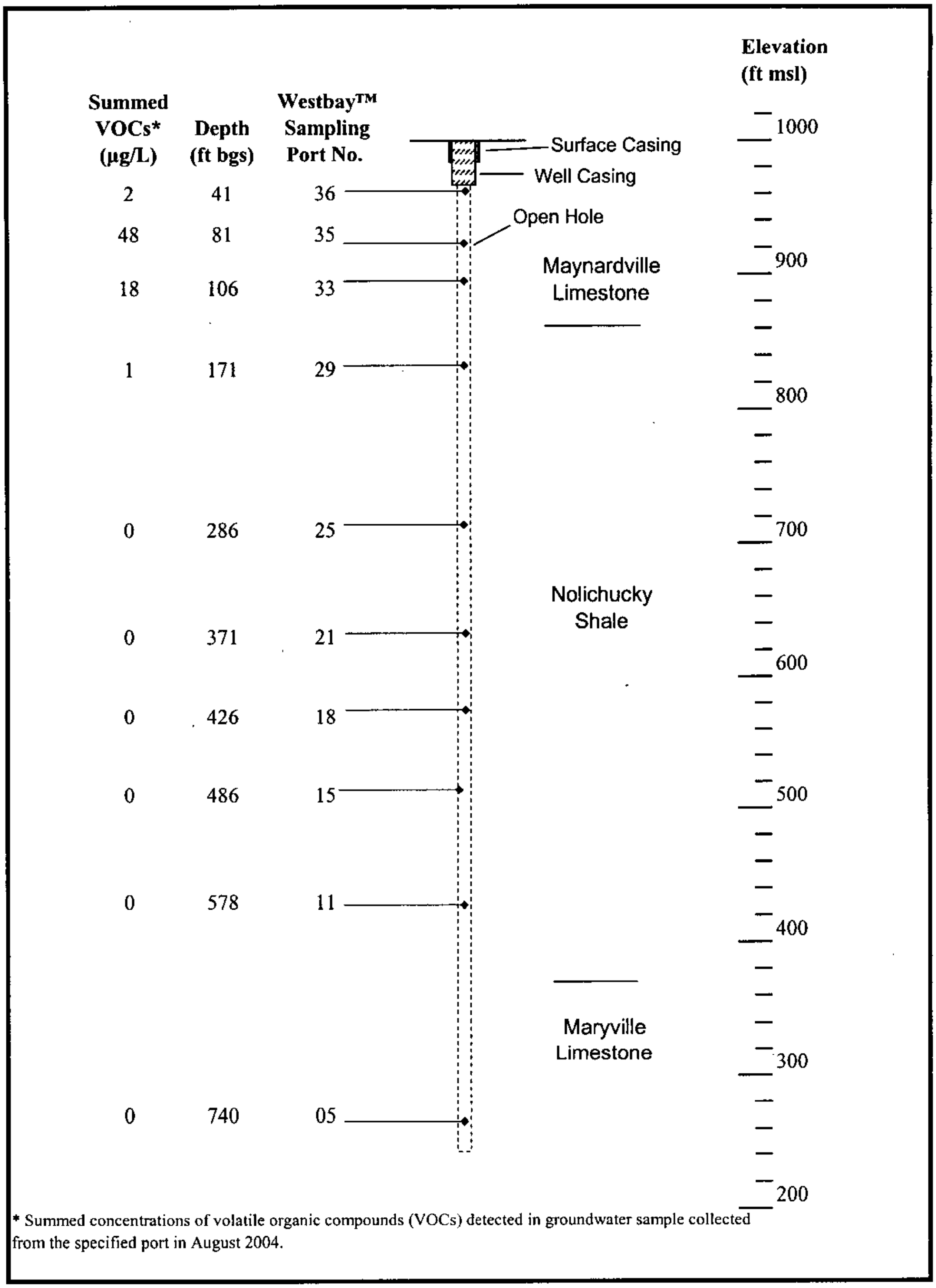

Summed VOCs* (µg/L)
Depth (ft bgs)
Westbay™ Sampling Port No.
Elevation (ft msl)
Surface Casing
Well Casing
Open Hole
2 41 36
48 81 35
18 106 33
1 171 29
0 286 25
0 371 21
0 426 18
0 486 15
0 578 11
0 740 05
Maynardville Limestone
Nolichucky Shale
Maryville Limestone
1000
900
800
700
600
500
400
300
200
* Summed concentrations of volatile organic compounds (VOCs) detected in groundwater sample collected from the specified port in August 2004.

Figure 2

MAXIMUM CONCENTRATION: 2004

ND	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-135-03

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 03 Port Depth : 1206 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/08/99	08/21/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	29 µg/L	09/08/99	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 03

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 03 being 1,206 ft bgs, which is approximately 20 ft below sea level (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 03 yields groundwater from the deep bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 03 yields extremely mineralized sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS above 40,000 mg/L;
- pH (field measurements) near 6.5;
- extremely high concentrations of calcium (>1,000 mg/L), chloride (>20,000 mg/L), sodium (>10,000 mg/L), and sulfate (>2,000 mg/L); and

- very high total (unfiltered sample) concentrations of arsenic (>1 mg/L), boron (>3 mg/L), lithium (>10 mg/L), selenium (>4 mg/L), and strontium (>30 mg/L).

These geochemical characteristics suggest that this port essentially monitors connate water (brine). Additionally, the elevated trace metal concentrations are attributable to natural geochemical processes at depth in the Maynardville Limestone, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite ($BaSO_4$) and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Benzene concentrations of 13 μg/L and 15 μg/L were detected in the groundwater samples collected in September 1999 and August 2004, respectively. Both results exceed the drinking water MCL for benzene (5 μg/L). In addition to benzene, each sample also contained low (estimated) concentrations of styrene (3 μg/L). Also, ethylbenzene was detected (2 μg/L) in the sample collected in August 2004.

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from all other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Acrylonitrile was detected (13 µg/L) in the groundwater sample collected in September 1999. According to the manufacturer, the Westbay™ sampling system contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN..

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

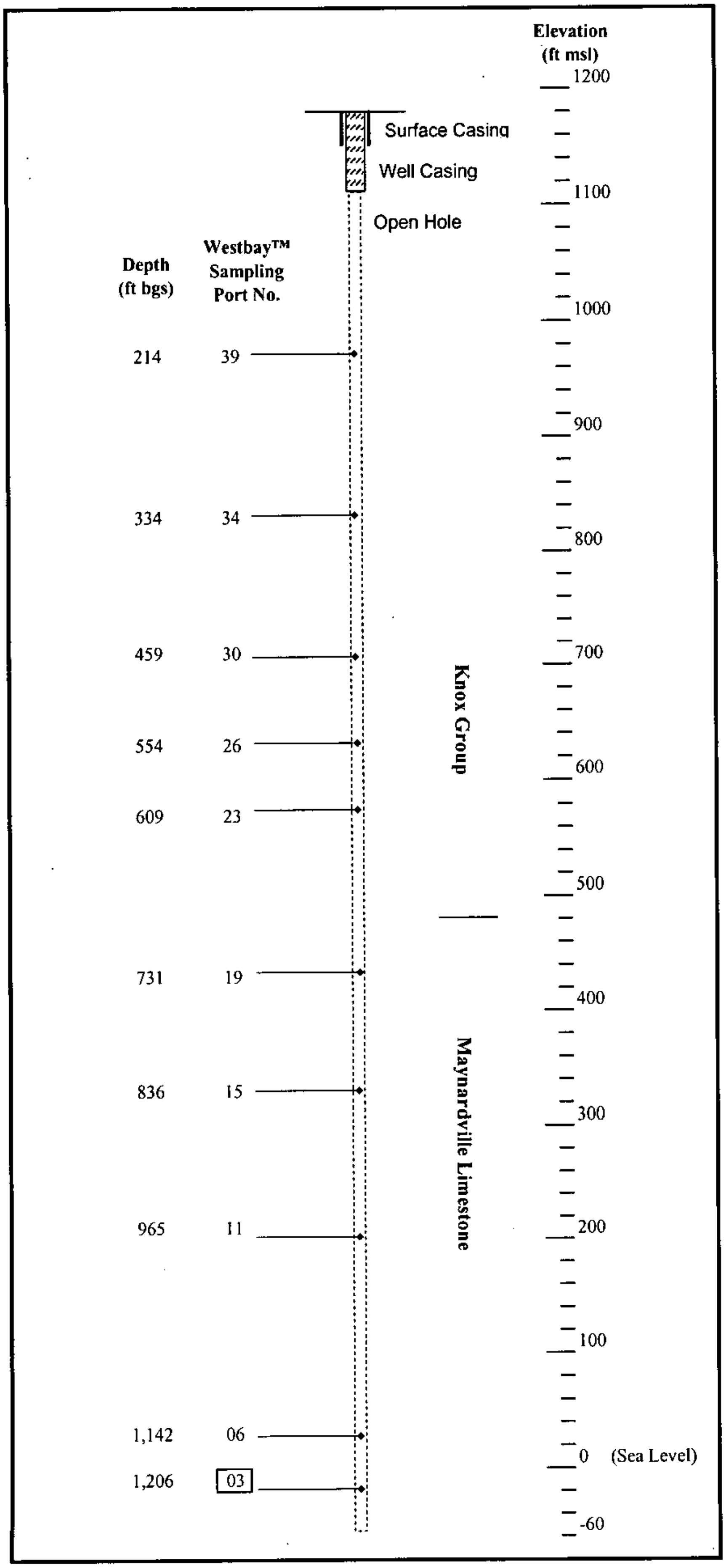


Figure 1

GW-135-03

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	5 - 50	ND	ND

GW-135-06

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 06 Port Depth : 1142 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/13/99	08/21/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	25 µg/L	08/21/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 06

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 06 being 1,142 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 06 yields groundwater from the deep bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 06 yields sulfate-enriched, sodium-chloride-bicarbonate groundwater generally characterized by:

- TDS above 6,000 mg/L;
- pH (field measurements) near 7.0;
- sulfate concentrations of above 2,000 mg/L; and
- elevated total (unfiltered sample) concentrations of boron (>2 mg/L), lithium (>1 mg/L), and strontium (>5 mg/L).

Elevated trace metal concentrations are probably attributable to natural geochemical processes at depth in the Maynardville Limestone, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

One groundwater sample collected to date had a total uranium concentration above the applicable analytical reporting limit, and this result (0.000533 mg/L in September 1999) is substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Benzene concentrations of 2 μg/L and 22 μg/L were reported for the groundwater samples collected in September 1999 and August 2004, respectively; the latter result exceeds the drinking water MCL for benzene (5 μg/L). Also, ethylbenzene was detected (2 μg/L) in the sample collected in August 2004. Considering the depth of water-producing intervals that provide inflow to this sampling port, the detection of these petroleum hydrocarbons in the groundwater samples probably reflects the presence of petroliferous zones at depth in the Maynardville Limestone.

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from all other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN..

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135,.and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

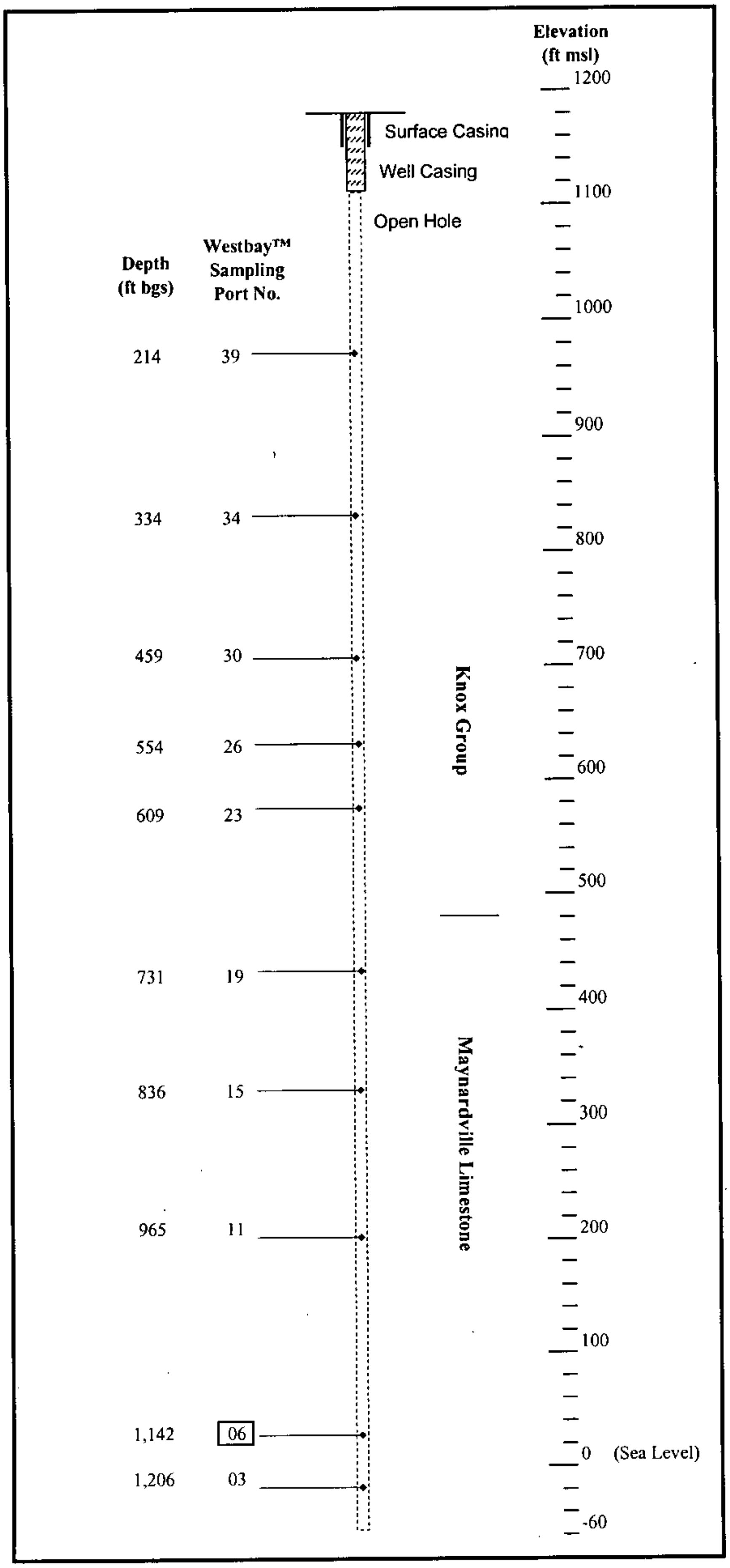


Figure 1

GW-135-06

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	5 - 50	ND	ND

GW-135-11

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 11 Port Depth : 965 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/13/99	08/21/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	.	08/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	34 µg/L	09/13/99	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 11

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 11 being 965 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 11 yields groundwater from the deep bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 11 yields chloride-, sulfate-, and sodium-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS above 3,000 mg/L;
- pH (field measurements) near 7.0;
- high concentrations of sulfate (>1,500 mg/L) and sodium (>100 mg/L);
- elevated total (unfiltered sample) concentrations of boron (>1 mg/L) and strontium (>7 mg/L); and

- total concentrations of trace metals (except boron and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated boron and strontium concentrations are attributable to natural geochemical processes at depth in the Maynardville Limestone, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of barite ($BaSO_4$) and celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Toran and Saunders 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Benzene concentrations of 34 μg/L and 26 μg/L were detected in the groundwater samples collected in September 1999 and August 2004, respectively. Both of these results substantially exceed the drinking water MCL for benzene (5 μg/L). Also, low (estimated) concentrations of ethylbenzene (1 μg/L), toluene (2 μg/L), and styrene (1 μg/L) in the sample collected in August 2004.

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from all other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN..

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

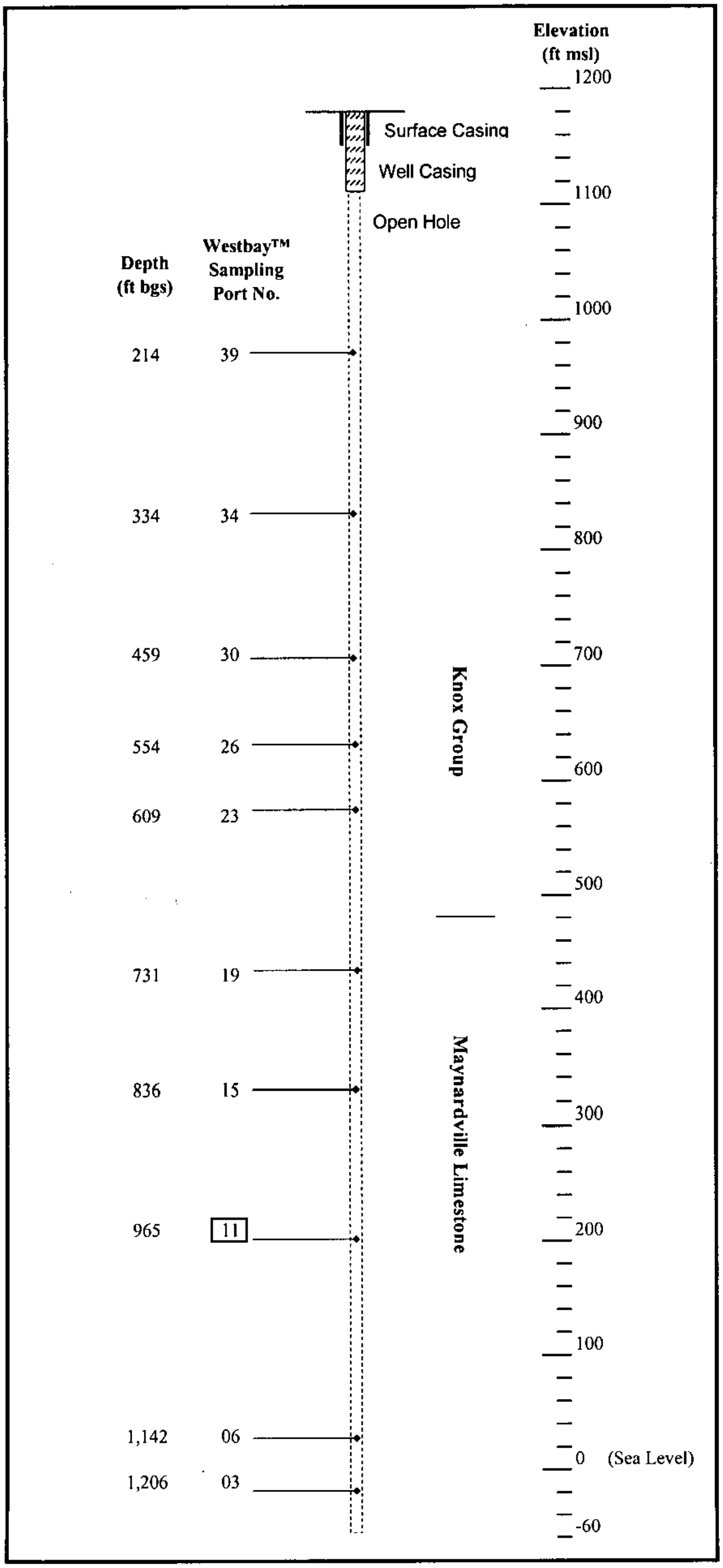


Figure 1

GW-135-11

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	<5	ND	ND

GW-135-15

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 15 Port Depth : 836 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/14/99	08/21/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . *pre-sampling measurements (ft)*

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 15

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 15 being 836 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 15 yields groundwater from the upper most formation (Maynardville Limestone) of the Conasauga Group, which underlies the axis of Bear Creek Valley (BCV) and dips southeast beneath the overlying Knox Group formations that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth. Also, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 15 yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 243 and 336 mg/L;
- pH (field measurements) of 7.7;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Low (estimated) concentrations of ethylbenzene (1 μg/L) and styrene (2 μg/L) were detected in the groundwater sample collected August 2004. Considering the depth of water-producing intervals that provide inflow to this sampling port, the detection of these petroleum hydrocarbons in the groundwater sample possibly reflects the presence of petroliferous zones at depth in the Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

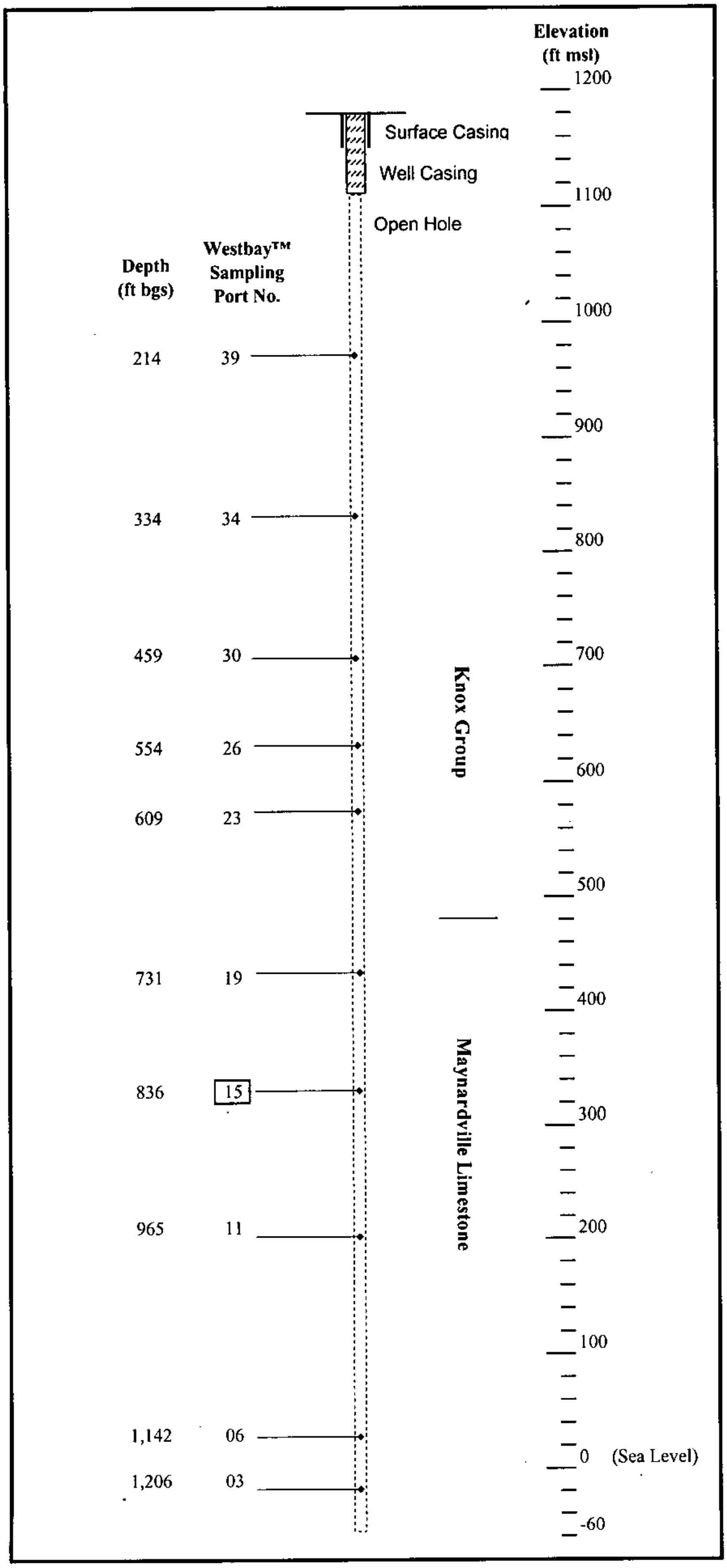


Figure 1

GW-135-15

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	ND	<7.5	ND

GW-135-19

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 19 Port Depth : 731 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/14/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 19

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 19 being 731 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 19 yields groundwater from the deep bedrock interval in the uppermost formation of the Conasauga Group (Maynardville Limestone). The Maynardville Limestone subcrops along the axis of BCV, underlies the main channel of Bear Creek, and dips to the southeast below the Knox Group carbonates that form Chestnut Ridge. The bulk of the groundwater flow in the Maynardville Limestone occurs at shallow depths (<150 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Because the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity decreases with depth (Solomon et. al. 1992). Additionally, there are seven stratigraphic zones (number from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et. al. 1995). The more permeable zones are at the bottom (Zone 2) and top (zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater flow in this formation (Goldstrand 1995).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 19 yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 192 and 317 mg/L;
- pH (field measurements) near 7.5;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at

Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

Total uranium concentrations reported for the groundwater samples collected in September 1999 (0.00101 mg/L) and August 2004 (0.00119 mg/L) exceed the applicable analytical reporting limit, and both results are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to data contained VOCs.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA was reported for the groundwater samples collected in September 1999 (5.6 pCi/L) and August 2004 (4.3 pCi/L). Both results are substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity Within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN..

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

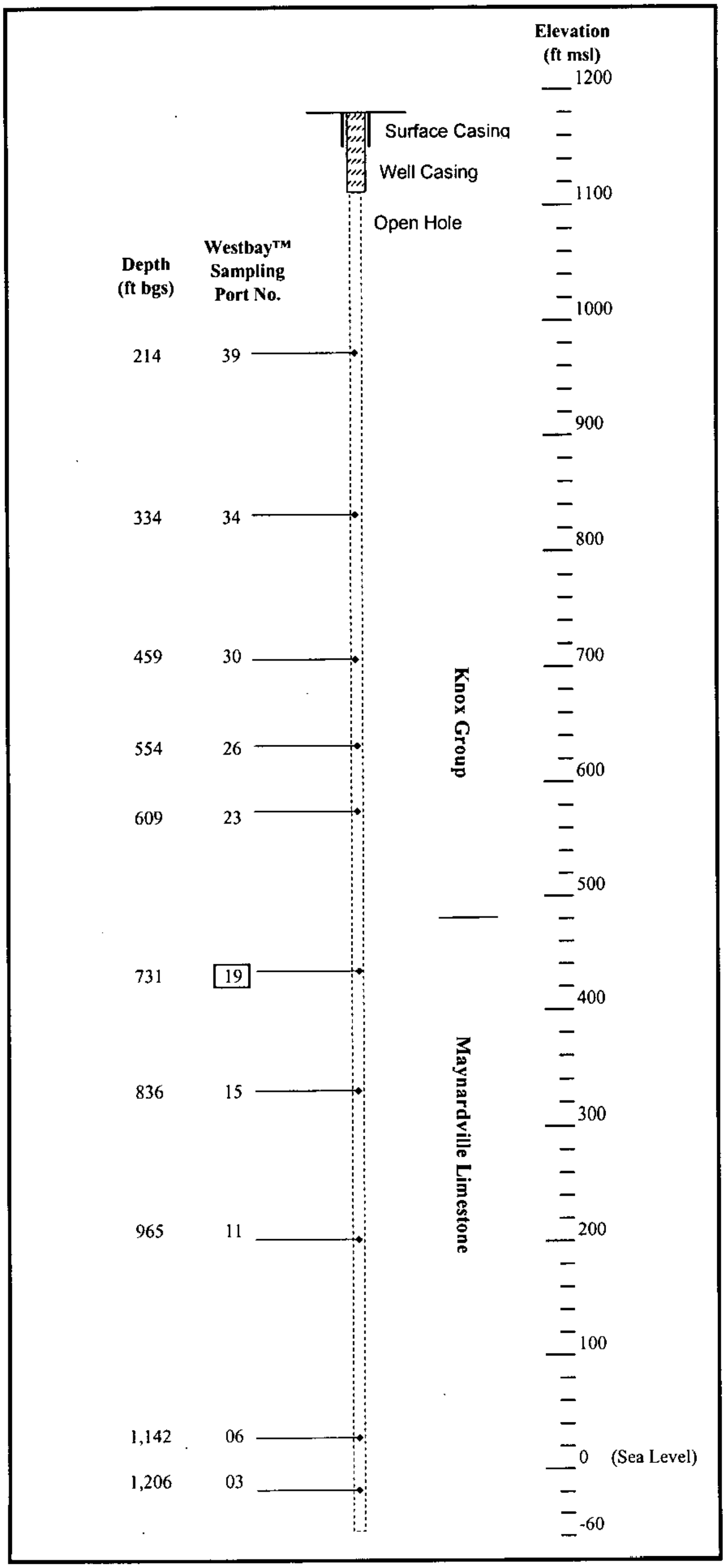


Figure 1

GW-135-19

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	5 - 50	ND	ND

GW-135-23

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 23 Port Depth : 609 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	09/15/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . *pre-sampling measurements (ft)*

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	27 µg/L	08/22/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 23

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 23 being 609 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 23 yields groundwater from the lower Knox Group (Chepultepec Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures (e.g., bedding plane fractures) form water-producing zones within an essentially impermeable matrix, with preferred flow in directions that parallel geologic strike. Dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers, but the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth. Consequently, the bulk hydraulic conductivity is vertically gradational, with the bulk of the groundwater flux occurring within the transitional horizon between residuum and unweathered bedrock and substantially lower flux (and longer solute residence times) at successively greater depths in the bedrock (Solomon et al. 1992).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 23 yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS above 3,000 mg/L;
- pH (field measurements) near 7.2;
- sulfate concentrations above 2,000 mg/L along with unusually high concentrations of potassium (>50 mg/L) and sodium (>70 mg/L);

- elevated total (unfiltered sample) concentrations of boron (>2 mg/L), fluoride (>1 mg/L), iron (>1 mg/L), and strontium (>8 mg/L); and
- total concentrations of trace metals (except boron, iron, and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Elevated trace metal concentrations may be attributed to natural geochemical processes, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

One of the groundwater samples collected to date had a total uranium concentration above the analytical reporting limit, and this result (0.000668 mg/L in September 1999) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Benzene concentrations of 14 µg/L and 19 µg/L were reported for the groundwater samples collected in September 1999 and August 2004, respectively. Both of these results substantially exceed the drinking water MCL for benzene (5 µg/L). Each sample also contained low (estimated) concentrations of ethylbenzene (3 µg/L and 4 µg/L, respectively) and toluene (3 µg/L and 2 µg/L, respectively), and the sample collected in August 2004 had a trace of styrene (2 µg/L).

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from all other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

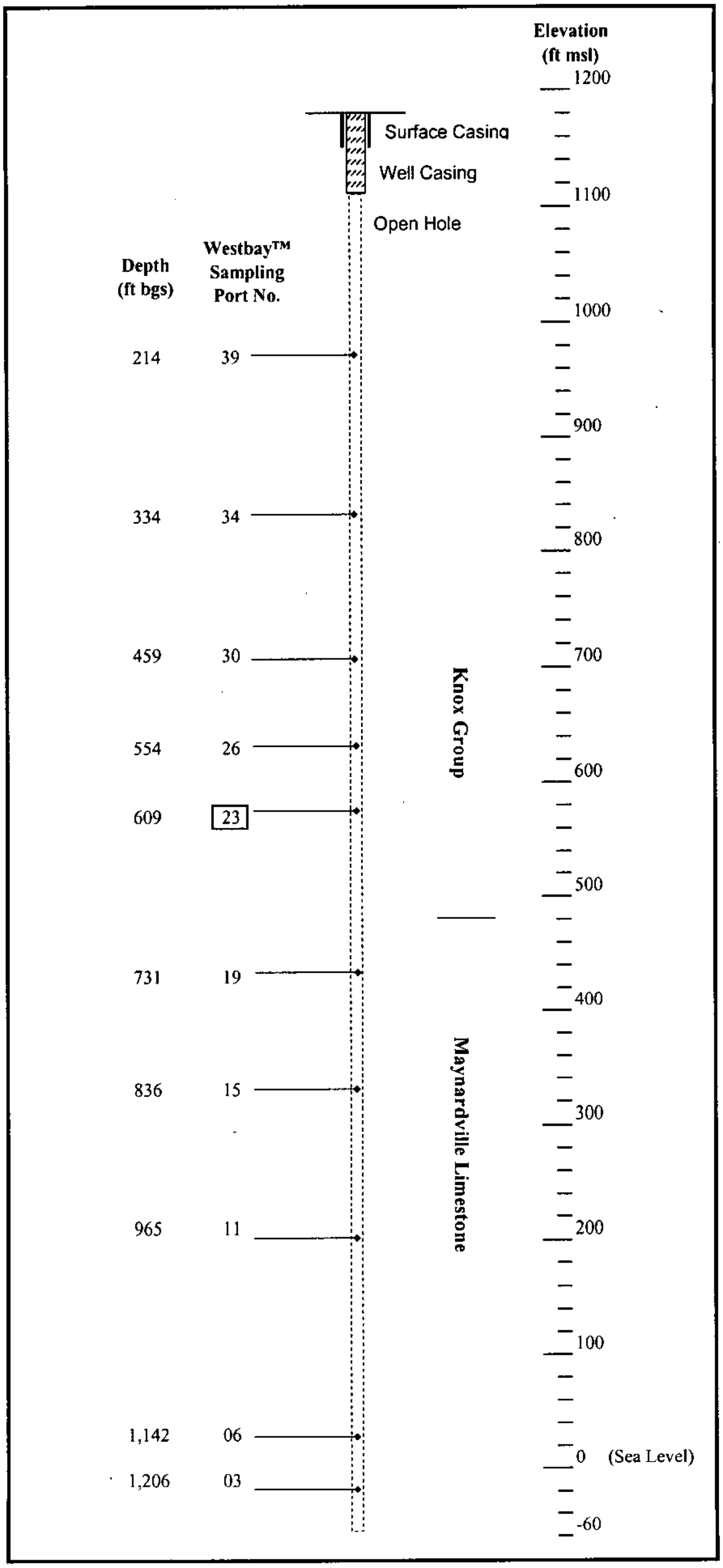


Figure 1

GW-135-23

MAXIMUM CONCENTRATION: 2004

ND	ND	50 - 500	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-135-26

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 26 Port Depth : 554 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	09/15/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	70 µg/L	08/22/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 26

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 26 being 554 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 26 yields groundwater from the lower Knox Group (Chepultepec Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 26 yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS above 2,500 mg/L;
- pH (field measurements) near 7.1;
- sulfate concentrations above 1,500 mg/L along with unusually high concentrations of potassium (>20 mg/L);

- elevated total (unfiltered sample) concentrations of boron (>1 mg/L), fluoride (>1 mg/L), iron (>4 mg/L), and strontium (>7 mg/L); and
- total concentrations of trace metals (except boron, iron, and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Elevated trace metal concentrations may be attributed to natural geochemical processes, including: mixing of sulfate-enriched groundwater with brines at depth, which may cause the precipitation of celestite ($SrSO_4$); upward diffusion of solutes from brines in the deeper bedrock; and matrix diffusion from disseminated minerals in the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Low (estimated) concentrations of benzene (4 μg/L), ethylbenzene (3 μg/L), and styrene (1 μg/L) were detected in the groundwater sample collected in September 1999. Higher concentrations of benzene (6 μg/L), which slightly exceeds the drinking water MCL (5 μg/L), ethylbenzene (11 μg/L), and styrene (11 μg/L) were detected in the sample collected in August 2004, along with toluene (6 μg/L) and xylenes (5 μg/L).

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this sampling port: (1) residual contamination from installation of the well; (2) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (3) contamination of the samples during sampling or handling; and (4) traces of natural hydrocarbons in the low-permeability bedrock.

Residual contamination from installation/construction of the well seems an unlikely source of the hydrocarbons in light of the age of the well (>8 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple, if not all, sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from all other ports in the well.

Traces of petroleum hydrocarbons naturally present at depth in the low-permeability bedrock may explain the detection of these compounds in the groundwater samples from this port. These hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Acrylonitrile was detected (31 µg/L) in the groundwater sample collected in August 2004. According to the manufacturer, the Westbay™ sampling system contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

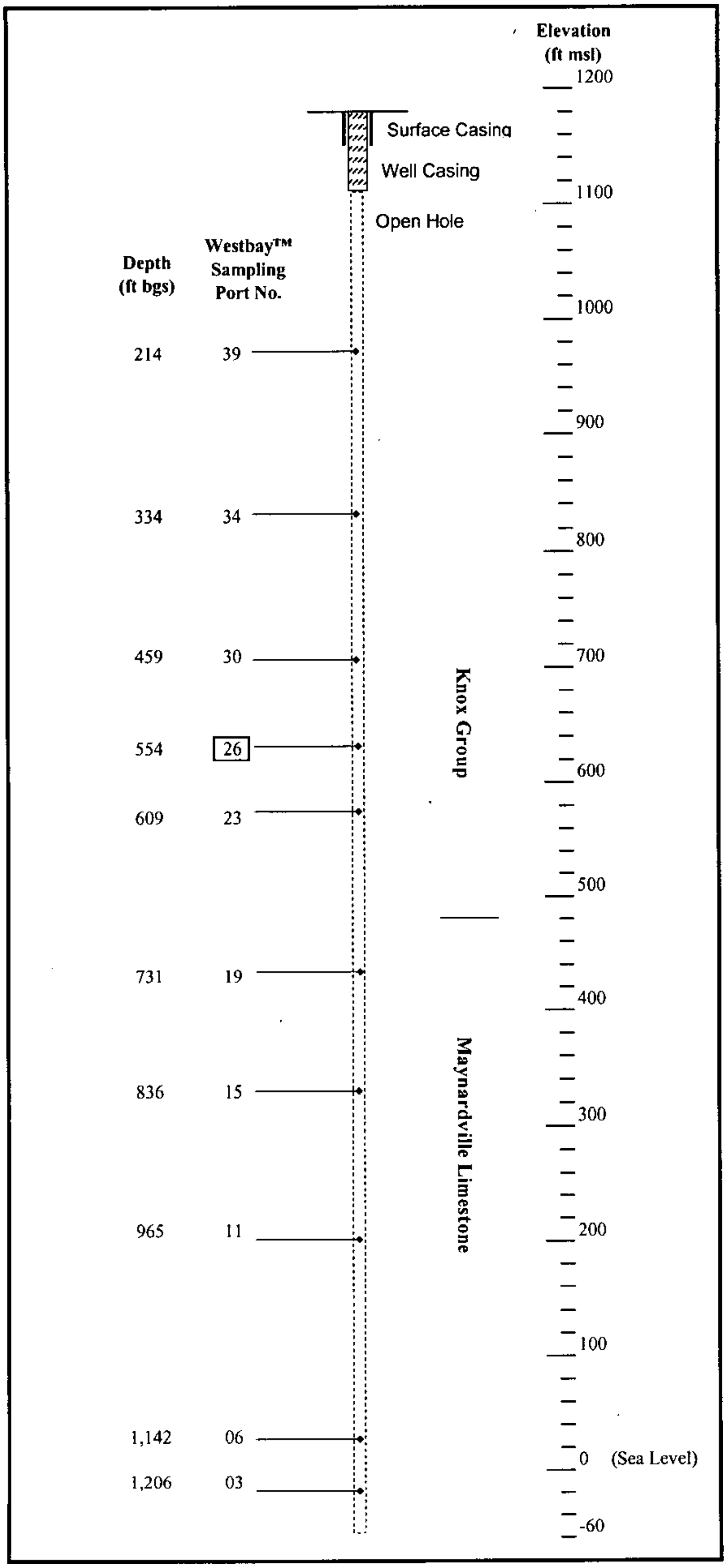


Figure 1

GW-135-26

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-135-30

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 30 Port Depth : 459 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/15/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 30

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 30 being 459 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 30 yields groundwater from the lower Knox Group (Chepultepec Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 30 yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 188 and 275 mg/L;
- pH (field measurements) of 7.69 and 7.75;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Two of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, and both results (0.0323 mg/L in September 1999 and 0.0606 mg/L in August 2004) are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit, and both results (0.000879 mg/L in September 1999 and 0.000699 mg/L in August 2004) are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

One of the groundwater samples collected to date had gross alpha activity above the applicable MDA, and this result (11 pCi/L in September 1999) is less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

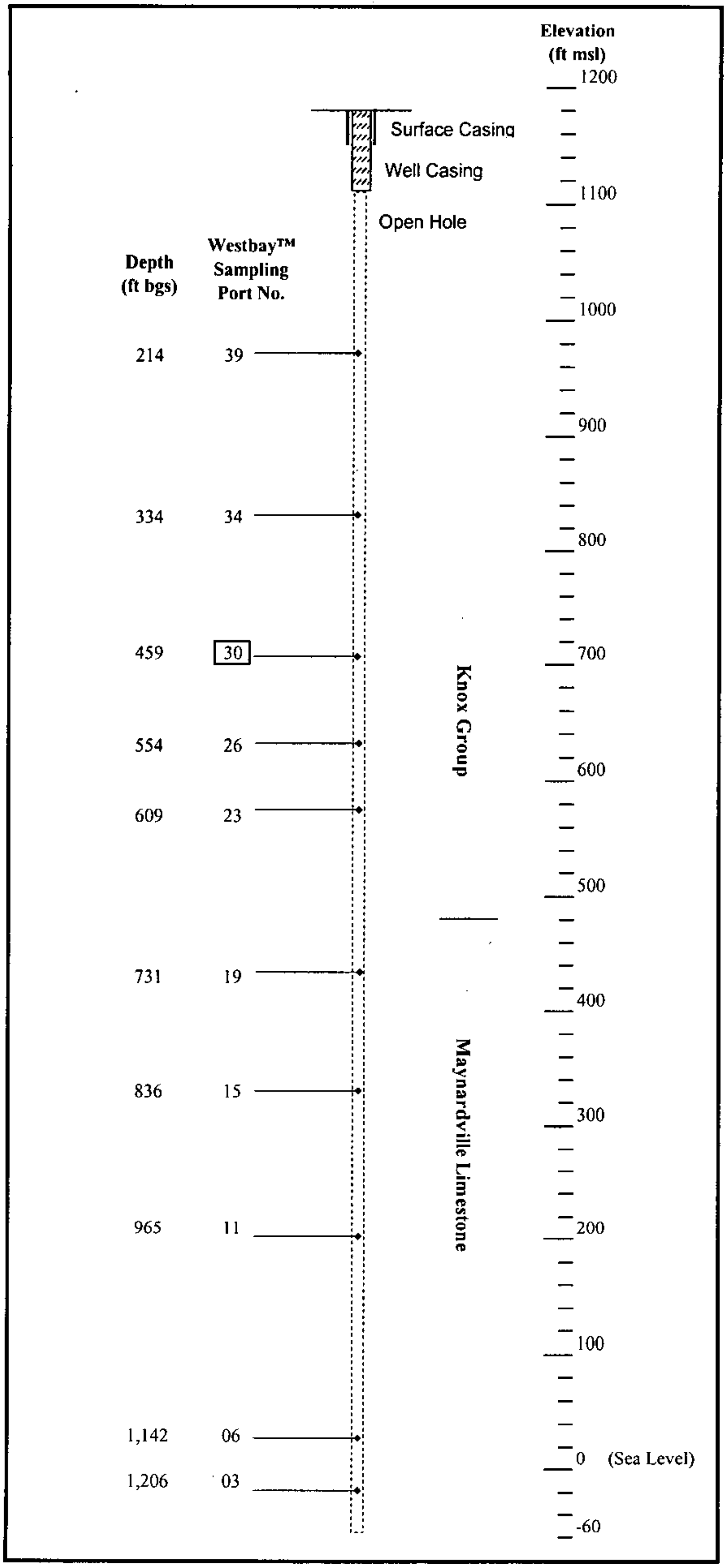


Figure 1

GW-135-30

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-135-34

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 34 Port Depth : 334 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS:	2	First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	. samples	09/16/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 34

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 34 being 334 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 34 yields groundwater from the lower Knox Group (Chepultepec Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 34 yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 187 and 194 mg/L;
- pH (field measurements) of 7.49 and 7.55;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Two of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, and both results (0.134 mg/L in September 1999 and 0.167 mg/L in August 2004) are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit, and both results (0.00127 mg/L in September 1999 and 0.000889 mg/L in August 2004) are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

One of the groundwater samples collected to date had gross alpha activity above the applicable MDA, and this result (5.9 pCi/L in September 1999) is less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

One of the groundwater samples collected to date had gross beta activity above the applicable MDA, and this result (6.5 pCi/L in September 1999) is less than the Safe Drinking Water Act screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity pCi/L). Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135),* Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

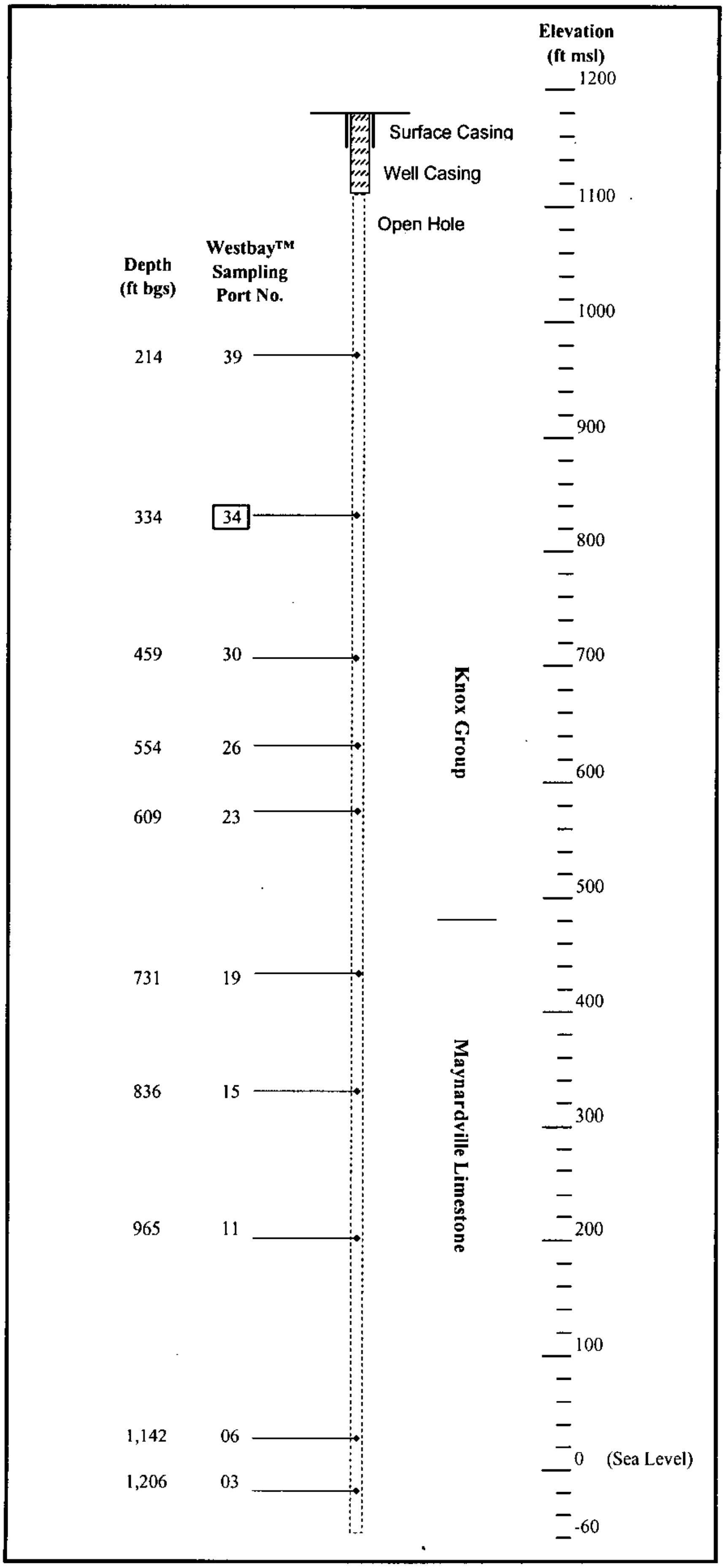


Figure 1

GW-135-34

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-135-39

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 53,053.00
Y-12 GRID NORTH COORDINATE: 28,731.00
SURFACE ELEVATION: 1,175.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/14/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.78 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 39 Port Depth : 214 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	09/16/99	08/22/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	.	08/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-135
Sampling Port 39

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well is located on the crest of Chestnut Ridge near the west end of Y-12, on the east side of Industrial Landfill IV. The well was converted from a core hole that was drilled as part of a geologic investigation performed at Y-12 during the summer of 1985 (King and Haase 1987), and was included in several subsequent hydrogeologic and geochemical studies (King and Haase 1988; Toran and Saunders 1992; Dreier, Early, and King 1993). The well has nominal 4.5-inch diameter steel (SF25) riser casing above an open-hole interval that extends from a depth of 80 to 1,275 ft bgs. In March 1990, a multiport monitoring system (Westbay™) was installed in the well. This equipment enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval (Martin Marietta Energy Systems 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 39 being 214 ft bgs (Figure 1). Only two samples have been collected from this port, one in September 1999 and one in August 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 39 yields groundwater from the lower Knox Group (Chepultepec Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 39 yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 149 and 178 mg/L;
- pH (field measurements) of 7.32 and 7.41;
- low molar proportions of chloride, fluoride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Two of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, and both results (0.2616 mg/L in September 1999 and 0.245 mg/L in August 2004) are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

None of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA. Additionally, the sample collected in August 2004 was analyzed for Tc-99, a beta-emitting radionuclide that is a primary component of the groundwater contaminant plume emplaced during historical operation of the former S-3 Ponds. The analytical result for Tc-99 is below the MDA, which is consistent with the results for gross beta activity.

6.0 REFERENCES

Dreier, R. B., T. O. Early, and H. L. King 1993. *Results and Interpretation of Groundwater Data Obtained from Multiport-Instrumented Coreholes (GW-131 through GW-135), Fiscal Years 1990 and 1991. Y-12 Plant*, Y/TS-803, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

King, H.L., and C.S. Haase. 1987. *Subsurface Controlled Geologic Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*, ORNL/TM-10112, prepared for Martin Martin Energy Systems, Inc., Oak Ridge, TN.

King, H. L., and C. S. Haase 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing In Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant,* Y/TS-495, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Martin Marietta Energy Systems, Inc. 1995. *Westbay Multi-Port Monitoring System Completion Reports for GW-131, GW-132, GW-133, GW-134, GW-135, and GW-722 at the Y-12 Plant, Oak Ridge, Tennessee,* Y/TS-1324, Martin Marietta Energy Systems, Inc, Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Toran, L. E., and J. A. Saunders 1992. *Geochemical and Groundwater Flow Modeling of Multiport-Instrumented Coreholes (GW-131 Through GW-135)*, Y/TS-875, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

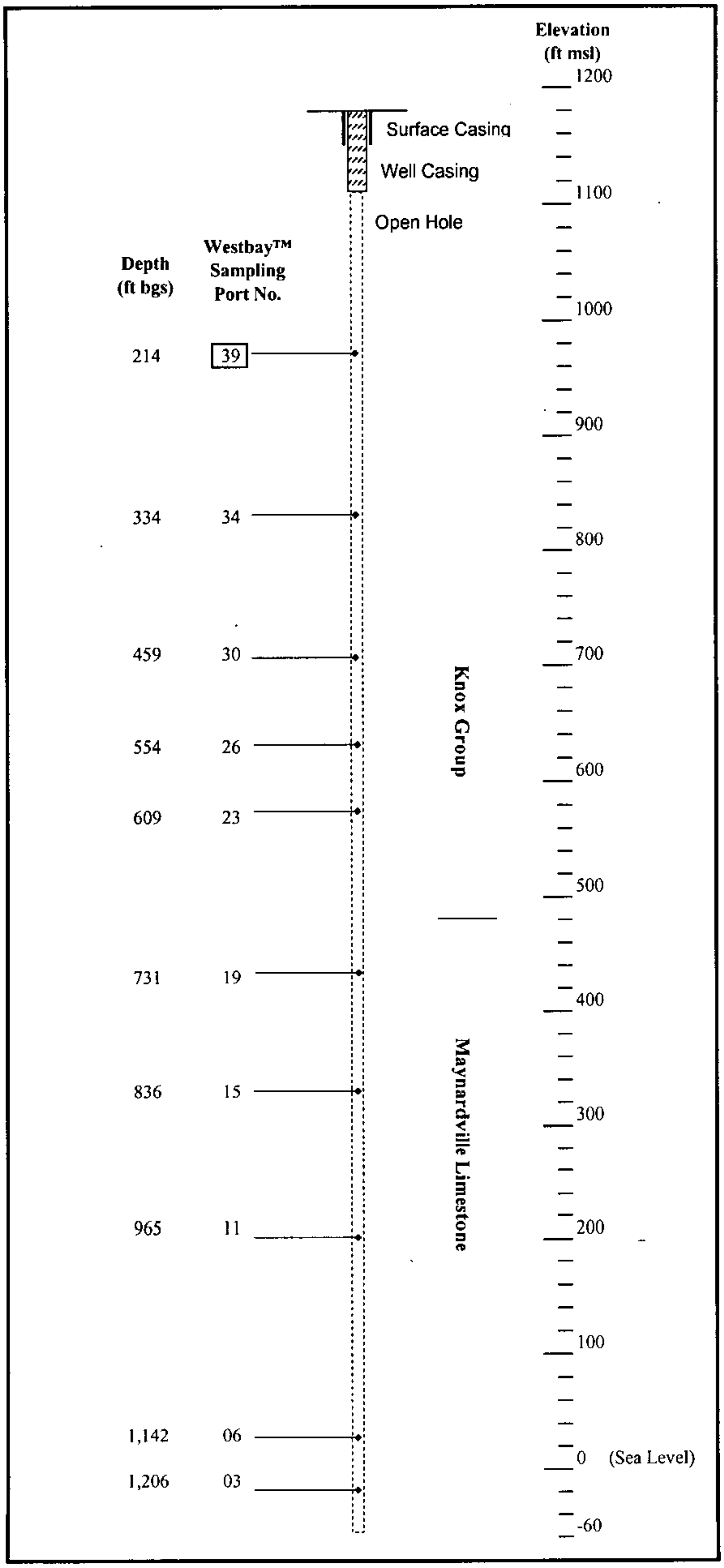


Figure 1

GW-135-39

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-141

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill IV
Y-12 GRID EAST COORDINATE: 52,463.45
Y-12 GRID NORTH COORDINATE: 28,754.79
SURFACE ELEVATION: 1,183.45 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/04/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 158.81 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,186.23 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	141.0	1042.45
BOTTOM (filter pack or open hole):	156.0	1027.45
MIDPOINT (filter pack or open hole):	148.5	1034.95
PUMP INTAKE:	147.72	1035.73
WATER LEVEL (average):	91.54	1091.91

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	51		
CONVENTIONAL SAMPLING METHOD:	37 samples	02/18/88	07/23/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/08/98	07/15/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/22/04	.	07/15/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.32 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	9.4 μg/L	02/07/00	Outlier
GROSS ALPHA (15 pCi/L):	2	17 pCi/L	01/07/97	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-141

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1987, completed with a screened monitored interval from 141 to 156 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the crest of Chestnut Ridge southwest of the west end of Y-12, about 100 ft directly north (hydraulically downgradient) of Industrial Landfill IV. In operation since 1989, this landfill receives about 12,000 ft^2 per year of nonhazardous and nonradioactive industrial wastes, including cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 37 samples between February 1988 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group (Copper Ridge Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 90 ft bgs and exhibits moderate seasonal fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 160 – 284 mg/L;
- pH (field measurements) of 6.2 – 7.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are less than 0.5 mg/L.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 37 groundwater samples collected from the well since January 1991.

5.1 NITRATE

All but one groundwater sample had nitrate above the applicable analytical reporting limit, with the highest concentration (0.88 mg/L in January 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0014 mg/L in January 1997) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples: acetone (9 μg/L) in February 2000, MC (0.89 μg/L) in July 2000, and carbon disulfide (0.64 μg/L) in July 2004. These compounds are common laboratory agents and the results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the two highest values (16.6 pCi/L in January 1996 and 17 pCi/L in January 1997) being slightly above the MCL for gross alpha activity (15 pCi/L). Alpha activity has been below the applicable MDA in every sample collected since January 1997.

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (35 pCi/L in January 1997) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

.	ND	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-142

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Kerr Hollow Quarry
Y-12 GRID EAST COORDINATE: 64,030.00
Y-12 GRID NORTH COORDINATE: 24,524.00
SURFACE ELEVATION: 968.29 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/03/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 298.20 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 971.15 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	248.5	719.79
BOTTOM (filter pack or open hole):	295.0	673.29
MIDPOINT (filter pack or open hole):	271.75	696.54
PUMP INTAKE:	272.94	695.35
WATER LEVEL (average):	139.40	828.89

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	95		
CONVENTIONAL SAMPLING METHOD:	53 samples	02/27/86	08/07/97
LOW-FLOW SAMPLING METHOD:	42 samples	11/10/97	10/08/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/03/03	.	10/08/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 80.16 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	1	0.032 mg/L	08/25/93	Indeterminate
SUMMED VOCs (5 µg/L):	2	17 µg/L	10/21/96	Anomalous Result
GROSS ALPHA (15 pCi/L):	2	16.8 pCi/L	01/04/96	Decreasing
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-142

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from 248.5 to 295 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well is located on the southern flank of Chestnut Ridge directly south of the east end of Y-12, about 300 ft east (hydraulically upgradient) of Kerr Hollow Quarry (KHQ). KHQ is an inactive, water-filled quarry formerly used for disposal of various hazardous and nonhazardous wastes generated from historical DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 53 samples between February 1986 and August 1997, and the low-flow sampling method used to obtain 42 samples between November 1997 and October 2003.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher levels of uranium than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling", when groundwater samples are collected with the low-flow sampling method one day and the conventional sampling method the next day, are needed to determine if the uranium concentrations are biased by the sampling method.

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features that may not be proximal to the pump intake. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the well. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of contaminated groundwater into the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Mascot Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 139 ft bgs and exhibit unusually wide (>80 ft) fluctuations (Figure 1). However, the conventional sampling method is associated with the largest apparent water level fluctuations. Purging the well during conventional sampling typically decreases the water level in the well by 40 ft or more, and the water level is very slow to recover to the presampling level (Figure 2). Moreover, the protocol of consecutive daily sampling required for RCRA post-closure detection monitoring at the KHQ was discontinued in part because the water level in this well would not sufficiently recover between sampling events (Bechtel Jacobs Company LLC [BJC] 2001).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (150 mg/L – 800 mg/L);
- pH (field measurements) of 7.1 – 8.5;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 76 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twenty groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.9 mg/L in March 1991) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.032 mg/L in August 1993) being slightly above the MCL for uranium (0.03 mg/L). As noted in Section 2.0, uranium concentrations may be significantly higher in conventional samples from this well than in low-flow samples. Uranium concentrations reported for low-flow samples have been either non-detect values or less than 0.005 mg/L, and uranium concentrations reported for conventional samples were commonly above 0.01 mg/L (Figure 3). Furthermore, uranium has been detected in only one semiannual sample (0.004 mg/L in October 2001) since 1999, when the reporting limit increased from 0.0005 mg/L to 0.004 mg/L.

A time-series plot of the uranium concentrations in each sample from well GW-142 shows a generally decreasing trend, which may be skewed by the change to low-flow sampling in October 1997 (Figure 3). Although the well is located hydraulically upgradient of KHQ, the significant drop in water level (> 40 ft) induced by the conventional method (Figure 2) would temporarily establish a fairly strong hydraulic gradient toward the well from the site. If uranium flux was induced toward well GW-142 by the periodic gradient reversals caused by aggressively purging the well for the conventional sampling method, then the low-flow sampling method may effectively keep uranium concentrations low in samples from the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for 61 groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Chestnut Ridge Regime. Low concentrations of PCE were detected in samples collected in March 1991 (0.7 μg/L), August 1991 (0.7 μg/L), November 1991 (0.8 μg/L), May 1992 (2 μg/L), November 1995 (1 μg/L), and April 1997 (1 μg/L). Samples collected in April 1997 also had low levels (1 μg/L) of chloroform. The series of PCE detections between March 1991 and May 1992 generally coincide with the disturbance of wastes in KHQ from efforts to achieve clean closure of site (BJC 2001).

5.4 GROSS ALPHA ACTIVITY

Forty-one groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (16.8 pCi/L in January 1996) being slightly above the MCL for gross alpha activity (15 pCi/L). However, none of the other results for gross alpha activity exceed the MCL, with values below 5 pCi/L reported for each sample collected since November 1997.

5.5 GROSS BETA ACTIVITY

Forty-five of the groundwater samples had gross beta activity above the applicable MDA and/or the corresponding CE, with the highest value (38.8 pCi/L in February 1992) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). However, this result is a suspected outlier because none of the other results for gross beta activity exceed 15 pCi/L and values have been below 10 pCi/L reported for each sample collected since July 1995.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC 2001. *Calendar Year 2000 Annual Resource Conservation and Recovery Act Groundwater Monitoring Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-885, Bechtel Jacobs Company LLC, Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

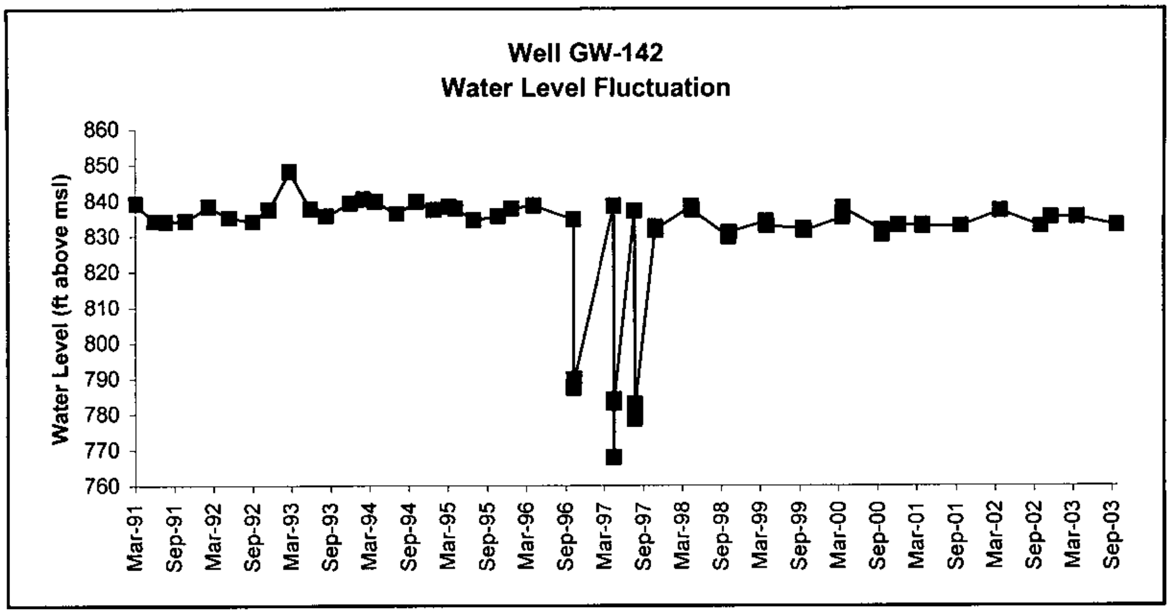


Figure 1

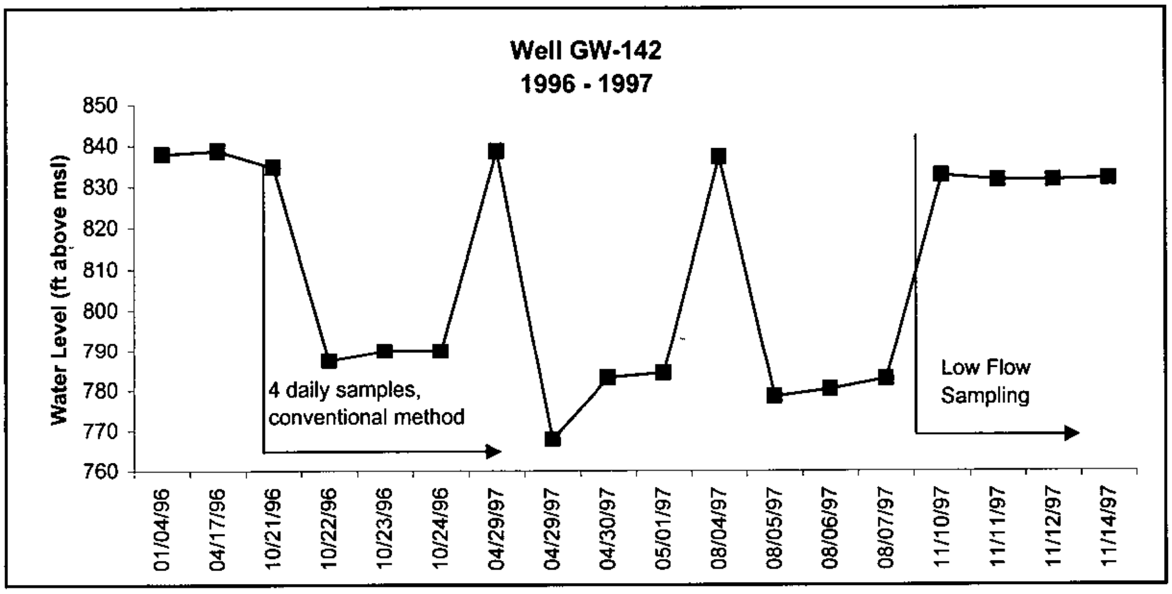


Figure 2

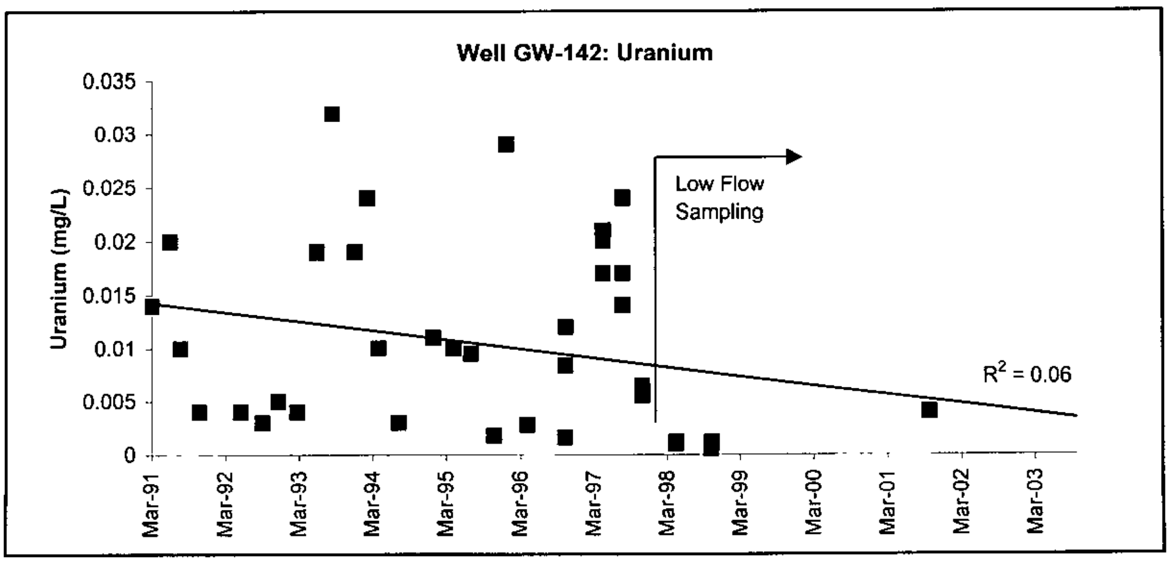


Figure 3

GW-142

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	<7.5	<25

GW-143

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Kerr Hollow Quarry
Y-12 GRID EAST COORDINATE: 63,522.00
Y-12 GRID NORTH COORDINATE: 24,257.00
SURFACE ELEVATION: 911.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/85 PAIRED/CLUSTERED WITH: GW-144
TAG DEPTH (measured): 252.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 913.98 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	205.0	706.04
BOTTOM (filter pack or open hole):	253.0	658.04
MIDPOINT (filter pack or open hole):	229	682.04
PUMP INTAKE:	226.06	684.98
WATER LEVEL (average):	77.18	833.86
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	97		
CONVENTIONAL SAMPLING METHOD:	53 samples	03/06/86	08/07/97
LOW-FLOW SAMPLING METHOD:	44 samples	11/10/97	10/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/12/04	.	10/12/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 108.33 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	102 µg/L	04/30/97	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-143

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from 205 to 253 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well forms a cluster with well GW-144 and is located on the southern flank of Chestnut Ridge directly south of the east end of Y-12, about 250 ft south (hydraulically downgradient) of Kerr Hollow Quarry (KHQ). KHQ is an inactive, water-filled quarry formerly used for disposal of various hazardous and nonhazardous wastes generated from historical DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 53 samples between March 1986 and August 1997, and the low-flow sampling method used to obtain 44 samples between November 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Mascot Dolomite). The average static groundwater level in the well is about 77 ft bgs. Presampling depth-to-water measurements for the well indicate unusually wide (>100 ft) fluctuations in groundwater surface elevations (Figure 1). However, the conventional sampling method is associated with the largest apparent water level fluctuations. Purging the well during conventional sampling typically decreases the water level in the well by 90 ft or more, and the water level is very slow to recover to the presampling level (Figure 2). Moreover, the protocol of consecutive daily sampling required for RCRA post-closure detection monitoring at the KHQ was discontinued in part because the water level in this well would not sufficiently recover between sampling events, as shown on Figure 1 (Bechtel Jacobs Company LLC [BJC] 2001).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 120 – 300 mg/L;
- pH (field measurements) of 6.9 – 8.5;
- unequal molar proportions of calcium and magnesium;
- concentrations of sulfate (>30 mg/L), sodium (>20 mg/L), chloride (>109 mg/L), and fluoride (>2 mg/L) that are much higher than typical of other wells in the Knox Group; and
- total (unfiltered sample) concentrations of trace metals (except boron and strontium that are substantially higher than evident in other Knox Group wells) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of locally disseminated gypsum ($CaSO_4 \cdot 2 H_2O$) may account for the sulfate-enriched geochemistry (Lockheed Martin Energy Systems, Inc. 1999) and enriched levels of other solutes, including boron and strontium, may be a legacy of the sedimentary basin brines that are encountered at depth elsewhere on the ORR (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 79 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Eight groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.3 mg/L in September 1991) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Forty-one groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.006 mg/L in September 1992) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in 13 groundwater samples and the summed VOC concentration exceeded 5 μg/L in three of these samples (March 1996, April 1997, and November 1997). None of the VOC concentrations exceeded an applicable MCL. Very low concentrations (2 μg/L or less) of TCE, CT, and/or chloroform were detected in the six samples collected in August 1993, March 1994, and April-May 1997. Similarly low levels of PCE (1 μg/L), ethylbenzene (2 μg/L), total xylene (1 μg/L), bromomethane (4 μg/L), chloromethane (8 μg/L), and TCFM (2 μg/L) were detected in the sample collected in November 1997. These VOCs are known or suspected to have been included in the wastes disposed at KHQ and their repeated detection in the groundwater samples collected from the well during the early and mid-1990s generally coincides with efforts to remove or otherwise stabilize the submerged wastes during RCRA closure of the site.

One sample (April 1997) had 2-butanone (13 μg/L), and acetone was detected in four samples: the highest acetone concentration (100 μg/L) was in April 1997, and most recent detection (1 μg/L) was in December 2002. The results for acetone and 2-butanone are probable artifacts because these compounds are commonly detected in blank samples.

5.4 GROSS ALPHA ACTIVITY

Forty-nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (12 pCi/L in October 1994) being slightly below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Sixty-four groundwater samples had gross beta activity above the applicable MDA and the corresponding CE, with the highest value (44 pCi/L in November 1997) being slightly below the SDWA screening level for gross beta activity.

6.0 REFERENCES

Bechtel Jacobs Company LLC 2001. *Calendar Year 2000 Annual Resource Conservation and Recovery Act Groundwater Monitoring Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-885, Bechtel Jacobs Company LLC, Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Lockheed Martin Energy Systems, Inc. 1999. *Groundwater Protection Program Calendar Year 1998 Evaluation of Groundwater Quality Data for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/SUB/99-MVM64V/3, Lockheed Martin Energy Systems, Oak Ridge, TN.

Saunders, J.A. and L.E. Toran. 1992. *Evolution of Ca-Mg-SO_4 Type and Na-Ca-SO_4 Type Water in Fractured Sedimentary Rock Near Oak Ridge, Tennessee*, Y/TS-875/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

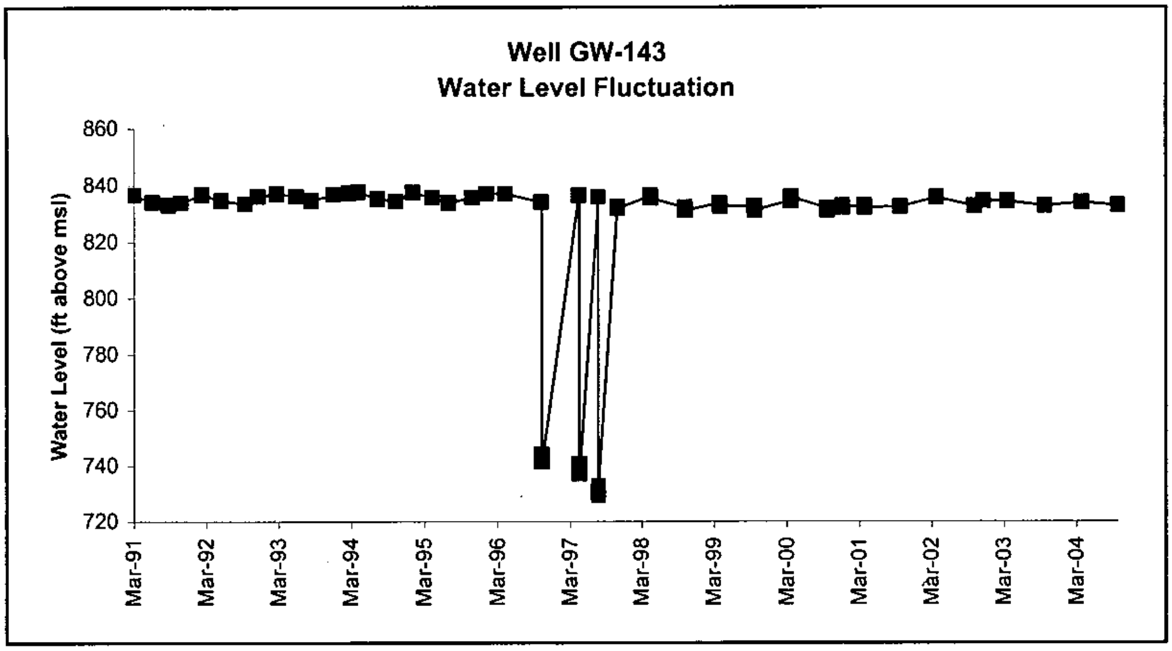


Figure 1

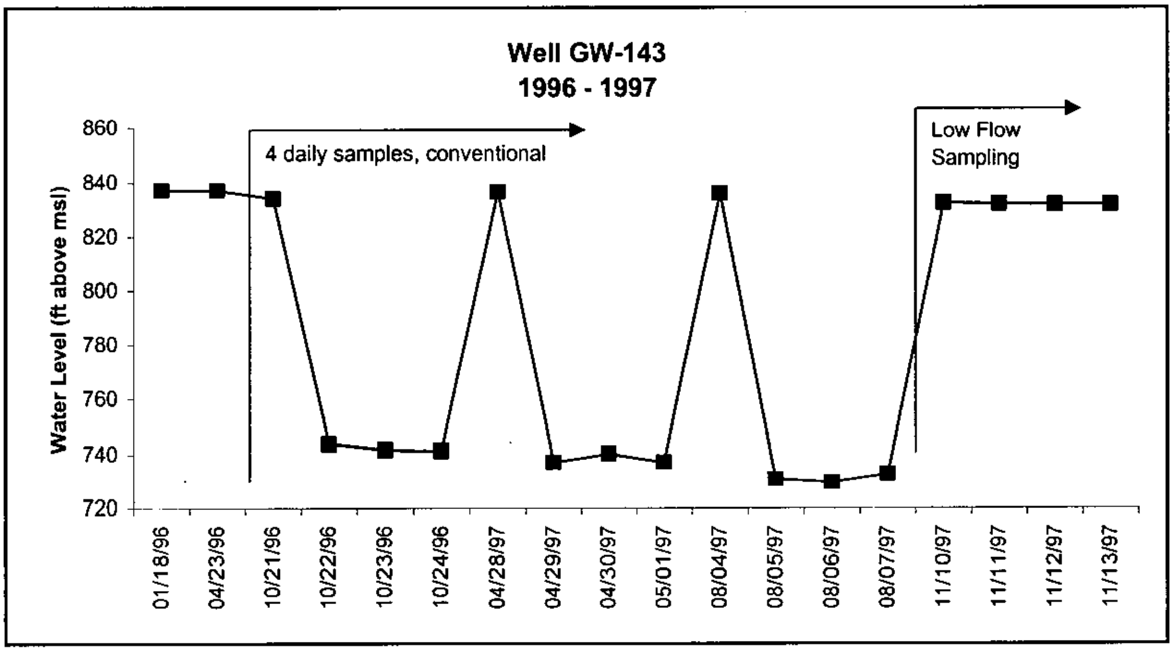


Figure 2

MAXIMUM CONCENTRATION: 2004

.	ND	ND	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-144

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Kerr Hollow Quarry
Y-12 GRID EAST COORDINATE: 63,502.00
Y-12 GRID NORTH COORDINATE: 24,255.00
SURFACE ELEVATION: 910.48 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/85 PAIRED/CLUSTERED WITH: GW-143
TAG DEPTH (measured): 194.34 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 913.54 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	148.0	762.48
BOTTOM (filter pack or open hole):	195.0	715.48
MIDPOINT (filter pack or open hole):	171.5	738.98
PUMP INTAKE:	170.94	739.54
WATER LEVEL (average):	76.76	833.72

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	98		
CONVENTIONAL SAMPLING METHOD:	54 samples	02/28/86	08/07/97
LOW-FLOW SAMPLING METHOD:	44 samples	11/10/97	10/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/12/04	.	10/12/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.29 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	6 µg/L	06/15/91	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-144

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 148 to 195 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with well GW-143 on the southern flank of Chestnut Ridge directly south of the east end of Y-12, about 250 ft south (hydraulically downgradient) of Kerr Hollow Quarry (KHQ), which is a closed, water-filled quarry formerly used for disposal of various hazardous and nonhazardous waste generated from historical DOE operations on the ORR. Groundwater monitoring is performed at KHQ in accordance with the requirements of a RCRA post-closure permit issued by the TDEC in 1995 (TDEC 1995).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 54 samples between February 1986 and August 1997, and the low-flow sampling method used to obtain 44 samples between November 1997 and October 2004. Many of these samples were collected in accordance with the replicate sampling protocol associated with RCRA post-closure detection monitoring performed between October 1996 and April 2001, when four samples were collected over consecutive days during each semiannual sampling event.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group (Mascot Dolomite); the monitored interval for the well intercepts a water-producing fracture at 170 ft bgs that yields over 20 gallons per minute (BWXT Y-12. 1995). The average static groundwater level in the well is 77 ft bgs. Presampling depth-to-water measurements for the well indicate moderate (<6 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 130 – 240 mg/L, excluding a suspected outlier (104 mg/L) in January 1995;
- pH (field measurements) of 6.5 – 8.2;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 78 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Forty-six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, and the historical maximum concentration (6.89 mg/L in April 1998) is below the MCL for nitrate (10 mg/L). As shown on Figure 1, nitrate levels in the well show wide fluctuations, with peak concentrations evident during seasonally high flow (winter and spring). The source of the nitrate may be municipal sewage sludge application sites in hayfields located about 800 ft west-northwest (across geologic strike) of KHQ. In an effort to better determine if downgradient transport from the sludge application site is a source of the nitrate, groundwater samples collected in October 1998 from KHQ wells GW-142, GW-143, GW-144, GW-145, and GW-231 and Outfall 301 were analyzed for ammonia, fecal coliform, nitrate, and total phosphate (as phosphorous). Nitrate was detected only in the sample from Outfall 301 (1.38 mg/L) and trace levels of ammonia were detected in samples from wells GW-145 (0.42 mg/L) and GW-231 (0.22 mg/L); the fecal coliform count and total phosphate level for each sampling location did not exceed respective analytical reporting limits.

5.2 URANIUM

Forty-five groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the historical maximum concentration (0.007 mg/L in August 1995) being slightly above the applicable UTL (0.005 mg/L) and substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in 21 groundwater samples collected from the well since 1991. Acetone (1 μg/L in April 1998) and chloromethane (3 μg/L in April 1999) were each detected in one sample. However, as shown below in Table 1, low concentrations (5 μg/L or less) of PCE, CTET, and/or chloroform were detected in 19 of the samples from the well, most recently in the sample collected in December 2002.

Table 1. VOC data for well GW-144

Sampling Date	Concentration (μg/L)		
	PCE	CTET	Chloroform
06/15/91	1 J	5	FP
09/05/91	2 J	2 J	2 J
11/06/91	1 J	1 J	2 J
05/29/92	.	2 J	.
09/15/92	.	2 J	.
12/01/92	.	5	0.8 J
08/26/93	.	3 J	0.7 J
12/15/93	.	3 J	.
04/19/94	.	2 J	.
01/18/95	1 J	3 J	.
04/25/95	.	3 J	1 J
11/14/95	.	2 J	.
01/22/96	.	3 J	.
04/24/96	.	4 J	.
04/28/97	.	.	1 J
04/29/97	.	2 J	FP
04/30/97	2 J	1 J	FP
05/01/97	1 J	.	FP
12/02/02	0.4 J	.	.

Note: "." = Not detected; J = Estimated concentration; FP = false positive result

These VOCs are known or suspected to have been included in the wastes disposed at KHQ and their repeated detection in the groundwater samples collected from the well during the early and mid-1990s generally coincides with efforts to remove or otherwise stabilize the submerged wastes during RCRA closure of the site.

5.4 GROSS ALPHA ACTIVITY

Forty groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.43 pCi/L in October 1994) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirty of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.49 pCi/L in October 1994) being substantially below the SDWA screening level for gross beta activity.

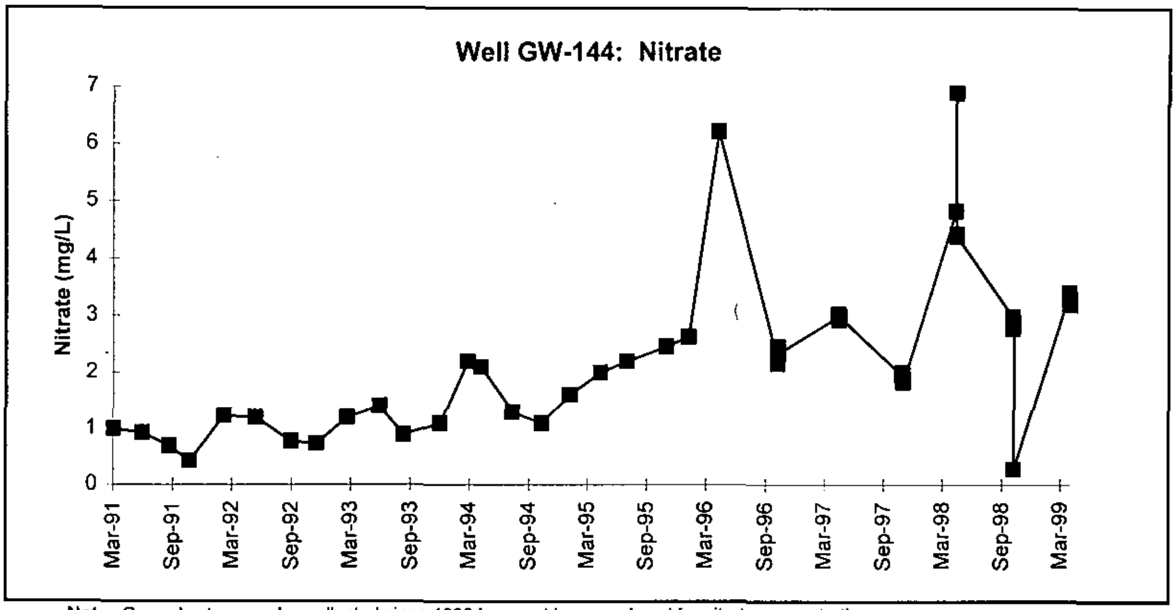
6.0 REFERENCES

BWXT Y-12 L.L.C. (BWXT) 2003. *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation*, Y/TS-881/R5, BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Tennessee Department of Environment and Conservation (TDEC). 1996. *Resource Conservation and Recovery Act Post-Closure Permit for the Chestnut Ride Hydrogeologic Regime, EPA ID No. TN3 89 009 001, Tennessee Permit No. TNHW-088*, Tennessee Department of Environment and Conservation-Division of Solid Waste Management, Nashville, TN.

U.S. Department of Energy (DOE). 1995. *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/02-1398&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.



Note: Groundwater samples collected since 1999 have not been analyzed for nitrate concentrations.

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	<0.015	ND	7.5 - 15	<25

GW-145

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Kerr Hollow Quarry
Y-12 GRID EAST COORDINATE: 63,266.00
Y-12 GRID NORTH COORDINATE: 24,441.00
SURFACE ELEVATION: 837.29 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/14/85 PAIRED/CLUSTERED WITH: GW-146
TAG DEPTH (measured): 113.49 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 840.24 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	86.0	751.29
BOTTOM (filter pack or open hole):	110.0	727.29
MIDPOINT (filter pack or open hole):	98	739.29
PUMP INTAKE:	100.05	737.04
WATER LEVEL (average):	2.82	834.47

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	98		
CONVENTIONAL SAMPLING METHOD:	54 samples	03/05/86	08/07/97
LOW-FLOW SAMPLING METHOD:	44 samples	11/10/97	10/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/13/04	.	10/12/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 41.8 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	8 μg/L	04/28/97	Outlier
GROSS ALPHA (15 pCi/L):	11	28 pCi/L	09/15/92	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-145

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 86 to 110 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with well GW-146 and is located on the southern flank of Chestnut Ridge directly south of the east end of Y-12, about 150 ft southwest (hydraulically downgradient) of Kerr Hollow Quarry (KHQ). KHQ is an inactive, water-filled quarry formerly used for disposal of various hazardous and nonhazardous wastes generated from historical DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 54 samples between March 1986 and August 1997, and the low-flow sampling method used to obtain 44 samples between November 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Mascot Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits unusually wide (>40 ft) fluctuations. However, the conventional sampling method is associated with the largest apparent water level fluctuations (Figure 1). Purging the well during conventional sampling typically decreases the water level in the well by 90 ft or more, and the water in the well recovers very slowly to the presampling level. Moreover, the protocol of consecutive daily sampling required for RCRA post-closure detection monitoring at the KHQ was discontinued in part because the water level in this well would not sufficiently recover between sampling events, as shown on Figure 1 (Bechtel Jacobs Company LLC [BJC] 2001).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 164 – 356 mg/L, excluding an outlier (940 mg/L) from October 5, 2000;
- pH (field measurements) of 6.6 – 8.6;
- unequal molar proportions of calcium and magnesium;
- concentrations of sulfate (>30 mg/L), sodium (>20 mg/L), chloride (>109 mg/L), and fluoride (>2 mg/L) that are much higher than typical of other wells in the Knox Group; and
- total (unfiltered sample) concentrations of trace metals (except boron and strontium that are substantially higher than evident in other Knox Group wells) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of locally disseminated gypsum ($CaSO_4 \cdot 2\ H_2O$) may account for the sulfate-enriched geochemistry (Lockheed Martin Energy Systems, Inc. 1999) and enriched levels of other solutes, including boron and strontium, may be a legacy of the sedimentary basin brines that are encountered at depth elsewhere on the ORR (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 78 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-three groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.95 mg/L in July 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Seventy-one groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0223 in October 2000) being slightly below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels (<5 μg/L) in five groundwater samples, with the maxium summed VOC concentration (8 μg/L in April 1997) slightly exceeding 5 μg/L. A low concentration (2 μg/L) of PCE was detected in the sample collected in July 1995. Also, similarly low concentrations of PCE (1 μg/L), TCE (2 μg/L), 11DCE (2 μg/L), and chloroform (3 μg/L) were detected in the sample collected in April 1997. Chloromethane was detected at very low levels in the samples collected in April 1999 (3 μg/L) and October 2000 (1 μg/L).

5.4 GROSS ALPHA ACTIVITY

Sixty-seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (28 pCi/L) exceeding the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Sixty-two groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (27.9 pCi/L) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Lockheed Martin Energy Systems, Inc. 1999. *Groundwater Protection Program Calendar Year 1998 Evaluation of Groundwater Quality Data for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/SUB/99-MVM64V/3, Lockheed Martin Energy Systems, Oak Ridge, TN.

Saunders, J.A. and L.E. Toran. 1992. *Evolution of $Ca\text{-}Mg\text{-}SO_4$ Type and $Na\text{-}Ca\text{-}SO_4$ Type Water in Fractured Sedimentary Rock Near Oak Ridge, Tennessee*, Y/TS-875/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

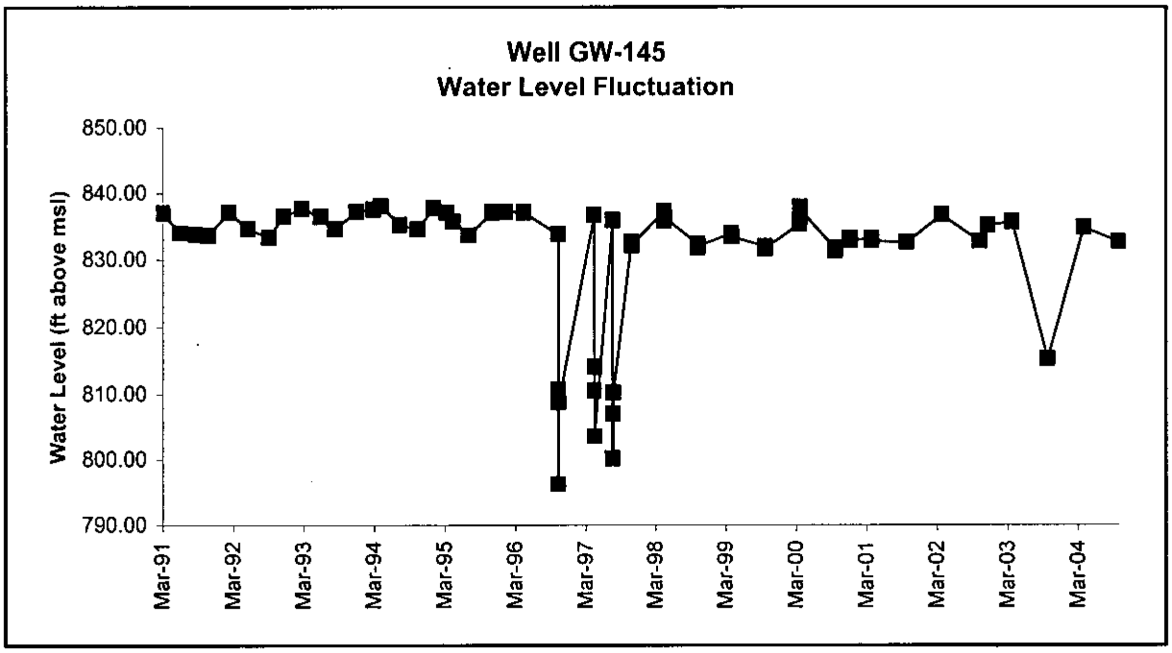


Figure 1

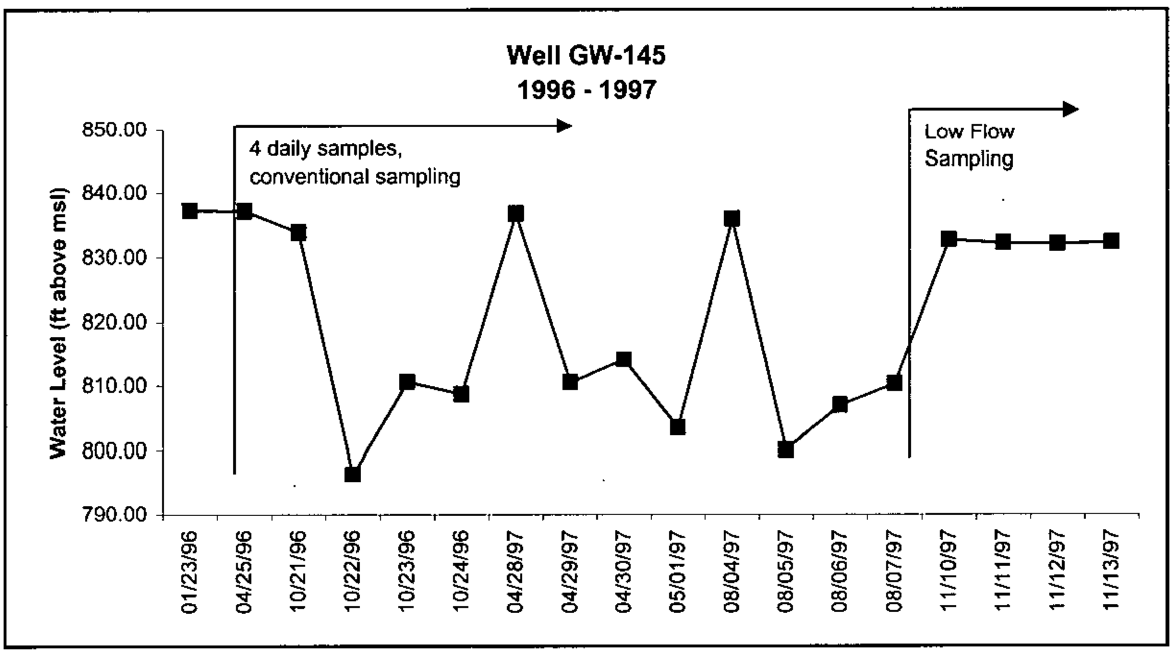


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	500 - 5,000	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-151

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime

FUNCTIONAL AREA: New Hope Pond

Y-12 GRID EAST COORDINATE: 64,232.00

Y-12 GRID NORTH COORDINATE: 28,958.00

SURFACE ELEVATION: 913.06 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA

HYDROLOGIC MONITORING: X

OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/14/85 PAIRED/CLUSTERED WITH: GW-220 GW-150

TAG DEPTH (measured): 99.63 ft below top of casing (TOC)

MEASURING POINT ELEVATION: 916.17 ft above msl MEASURING POINT: TOWW

WELL BORE DIAMETER: 11 inches

WELL CASING MATERIAL: PVC40

WELL CASING DIAMETER: 4.5 inches (outside diameter)

WELL SCREEN TYPE: PVC/SW/0.01

DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	85.0	828.06
BOTTOM (filter pack or open hole):	96.5	816.56
MIDPOINT (filter pack or open hole):	90.75	822.31
PUMP INTAKE:	90.79	822.27
WATER LEVEL (average):	11.82	901.24

GEOLOGIC FORMATION: Maynardville Limestone

HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	60		
CONVENTIONAL SAMPLING METHOD:	45 samples	02/20/86	04/14/97
LOW-FLOW SAMPLING METHOD:	15 samples	02/13/98	08/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/12/04	.	08/10/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)

GROUT CONTAMINATION: . LOW pH: . (<5.5)

SAMPLING METHOD SENSITIVITY: X OTHER: .

WATER LEVEL FLUCTUATION: 2.41 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	39	2,707 µg/L	02/11/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-151

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 85 to 96.5 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-150 and GW-220 and is located in Bear Creek Valley near the east end of Y-12, immediately east of the Upper East Fork Poplar Creek (UEFPC) diversion channel on the east side (hydraulically downgradient) of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC bypasses Lake Reality and is directed through the concrete-lined diversion channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 45 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 15 samples between February 1998 and August 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially lower contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and may substantially increase the relative inflow of uncontaminated groundwater into the well.

It is possible, however, that the disparity in the VOC concentrations is attributable to an increasing long-term concentration trend (see Section 5.3). Results of "paired" groundwater sampling, with the low-flow sampling method used to collect a sample one day and the conventional sampling method used to collect a sample the next day, are needed to determine if the VOC concentrations are biased by the sampling method.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits minor (<3 ft) seasonal fluctuations. Presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are about 0.8 ft higher in well GW-151 than well GW-220, which is completed at a shallower depth (45 ft bgs) in the Maynardville Limestone. Based on the distance (52 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.004 - 0.046) during seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-151 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 500 ft south-southeast of well GW-151 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 222 – 394 mg/L;
- pH of 4.9 – 8.3 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirty-nine groundwater samples had nitrate above the analytical reporting limit, with the highest concentration (8.6 mg/L in August 2000) being slightly below the drinking water MCL for nitrate (10 mg/L). However, this result is a suspected outlier because all other nitrate results are less than 2 mg/L.

5.2 URANIUM

Very low levels of uranium were detected in the groundwater samples collected in February 1994 (0.002 mg/L) and May 1994 (0.002 mg/L). Each concentration is substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 1): CTET, chloroform, PCE, TCE, 11DCE, 12DCE (c12DCE), 111TCA, and carbon disulfide. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 500 ft south-southeast (across geologic strike) of well GW-151; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The principal VOCs in the groundwater samples are CTET and PCE; one or both compounds were detected in each sample, with historical maximum concentrations above 1,000 µg/L and 500 µg/L, respectively (Table 1). Also, the most recent sampling results show that the concentrations of both VOCs remain substantially above respective drinking water MCLs. Secondary compounds in the samples are chloroform, TCE, and 12DCE (c12DCE), at least one of which was detected in all but four of the samples, including each sample collected since December 1995. Historical maximum concentrations exceed 100 µg/L for PCE, 50 µg/L for chloroform, and 25 µg/L for c11DCE, with the most recent sampling results showing that the TCE concentrations substantially exceed the MCL (Table 1). Minor VOCs in the samples are 11DCE, 111TCA, and carbon disulfide. The four most recent samples had traces of 11DCE; 111TCA (1 µg/L in May 1994) and carbon disulfide (5 µg/L in August 2004) were each detected in only one sample.

A time-series plot of summed VOC concentrations reported for the samples obtained with the conventional sampling method between January 1991 and April 1997 shows a seasonally cyclic pattern (Figure 1), with the VOC concentrations in samples obtained during seasonally low flow conditions (summer and fall) typically being higher than VOC concentrations in samples obtained during seasonally high flow conditions (winter and spring). However, similar seasonal concentration fluctuations are not evident from the low-flow sampling results, which instead show a strongly increasing concentration trend that may have stabilized in CY 2003 (Figure 1). Moreover, as illustrated by the data summarized in Table 1, concurrently increasing concentration trends are evident for individual compounds (CTET, chloroform, PCE, TCE, and 12DCE). This suggests an overall increase in the relative flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. This increase may result from a combination of reduced recharge following closure of NHP and the strong local hydrologic influence of the UEFPC distribution channel underdrain (DOE 1998). The increasing VOC concentration trend may be at least partially attributable to the change in groundwater sampling methods (see Section 2.0 and Figure 1). Notably, the full-time operation of groundwater extraction well GW-845 appears to have influenced CTET and chloroform (chloromethanes) concentrations in the groundwater at this well, but not PCE, TCE, and 12DCE (chloroethenes) concentrations. As shown by a time-series plot of summed chloromethanes, the increasing trend appears to have stabilized from January 2000 through January 2003, then decreased steadily through July 2004. However, the increasing trend in chloroethene concentrations continues uninterrupted (Figure 2). These divergent trends suggest different sources and/or flowpaths for dissolved chloromethanes and chloroethenes intercepted by the monitored interval of the well.

5.4 GROSS ALPHA ACTIVITY

Six of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.75 pCi/L in December 1995) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nineteen of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.12 pCi/L in January 2002) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C. Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee,* DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Summary of VOC results for well GW-151

Sampling Date	VOC Concentration (µg/L)					
	CTET	Chloroform	PCE	TCE	12DCE	11DCE
Conventional Sampling						
01/31/91	270	FP	15	.	.	.
05/01/91	160	FP	10	.	.	.
08/24/91	250	15	17	3 J	1 J	.
10/23/91	410	16	18	.	.	.
01/25/92	280	FP	13	.	.	.
04/21/92	310	13	13	.	.	.
08/02/92	290	13	16	2 J	.	.
10/22/92	370	16	19	.	.	.
01/26/93	220	9	12	2 J	.	.
04/24/93	330	15	19	3 J	.	.
08/06/93	520	19	21	.	.	.
11/02/93	610	21	27	4 J	.	.
02/05/94	450	20	21	3 J	1 J	.
05/12/94	560	20	21	.	2 J	.
09/22/94	370	19	27	3 J	.	.
11/16/94	300	15	15	.	.	.
02/28/95	500	.	26	4 J	21	.
05/24/95	680	27	30	.	.	.
08/29/95	680	.	.	.	.	.
12/04/95	160	21	16	4 J	2 J	.
03/20/96	410	22	25	4 J	2 J	.
06/17/96	400	22	27	4 J	2 J	.
07/09/96	420	20	22	4 J	.	.
11/20/96	750	48	59	10	4 J	.
04/14/97	.	29	28	.	.	.
Low-Flow Sampling						
03/04/98	500	26	19	3 J	2 J	.
07/22/98	590	27	44	8	3 J	.
02/08/99	830	40	78	25	.	.
08/16/99	1,000	40	80	16	.	.
05/16/00	1,400	46	120	24	9	.
08/17/00	1,500	52	140	29	10	.
01/11/01	1,700	68	200	60	15	.
07/30/01	1,600	75	290	75	29	.
01/30/02	1,100	77	240	120	32	.
08/05/02	1,500	91	500	120	46	.
02/11/03	1,800	70	670	120	45	2 J
08/11/03	1,700	63	690	120	47	2 J
02/12/04	1,600	80	740	120	58	2 J
08/10/04	1,400	77	740	140	62	2 J
MCL	**5**	**80***	**5**	**5**	**70****	**7**

Note: "." = Not detected; J = Estimated value; FP = False positive; NA = Not applicable
* MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane; ** MCL is for c12DCE

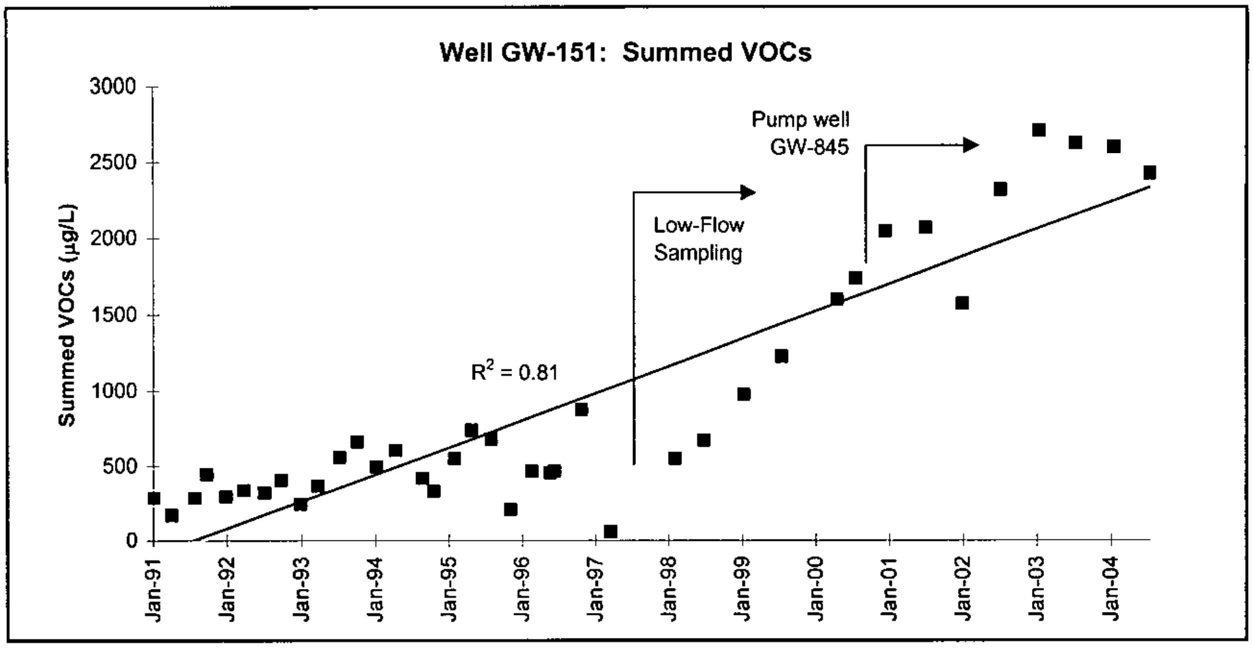


Figure 1

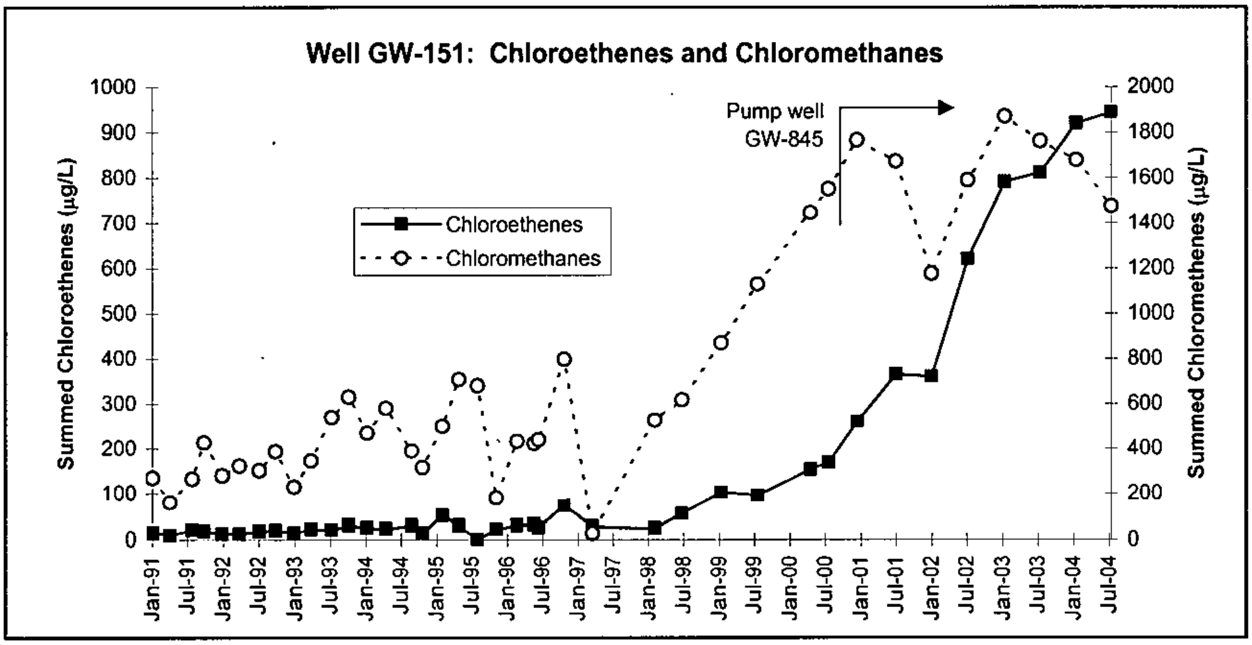


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	<0.015	50 - 500	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-153

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 63,728.00
Y-12 GRID NORTH COORDINATE: 28,613.00
SURFACE ELEVATION: 918.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/31/85 PAIRED/CLUSTERED WITH: GW-152 GW-240
TAG DEPTH (measured): 60.84 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 921.68 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	45.0	873.53
BOTTOM (filter pack or open hole):	60.0	858.53
MIDPOINT (filter pack or open hole):	52.5	866.03
PUMP INTAKE:	52.85	865.68
WATER LEVEL (average):	17.05	901.48

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	31 samples	02/24/86	05/21/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/03/97	11/01/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/20/04	.	11/01/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.39 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	26	341 µg/L	12/07/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-153

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 45 to 60 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-152 and GW-240 and is located in Bear Creek Valley near the east end of Y-12, directly south of the Upper East Fork Poplar Creek (UEFPC) diversion channel on the south side of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through the concrete-lined distribution channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 31 samples between February 1986 and May 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits minor (<3 ft) seasonal fluctuations. Presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are about 0.5 ft higher in well GW-153 than well GW-240, which is completed at a shallower depth (29.5 ft bgs) in the Maynardville Limestone. Based on the distance (28.2 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.011 - 0.024) during seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-153 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 450 ft south-southeast (hydraulically downgradient) of well GW-151 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

As part of an aquifer pumping test in well GW-845 in July 1998, eosine dye was injected in well GW-153 and rapid breakthrough of the dye observed in the pumping well, which clearly demonstrated the hydraulic connection between the shallow and intermediate/deep groundwater flowpaths along strike in the Maynardville Limestone. Additionally, confirmed detection of the dye in two shallow wells (GW-220 and GW-832) located about 600 ft northeast (across geologic strike) of the injection well (and about 300 ft northwest of the pumping well) suggests that the degree of hydrologic connection with the UEFPC distribution channel underdrain. This indicates that groundwater movement along dip parallel or conjugate fracture flowpaths in the shallow flow system are strong enough to overcome the hydraulic capture zone in the intermediate to deep flow systems created by extraction of groundwater from well GW-845 (BJC 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS 164 – 366 mg/L;
- pH of 7.2 – 8.6 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Each groundwater sample had nitrate above the analytical reporting limit, with the highest concentration (1.7 mg/L in August 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Uranium concentrations at or above the applicable analytical reporting limit were reported for all but one of the groundwater samples, with the highest value (0.00228 mg/L in November 2004) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in all but one of the groundwater samples (Table 1): bromodichloromethane, bromoform, CTET, chloroform, dibromochloromethane, PCE, and TCE. Most of these compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 700 ft east (parallel with geologic strike) of well GW-153; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The primary VOC in the groundwater samples is CTET, which was detected at a concentration of 100 µg/L in all but seven of the groundwater samples (Table 1). Secondary compounds are chloroform and PCE, with one or both compounds detected in each sample collected since November 1999. In contrast, TCE was detected in only one sample since November 1999 (2 µg/L in October 2001). Similarly, bromodichloromethane, bromoform, and dibromochloromethane were detected only in a series of samples collected between December 1998 and April 2001, with the highest concentrations (>10 µg/L) reported for dibromochloromethane. Also, the most recent sampling results show that only the CTET concentrations remain above the applicable drinking water MCL (Table 1).

A time-series plot of summed VOC concentrations for each groundwater sample (Figure 1) shows a widely variable but generally increasing trend between January 1991 (42 µg/L) and October 2000 (299 µg/L), followed by a sharply decreasing trend through October 2003 (58 µg/L). Note that the decreasing trend coincides with full-time operation of groundwater extraction well GW-845. Decreasing concentrations are particularly evident for CTET, with the concentration reported for the groundwater sample collected in October 2003 (51 µg/L) being about 80% lower than the historical maximum CTET concentration (280 µg/L) reported for samples June 1999 and October 2000. However, decreasing concentrations are not evident for all of the VOCs (Table 1), as illustrated by the similar levels of PCE reported for groundwater samples collected before and after operation of the extraction well (e.g., 4 µg/L in November 1994 and April 2001). This pattern suggests different sources and flowpaths for the different VOCs.

5.4 GROSS ALPHA ACTIVITY

Six of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4 pCi/L in November 1999) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity above the MDA and corresponding CE was reported for the groundwater samples collected in May 1991 (4.36 pCi/L), November 1994 (5.44 pCi/L), November 1995 (4.92 pCi/L), and November 2004 (10 pCi/L). These values reflect background levels and are substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 1998. *East End VOC Plume Pump and Tracer Test Technical Memorandum.* (BJC/OR-103).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-153: summary of VOC results

Sampling Date	VOC Concentration (µg/L)			
	CTET	Chloroform	PCE	TCE
01/31/91	42	FP	.	.
05/02/91	120	7	.5	1 J
11/14/94	100	8	4 J	1 J
02/22/95	160	6	5	1 J
05/25/95	180	7	6	1 J
08/23/95	110	6	5	1 J
11/28/95	160	6	5	1 J
03/14/96	140	6	5	.
06/11/96	140	5	5	.
08/21/96	110	FP	5	1 J
11/18/96	270	10	8	.
05/21/97	200	10	7	2 J
12/03/97	.	.	.	.
05/28/98	86	4 J	3 J	.
12/07/98	270	14	7	.
06/02/99	280	15	7	.
11/09/99	260	14	5	2 J
05/11/00	270	12	7	.
10/12/00	280	12	7	.
04/26/01	200	13	4 J	.
10/23/01	170	10	4 J	.
04/25/02	110	7	2 J	2 J
10/21/02	140	7	4 J	.
06/16/03	81	5 J	3 J	.
10/16/03	51	5 J	2 J	.
05/20/04	83	5 J	3 J	.
11/01/04	46	5 J	2 J	.
MCL	**5**	**80***	**5**	**5**

Table 1 (continued)

Sampling Date	VOC Concentration (µg/L)		
	Bromodichloromethane	Bromoform	Dibromochloromethane
01/31/91	.	.	.
05/02/91	.	.	.
11/14/94	.	.	.
02/22/95	.	.	.
05/25/95	.	.	.
08/23/95	.	.	.
11/28/95	.	.	.
03/14/96	.	.	.
06/11/96	.	.	.
08/21/96	.	.	.
11/18/96	.	.	.
05/21/97	.	.	.
12/03/97	.	.	.
05/28/98	.	.	.
12/07/98	7	25	16
06/02/99	4	13	7
11/09/99	4	14	9
05/11/00	.	.	3
10/12/00	.	.	.
04/26/01	7	22	13
10/23/01	.	.	.
04/25/02	.	.	.
10/21/02	.	.	.
06/16/03	.	.	.
10/16/03	.	.	.
05/20/04	.	.	.
11/01/04	.	.	.
MCL	**80***		

Note: "." = Not detected; J = Estimated value; FP = False positive; NA = Not applicable;
* MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane

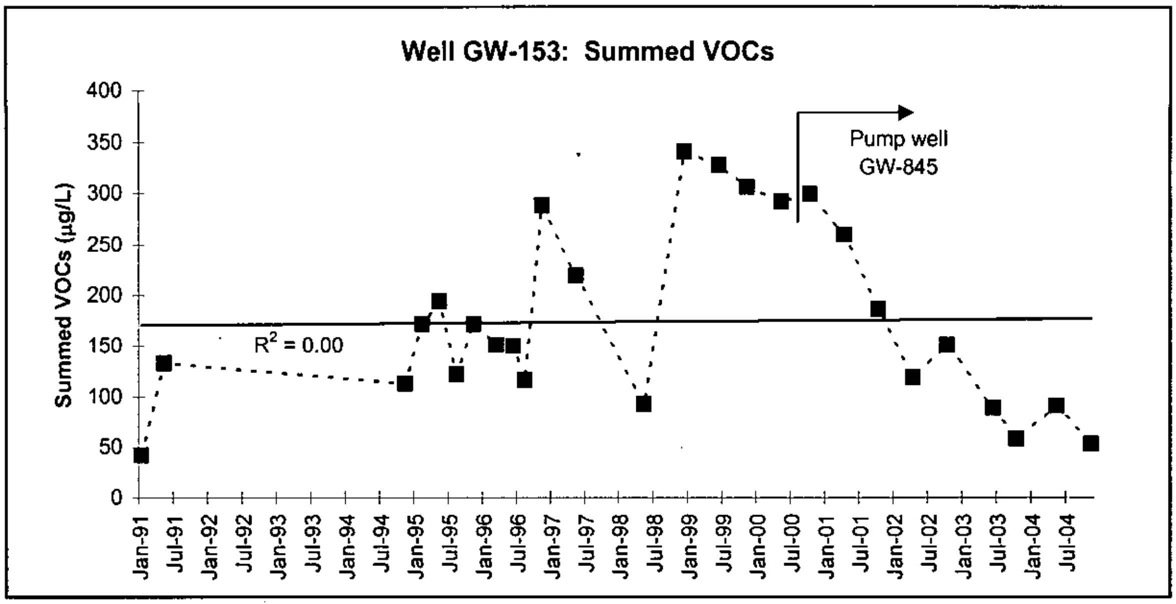

Well GW-153: Summed VOCs
Summed VOCs (µg/L)
400
350
300
250
200
150
100
50
0
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
R² = 0.00
Pump well
GW-845

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	0.3 - 3.0	ND	150 - 1,500	50 - 500

GW-154

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 63,346.00
Y-12 GRID NORTH COORDINATE: 28,987.00
SURFACE ELEVATION: 908.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/30/85 PAIRED/CLUSTERED WITH: GW-222 GW-223
TAG DEPTH (measured): 13.35 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 911.70 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.7	903.90
BOTTOM (filter pack or open hole):	11.2	897.40
MIDPOINT (filter pack or open hole):	7.95	900.65
PUMP INTAKE:	8.40	900.20
WATER LEVEL (average):	6.04	902.56

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	48		
CONVENTIONAL SAMPLING METHOD:	34 samples	02/23/86	09/17/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/19/98	08/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/18/04	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.28 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	22	1.37 mg/L	07/30/01	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	25	1,270.56 pCi/L	08/05/02	Increasing
GROSS BETA (50 pCi/L):	25	340.64 pCi/L	01/29/91	Decreasing

WELL GW-154

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1985, completed with a screened monitored interval from 4.7 to 11.2 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-222 and GW-223 and is located in Bear Creek Valley (BCV) at the east end of Y-12, near the former Oil Skimmer Basin (OSB) and immediately west (hydraulically upgradient) of New Hope Pond (NHP)/Lake Reality. The OSB, formerly located near the inlet to NHP, was a 25 x 40 ft sediment-accumulation basin and oil/water separator; visual evidence of a direct hydraulic connection with the OSB was observed during installation of wells GW-154 and GW-223 (Geraghty & Miller, Inc. 1989). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through a concrete-lined diversion channel bordering the south and east sides of NHP/Lake Reality. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was diverted through the Lake Reality spillway, which discharges into the mainstream of UEFPC directly north (downstream) of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 34 samples between February 1986 and September 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in thc in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits minor (<4 ft) seasonal fluctuations, although a particularly sharp "spike" in the groundwater elevation is indicated by presampling water-level measurement recorded in July 2001 (Figure 1). Also, presampling water-level measurements recorded during contemporaneous sampling events (i.e., within 24 hours) performed after the closure of NHP (and the OSB) show groundwater elevations in well GW-154 being consistently higher than evident in wells GW-222 and GW-223, which are completed at greater depths in the Maynardville Limestone (25 ft and 90 ft bgs, respectively). Based on the distance between the monitored interval midpoint (elevation) in the wells, the relationships between the groundwater elevations indicate: (1) downward vertical hydraulic gradients (0.014 - 0.067) from the water table interval (GW-154) to the shallow bedrock (GW-222) and (2) lesser downward vertical hydraulic gradients (0.001 - 0.008) within the bedrock interval between GW-222 and GW-223. However, presampling groundwater elevations determined from contemporaneous sampling events performed before the closure of NHP show higher groundwater elevations in well GW-223 (and GW-222) relative to well GW-154 and indicate upward hydraulic gradients (Figure 1). Thus, the closure of NHP (and the OSB) and installation of the low-permeability cap at the site appears to have reversed the local vertical hydraulic gradients.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-154 indicate east-northeasterly flow toward the UEFPC drainage system. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2000, groundwater has been pumped from a well (GW-845) located about 1,200 ft southeast of well GW-154 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002). Groundwater elevations in well GW-154 do not appear to exhibit any direct response to the operation of well GW-845 (Figure 1).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 334 – 620 mg/L;
- pH (field measurements) of 5.96 – 8.1;
- high concentrations of sulfate (>70 mg/L) compared to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of sodium, potassium, chloride and nitrate (<10% of total anions/cations);
- total concentrations of trace metals (excluding uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the groundwater samples collected since January 1991, the principal contaminants present in the groundwater at this well are uranium, gross alpha activity, and gross beta activity.

5.1 NITRATE

Twenty-three groundwater samples had nitrate concentrations above the applicable analytical reporting limit (one sample was not analyzed for nitrate; Table 1), with the highest concentration (3.4 mg/L in July 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Total uranium concentrations reported for 22 groundwater samples (five samples were not analyzed for uranium) exceed the applicable analytical reporting limit (Table 1) and each result is at least an order-of-magnitude above the MCL for uranium (0.03 mg/L). The specific source of the uranium in the shallow groundwater at this well has not been identified, but is probably the former OSB, which is believed to have retained uranium-contaminated oils (DOE 1998), particularly in light of the direct hydraulic connection with the OSB that was observed during installation of the well (see Section 1.0). Considering the relatively neutral pH of the samples, the uranium is probably present as uranyl cations combined with available anions in the groundwater (Fetter 1993), including carbonate dissolved from the Maynardville Limestone, which may greatly increase the relative mobility of uranium in the groundwater flow system.

Uranium concentrations reported for the groundwater samples range between the historical minimum value of 0.2 mg/L in August 1996 and the historical maximum value of 1.37 mg/L in July 2001 (Table 1). Note that the highest and lowest uranium values were reported for samples obtained during seasonally low groundwater flow conditions, which illustrates the lack of any clear and consistent relationship between temporal changes in uranium concentrations and inferred seasonal flow conditions. Also, the uranium concentrations are typically an order-of-magnitude higher than evident in samples of the deeper groundwater from well GW-223 (e.g., 0.0342 mg/L in August 2003). Considering the downward vertical hydraulic gradients indicated by presampling groundwater elevations recorded following closure of NHP (and the former OSB) and installation of the low-permeability cap at the site (see Section 3.0), recharge of uranium-contaminated groundwater from the shallow flow system may help maintain the (elevated) uranium concentrations in the deeper groundwater.

A time-series plot of the uranium concentrations reflects a fairly indeterminate long-term concentration trend that encompasses gaps in the sampling history for the well (April 1991 – November 1994) and the analytical history for uranium (September 1997 – August 1999) (Figure 2). Also, the uranium concentrations exhibit significant short-term variation, with conspicuous temporal "peaks" evident in May 1995 (0.66 mg/L), November 1996 (0.47 mg/L), and July 2001 (1.37 mg/L), the latter result corresponding with a sharp spike in the groundwater elevation in the well (Figure 1). This relationship suggests wide temporal changes in the relative advective flux of uranium along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Moreover, uranium results obtained between July 2001 (1.37 mg/L) and 2003 (0.411 mg/L) show a clearly decreasing concentrations trend, which potentially reflect a response to the full-time operation of groundwater extraction well GW-845 (see Section 3.0), although subsequent sampling result suggest a slight concentration rebound through August 2004 (0.61 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, only trace (estimated) concentrations of PCE (2 µg/L in June 1996) and bromoform (1 µg/L in February 2003) were detected in any of the groundwater samples collected since January 1991, and both of these results are probably sampling or analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

All but two of the groundwater samples collected since January 1991 had gross alpha activity above the applicable MDA and corresponding CE (the sample collected in February 1996 was not analyzed for gross alpha activity; Table 2), and all of these results substantially exceed the MCL for gross alpha activity (15 pCi/L). Uranium isotopes are the source of the elevated gross alpha activity in the groundwater at this well; U-234 and U-238 were detected (i.e., >MDA and

CE) in each of the samples analyzed for these isotopes (Table 2), with activities ranging between 49.9 pCi/L (U-238) and 543 pCi/L (U-234). As with total uranium (see Section 5.2), contamination resulting from historical operation of former OSB is the suspected source of the uranium isotopes in the shallow groundwater at this well (DOE 1998).

Excluding the non-detect gross alpha activity (i.e., <MDA) reported for the groundwater sample collected in November 1995 (Table 2), which is an outlier compared to the other results and is a likely analytical artifact, the other samples define a wide range of gross alpha activity, with the historical maximum value (1,270 pCi/L in August 2003) being about 450% higher than the historical minimum value (271 pCi/L in June 1996). Also, the gross alpha activity reported for each sample is at least an order-of-magnitude higher than reported for samples of the deeper groundwater from well GW-223 (e.g., 11.91 pCi/L in August 2003). Considering the downward vertical hydraulic gradients indicated by presampling groundwater elevations recorded following the closure/capping of NHP (see Section 3.0), the relatively low levels of gross alpha activity in the deeper groundwater suggest limited vertical flux of the uranium isotopes present in the shallow groundwater.

A time-series plot of the gross alpha activity (excluding the non-detect result noted above) encompasses the three-year gap in the sampling history (April 1991 – November 1994) for the well and shows a variable but slightly increasing trend that appears to be skewed upward by a conspicuous "spike" (1,270 pCi/L) in August 2002 (Figure 3). However, unlike a similarly sharp temporal peak in the concentration of total uranium in July 2001 (see Section 5.2), this result for gross alpha activity correlates with a temporal low, rather than temporal high, groundwater elevation (Figure 1). Accordingly, it is not clear if this and other temporal peak values for gross alpha activity (e.g., 685 pCi/L in January 2001) are significant with respect to the relative flux of uranium isotopes in the groundwater. Additionally, the highest values for gross alpha activity, including all but two results that exceed 500 pCi/L, were reported for samples obtained with the low-flow sampling method. This suggests that the increasing trend may be an artifact of the sampling method. Moreover, the close similarity between the gross alpha activity reported for the samples collected in January 1991 (551 pCi/L) and August 2003 (518 pCi/L) suggests a fairly indeterminate long-term trend and indicates minimal overall change in the relative flux of uranium isotopes in the shallow groundwater from this well. This interpretation is supported by the results for uranium isotopes, as illustrated by the similar levels of U-234 reported for the samples collected in January 1991 (451 pCi/L) and February 2003 (428 pCi/L).

5.5 GROSS BETA ACTIVITY

All but two groundwater samples had gross beta activity above the applicable MDA and corresponding CE (the sample collected in February 1996 was not analyzed for gross beta activity; Table 2), and all these results exceed the SDWA screening level (50 pCi/L) for gross beta activity. Elevated gross beta activity in the groundwater at this well is probably attributable to uranium isotopes and related daughter products that emit beta particles and, as noted previously for gross alpha activity, reflects contamination associated with historical operation of the former OSB.

Excluding the non-detect gross beta activity (i.e., <MDA) reported for the groundwater sample collected in November 1995 (Table 2), which is clearly an outlier, results for the other samples define a wide range of gross beta activity, with the historical maximum value (340 pCi/L in January 1991) being about 650% higher than the historical minimum value (51 pCi/L in July 2001). Also, as with gross alpha activity, the available data show that gross beta activity in the shallow groundwater from well GW-154 is consistently higher than evident in the deeper groundwater from well GW-223, as illustrated by the results reported for the samples collected

from each well in January 2003 (165 pCi/L and 15 pCi/L, respectively). This too suggests minimal vertical migration of uranium isotopes (and beta particle-emitting daughter products) into the deeper flow system near these wells.

A time-series plot of the gross beta activity (excluding the non-detect result noted above) encompasses the three-year gap in the sampling history (April 1991 – November 1994) for the well and shows a variable but slightly decreasing trend (Figure 4). As with the gross alpha activity, the temporal peak gross beta result reported for the sample collected in August 2002 (275 pCi/L) correlates with a temporal low, rather than temporal high, presampling groundwater elevation (Figure 1). Accordingly, it is not clear if this and other temporal peak values for gross beta activity (e.g., 144 pCi/L in January 2001) are significant with respect to the relative flux of uranium isotopes (and beta-particle emitting daughter products) in the groundwater.

6.0 REFERENCES

Geraghty & Miller, Inc. 1989. *Groundwater Quality Assessment Report for New Hope Pond at the Y-12 Plant, 1988.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/89-002-6C/5).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-154: summary of results for nitrate and uranium

Sampling Date	Concentration (mg/L)	
	Nitrate	Uranium
01/29/91	0.2	0.81
04/26/91	0.49	0.386
11/15/94	0.42	0.465
02/27/95	1	0.49
05/23/95	0.25	0.66
08/24/95	0.48	0.55
11/29/95	0.39	0.37
02/23/96	0.31	0.4
06/12/96	<0.02	0.37
08/22/96	0.41	0.2
11/19/96	0.19	0.47
03/18/97	Not Analyzed	0.122
09/17/97	0.46	Not Analyzed
02/19/98	0.33	Not Analyzed
07/23/98	0.39	Not Analyzed
02/10/99	0.23	Not Analyzed
08/30/99	0.09	Not Analyzed
05/17/00	0.32	0.766
08/22/00	2.8	0.609
01/11/01	0.12	0.643
07/30/01	3.4	1.37
01/30/02	1.4	0.853
08/05/02	0.27	0.884
02/12/03	0.14	0.491
08/12/03	0.14	0.411
02/18/04	.	0.477
08/11/04	.	0.61
MCL	**10**	**0.03**

Table 2. Well GW-154: summary of results for gross alpha activity, gross beta activity, and uranium isotopes

Sampling Date	Concentration (pCi/L)			
	Gross Alpha Activity	Gross Beta Activity	U-234	U-238
01/29/91	551.59	340.64	451	279
04/26/91	332.42	155.83	118	49.9
11/15/94	443	221	.	.
02/27/95	508	233	.	.
05/23/95	460	285	.	.
08/24/95	325	176	.	.
11/29/95	<MDA	<MDA	.	.
06/12/96	271	57.9	.	.
08/22/96	278	58.4	.	.
11/19/96	447	108	.	.
03/18/97	415	83.3	360	58
09/17/97	479.97	144.88	365.2	114.5
02/19/98	557.69	87.82	556.7	88.45
07/23/98	297.41	94.17	284.8	94.71
02/10/99	460.99	77.13	543	96.75
08/30/99	432.43	55.49	535.3	139.7
05/17/00	496	97.23	454.5	312.1
08/22/00	572.43	171.56	438.4	184.9
01/11/01	685.09	92.67	521.6	176.2
07/30/01	391.44	51.71	268.8	186.1
01/30/02	755.5	103.65	392.7	251
08/05/02	1270.56	275.92	295.3	248
02/12/03	829.14	165.21	428.8	147
08/12/03	518.85	186.04	369.9	151.6
02/18/04	620.78	106.56	568.5	140.9
08/11/04	698.14	288.53	336.2	202.5
MCL	**15**	**50***	**Not applicable**	

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

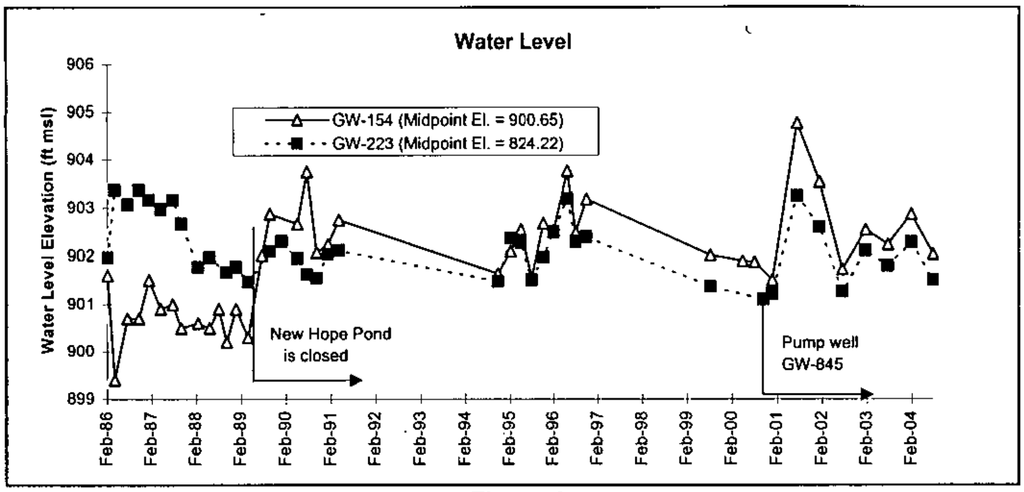


Figure 1

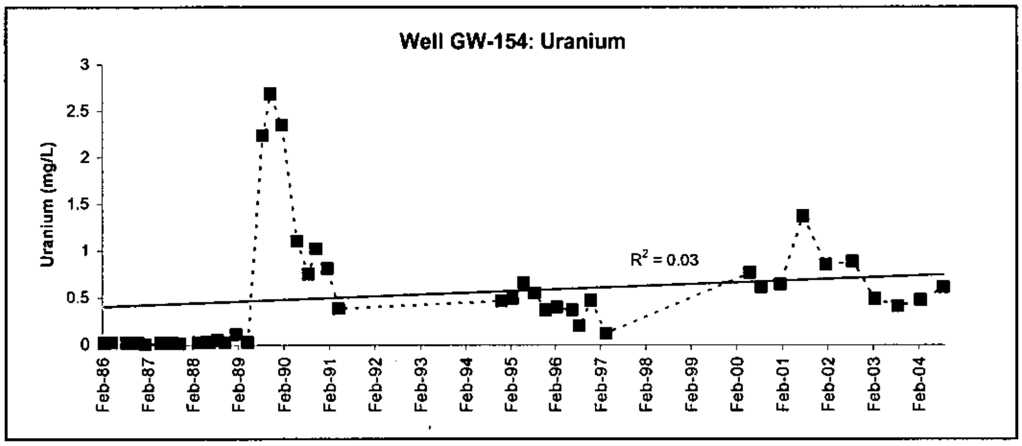


Figure 2

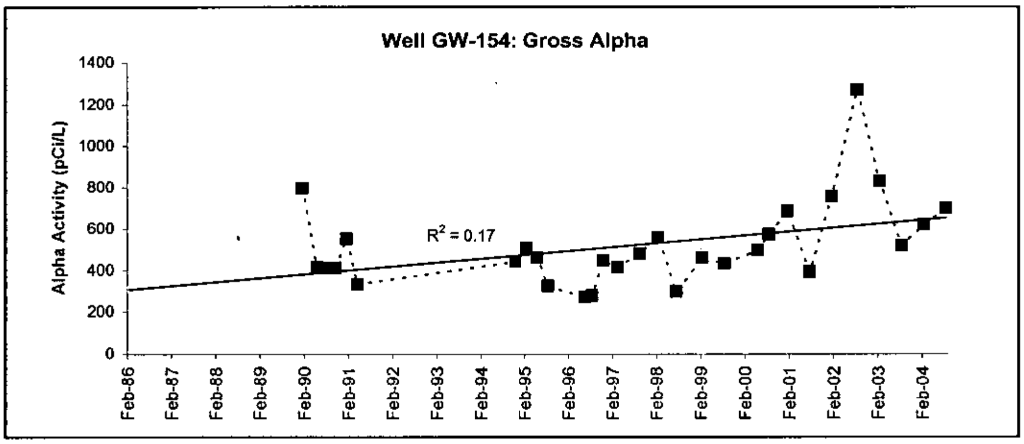


Figure 3

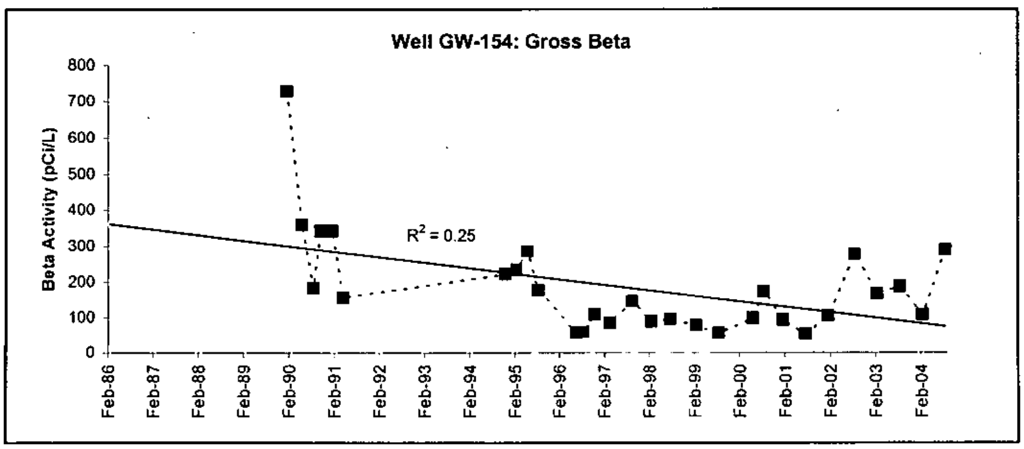


Figure 4

GW-154

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-156

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Sediment Disposal Basin
Y-12 GRID EAST COORDINATE: 64,020.00
Y-12 GRID NORTH COORDINATE: 27,626.00
SURFACE ELEVATION: 1,046.94 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/18/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 157.65 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,049.28 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.5 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	145.0	901.94
BOTTOM (filter pack or open hole):	157.6	889.34
MIDPOINT (filter pack or open hole):	151.3	895.64
PUMP INTAKE:	150.66	896.28
WATER LEVEL (average):	140.36	906.58

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	89		
CONVENTIONAL SAMPLING METHOD:	50 samples	02/22/86	04/24/97
LOW-FLOW SAMPLING METHOD:	39 samples	10/20/97	10/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/13/04	.	10/14/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 23.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-156

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 145 to 157.6 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and PVC well screen (0.01 slot). The well is located on the crest of Chestnut Ridge southeast of the east end of Y-12, about 100 ft east (hydraulically downgradient) of the Chestnut Ridge Sediment Disposal Basin (CRSDB). The CRSDB is a former sinkhole filled with contaminated sediments generated from remedial actions at Y-12 and covered with a low-permeability, multilayer cap during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 50 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 39 samples between October 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 140 ft bgs and exhibit substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 266 – 414 mg/L;
- pH (field measurements) of 6.6 – 7.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 74 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Forty-five groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.71 mg/L) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Forty-three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.007 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs have not been detected in any of the groundwater samples from this well that were analyzed for VOCs (between February 1991 and July 1995).

5.4 GROSS ALPHA ACTIVITY

Nineteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.48 pCi/L) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (14.85 pCi/L) being substantially below the SDWA for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-159

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Sediment Disposal Basin
Y-12 GRID EAST COORDINATE: 63,496.00
Y-12 GRID NORTH COORDINATE: 27,764.00
SURFACE ELEVATION: 1,048.79 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/18/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 155.87 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,051.38 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.5 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	145.0	903.79
BOTTOM (filter pack or open hole):	157.0	891.79
MIDPOINT (filter pack or open hole):	151	897.79
PUMP INTAKE:	148.41	900.38
WATER LEVEL (average):	115.48	933.31
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	93		
CONVENTIONAL SAMPLING METHOD:	54 samples	02/19/86	04/24/97
LOW-FLOW SAMPLING METHOD:	39 samples	10/20/97	10/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/14/04	.	10/13/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 31.5 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	15 µg/L	06/01/91	Outlier
GROSS ALPHA (15 pCi/L):	1	450 pCi/L	05/14/96	Outlier
GROSS BETA (50 pCi/L):	1	535 pCi/L	05/14/96	Outlier

WELL GW-159

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 145 to 157 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the crest of Chestnut Ridge southeast of the east end of Y-12, about 100 ft west (hydraulically upgradient) of the Chestnut Ridge Sediment Disposal Basin (CRSDB). The CRSDB is a former sinkhole filled with contaminated sediments generated from remedial actions at Y-12 and covered with a low-permeability, multilayer cap during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 54 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 39 samples between October 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 115 ft bgs and exhibit unusually wide (>25 ft) water-level fluctuations (Figure 1). However, the conventional sampling method is associated with the largest apparent water level fluctuations. Purging the well during conventional sampling typically decreases the water level in the well by 40 ft or more, and the water level is very slow to recover to the presampling level (Figure 2). Moreover, the protocol of consecutive daily sampling required for RCRA post-closure detection monitoring at the CRSDB was discontinued in part because the water level in this well would not sufficiently recover between sampling events (Bechtel Jacobs Company LLC [BJC] 2001).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 176 – 251 mg/L;
- pH (field measurements) of 7.0 – 8.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 74 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-five groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.72 mg/L) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Forty-two groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.003 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, only acetone has been detected in one of the groundwater samples from this well that were analyzed for VOCs (between February 1991 and July 1995). The sample collected in June 1991 had an acetone concentration of 15 µg/L, and this result is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Eighteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (450 pCi/L) being substantially above the MCL for gross alpha activity (15 pCi/L). However, this result was identified as an outlier (none of the other gross alpha results exceed 10 pCi/L) and is a sampling or analytical artifact.

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (535 pCi/L) being substantially above the SDWA for gross beta activity (50 pCi/L). However, this result was identified as an outlier (none of the other gross beta results exceed 15 pCi/L) and is probably a sampling or analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

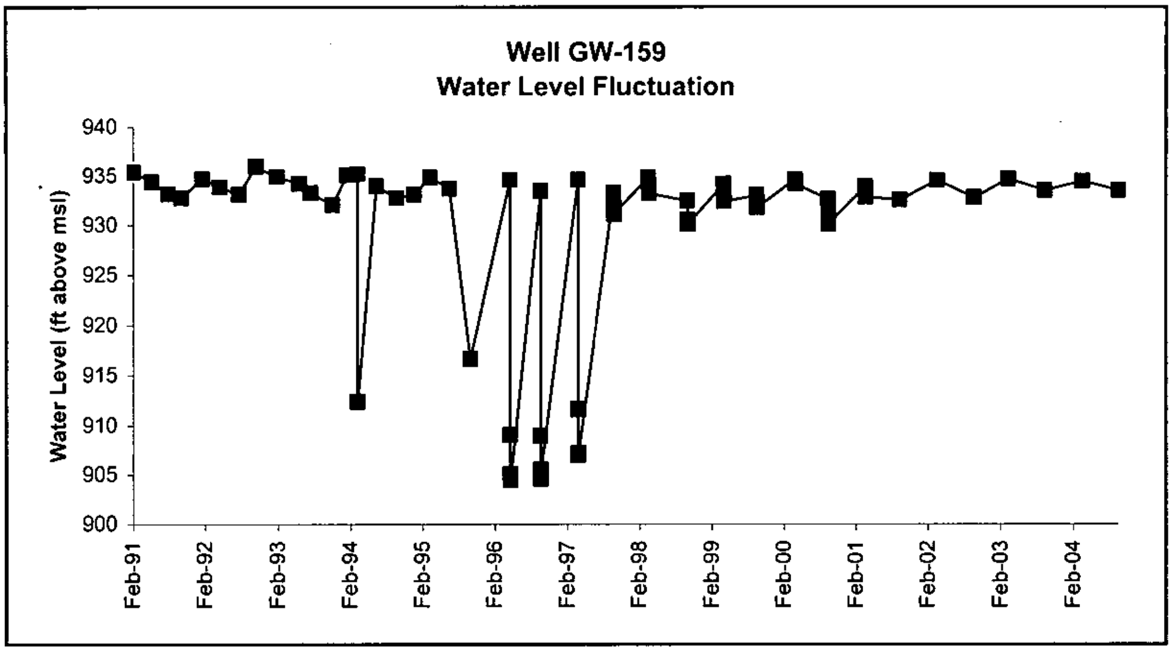


Figure 1

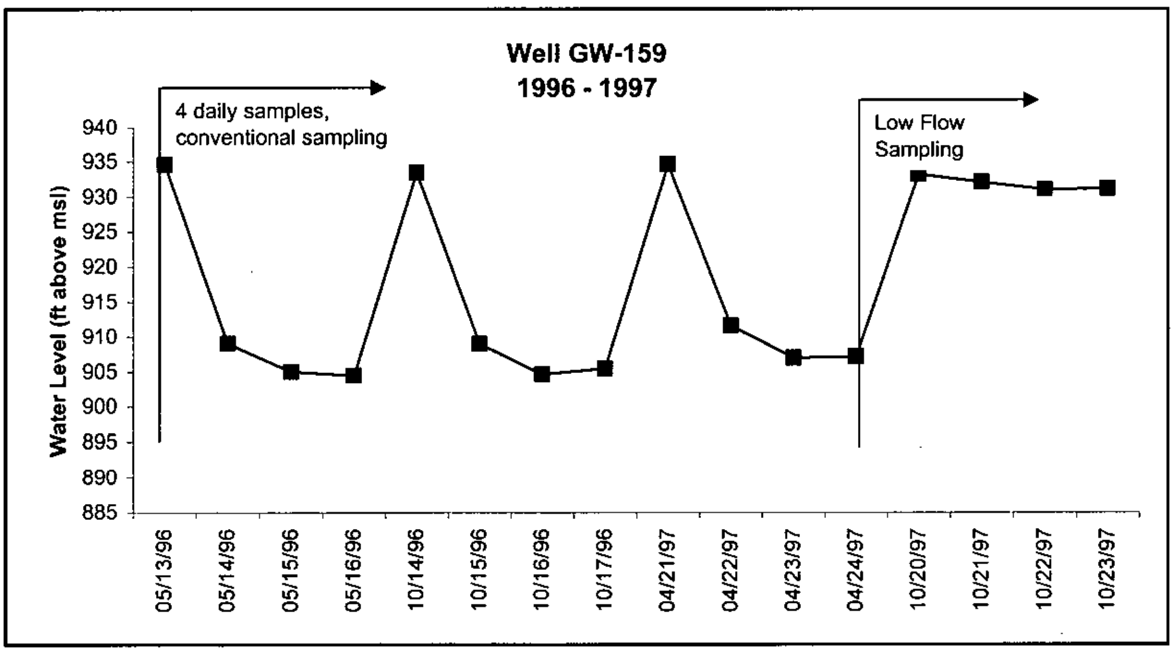


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	.	<5	<7.5	<25

GW-169

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 66,854.00
Y-12 GRID NORTH COORDINATE: 28,545.00
SURFACE ELEVATION: 929.95 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/16/86 PAIRED/CLUSTERED WITH: GW-170 GW-232
TAG DEPTH (measured): 36.23 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 932.12 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	28.7	901.25
BOTTOM (filter pack or open hole):	34.8	895.15
MIDPOINT (filter pack or open hole):	31.8	898.20
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	27.67	902.28

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	41			
CONVENTIONAL SAMPLING METHOD:	21	samples	03/01/91	09/03/97
LOW-FLOW SAMPLING METHOD:	20	samples	02/13/98	10/25/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	04/20/04	08/09/04	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 12 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	7	10 µg/L	03/01/91	Decreasing
GROSS ALPHA (15 pCi/L):	7	72 pCi/L	11/01/93	Decreasing
GROSS BETA (50 pCi/L):	2	71 pCi/L	11/12/91	Decreasing

WELL GW-169

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1986, completed with a screened monitored interval from 28.7 to 34.8 ft bgs, and constructed with nominal 2.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-170 and GW-232 and is located in Union Valley east of Y-12, about 1,500 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between March 1991 and September 1997, and the low-flow sampling method used to obtain 20 samples between February 1998 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 28 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10-25 ft) water level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 105 mg/L – 576 mg/L;
- pH (field measurements) of 5.8 – 7.6;
- high total suspended solids (>1,000 mg/L) commonly reported for samples collected before 1996;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (excluding artifacts of high suspended solids: aluminum, iron, etc.) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 41 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-eight groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.4 mg/L in February 2003) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Ten groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0052 mg/L in September 1995) being substantially below the MCL for uranium (0.3 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Low levels of PCE (1 – 4 μg/L) were detected in all but one (January 2000) of the groundwater samples collected to date. Also, TCE was detected in 20 of 23 samples collected through February 1999, but none of the samples collected since then, with the highest concentration reported for the initial sample collected in March 1991 (6 μg/L). This is the only result to exceed the MCL for TCE (5 μg/L). Acetone was detected in October of 2004 (2 μg/L), but this result is probably a sampling or analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Twenty-seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE. As shown below in Table 1, gross alpha activity reported for seven of the samples collected between November 1991 and September 1995 exceed the MCL for gross alpha activity (15 pCi/L). Much lower (<4 pCi/L) and less widely variable levels of gross alpha activity were reported for the 22 groundwater samples collected since September 1995, with results below the MDA reported for nine of these samples.

Table 1. Gross alpha results for well GW-169 that exceed the MCL

Sampling Date	Gross Alpha Activity (pCi/L)
11/12/91	45.9
11/11/92	40.1
01/23/93	25.6
08/19/93	24.3
11/01/93	72
06/12/95	18.7
09/28/95	17.4

The source of the alpha activity has not been determined. Ten of the groundwater samples collected from the well have been analyzed for uranium isotopes, most recently in February 1998. The highest levels of U-234 (2.23 pCi/L in December 1994) and U-238 (0.929 pCi/L in September 1995) are substantially lower than the gross alpha results summarized in Table 1. The inconsistent detection and widely variable results for gross alpha activity are probably related to analytical interference associated with the very high suspended solids of the (unfiltered) groundwater samples (see Section 4.0).

5.5 GROSS BETA ACTIVITY

Thirty-four groundwater samples had gross beta activity above the applicable MDA and corresponding CE. The gross beta results for samples collected in November 1991 (71 pCi/L, the historical maximum) and November 1993 (65.5 pCi/L) exceed the SDWA screening level for gross alpha activity (50 pCi/L). As with gross alpha activity in the well, much higher gross beta activity was reported for groundwater samples collected through September 1995 (35.8 pCi/L) compared to subsequent samples, all of which had gross beta activity below 10 pCi/L. Also, the source of the beta activity likewise is not known. The lack of uranium isotopes in the well tends to discount uranium daughters as potential sources of beta activity in the well. Also, six of the samples from the well were analyzed for Tc-99, which was detected (i.e., Tc-99 activity >MDA and CE) only in the sample collected in August 1994 (33 pCi/L) and the gross beta activity for this sample is less than the CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	.	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-170

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 66,843.00
Y-12 GRID NORTH COORDINATE: 28,545.00
SURFACE ELEVATION: 930.70 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/01/86 PAIRED/CLUSTERED WITH: GW-169 GW-232
TAG DEPTH (measured): 156.16 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 932.64 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.62 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	104.0	826.70
BOTTOM (filter pack or open hole):	156.9	773.80
MIDPOINT (filter pack or open hole):	130.5	800.25
PUMP INTAKE:	124.06	806.64
WATER LEVEL (average):	31.61	899.09

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	47		
CONVENTIONAL SAMPLING METHOD:	23 samples	06/04/90	09/08/97
LOW-FLOW SAMPLING METHOD:	24 samples	06/23/98	10/25/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	04/20/04	08/09/04	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: X LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.33 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	46	226 µg/L	11/17/94	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-170

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1986, completed with an open-hole monitored interval from 104 to 156.9 ft bgs, and constructed with nominal 4.5-inch diameter steel (F25) riser casing. The well forms a cluster with wells GW-169 and GW-232 and is located in Union Valley about 1,500 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 23 samples between June 1990 and September 1997, and the low-flow sampling method used to obtain 24 samples between June 1998 and October 2004.

Groundwater samples from the well exhibit conspicuous geochemical characteristics (see Section 4.0) potentially attributable to localized contamination from cement (grout). Redevelopment of the well before sampling also may be necessary to obtain the most representative (i.e., the least grout-contaminated) groundwater samples.

Note that a Hydrolab™ water quality multiprobe became lodged in well GW-170 in 1996. All attempts to retrieve the probe have failed, and it remains at the bottom of the open-hole interval.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 32 ft bgs and exhibits moderate (about 7 ft) seasonal fluctuations. Presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically more than 5 ft lower in well GW-170 than well GW-169, which is completed at a shallower depth (42 ft bgs) in the Maynardville Limestone. Based on the distance (98 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate consistently downward vertical hydraulic gradients (0.001 - 0.09) during seasonally high and low flow conditions. Similarly, the relationship between presampling groundwater elevations and monitored-interval midpoints for wells GW-170 and GW-232, which is completed are a substantially greater depth (341 ft) in the Maynardville Limestone, likewise indicate downward vertical gradients of similar magnitude, but sometimes show slightly upward vertical gradients (0.0003 – 0.006), typically during seasonally low groundwater flow (summer and fall).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in Union Valley near the east end of Y-12 and the vicinity of well GW-170 indicate components of flow toward unnamed drainage features in Union Valley to the east-southeast of the well (parallel with geologic strike in the Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Before January 2000, the well produced calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 96 – 310 mg/L;
- pH of 7.2 – 12.2 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (>10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

As illustrated by the data summarized in Table 1, the groundwater samples obtained since January 2000 exhibit significantly different geochemical characteristics than reported for samples collected previously, including atypical levels of carbonate and bicarbonate, strongly basic pH, and unusually high potassium concentrations. The abrupt change in geochemical characteristics does not appear to be related to the groundwater sampling method because the conventional and low-flow sampling results obtained before January 2000 show similar values for pH, potassium, and TDS. Similar geochemical characteristics evident for other monitoring wells at Y-12 are believed to be the result of localized contamination by cement grout circulated into the surrounding bedrock during their installation and construction. However, grout contamination related to the installation of well GW-170, or the wells with which it is clustered (GW-169 and GW-232), seems unlikely considering their age (19 years) and the lack of any previous evidence of grout contamination in any of the wells (as illustrated by the data in Table 1). Moreover, residual grout contamination from well installation/construction does not explain the apparent sharp decrease in TDS. Low TDS implies short groundwater residence time and, considering the depth to the open-hole monitored interval in the well (>100 ft bgs), potentially indicates a more direct hydraulic connection with the shallower flow system than previously evident. Perhaps construction activities performed during CY 1999 near well GW-170, including the widening of Highway 61 east of the well, which has involved blasting and excavation of the bedrock (Copper Ridge Dolomite), and the construction of an office building to the west of the well, which involved excavation of footings into the bedrock (Maynardville Limestone) and installation of a (concrete) slab-on-grade foundation, in some way altered the groundwater geochemistry and the matrix of groundwater flowpaths (and contaminant transport pathways) intercepted by the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since March 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirty-four groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (1.2 mg/L in September 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Six groundwater samples had uranium concentrations above the analytical reporting limit, with the highest concentration (0.0019 mg/L in September 1995) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): acetone, benzene, CTET, chloroform, methylene chloride (MC), PCE, TCE, toluene, and 12DCE. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 800 ft west of Scarboro Road (about 2,300 ft west of well GW-170); treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The primary VOC in the groundwater samples is CTET, which was detected in all but two of the groundwater samples, with concentrations of 100 μg/L or more evident in September 1991, April 1992, October 1992, and November 1994 (Table 2). Secondary VOCs in the samples are benzene, chloroform, PCE, and TCE. Chloroform was detected in all but one of the samples, with concentrations of 50 μg/L or more evident in January 1993, March 1993, February 1994, August 1994, and December 1995. Low levels of PCE and TCE were detected in each sample, with the bulk of the results for both compounds being estimated values below their respective analytical reporting limits (5 μg/L). Benzene was not detected in any of the groundwater samples collected before January 2000, but was detected at estimated concentrations below 5 μg/L in all but two of the samples collected since then. Excluding false positive results, the other VOCs were detected much more sporadically, with low levels (4 μg/L or less) of methylene chloride detected in six samples and traces (1 μg/L or less) of 12DCE detected in four samples. Also, the most recent data show that concentrations of each applicable VOC remain below corresponding drinking water MCLs (Table 2).

A time-series plot of summed VOC (solvent) concentrations for each groundwater sample (Figure 1) shows a widely variable and generally indeterminate trend between March 1991 and July 1998, followed by a decreasing trend through January 2000, with sharply lower concentrations evident thereafter (Figure 1). This is primarily attributable to substantially lower concentrations of CTET evident since January 2000. Also, the repeated detection of benzene, which was not detected in any of the samples collected before January 2000, coincides with the sharply lower concentrations of CTET (Figure 1). An explanation for the decrease in CTET concentrations and the concurrent detection of benzene is not apparent from the monitoring results, especially considering the lack of similarly significant changes in the concentrations of the other VOCs in the well (Table 1), although both coincide with conspicuous changes in the geochemical characteristics of the groundwater samples obtained from the well (see Section 4).

5.4 GROSS ALPHA ACTIVITY

Seventeen groundwater samples had gross alpha activity above the MDA and corresponding CE, with the highest value (7.06 pCi/L in September 1997) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty-nine groundwater samples had gross beta activity above the MDA and corresponding CE, with the highest value (36.05 pCi/L in July 1998) being slightly below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The elevated levels of gross beta activity may be related to the elevated potassium concentrations in the grout-contaminated groundwater samples from the well. Potassium-40 (K-40) is a beta-emitting isotope and, based on the natural ratio of K-40 to total K (K-40 = 0.0119% total K; Brownlow 1979), should be present in the groundwater samples. The presence of K-40 would account for the strong correlation between the monitoring results for gross beta activity and total potassium (Figure 2).

6.0 REFERENCES

Brownlow, A.H. 1979. *Geochemistry.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-170: selected results for pH, alkalinity, potassium, and TDS

Parameter	Conventional Sampling				Low-Flow Sampling						
	Aug. 1993	Feb. 1994	June 1995	Mar. 1996	Feb. 1999	Aug. 1999	Jan. 2000	May 2000	Aug. 2000	Nov. 2000	Jan. 2001
Field pH	7.6	7.7	7.6	8.1	7.41	7.23	11.98	11.55	11.02	11.44	11.55
Bicarbonate	216	213	217	209	NA	NA	<2	<2	2	<2	<2
Carbonate	<1	<1	<1	<1	NA	NA	30	140	84	67	32
Potassium	1.5	2.1	2.1	2.1	NA	NA	NA	NA	NA	NA	NA
TDS	286	258	274	256	280	280	96	170	140	30	192

Parameter	Low-Flow Sampling										
	May 2001	Jul. 2001	Nov. 2001	Feb. 2002	May 2002	Aug. 2002	Nov. 2002	Feb. 2003	Apr. 2003	Aug. 2003	Oct. 2003
Field pH	11.62	7.6	7.7	11.77	12.03	11.4	11.97	11.98	12.03	11.42	11.6
Bicarbonate	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Carbonate	16	16	2	26	10	14	38	22	14.8	17.2	64.8
Potassium	NA	NA	7.87	7.08	13.2	12.1	9.3	8.48	17.7	18.1	15.5
TDS	143	117	146	112	161	192	157	185	215	288	272

Parameter	Low-Flow Sampling										
	Feb. 2004	May 2004	Aug. 2004	Nov. 2004							
Field pH	12.16	11.74	11.81	11.97							
Bicarbonate	<2	<2	<2	<2							
Carbonate	52	34	16	<2							
Potassium	10.3	8,69	8.17	7.53							
TDS	218	122	248	289							

Note: Field pH in standard units; bicarbonate, carbonate, potassium, and TDS in mg/L;
NA = Not analyzed

Table 2. Well GW-170: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	Benzene	CTET	Chloroform	MC
03/01/91	.	99	8	2 J
05/13/91	.	6	28	4 J
09/02/91	.	100	FP	.
11/06/91	.	91	7	.
02/05/92	.	31	20	FP
04/29/92	.	110	FP	.
08/10/92	.	6	31	FP
10/27/92	.	120	18	FP
01/23/93	.	1 J	57	2 J
05/24/93	.	.	59	2 J
08/21/93	.	16	43	FP
11/04/93	.	39	41	1 J
02/02/94	.	4 J	95	FP
08/11/94	.	2 J	69	3 J
11/17/94	.	200	12	.
03/22/95	.	.	42	FP
06/19/95	.	9	34	.
09/28/95	.	2 J	36	.
12/12/95	.	19	50	.
03/18/96	.	81	7	.
06/19/96	.	68	FP	.
09/08/97	.	56	17	2 J
06/23/98	.	40	14	.
07/21/98	.	97	8	.
02/08/99	.	57	14	.
08/31/99	.	31	12	.
01/24/00	3 J	3 J	13	.
05/22/00	4 J	2 J	13	.
08/08/00	3 J	2 J	10	.
11/01/00	4 J	4 J	11	.
01/10/01	3 J	5 J	12	.
05/01/01	4 J	4 J	10	.
07/31/01	3 J	2 J	9	.
11/07/01	4 J	2 J	10	.
02/04/02	3 J	3 J	8	.
05/14/02	4 J	2 J	8	.
08/06/02	.	2 J	7	.
11/11/02	.	5 J	.	.
02/13/03	3 J	3 J	5	.
04/30/03	4 J	2 J	4 J	.
08/18/03	4 J	2 J	3 J	.
10/28/03	3 J	2 J	3 J	.
MCL	**5**	**5**	**80***	**5**

Table 2 (continued)

Date Sampled	VOC Concentration (µg/L)			
	Benzene	CTET	Chloroform	MC
02/09/04	3 J	4 J	3 J	.
04/20/04	3 J	4 J	3 J	.
08/09/04	2 J	4 J	3 J	.
10/25/04	2 J	5 J	3 J	3 J
MCL	**5**	**5**	**80***	**5**

Date Sampled	VOC Concentration (µg/L)		
	PCE	TCE	12DCE (total)
03/01/91	7	3 J	.
05/13/91	3 J	.	.
09/02/91	8	3 J	.
11/06/91	10	3 J	.
02/05/92	4 J	2 J	.
04/29/92	8	4 J	.
08/10/92	4 J	2 J	.
10/27/92	9	3 J	.
01/23/93	7	2 J	.
05/24/93	6	2 J	.
08/21/93	6	3 J	.
11/04/93	6	2 J	1 J
02/02/94	10	2 J	0.9 J
08/11/94	7	3 J	.
11/17/94	11	3 J	.
03/22/95	6	3 J	.
06/19/95	5	2 J	.
09/28/95	4 J	2 J	.
12/12/95	6	2 J	.
03/18/96	4 J	3 J	.
06/19/96	5	4 J	1 J
09/08/97	4 J	3 J	.
06/23/98	4 J	3 J	.
07/21/98	6	3 J	.
02/08/99	4 J	3 J	.
08/31/99	2 J	2 J	.
01/24/00	2 J	2 J	.
05/22/00	4 J	3 J	.
08/08/00	2 J	2 J	.
11/01/00	2 J	2 J	.
01/10/01	2 J	1 J	.
05/01/01	2 J	2 J	.
07/31/01	2 J	1 J	.
11/07/01	2 J	2 J	.
02/04/02	2 J	1 J	.
05/14/02	3 J	2 J	.
08/06/02	2 J	2 J	.
11/11/02	3 J	2 J	0.3 J
MCL	**5**	**5**	**70****

Table 2 (continued)

Date Sampled	VOC Concentration (µg/L)		
	PCE	TCE	12DCE (total)
02/13/03	2 J	2 J	.
04/30/03	2 J	2 J	.
08/18/03	2 J	2 J	.
10/28/03	2 J	2 J	.
02/09/04	2 J	2 J	.
04/20/04	2 J	2 J	.
08/09/04	2 J	2 J	.
10/25/04	2 J	2 J	.
MCL	**5**	**5**	**70****

Note: "." = Not detected; FP = False positive; J = Estimated value; NA = Not applicable; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane; ** MCL is for c12DCE

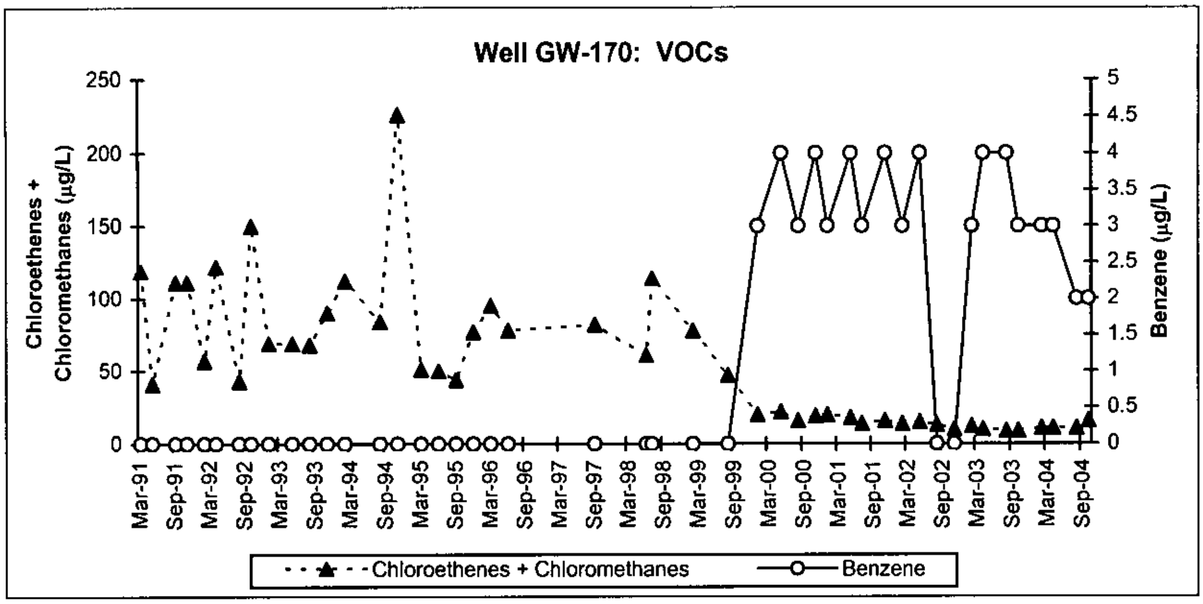


Figure 1

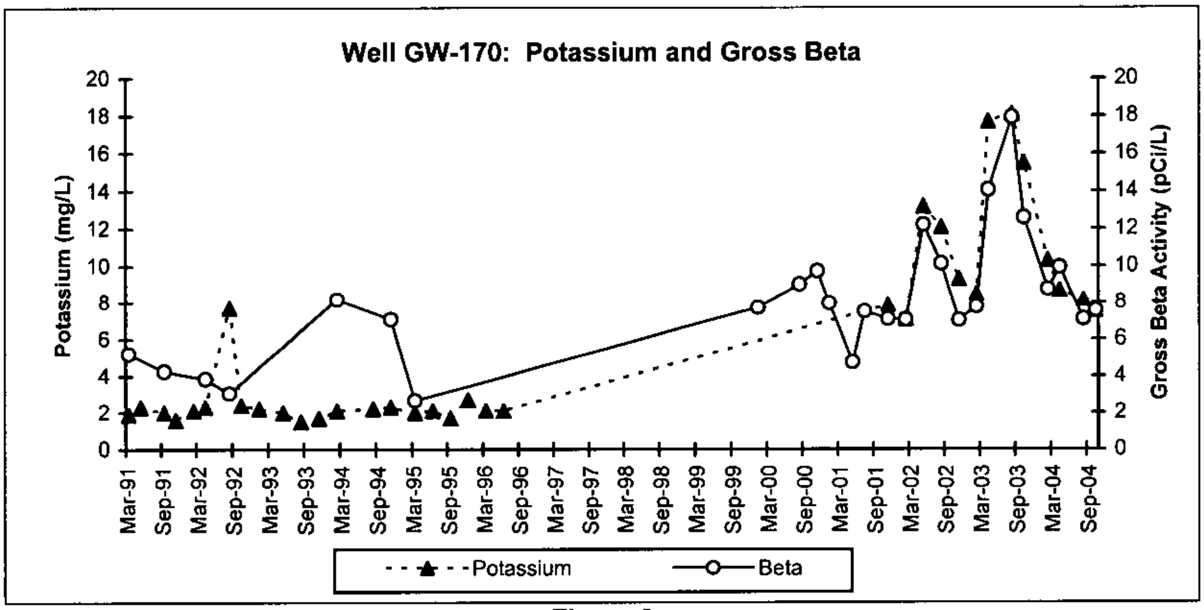


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-171

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 69,654.00
Y-12 GRID NORTH COORDINATE: 28,403.00
SURFACE ELEVATION: 918.55 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/26/86 PAIRED/CLUSTERED WITH: GW-172 GW-230
TAG DEPTH (measured): 32.64 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 920.72 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	25.8	892.75
BOTTOM (filter pack or open hole):	31.2	887.35
MIDPOINT (filter pack or open hole):	28.5	890.05
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	7.01	911.54

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	10 samples	09/27/94	09/03/97
LOW-FLOW SAMPLING METHOD:	15 samples	02/17/98	08/09/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/10/04	.	08/09/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 12.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-171

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 1986, completed with a screened monitored interval from 25.8 to 31.2 ft bgs, and constructed with nominal 2.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-172 and GW-230 and is located in Union Valley east of Y-12, about 4,300 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between September 1994 and September 1997, and the low-flow sampling method used to obtain 15 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibit substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 330 mg/L;
- pH (field measurements) of 5.8 – 7.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for the groundwater samples collected from the well since January 1991.

5.1 NITRATE

Eleven groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.5 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and the corresponding CE, with the highest value (7.96 pCi/L in September 1997) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nineteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (27.4 pCi/L in June 1996) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

.	.	ND	.	.
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-172

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 69,578.94
Y-12 GRID NORTH COORDINATE: 28,358.45
SURFACE ELEVATION: 922.85 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/05/86 PAIRED/CLUSTERED WITH: GW-171 GW-230
TAG DEPTH (measured): 137.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 926.69 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.62 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	105.0	817.85
BOTTOM (filter pack or open hole):	133.8	789.05
MIDPOINT (filter pack or open hole):	119.4	803.45
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	14.14	908.71

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	24		
CONVENTIONAL SAMPLING METHOD:	10 samples	06/04/90	09/04/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/17/98	08/09/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	.	08/09/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.92 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-172

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1986, completed with an open-hole monitored interval from 105 to 133.8 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well forms a cluster with wells GW-171 and GW-230 and is located in Union Valley east of Y-12, about 4,300 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between June 1990 and September 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the intermediate bedrock interval (>100 ft bgs) in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 15 ft bgs and exhibit moderate (about 10 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 219 – 600 mg/L;
- pH (field measurements) of 6.5 – 7.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Eight groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.4 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the seven groundwater samples collected between September 1994 and February 1996 were analyzed for uranium and two of the samples had concentrations above the applicable analytical reporting limit: 0.00073 mg/L in March 1995 and 0.0089 mg/L in December 1995. Both results are substantially below the MCL for uranium (0.3 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and the corresponding CE, with the highest value (3.17 pCi/L in February 1999) being substantially below less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nine groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (30.5 pCi/L in August 2001) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-173

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 59,472.00
Y-12 GRID NORTH COORDINATE: 28,271.00
SURFACE ELEVATION: 1,112.97 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/15/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 167.34 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,115.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	154.0	958.97
BOTTOM (filter pack or open hole):	165.0	947.97
MIDPOINT (filter pack or open hole):	159.5	953.47
PUMP INTAKE:	162.97	950.00
WATER LEVEL (average):	140.01	972.96

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	27 samples	02/04/86	07/16/92
LOW-FLOW SAMPLING METHOD:	2 samples	05/06/04	10/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/06/04	.	10/04/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 25.07 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	9	21 µg/L	05/06/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	1	65.9 pCi/L	04/07/92	Outlier

WELL GW-173

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 154 to 165 ft bgs, and constructed nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 200 ft east of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between February 1986 and July 1992, and the low-flow sampling method used to obtain samples in March 2004 and October 2004.

Presampling depth-to-water measurements show that the static water level in the well exhibits substantial (>25 ft) temporal (seasonal) fluctuations (Figure 1). Similarly distinctive groundwater elevation fluctuations also are evident in other wells completed in the Knox Group on Chestnut Ridge, particularly wells located at or near the crest of the ridge, which is both a recharge area and a groundwater flow divide (Solomon et al. 1992).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 140 ft bgs. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV; to the east along the axis of the ridge (toward well GW-173), parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 174 – 240 mg/L;
- pH of 6.9 – 7.8 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (1.3 mg/L in August 1991 and February 1992) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in all but one groundwater sample collected to date: PCE, 111TCA, TCFM, and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113 (F113). These compounds are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via strike-parallel flowpaths in the Knox Group (e.g., bedding-plane fractures). Additionally, low levels of 111TCA detected in several downgradient monitoring wells on the southern flank of the ridge potentially reflect groundwater flow/contaminant transport via "quickflow" conduits that cut across geologic strike (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

Each groundwater sample collected to date contained PCE, with the low (estimated) concentration (4 μg/L) detected in the sample collected most recently (October 2004) being an apparent outlier compared to the other PCE results, which range between 11 and 15 μg/L (Table 1). In contrast, 111TCA was detected in only one sample (0.6 μg/L in May 1991) and low levels of TCFM (3 μg/L) and freon-113 (3 μg/L) were detected in the samples collected in May and October 2004 (analytical results for these VOCs were not reported for samples collected before May 2004). The preponderance of PCE in the groundwater from this well is the likely result of down-dip (i.e., bedding-plane parallel) and strike-parallel (eastward) migration from the eastern disposal trenches at the CRSP. Moreover, none of the groundwater samples collected to date contained PCE degradation products, particularly TCE and 12DCE, indicating that the monitored interval for the well does not intercept groundwater flow/transport pathways where biologically mediated degradation (reductive dechlorination) of PCE occurs.

Excluding the potential outlier result noted above, the PCE results suggest an indeterminate or slightly increasing long-term trend that spans the 12-year gap in the sampling history for the well (Figure 1). Also, the available data suggest that the PCE concentrations do not exhibit strong seasonal fluctuations or consistent correlations with the presampling water level in the well.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.65 pCi/L in October 1991) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE. Excluding the sample in April 1992 (65.9 pCi/L) which appears to be an outlier, the highest value (9.05 pCi/L in July 1992) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-173: summary of VOC results

Date Sampled	Concentration (µg/L)			
	PCE	11TCA	TCFM	F113
02/04/86	.	.	NR	NR
04/15/86	7	.	NR	NR
07/29/86	4 J	5	NR	NR
10/17/86	22	3 J	NR	NR
01/08/87	15	2 J	NR	NR
04/02/87	12	5	NR	NR
08/07/87	14	2 J	NR	NR
10/06/87	15	6	NR	NR
03/12/88	15	1 J	NR	NR
06/07/88	17	2 J	NR	NR
08/05/88	15	2 J	NR	NR
10/24/88	19	2 J	NR	NR
01/05/89	20	2 J	NR	NR
04/04/89	15	1 J	NR	NR
08/10/89	14	.	NR	NR
10/04/89	16	.	NR	NR
02/03/90	13	0.9 J	NR	NR
05/22/90	11	0.9 J	NR	NR
07/25/90	13	.	NR	NR
10/27/90	14	1 J	NR	NR
02/01/91	11	.	NR	NR
05/03/91	12	0.6 J	NR	NR
08/06/91	11	.	NR	NR
10/10/91	13	.	NR	NR
02/07/92	12	.	NR	NR
04/07/92	11	.	NR	NR
07/16/92	12	.	NR	NR
05/06/04	15	.	3 J	3 J
10/04/04	4 J	.	3 J	3 J
MCL	**5**	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NR = Not reported; NA = Not applicable

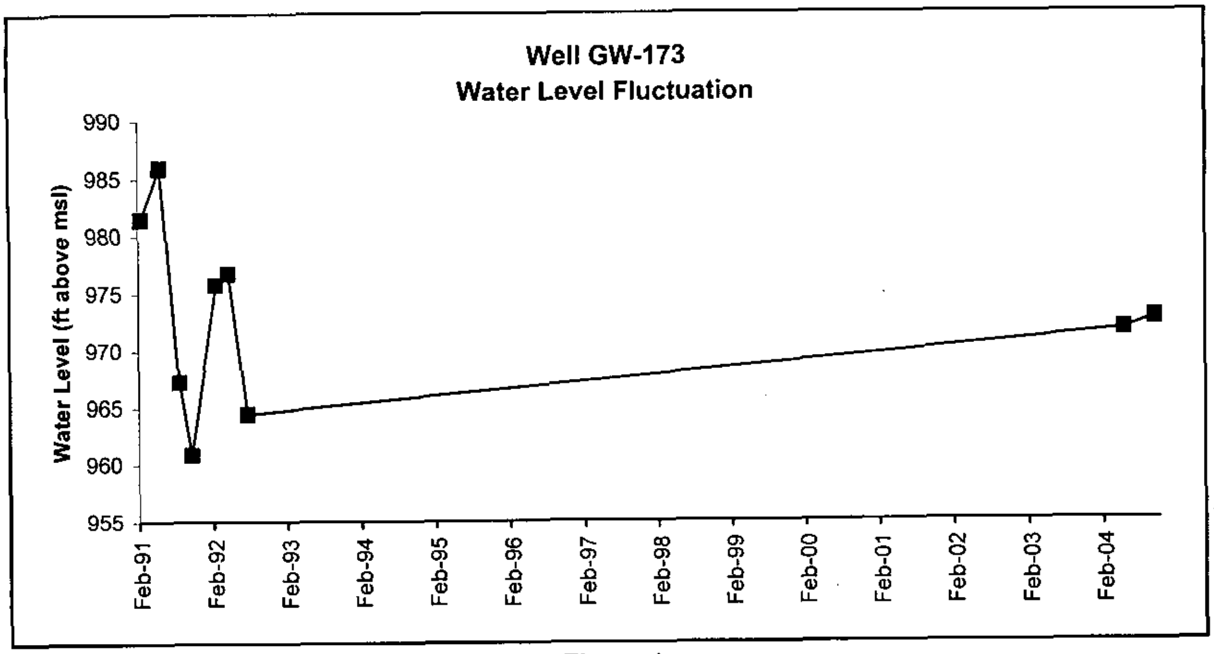


Figure 1

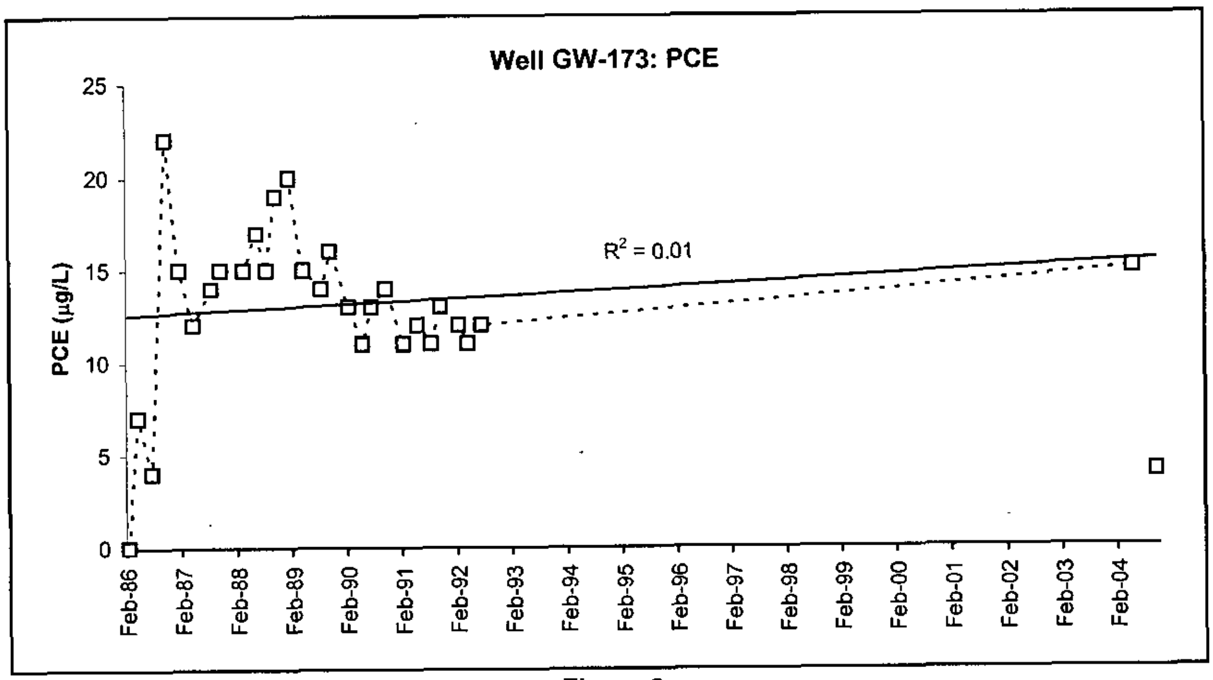


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-175

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,686.23
Y-12 GRID NORTH COORDINATE: 28,676.73
SURFACE ELEVATION: 1,081.89 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/22/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 169.49 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,084.19 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	148.3	933.59
BOTTOM (filter pack or open hole):	166.7	915.19
MIDPOINT (filter pack or open hole):	157.5	924.39
PUMP INTAKE:	162.7	919.19
WATER LEVEL (average):	117.15	964.74

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	35		
CONVENTIONAL SAMPLING METHOD:	31 samples	08/17/88	02/25/96
LOW-FLOW SAMPLING METHOD:	4 samples	03/20/01	10/06/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/06/04	.	10/06/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 21.1 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	25	55 µg/L	08/08/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-175

1.0 *INSTALLATION, CONSTRUCTION, AND LOCATION*

This well was installed in June 1988, completed with a screened monitored interval from 148 to 167 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 200 ft west of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 31 samples between August 1988 and February 1996, and the low-flow sampling method used to obtain four samples between March 2001 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 117 ft bgs and exhibits moderate (about 21 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV (toward well GW-175); to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 130 – 298 mg/L;
- pH of 7.3 – 8.5 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-one groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.763 mg/L in November 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Ten groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in August 1991, October 1991, February 1992, July 1992, October 1992, June 1993, and September 1993) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: acetone, methylene chloride, PCE, TCE, TCFM, 11DCE, and 111TCA. Each compound except acetone is a confirmed component of the dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

The VOCs detected most frequently in the groundwater samples are PCE and 111TCA (Table 1). Only eight of the samples contained other VOCs (excluding false positive results) and none of the compounds were detected in more than four samples. Note that TCFM was detected in each of the samples collected since March 2001; however, VOC results reported for previous samples do not include TCFM. Aside from the results for PCE and TCFM, which have historical maximum concentrations of 41 μg/L and 16 μg/L, respectively, the bulk of the results are estimated values below 5μg/L. Also, the most recent sampling results show that PCE concentrations remain above the MCL for drinking water (5 μg/L). The dominance of PCE and 111TCA in the groundwater samples suggest that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs that originate from both the western and eastern waste disposal trenches at the CRSP. Additionally, the infrequent detection of PCE and 111TCA degradation products in the samples collected to date suggests that the monitored interval in the well does not intercept groundwater flowpaths where biologically mediated degradation of these compounds occurs. Indeed, the lack of 111TCA degradation products (i.e., 11DCA) in the samples indicates that the geochemistry of the groundwater in the well is not especially conducive to abiotic (chemical) degradation of the 111TCA.

A time-series plot of summed concentrations of VOCs detected in the groundwater samples (excluding false positive results) shows a slightly decreasing, widely variable long-term trend that encompasses 5-year (February 1996 - March 2001) and 3-year (August 2001 – May 2004) gaps in the sampling history for the well (Figure 1). The fluctuations in summed VOC concentrations do not appear to exhibit any clear or consistent correlation with seasonal groundwater flow conditions, as illustrated by the temporal "peak" VOC concentrations evident during seasonally high flow (e.g., 91 μg/L in April 1989) and seasonally low flow (e.g., 55 μg/L in August 1991). Additionally, in contrast to other wells near the CRSP, the VOC concentrations in well GW-175 do not show any direct response to the closure of the site in 1988 and installation of the low-permeability cap in 1989, as illustrated by the stable PCE concentrations detected over time (Table 1). This suggests minimal overall change in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.39 pCi/L in October 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

One groundwater sample collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (14.3 pCi/L in June 1993) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-175: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	TCE	11DCE	111TCA	TCFM	Other
08/17/88	8	.	.	3 J	NR	.
10/24/88	10	.	.	5	NR	.
01/06/89	6	.	.	2 J	NR	.
04/06/89	69	.	.	4 J	NR	.
08/14/89	16	.	.	5	NR	.
10/20/89	17	.	.	5	NR	.
03/05/90	32	.	.	10	NR	.
05/22/90	35	.	2 J	12	NR	.
07/24/90	27	.	.	8	NR	.
10/26/90	12	.	.	4 J	NR	.
01/31/91	23	.	.	8	.NR	.
05/01/91	5	.	.	5	NR	.
08/08/91	41	1 J	2 J	11	NR	.
10/13/91	25	.	.	6	NR	.
02/09/92	28	.	1 J	7	NR	MC (1 J)
04/11/92	29	.	.	8	NR	.
07/21/92	20	.	.	5	NR	.
10/08/92	16	.	.	5	NR	.
03/27/93	16	.	.	5	NR	.
06/15/93	15	.	.	4 J	NR	.
09/11/93	13	.	.	3 J	NR	.
12/19/93	9	.	0.6 J	3 J	NR	.
02/23/94	18	.	.	4 J	NR	.
05/20/94	22	.	.	5	NR	.
08/13/94	20	.	.	4 J	NR	.
12/01/94	22	.	.	6	NR	.
02/14/95	19	1 J	1 J	.	NR	Acetone (10)
05/15/95	15	.	.	.	NR	.
08/01/95	21	.	.	.	NR	.
11/17/95	15	.	.	.	NR	.
02/25/96	11	.	.	2 J	NR	.
03/20/01	8	.	.	.	8	.
08/20/01	7	.	.	.	7	.
05/06/04	14	.	.	2 J	16	.
10/06/04	10	.	.	2 J	13	.
MCL	**5**	**5**	**7**	**200**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable

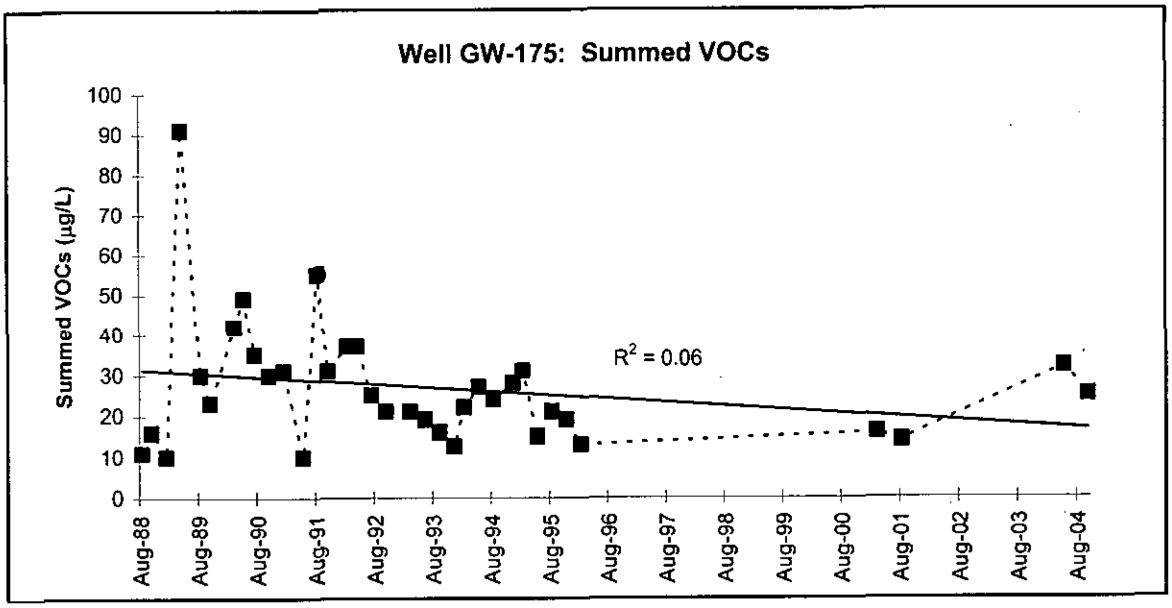

Well GW-175: Summed VOCs
Summed VOCs (µg/L)
100
90
80
70
60
50
40
30
20
10
0
$R^2 = 0.06$
Aug-88
Aug-89
Aug-90
Aug-91
Aug-92
Aug-93
Aug-94
Aug-95
Aug-96
Aug-97
Aug-98
Aug-99
Aug-00
Aug-01
Aug-02
Aug-03
Aug-04

Figure 1

MAXIMUM CONCENTRATION: 2004				
<5	ND	50 - 500	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-176

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,450.00
Y-12 GRID NORTH COORDINATE: 28,294.00
SURFACE ELEVATION: 1,122.13 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/27/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 147.33 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,125.30 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	134.0	988.13
BOTTOM (filter pack or open hole):	145.0	977.13
MIDPOINT (filter pack or open hole):	139.5	982.63
PUMP INTAKE:	138.83	983.30
WATER LEVEL (average):	113.42	1008.71

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	27 samples	02/04/86	07/23/92
LOW-FLOW SAMPLING METHOD:	2 samples	05/10/04	10/07/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/10/04	.	10/07/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.87 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	9	244 µg/L	05/04/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-176

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 134 to 145 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 150 ft south of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between February 1986 and July 1992, and the low-flow sampling method used to obtain samples in May 2004 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 113 ft bgs and exhibits minor (about 2 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV; to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 212 – 346 mg/L;
- pH of 6.7 – 7.0 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- total concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995); and
- boron concentrations of 0.147 - 0.7 mg/L.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.6 mg/L in February 1992) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Only one groundwater sample collected to date had a uranium concentration at or above the applicable analytical reporting limit, and this result (0.001 mg/L in August 1991) is an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date: PCE, 11DCE, 11DCA, 12DCA, and 111TCA (Table 1). Each compound is a confirmed component of the dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

Each groundwater sample contained 11DCA and 111TCA; all but one of the samples had PCE and/or 11DCE; and 12DCA was detected in only two of the samples (Table 1). With maximum historical concentrations above 300 μg/L and 150 μg/L, respectively, 111TCA and 11DCA are the dominant compounds, which suggests that the monitored interval in the well intercepts groundwater flow/contaminant transport pathways for VOCs that originate from the western disposal trenches at the CRSP. The other VOCs were detected at much lower concentrations, with all the results for PCE and 11DCE being less than 10 μg/L and 25 μg/L, respectively, and only trace levels (2 μg/L) of 12DCA. The most recent sampling results (October 2004) show that the concentrations of PCE, 11DCE, and 111TCA remain below respective drinking water MCLs (Table 1).

As noted previously, some of the compounds in the CRSP VOC plume are present as a result of the degradation of related parent compounds. Abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), probably explains the frequent detection and relatively high concentrations of 11DCA and 11DCE in the groundwater samples from well GW-176. This is clearly illustrated by a time-series plot of the proportional distribution of 111TCA, 11DCA, and 11DCE concentrations in each groundwater sample collected to date (Figure 1), whereby a substantial decrease in the relative proportion of 111TCA is accompanied by a concurrent increase in the proportions of 11DCA and 11DCE.

A time-series plot of summed concentrations of VOCs detected in the groundwater samples (excluding false positive results) shows a generally decreasing but widely variable long-term trend that encompasses the 12-year (July 1992 – May 2004) gap in the sampling history for the well (Figure 2). The fluctuations in summed VOC concentrations show a strong correlation with seasonal groundwater flow conditions, with prominent temporal "peak" VOC concentrations evident in samples collected during seasonally high flow, including samples collected in April 1987 (369 μg/L), March 1988 (520 μg/L), April 1989 (583 μg/L), and January 1990 (403 μg/L). This relationship suggests seasonally variable flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Additionally, the concentrations of most VOCs decreased rapidly and seasonal fluctuations moderated in response to the closure of the site in 1988 and installation of the low-permeability cap in 1989. For instance, summed VOC concentrations decreased about 43% between February 1986 (319 μg/L) and April 1992 (182 μg/L). Since then, however, summed VOC concentrations have remained fairly unchanged, as illustrated by the nearly equal summed VOC concentrations evident for samples collected in July 1992 (98 μg/L) and October 2004 (92 μg/L).

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.92 pCi/L in May 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.32 pCi/L in May 1991) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-176: summary of VOC results

Date Sampled	Concentration (µg/L)				
	111TCA	**11DCA**	**12DCA**	**PCE**	**11DCE**
02/04/86	260	22	.	.	.
04/14/86	270	26	.	.	11
07/29/86	200	16	.	7	10
10/15/86	115	8	.	11	6
01/07/87	99	8	.	10	5
04/06/87	280	50	.	12	21
08/07/87	160	22	.	7	12
10/06/87	100	13	.	8	9
03/11/88	390	83		14	30
06/07/88	130	26	.	10	12
08/11/88	130	16	.	10	10
10/25/88	100	12	.	8	8
01/06/89	150	64	.	11	14
04/03/89	350	170	.	15	39
08/11/89	110	25	.	8	10
10/12/89	110	32	.	8	11
01/27/90	220	93	.	12	32
05/24/90	150	57	.	6	19
07/28/90	100	27	.	10	16
10/29/90	120	45	.	5	15
02/04/91	110	65	.	7	21
05/04/91	150	61	1 J	7	24
08/09/91	90	25	2 J	6	13
10/14/91	63	20	.	5	12
02/19/92	86	35	.	5	14
04/13/92	110	45	.	6	21
07/23/92	62	19	.	4 J	12
05/10/04	25	50	.	2 J	21
10/07/04	21	47	.	2 J	22
MCL	**200**	**NA**	**5**	**5**	**7**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable

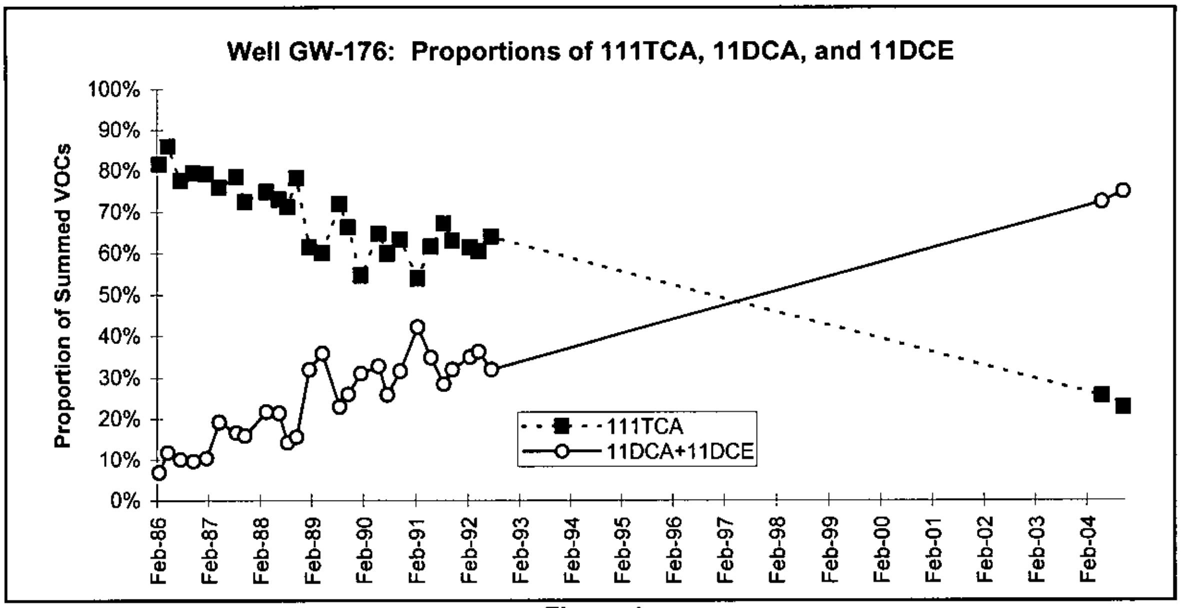


Figure 1

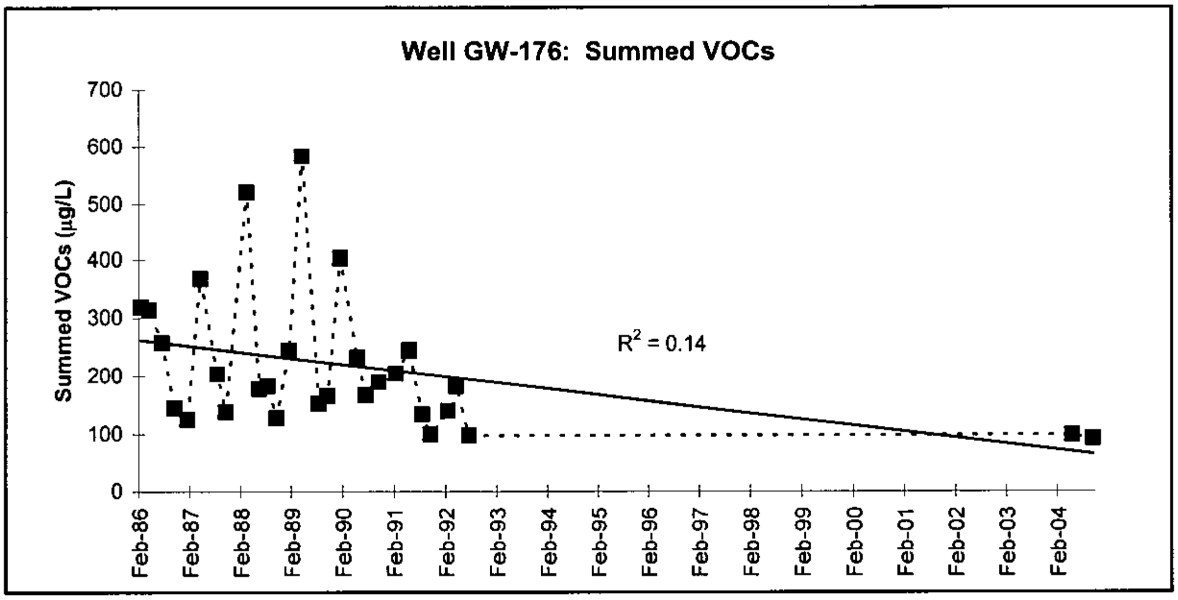


Figure 2

GW-176

MAXIMUM CONCENTRATION: 2004

.	ND	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-177

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 57,497.00
Y-12 GRID NORTH COORDINATE: 28,483.00
SURFACE ELEVATION: 1,155.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 150.69 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,158.20 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	130.0	1025.52
BOTTOM (filter pack or open hole):	145.0	1010.52
MIDPOINT (filter pack or open hole):	137.5	1018.02
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	115.23	1040.29
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	49		
CONVENTIONAL SAMPLING METHOD:	41 samples	02/04/86	02/25/96
LOW-FLOW SAMPLING METHOD:	8 samples	03/26/01	07/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/12/04	.	07/13/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.3 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	50 µg/L	11/30/94	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	.0	< pCi/L		

WELL GW-177

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 130 to 145 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 200 ft west of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 41 samples between February 1986 and February 1996, and the low-flow sampling method used to obtain 8 samples between March 2001 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Copper Ridge Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 115 ft bgs and exhibits moderate (about 11 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-177 indicate radial flow directions, with components of flow to the north into BCV, to the east along the axis of the ridge (parallel with geologic strike), and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

This well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 120 – 272 mg/L;
- pH of 7.2 – 8.2 (field measurements);

- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Fourteen groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.847 mg/L in November 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-one groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.003 mg/L in April 1992 and June 1993) being an order-of-magnitude lower than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample: CTET, PCE, 11DCE, 12DCE, 11DCA, and 111TCA. These compounds are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via strike-parallel flowpaths in the Knox Group (e.g., bedding-plane fractures). Nevertheless, the presence of dissolved VOCs in the groundwater at this well indicates that there is a component of groundwater flow/contaminant transport to the west of the CRSP. Additionally, low levels of 111TCA detected in several downgradient monitoring wells on the southern flank of the ridge potentially reflect groundwater flow/contaminant transport via "quickflow" conduits that cut across geologic strike (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

The VOCs detected most frequently in the groundwater samples are 111TCA, 11DCA, and 11DCE (Table 1). Carbon tetrachloride, PCE, and 12DCE were detected only in samples collected in October 1991 (PCE), December 1993 (12DCE), and November 1995 (CTET). As shown in Table 1, the highest concentrations were reported for 111TCA (29 µg/L in December 1993) and 11DCA (25 µg/L in January 2002). Much lower levels are evident for 11DCE (most are estimated values below 5 µg/L), although the historical maximum 11DCE concentration (8 µg/L in January 2002) slightly exceeds the MCL. The preponderance of 111TCA and 11DCA in the well suggests transport of contaminants primarily from the western disposal trenches at the CRSP.

As illustrated by results for 111TCA (Figure 1), the concentrations of VOCs in the groundwater samples often show an inverse correlation with the presampling water level in the well (i.e., concentrations are highest in samples collected when water levels are lowest). This relationship suggests greater dilution of the groundwater samples collected during seasonally (or episodically) high flow conditions. Also, the VOC concentrations decreased sharply immediately after closure of the CRSP in 1988 and installation of the low-permeability cap in 1989, which probably reflects the substantially reduced flux of contaminants from the source areas. Since then, however, the sampling results show a relatively indeterminate long-term concentration trend, as illustrated by the 111TCA concentrations reported for the groundwater samples collected in January 1991 (12 µg/L), February 1996 (10 µg/L), March 2001 (11 µg/L), and January 2004 (8 µg/L).

5.4 GROSS ALPHA ACTIVITY

Sixteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.72 pCi/L in May 1995) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10.05 pCi/L in February 1991) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

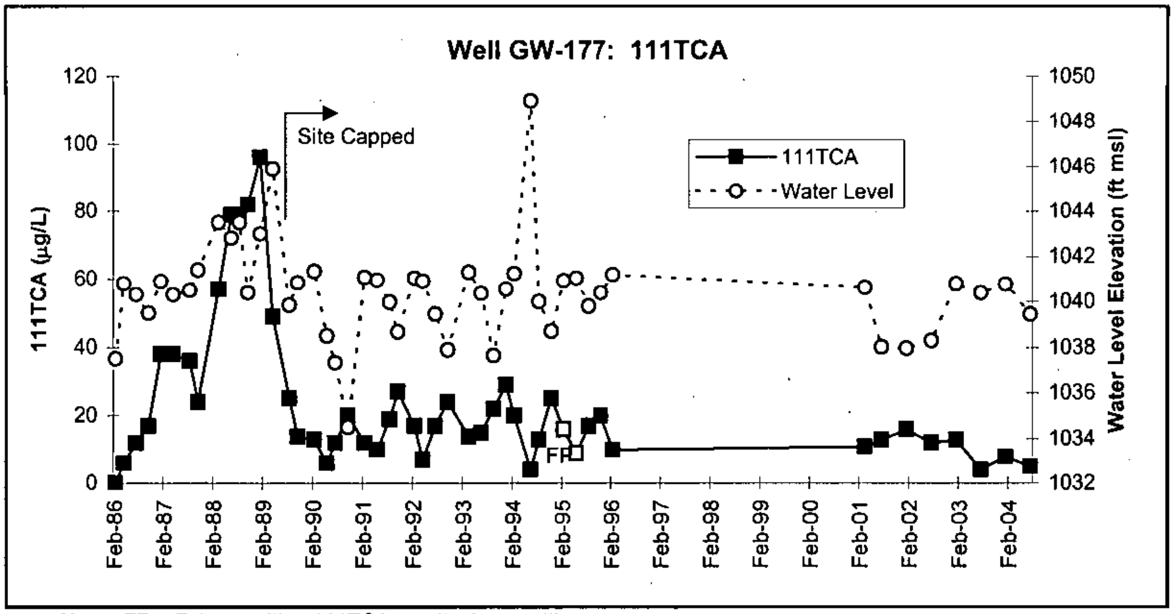
Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. **Well GW-177: summary of VOC data**

Date Sampled	VOC Concentration (μg/L)			
	111TCA	11DCA	11DCE	OTHER
02/02/91	12	7	.	.
05/03/91	10	5	1 J	.
08/08/91	19	8	2 J	.
10/13/91	27	11	3 J	PCE (1 J)
02/08/92	17	7	.	.
04/08/92	7	4 J	.	.
07/21/92	17	8	3 J	.
10/08/92	24	12	3 J	.
03/30/93	14	8	2 J	.
06/14/93	15	9	.	.
09/30/93	22	11	2 J	12DCE (0.6 J)
12/19/93	29	16	4 J	.
02/28/94	20	10	.	.
06/29/94	4 J	4 J	.	.
08/13/94	13	10	2 J	.
11/30/94	25	21	4 J	.
02/13/95	FP	13	2 J	.
05/11/95	FP	8	1 J	.
08/01/95	17	11	3 J	CTET (2 J)
11/16/95	20	17	3 J	.
02/25/96	10	10	2 J	.
03/26/01	11	18	4 J	.
07/25/01	13	17	5	.
01/09/02	16	25	8	.
07/10/02	12	19	5	.
01/09/03	13	23	6	.
07/14/03	4 J	7	2 J	.
01/12/04	8	15	5 J	.
07/13/04	5	9	3 J	.
MCL	**200**	**NA**	**7**	**5/70***

Note: "." = Not detected; FP = False positive; J = Estimated value; NA = Not applicable; *MCL for CTET and PCE = 5 μg/L; MCL for c12DCE = 70 μg/L



Note: FP = False positive 111TCA result, shown with an open square.

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-178

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 57,807.73
Y-12 GRID NORTH COORDINATE: 28,551.80
SURFACE ELEVATION: 1,141.06 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/20/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 134.68 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,143.49 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	117.5	1023.56
BOTTOM (filter pack or open hole):	133.0	1008.06
MIDPOINT (filter pack or open hole):	125.3	1015.81
PUMP INTAKE:	127.57	1013.49
WATER LEVEL (average):	89.08	1051.98

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	17 samples	03/12/88	02/08/92
LOW-FLOW SAMPLING METHOD:	2 samples	05/10/04	10/06/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/10/04	.	10/06/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.49 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	7	45 µg/L	08/08/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-178

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1987, completed with a screened monitored interval from 118 to 133 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 50 ft north of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between March 1988 and February 1992, and the low-flow sampling method used to obtain samples in May and October 2004.

The groundwater samples collected from this well in 2004 had a pink color. Well GW-178 was used as an injection point for two dye trace studies performed in 1990 and 1992. The first study used 10 kilograms of Fluorocene dye, and the second study used 225 pounds of a 20% solution of Rhodamine WT and 246 pounds of a 100% solution of an optical brightener (FB28). The pink color of the groundwater samples shows that at least some of the dye from the second test is still present in the well 14 years after injection.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 89 ft bgs and exhibits moderate (about 9 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV (toward well GW-178); to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 194 – 446 mg/L;
- pH of 7.1 – 7.7 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Six groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.5 mg/L in January 1991, April 1991, and February 1992) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, the VOCs detected in one or more of the groundwater samples collected to date are CTET, chloroform, MC, PCE, 11DCE, 11DCA, and 111TCA. Of these compounds, only 111TCA, 11DCA, 11DCE, and PCE are confirmed components of the dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south

(Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

Each groundwater sample collected to date contained 111TCA and all but three of the samples contained 11DCA (Table 1). Concentrations of 111TCA are all less than 50 µg/L, substantially below the drinking water MCL (200 µg/L), with the most recent sampling results (May and October 2004) showing concentrations below 10 µg/L. Conversely, the most recent sampling results for 11DCA (11 µg/L and 12 µg/L, respectively) are the highest concentrations reported for this compound. Other VOCs were detected less frequently than 111TCA and 11DCA and at much lower concentrations, with low levels (<5 µg/L) of PCE and 11DCE detected about half of the samples and chloroform detected in one sample (excluding false positive results). The dominance of 111TCA and 11DCA in the groundwater at this well suggests that the monitored interval in the well intercepts cross-strike groundwater flow/contaminant transport pathways for VOCs that originate primarily from the western disposal trenches at the CRSP. Indeed, considering that the well is only 50 ft from the closest disposal trench, the relatively modest levels of VOCs in the groundwater at this well suggest that these cross-strike pathways play only a minor role in the overall transport/migration of dissolved VOCs from the CRSP.

As noted previously, some of the compounds in the CRSP VOC plume are present as a result of the degradation of related parent compounds. Abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), probably explains the frequent detection 11DCA in the groundwater samples from well GW-178. This may explain why the long-term decrease in the concentration of 111TCA is accompanied by a concurrent increase in the concentration of 11DCA (Figure 1).

A time-series plot of summed concentrations of VOCs detected in each groundwater sample (excluding false positive results) shows a generally decreasing trend dominated by the 12-year gap (February 1992 – May 2004) in the sampling history for the well (Figure 2). Before the gap, summed VOC concentrations appear to have increased sharply between March 1988 (23 µg/L) and October 1988 (54 µg/L); decreased steadily through July 1990 (26 µg/L), rebounded to a peak level in August 1991 (45 µg/L), and decreased again through February 1992 (29 µg/L). The initial decrease probably reflects reduced flux of VOCs in response to closure of the CRSP and installation of the low-permeability cap over the waste disposal trenches. The significance of the latter temporal peak is not apparent from the available data. The most recent sampling results suggest that the rate of decrease in the concentrations of VOCs in the groundwater has slowed considerably, as indicated by the similar summed concentrations of VOCs detected in the samples collected in February 1992 and October 2004 (23 µg/L).

5.4 GROSS ALPHA ACTIVITY

Only one of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, and this result (8.4 pCi/L in October 1991) is below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta concentrations at or above the applicable analytical reporting limit.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-178: summary of VOC results

Date Sampled	Concentration (µg/L)				
	111TCA	11DCA	11DCE	PCE	Others
03/12/88	23	.	.	.	.
06/06/88	27	2 J	.	.	CTET(4 J)
09/15/88	37	4 J	.	.	.
10/24/88	44	4 J	2 J	4 J	.
01/06/89	39	5	2 J	.	MC(4 J)
04/04/89	38	6	2 J	0.8	.
08/11/89	33	5	2 J	.	.
10/06/89	32	6	2 J	0.9	.
01/28/90	33	6	.	0.8	.
05/17/90	27	.	.	.	.
07/21/90	6	.	.	.	Chloroform(20)
10/22/90	16	3 J	.	.	Chloroform(10)
01/15/91	23	4 J	.	.	.
04/22/91	25	6	2 J	2 J	.
08/08/91	34	6	2 J	.	Chloroform(3 J)
10/13/91	27	5	2 J	.	.
02/08/92	23	5	.	.	Chloroform(1 J)
05/10/04	6	11	2 J	.	.
10/06/04	8	12	3 J	.	.
MCL	**200**	**NA**	**7**	**5**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable

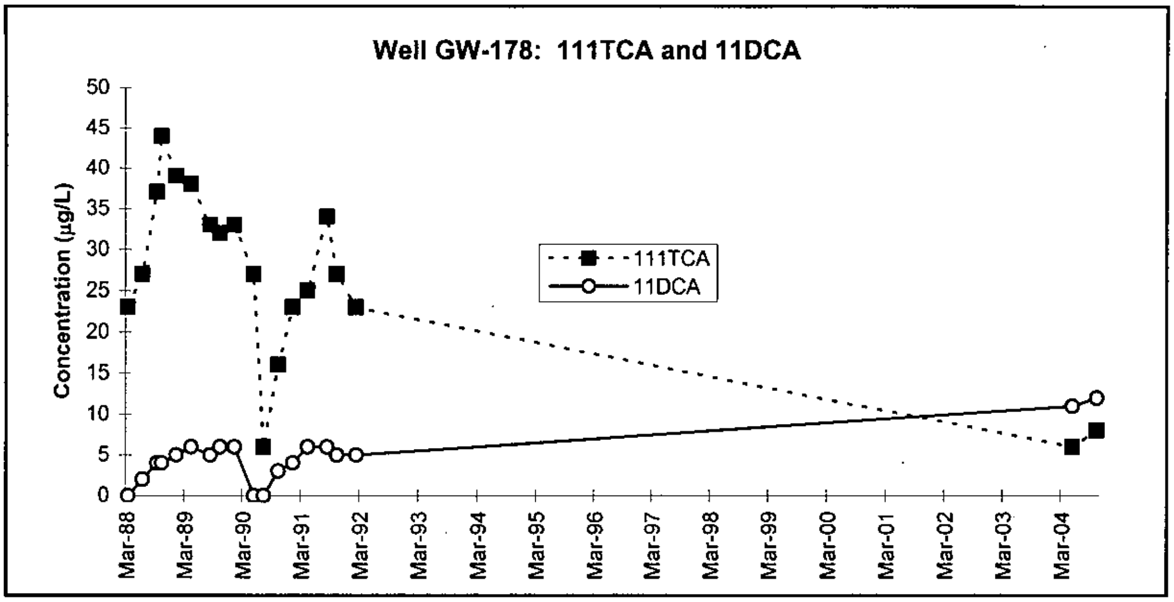


Figure 1

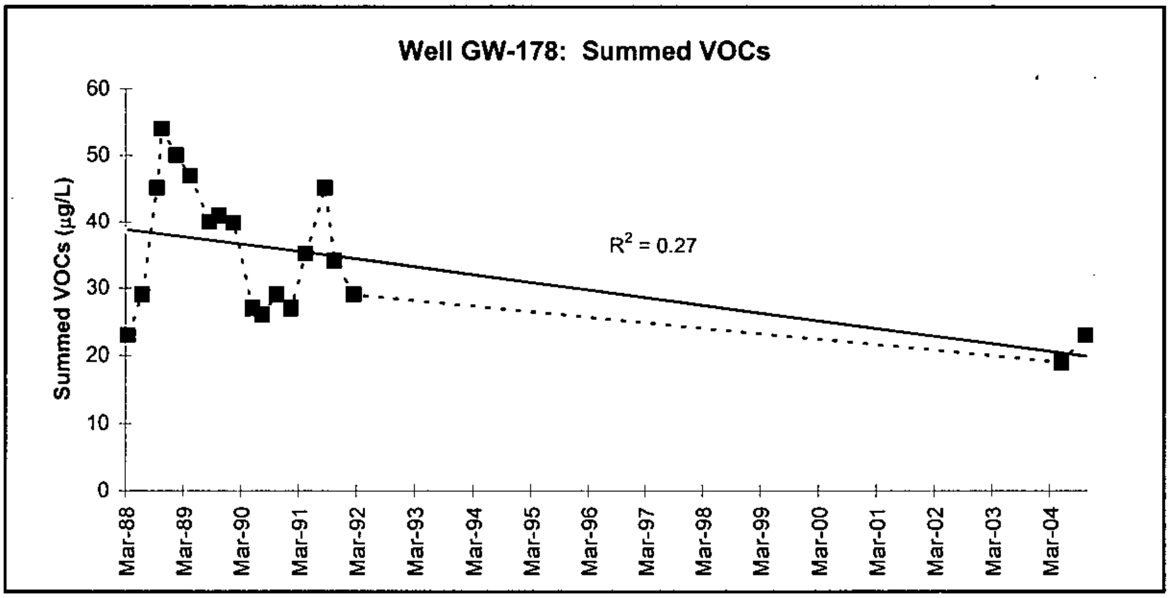


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-179

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,569.00
Y-12 GRID NORTH COORDINATE: 28,522.00
SURFACE ELEVATION: 1,124.33 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/03/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 122.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,128.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	106.0	1018.33
BOTTOM (filter pack or open hole):	117.0	1007.33
MIDPOINT (filter pack or open hole):	111.5	1012.83
PUMP INTAKE:	115.83	1008.50
WATER LEVEL (average):	112.16	1012.17

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	23 samples	02/10/86	07/27/92
LOW-FLOW SAMPLING METHOD:	2 samples	05/11/04	10/07/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/11/04	.	10/07/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 0.8 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	9	376 µg/L	05/08/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-179

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1985, completed with a screened monitored interval from 106 to 117 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, less than 50 ft north of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 23 samples between February 1986 and July 1992, and the low-flow sampling method used to obtain samples in May and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 112 ft bgs and exhibits minor (<1 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV (toward well GW-179); to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 256 – 294 mg/L;
- pH of 6.5 – 8.6 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nine groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.7 mg/L in February 1991) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in February 1991, May 1991, August 1991, and July 1992) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date: CTET, chloroform, MC, PCE, 11DCE, 12DCE, 11DCA, 111TCA, and TCFM. Only 111TCA, 11DCA, 11DCE, PCE, and TCFM have been detected in the groundwater samples collected since January 1991 and these VOCs are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

Each groundwater sample collected to date contained 111TCA, 11DCA, and 11DCE, with PCE detected in all but two of the samples (Table 1). A low level (11 μg/L) of TCFM was detected in the sample collected in October 2004, but this compound was not detected in the May 2004 sample and was not analyzed in historical samples (Table 1). Historical data show the highest concentrations for 111TCA and 11DCA, with respective maximum values of 1,100 μg/L (April 1986) and 300 μg/L (March 1988), and the preponderance of these compounds suggests that the well intercepts groundwater flow/contaminant transport pathways for VOCs that originate primarily from the western disposal trenches at the CRSP. However, the most recent (May and October 2004) sampling results show substantially lower concentrations of both compounds, with 111TCA levels substantially below the drinking water MCL (200 μg/L). Results for 11DCE show a historical maximum value of 77 μg/L (April 1986) and concentrations at or above 50 μg/L in most of the samples collected before February 1991 (Table 2). The most recent samples (May and October 2004) also show that the 11DCE concentrations remain above the MCL (7 μg/L). Although detected in most of the samples, PCE is a secondary compound compared to the other VOCs, with a historical maximum value of 42 μg/L (February 1986) that appears to be an outlier compared to the other PCE results, none of which exceed 15 μg/L, including very low levels (5 μg/L or less) reported for all but one of the samples collected since March 1990.

As noted previously, some of the compounds in the CRSP VOC plume are present as a result of the degradation of related parent compounds. Abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), probably explains the frequent detection and relatively high concentrations of 11DCA and 11DCE in the groundwater samples from well GW-179. This is clearly illustrated by a time-series plot of the proportional distribution of 111TCA, 11DCA, and 11DCE concentrations in each groundwater sample collected to date (Figure 1), whereby a substantial decrease in the relative proportion of 111TCA is accompanied by a concurrent increase in the proportions of 11DCA and 11DCE. In contrast, none of the groundwater samples collected to date contained PCE degradation products, particularly TCE and c12DCE, indicating that the monitored interval for the well does not intercept groundwater flow/transport pathways where biologically mediated degradation (reductive dechlorination) of PCE occurs.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample (excluding false positive results) generally shows a decreasing long term trend dominated by the nearly 12-year gap (July 1992 – May 2004) in the sampling history for the well (Figure 2). Before the sampling gap, the data show two distinct trends: a widely fluctuating trend evident before the CRSP were closed and capped and a less variable, clearly decreasing trend after the site was closed and capped. The wide concentration fluctuations generally correspond with seasonal groundwater elevations, with higher summed VOC concentration evident for samples collected during winter and spring, which suggests seasonally variable flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. The steadily decreasing trend segment reflects the substantially reduced flux of VOCs after closure of the site and installation of the low-permeability cap. Nevertheless, the rate of concentration decrease appears to have slowed, with summed VOC concentrations decreasing by about 1,045 μg/L in the four years between March 1988 (1,278 μg/L) and July 1992 (234 μg/L), but only by about 140 μg/L in the 12 years between July 1992 and October 2004 (93 μg/L). This suggests that the bulk of the most contaminated groundwater has been flushed from the flowpaths monitored by the well.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.19 pCi/L in April 1992) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (11.16 pCi/L in February 1991) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-179: summary of VOC results

Date Sampled	Concentration (µg/L)				
	111TCA	11DCA	11DCE	PCE	TCFM
02/10/86	790	160	54	42	NR
04/23/86	1,100	190	77	8	NR
08/05/86	790	240	52	11	NR
10/20/86	500	240	19	4 J	NR
01/09/87	820	230	64	11	NR
04/06/87	700	200	7	15	NR
08/07/87	710	207	75	.	NR
10/07/87	330	130	27	6	NR
03/14/88	990	300	71	12	NR
06/10/88	700	250	62	11	NR
08/11/88	880	240	62	10	NR
04/20/89	550	200	75	12	NR
03/21/90	290	120	59	.	NR
06/09/90	280	120	51	5	NR
09/24/90	210	110	40	4 J	NR
12/11/90	310	110	52	6	NR
02/08/91	220	89	44	5	NR
05/08/91	230	99	43	4 J	NR
08/12/91	170	90	31	3 J	NR
10/17/91	170	75	36	4 J	NR
02/19/92	180	80	41	5	NR
04/24/92	140	70	34	3 J	NR
07/27/92	140	65	26	3 J	NR
05/11/04	11	21	13	.	.
10/07/04	21	36	24	1 J	11
MCL	**200**	**NA**	**7**	**5**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

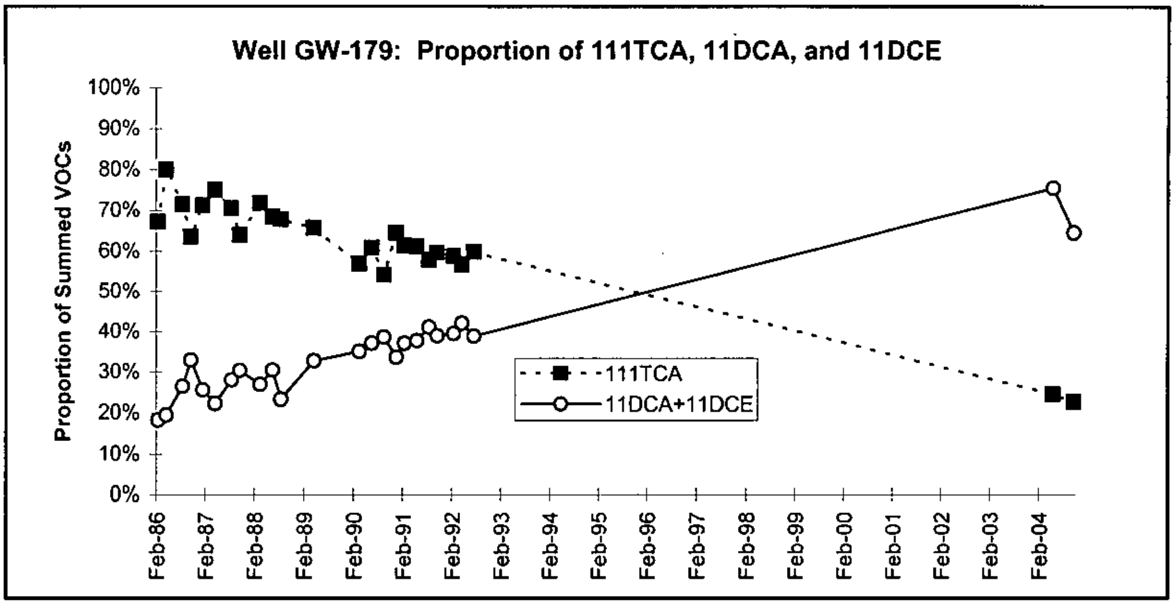


Figure 1

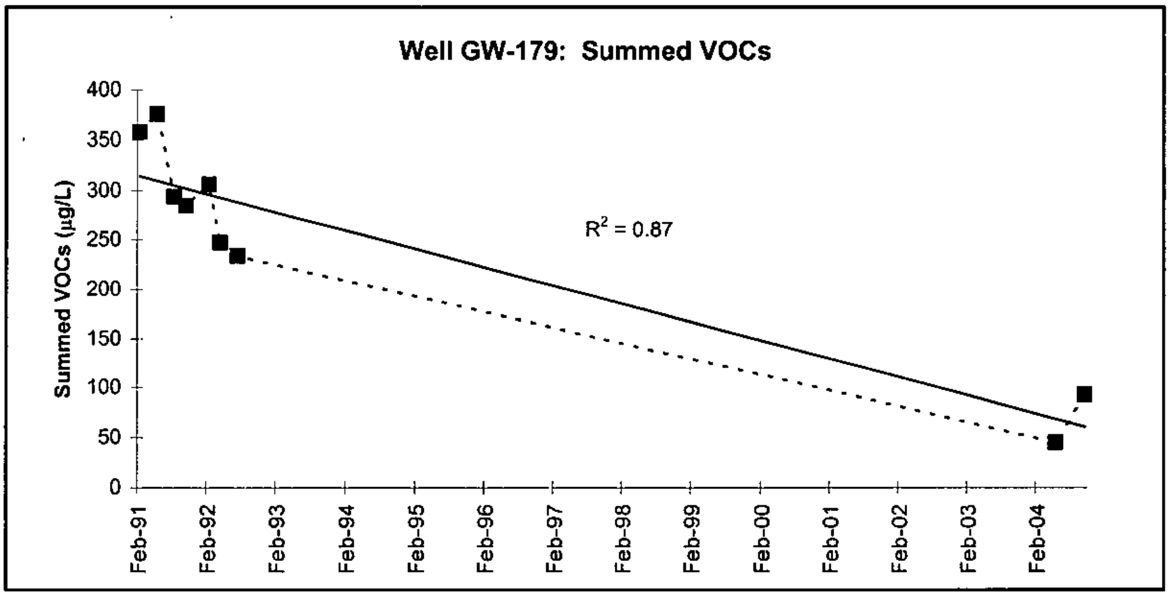


Figure 2

MAXIMUM CONCENTRATION: 2003

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-190

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Beta-4 Security Pits
Y-12 GRID EAST COORDINATE: 53,254.42
Y-12 GRID NORTH COORDINATE: 30,776.49
SURFACE ELEVATION: 1,030.19 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/01/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 29.84 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,033.69 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 8.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	8.0	1022.19
BOTTOM (filter pack or open hole):	26.2	1003.99
MIDPOINT (filter pack or open hole):	17.1	1013.09
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	9.31	1020.89

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	16 samples	06/20/90	11/16/93
LOW-FLOW SAMPLING METHOD:	2 samples	04/29/03	10/21/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/29/03	.	10/21/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 2.4 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	12	1,558.90 µg/L	12/15/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-190

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1989, completed with a screened monitored interval from 8 to 26.2 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley near the west end of Y-12, about 500 ft southeast of the intersection of Bear Creek Road and Old Bear Creek Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between June 1990 and November 1993, and the low-flow sampling method used to obtain samples in April and October 2003.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 9.3 ft below ground surface. Presampling depth-to-water measurements for the well indicate minor fluctuations (<3 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (200 -300 mg/L);
- pH (field measurements) of 6.3 – 7.3;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 15 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.26 mg/L in March 1991) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only one groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.001 mg/L in November 1993) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected from the well between March 1991 and November 1993: PCE, TCE, 12DCE, 11DCE, VC, 111TCA, and 11DCA. Summed concentrations of the compounds detected in each sample vary widely from a high of 1,559 ug/L in December 1991 to 65 ug/L in November 1993, with maximum concentrations of PCE (170 ug/L), TCE (230 ug/L), 12DCE (1,100 ug/L), and VC (66 ug/L) substantially above respective MCL. These historical VOC results also suggest a seasonally variable but generally indeterminate long-term concentration trend, as illustrated by the PCE concentrations evident in March 1991 (34 μg/L), December 1991 (170 μg/L), March 1992 (41 μg/L), November 1992 (75 μg/L), March 1993 (110 μg/L), and November 1993 (49 μg/L). The source of the VOCs in the groundwater at this well has not been confirmed but is probably one or more of the former waste handling and storage areas within the northern part of the Y-12 Salvage Yard.

The groundwater samples collected from the well in April and October 2003 did not contain VOCs. The apparent lack of VOCs in the groundwater at the well may reflect the combined and cumulative effects of various natural attenuation processes since the last previous sampling event (November 1993). However, this also may be an artifact of the change from conventional sampling to low-flow sampling. Conventional sampling involves collecting groundwater samples after purging at least three well-volumes of groundwater at a pumping rate (1-2 gallons per minute) which may substantially lower the water level in the well (or purge the well dry). Conventional sampling induces groundwater inflow into the well from water-producing features throughout the monitored interval, including features that may not be proximal to the pump intake, and the radius of influence may extend a significant distance from the well, particularly in the direction of geologic strike. Conversely, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to induce minimal water-level drawdown in the well (<1 ft per quarter hour) and collecting groundwater samples when field measurements show stable values for selected indicator parameters (e.g., temperature). Low-flow sampling induces groundwater inflow into the well from the water-producing feature(s) proximal to the pump intake, with a much smaller radius of influence compared to that of conventional sampling.

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.67 pCi/L in September 1991) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.31 pCi/L in September 1991) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-193

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Tank 2331-U
Y-12 GRID EAST COORDINATE: 59,536.17
Y-12 GRID NORTH COORDINATE: 29,343.93
SURFACE ELEVATION: 931.11 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/04/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 21.17 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 934.17 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.5	925.61
BOTTOM (filter pack or open hole):	18.45	912.66
MIDPOINT (filter pack or open hole):	12.0	919.14
PUMP INTAKE:	13.94	917.17
WATER LEVEL (average):	5.73	925.38

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	32		
CONVENTIONAL SAMPLING METHOD:	18 samples	06/18/90	08/13/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/16/98	07/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/08/04	.	07/13/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	2	0.086 mg/L	09/23/93	Decreasing
SUMMED VOCs (5 μg/L):	24	10,270 μg/L	05/07/92	Decreasing
GROSS ALPHA (15 pCi/L):	5	77.59 pCi/L	02/16/99	Decreasing
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-193

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1989, completed with a screened monitored interval from 5.5 to 18.45 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the east side of Bldg. 9201-1, about 300 ft south of Second Street in the east-central section of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-two groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between June 1990 and August 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is about 6 ft bgs. Presampling depth-to-water measurements for the well indicate minor fluctuations (<3 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 290 - 580 mg/L, excluding an outlier (1000 mg/L) in February 1999;
- pH of 6.4 – 7.8 (field measurements);
- high sulfate concentrations (>100 mg/L);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except iron and manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 29 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.3 mg/L in September 1993 and January 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-one groundwater samples had uranium concentrations above the applicable analytical reporting limit. Two of these results exceed the MCL for uranium (0.03 mg/L): 0.086 mg/L in September 1993 and 0.08 mg/L in November 1993. The remaining uranium concentrations are substantially lower, with non-detect results reported for all but two samples collected since

January 2000. A time-series plot of the detected uranium results (Figure 1) shows a slightly decreasing to indeterminate trend dominated by the concentration "spike" in 1993.

5.3 VOLATILE ORGANIC COMPOUNDS

Each groundwater sample collected between March 1991 and November 1993 contained summed concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) above 4,000 μg/L. These sampling results confirmed the release of petroleum hydrocarbons from Tank 2331-U, a former gasoline underground storage tank (UST) that was excavated and removed in December 1988 (DOE 1998). As shown by a time-series plot of the summed BTEX concentrations (Figure 2), the VOC concentrations in the groundwater at the well have decreased substantially. Only benzene has been detected in three of the samples collected since January 2001, and each result exceeds the MCL for benzene (5 μg/L). Along with the source control actions (i.e., removal of the UST), the substantially reduced levels of BTEX in the groundwater at this well are attributable to various natural attenuation processes because groundwater remedial action was not performed at the site.

5.4 GROSS ALPHA ACTIVITY

Twenty-four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with results that exceed the MCL (15 pCi/L) reported for samples collected in July 1992 (17.1 pCi/L), June 1993 (15.2 pCi/L), September 1993 (19 pCi/L), November 1993 (42.1 pCi/L), and February 1999 (77.59 pCi/L). The source of the alpha activity in the groundwater at this well has not been conclusively identified, but is suspected to be uranium isotopes, based on the detection of U-234 (4.5 pCi/L) and U-238 (6.93 pCi/L) in the sample collected in November 1996 (the only sample that was analyzed for uranium isotopes).

5.5 GROSS BETA ACTIVITY

Twenty-four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, although none of the results exceed the SDWA screening level for gross beta activity (50 pCi/L). Samples with the highest levels of gross beta activity were collected in November 1992 (24.3 pCi/L), September 1993 (24.9 pCi/L), November 1993 (41.6 pCi/L), and February 1999 (29.69 pCi/L). These results exceed background levels in the groundwater but are below the SDWA screening level for gross beta activity (50 pCi/L). Available data show that Tc-99 is not the source of the beta activity; each groundwater sample collected from the well since November 1996 was analyzed for Tc-99, as required by the RCRA post-closure permit for the East Fork Regime (TDEC 2003), and none of these results exceed the corresponding MDA. Uranium isotopes and associated daughters are the most likely source of the beta activity.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

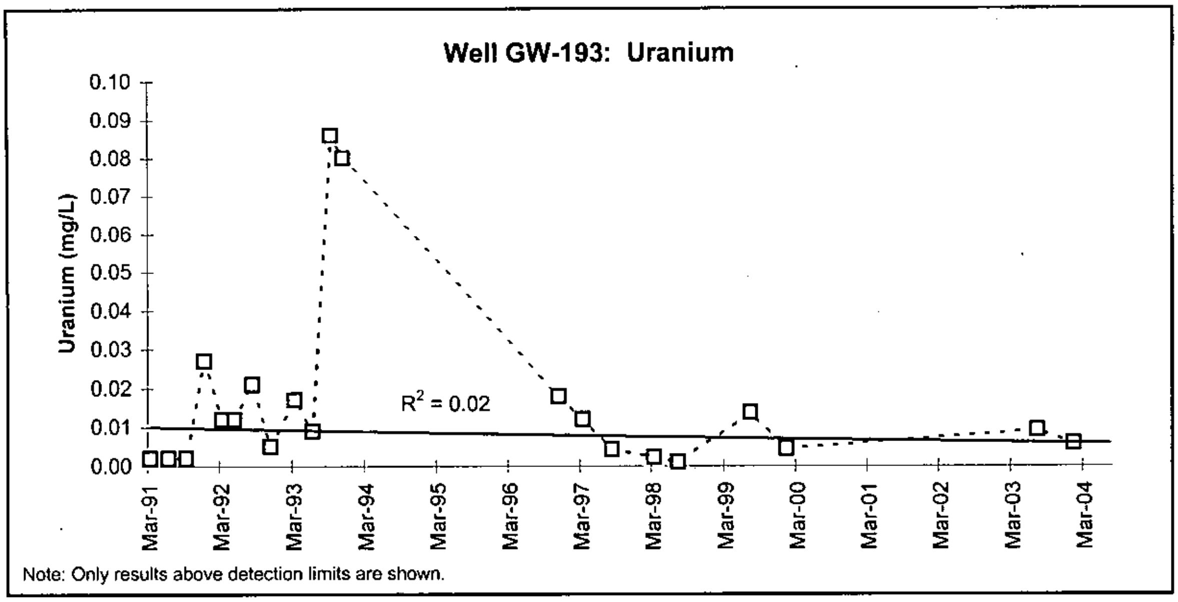


Figure 1

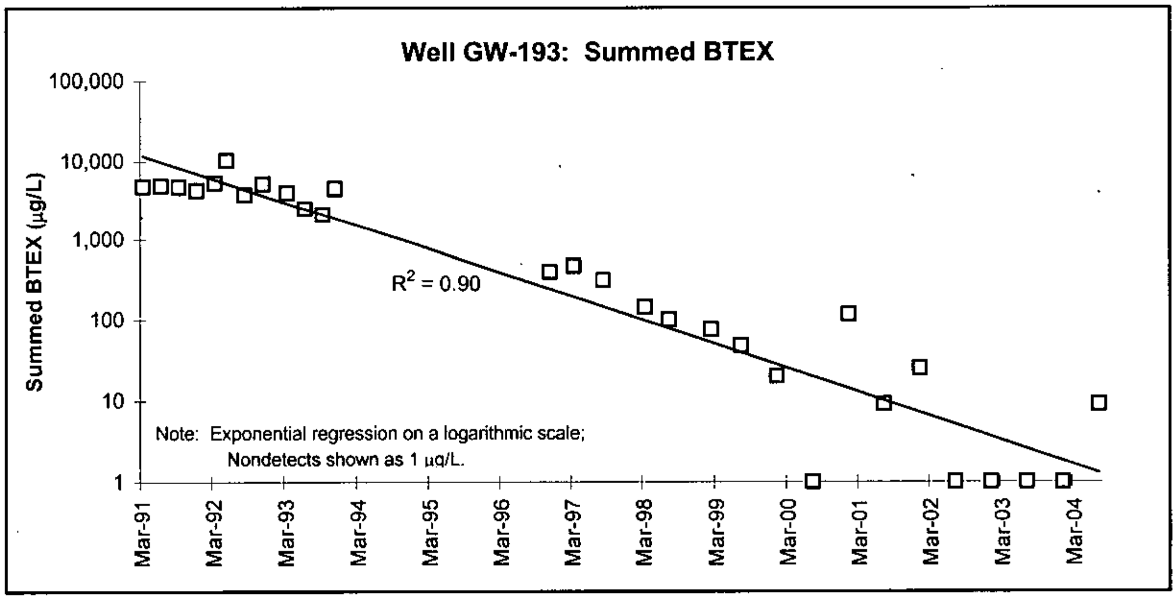


Figure 2

Y/TS-1983/R1/V3

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

MONITORING WELLS GW-200 THROUGH GW-699

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

Index of monitoring wells included in Volume 3

Well	Regime	Revision Year	Well	Regime	Revision Year	Well	Regime	Revision Year
GW-203	CR	2004	GW-277	BC	2005	GW-542	CR	2004
GW-204	EF	2004	GW-281	EF	2004	GW-543	CR	2004
GW-205	CR	2004	GW-286	BC	2005	GW-544	CR	2004
GW-207	EF	2004	GW-287	BC	2005	GW-557	CR	2004
GW-208	EF	2004	GW-288	BC	2005	GW-560	CR	2004
GW-217	CR	2004	GW-289	BC	2005	GW-562	CR	2004
GW-219	EF	2004	GW-291	BC	2005	GW-564	CR	2004
GW-220	EF	2004	GW-300	CR	2004	GW-601	BC	2005
GW-221	CR	2004	GW-301	CR	2004	GW-605	EF	2004
GW-222	EF	2004	GW-302	CR	2003	GW-606	EF	2004
GW-223	EF	2004	GW-305	CR	2004	GW-610	CR	2004
GW-225	BC	2004	GW-307	BC	2005	GW-611	CR	2004
GW-226	BC	2004	GW-310	BC	2005	GW-612	CR	2004
GW-227	BC	2005	GW-311	BC	2004	GW-615	BC	2004
GW-228	BC	2005	GW-312	BC	2005	GW-616	BC	2005
GW-229	BC	2004	GW-313	BC	2005	GW-618	EF	2003
GW-230	UV	2004	GW-315	BC	2004	GW-620	EF	2004
GW-231	CR	2004	GW-322	CR	2004	GW-624	BC	2005
GW-232	UV	2004	GW-336	EF	2003	GW-626	BC	2005
GW-236	BC	2004	GW-337	EF	2003	GW-627	BC	2004
GW-237	BC	2004	GW-339	CR	2003	GW-631	EF	2003
GW-242	BC	2005	GW-346	BC	2005	GW-633	EF	2004
GW-244	BC	2005	GW-363	BC	2004	GW-639	BC	2004
GW-245	BC	2005	GW-364	BC	2005	GW-653	BC	2004
GW-246	BC	2004	GW-365	BC	2005	GW-658	EF	2004
GW-247	BC	2005	GW-368	BC	2005	GW-679	CR	2004
GW-251	EF	2004	GW-380	EF	2004	GW-680	CR	2004
GW-253	EF	2003	GW-381	EF	2004	GW-683	BC	2004
GW-257	BC	2004	GW-382	EF	2004	GW-684	BC	2004
GW-269	EF	2003	GW-383	EF	2004	GW-690	EF	2003
GW-270	EF	2003	GW-505	EF	2003	GW-691	EF	2004
GW-271	EF	2003	GW-513	CR	2004	GW-692	EF	2004
GW-272	EF	2003	GW-521	CR	2004	GW-694	BC	2005
GW-273	EF	2003	GW-522	CR	2004	GW-695	BC	2004
GW-274	EF	2003	GW-526	BC	2004	GW-696	EF	2003
GW-275	EF	2003	GW-537	BC	2004	GW-698	EF	2004
GW-276	BC	2004	GW-540	CR	2004			

Notes:

BC = Bear Creek Hydrogeologic Regime
CR = Chestnut Ridge Hydrogeologic Regime
EF = Upper East Fork Poplar Creek Hydrogeologic Regime
UV = Union Valley (East of the EF Regime)

MAXIMUM CONCENTRATION: 2004

<5	ND	.	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-203

LOCATION

HYDROGEOLOGIC REGIME:	Chestnut Ridge Regime
FUNCTIONAL AREA:	United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE:	54,190.48
Y-12 GRID NORTH COORDINATE:	28,355.82
SURFACE ELEVATION:	1,102.34 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	CERCLA
HYDROLOGIC MONITORING:	X
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	10/24/85	PAIRED/CLUSTERED WITH:	
TAG DEPTH (measured):	157.61 ft below top of casing (TOC)		
MEASURING POINT ELEVATION:	1,105.45 ft above msl	MEASURING POINT:	TOWW
WELL BORE DIAMETER:	8.5 inches		
WELL CASING MATERIAL:	PVC40		
WELL CASING DIAMETER:	4.5 inches (outside diameter)		
WELL SCREEN TYPE:	PVC/SL/0.01		
DEDICATED SAMPLING EQUIPMENT:	Well Wizard	Sampling Port No.: .	Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	144.0	958.34
BOTTOM (filter pack or open hole):	156.0	946.34
MIDPOINT (filter pack or open hole):	150.0	952.34
PUMP INTAKE:	146.89	955.45
WATER LEVEL (average):	73.81	1028.53
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	54		
CONVENTIONAL SAMPLING METHOD:	40 samples	02/06/86	04/14/97
LOW-FLOW SAMPLING METHOD:	14 samples	11/12/97	08/03/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/25/04	.	08/03/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	.	
WATER LEVEL FLUCTUATION:	21.7 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	9 µg/L	07/26/93	Outlier
GROSS ALPHA (15 pCi/L):	2	20.1 pCi/L	01/18/93	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-203

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 144 to 156 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the crest of Chestnut Ridge directly south of Y-12, about 100 ft south (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge, radiologically-contaminated soils, and demolition debris. A multilayer, low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 40 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 14 samples between November 1997 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group (Copper Ridge Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 74 ft bgs and exhibit substantial (10 - 25 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 120 – 228 mg/L, excluding an outlier (78 mg/L) in May 1990;
- pH (field measurements) of 7.0 – 8.4;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 35 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (3.2 mg/L) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit, and this result (0.001 mg/L in January 1993) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only two groundwater samples: ethylbenzene (1 µg/L) was detected in July 1992, and 2-butanone (9 µg/L) was detected in March 1997. These results are considered to be outliers because each compound was detected only once.

5.4 GROSS ALPHA ACTIVITY

Eleven of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (20.1 pCi/L in January 1993) exceeding the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Sixteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (49.58 pCi/L in February 1999) being slightly below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision*. Information Resource Center No. F.0612.031.0008.

MAXIMUM CONCENTRATION: 2004

<5	0.03 - 0.3	ND	15 - 150	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-204

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Tank 0134-U
Y-12 GRID EAST COORDINATE: 57,410.93
Y-12 GRID NORTH COORDINATE: 29,955.91
SURFACE ELEVATION: 955.47 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/30/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 20.23 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 958.74 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	6.5	948.97
BOTTOM (filter pack or open hole):	17.3	938.17
MIDPOINT (filter pack or open hole):	11.9	943.57
PUMP INTAKE:	11.73	943.74
WATER LEVEL (average):	7.06	948.41

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	18 samples	06/19/90	11/13/03
LOW-FLOW SAMPLING METHOD:	12 samples	09/13/99	10/25/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/03/04	.	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 3.71 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	26	0.71 mg/L	06/21/91	Decreasing
SUMMED VOCs (5 µg/L):	7	816 µg/L	09/26/91	Decreasing
GROSS ALPHA (15 pCi/L):	23	102 pCi/L	06/22/93	Indeterminate
GROSS BETA (50 pCi/L):	1	238 pCi/L	03/09/92	Outlier

WELL GW-204

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1989, completed with a screened monitored interval from 6.5 to 17.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot spiral wound). This well, located in Bear Creek Valley on the east side of Bldg. 9204-2 in the central section of the Y-12 complex, was installed in the pit from which a petroleum fuel underground storage tank (UST) was excavated and removed in August 1988.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between June 1990 and November 2003, and the low-flow sampling method used to obtain 12 samples between September 1999 and October 2004. Note that the six-year gap in the sampling history for the well spans the change in groundwater sampling methods.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher uranium concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during seasonally high (May 2003) and seasonally low (November 2003) groundwater flow conditions, with the low-flow method used the first day and the conventional sampling method used the next, confirm the apparent sampling-method bias. As shown below in the summary of results for selected analytes, the unfiltered samples obtained with low-flow and conventional sampling methods exhibit substantial differences for some analytes (e.g., REDOX and dissolved oxygen) and minimal difference for other analytes (e.g., pH and chloride).

Table 1. Consecutive daily sampling results for uranium and other selected analytes, May and November 2003

Analyte	Units	May 2003		November 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.65	7.61	7.29	7.32
Dissolved Oxygen	ppm	1.41	2.85	0.1	6.07
REDOX	mV/L	-14	226	92	194
Dissolved Solids	mg/L	172	190	247	265
Suspended Solids	mg/L	3	90	5	181
Calcium	mg/L	47.5	50.2	59.1	96.5
Chloride	mg/L	3.05	2.86	2.28	2.17
Aluminum	mg/L	0.331	6.4	0.359	30.9
Iron	mg/L	0.212	4.21	0.279	38
Uranium	mg/L	0.0478	0.0535	0.0678	0.124

These results also show that the unfiltered groundwater samples obtained with the conventional method contain substantially more suspended solids than the unfiltered samples obtained with the low-flow method; the preservation of these turbid samples (i.e., reducing the pH below 2) explains the extremely high levels of aluminum and iron (and calcium). Unfiltered samples obtained with the conventional method likewise appear to have higher total uranium concentrations than unfiltered samples obtained with the low-flow method.

3.0 HYDROLOGIC CHARACTERISTICS

The former UST pit in which the well was installed is within the subcrop area of the Conasauga Group about 350 ft north of the geologic contact between the Nolichucky Shale and Maynardville Limestone. Note that the large monitored (screened) interval in the well is intended to straddle the water table during seasonally high and low flow conditions and facilitate detection of light non-aqueous phase liquids (LNAPL). The average static groundwater level in the well is about 7 ft bgs and presampling depth-to-water measurements for the well indicate minor (<4 ft) water-level fluctuations.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-204 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 143 mg/L – 532 mg/L;
- pH of 6.3 – 7.8 (field measurements);
- elevated sulfate concentrations (>25 mg/L);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for the 26 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twelve groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.28 mg/L in May 2001) being significantly below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Uranium was detected in each groundwater sample (Table 2) and the concentration reported for each sample, which range from 0.0316 mg/L (November 2001) to 0.71 mg/L (June 1991), exceeds the MCL for uranium (0.03 mg/L). Note that the uranium concentrations show no response to the excavation and removal of Tank 0134-U (August 1988); the source of the uranium has not been determined, but may be associated with Bldg. 9204-2 (DOE 1998). Based on available data, the uranium levels show a variable but decreasing long-term concentration trend (Figure 1). As described in Section 2, results of "paired" sampling in CY 2003 confirmed the suspected sampling-method bias: samples obtained with the conventional sampling method have substantially higher uranium concentrations than samples obtained with the low-flow sampling method. Thus, the decreasing long-term trend for uranium may be largely an artifact of the change in sampling methods. Considered separately, uranium results obtained with each sampling method show indeterminate concentration trends, as illustrated by the uranium levels evident from conventional sampling in September 1993 (0.126 mg/L) and November 2003 (0.124 mg/L) and the uranium levels evident from low-flow sampling in June 2000 (0.0665 mg/L) and November 2003 (0.0678 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Each groundwater sample collected between March 1991 and September 1993 contained summed concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) above 200 μg/L (Table 2). These sampling results confirmed the release of petroleum hydrocarbons from Tank T0134-U. The BTEX levels dropped below respective analytical reporting limits in December 1991, with low levels of individual compounds detected in August 1992 (xylene = 12μg/L), March 1993 (ethylbenzene = 2 μg/L), and November 1993 (xylene = 2μg/L and ethylbenzene = 2 μg/L), and non-detect values reported for each sample collected since September 1999 (Table 2 and Figure 2). Along with the source control actions (i.e., removal of the UST), the substantially reduced levels of BTEX in the groundwater at this well are attributable to various natural attenuation processes because groundwater remedial action was not performed at the site.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for all but two of the groundwater samples (Table 2) and all but one of these results exceed the MCL for gross alpha activity (15 pCi/L), with the highest values evident in June 1993 (102 pCi/L), October 2000 (71 pCi/L), and May 2001 (74 pCi/L). Radiological analyses of the samples collected during CY 2001 and CY 2002 confirm that the alpha radioactivity is from uranium isotopes (U-234 and U-238), with the highest levels of these isotopes reported for the samples collected in May 2001 (U-234 = 33 pCi/L and U-238 = 29 pCi/L) and May 2002 (U-234 = 21 pCi/L and U-238 = 16 pCi/L). Considering the relatively limited mobility of uranium isotopes in the groundwater with the neutral pH evident in the well, the source(s) of the isotopes may be proximal to the well, including Bldg. 9204-2 (DOE 1998).

Available data indicate an indeterminate long-term trend for gross alpha activity, as illustrated by the gross alpha results reported for the samples collected in September 1991 (22 pCi/L), March 1993 (31 pCi/L), June 2000 (28 pCi/L), and May 2003 (47 pCi/L). Additionally, the consecutive daily sampling results obtained during May and November 2003 (see Section 2.0) suggest that samples obtained with the conventional sampling method had somewhat higher alpha activity than samples obtained with the low-flow sampling method (Figure 3). However, the higher alpha activity reported for the conventional method samples (Table 2) may be related to analytical interference associated with the higher suspended solids of the groundwater samples (see Table 1).

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for all but two of the groundwater samples (Table 2). The historical maximum value for gross beta activity (238 pCi/L in March 1992) exceeds the SDWA screening level (50 pCi/L) but is considered an outlier because the remaining gross beta results are all less than 45 pCi/L. Uranium isotopes and associated daughters are the most likely source of the beta activity in the groundwater at the well. Excluding the historical maximum as an outlier, the available data show that the levels of gross beta activity may have increased slightly in the early 1990s, but since then exhibit a fairly indeterminate long-term trend, as illustrated by the gross beta results reported for the samples collected in June 1993 (36.8 pCi/L), October 2000 (34 pCi/L), May 2003 (39 pCi/L) Additionally, the consecutive daily sampling results obtained during May and November 2003 (see Section 2) suggest slightly lower gross beta results obtained with the low-flow method than the conventional sampling method (Table 2). However, the higher beta activity reported for the conventional method samples may be related to analytical interference associated with the higher suspended solids of the groundwater samples (see Table 1).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

Table 2. Well GW-204: summary of results for uranium, BTEX, gross alpha activity, and gross beta activity

Sampling Date	Concentration						
	Uranium (mg/L)	Benzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Total Xylene (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
03/07/91	0.051	65	.	15	150	22.08	17.54
06/21/91	0.71	120	.	30	390	20.2	16.06
09/26/91	0.07	110	130	56	520	21.59	15
12/26/91	0.132	.	.	.	.	.	4.07
03/09/92	0.1	.	.	.	.	48.6	[238]
05/07/92	0.059	.	.	.	.	27.2	36.9
08/19/92	0.11	.	.	.	12	14.6	15.4
11/09/92	0.036	.	.	.	.	27	31.7
03/11/93	0.075	.	2 J	.	.	30.7	20.8
06/22/93	0.21	.	.	.	.	102	36.8
09/23/93	0.126	.	.	.	.	50.1	32.8
11/16/93	0.094	.	2 J	.	2 J	67.1	39.1
09/13/99	0.143	.	.	.	.	95	30
06/07/00	0.0665	.	.	.	.	28	11
10/24/00	0.117	.	.	.	.	71	34
05/23/01	0.104	.	.	.	.	74	37
09/05/01	0.0637	.	.	.	.	.	.
11/12/01	0.0316	.	.	.	.	21	9.2
05/02/02	0.0439	.	.	.	.	35	.
11/06/02	0.0336	.	.	.	.	22	16
05/21/03	0.0478	.	.	.	.	47	21
05/22/03	**0.0535**	.	.	.	.	**55**	**39**
11/12/03	0.0678	.	.	.	.	44	25
11/13/03	**0.124**	.	.	.	.	**69**	**44**
05/03/04	0.0434	.	.	.	.	21	9.5
10/25/04	0.052	.	.	.	.	37	16
MCL	**0.03**	**5**	**700**	**1,000**	**10,000**	**15**	**50***

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; [ ] = suspected outlier; results in 2003 shown in **bold** typeface were obtained using the conventional sampling method; * = SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

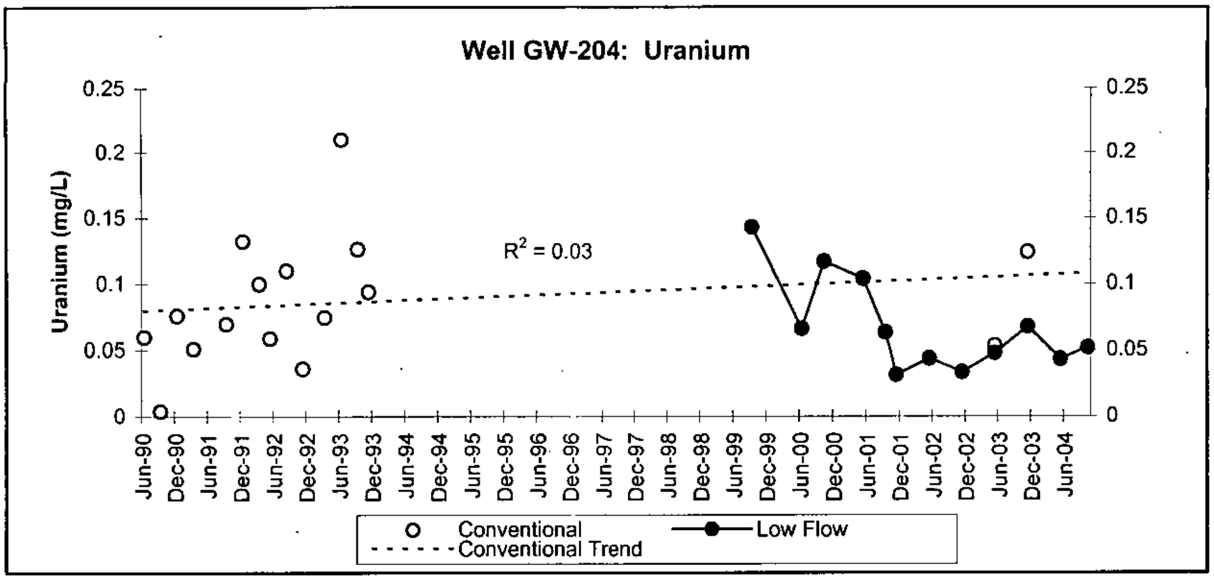


Figure 1

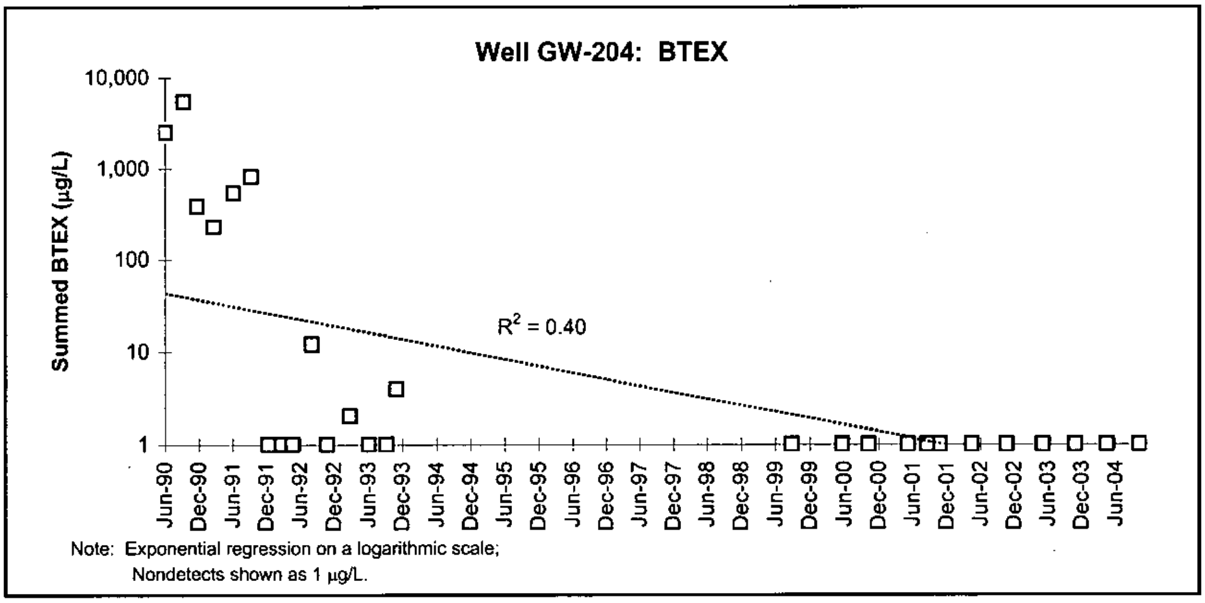


Figure 2

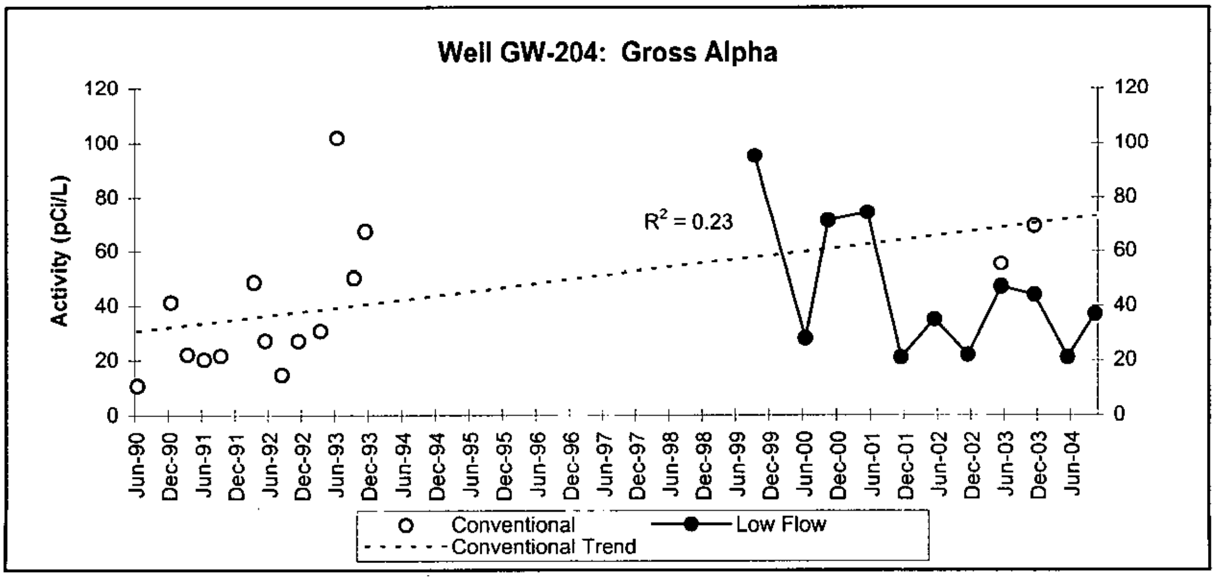


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	.	<7.5	50 - 500

GW-205

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE: 54,008.30
Y-12 GRID NORTH COORDINATE: 28,362.98
SURFACE ELEVATION: 1,101.46 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/25/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 165.13 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,104.14 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	152.0	949.46
BOTTOM (filter pack or open hole):	164.0	937.46
MIDPOINT (filter pack or open hole):	158.0	943.46
PUMP INTAKE:	147.32	954.14
WATER LEVEL (average):	72.28	1029.18

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	54			
CONVENTIONAL SAMPLING METHOD:	40	samples	02/06/86	04/14/97
LOW-FLOW SAMPLING METHOD:	14	samples	11/11/97	08/03/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/24/04	.	08/03/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: X
SAMPLING METHOD SENSITIVITY: X
WATER LEVEL FLUCTUATION: 19.4 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	13 µg/L	10/16/92	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	9	84.85 pCi/L	07/30/02	Indeterminate

WELL GW-205

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 152 to 164 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the crest of Chestnut Ridge south of Y-12, about 100 ft southwest (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge, radiologically-contaminated soils, and demolition debris. A multilayer, low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 40 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 14 samples between November 1997 and August 2004.

Groundwater samples from the well exhibit conspicuous geochemical characteristics (see Section 4.0) attributable to contamination from the cement (grout) lost into the surrounding bedrock during installation of the well. To ensure collection of representative groundwater samples, the well may need to be redeveloped before the low-flow sampling method is used or the conventional sampling method should be used.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is about 72 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10-20ft) water-level fluctuations, which is typical of many Knox Group wells.

4.0 GEOCHEMICAL CHARACTERISTICS

As noted in Section 2.0, this atypical geochemistry probably is a consequence of localized grout contamination. Moreover, as shown in Figure 1, the low-flow sampling method tends to obtain the more grout-contaminated groundwater samples from the well (i.e., samples with more basic pH levels and higher concentrations of potassium and sodium). This suggests that the conventional sampling method induces greater inflow of "fresh" groundwater into the well, which effectively dilutes the grout-contaminated groundwater entering the well; thus buffering the pH and lowering the concentrations of potassium and sodium. Nevertheless, considering that the well was installed in 1985, the persistent grout contamination in the well is a chronic problem with respect to obtaining representative groundwater samples. Before CY 1999, the well produced calcium-magnesium-bicarbonate groundwater typical of the Knox Group in the Chestnut Ridge Regime. However, since February 1999 the well has yielded groundwater generally characterized by:

- TDS of 150 - 660 mg/L;
- pH of 9.3 – 10.4 (field measurements);
- low molar proportion of calcium (<5% of total cations);
- high molar proportions of carbonate alkalinity and potassium (>50% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 35 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twenty-nine groundwater samples had nitrate concentrations above the analytical reporting limit. None of the results exceed the MCL for nitrate (10 mg/L), with concentrations below 1 mg/L reported for all but two of the samples: 6.3 mg/L in April 1995 and 8.4 mg/L in August 2000. These results are considered to be outliers.

5.2 URANIUM

Eighteen groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in two of the 21 groundwater samples analyzed for VOCs between January 1991 and April 1997: PCE (1 μg/L) in January 1991 and 2-butanone (13 μg/L) in October 1992. These results may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Fourteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.64 pCi/L in November 1995) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nineteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (84.85 pCi/L) exceeding the SDWA screening level for gross beta activity (50 pCi/L). Although the UNCS may be a source of beta-emitting radionuclides to the groundwater hydraulically upgradient of the well, it is also possible that the elevated gross beta activity reported for this well is a consequence of the elevated potassium concentrations in the grout-contaminated groundwater samples form the well. Potassium-40 (K-40) is a beta-emitting isotope and, based on the natural ratio of K-40 to total K (K-40 = 0.0119% total K; Brownlow 1979), the groundwater samples collected from the well in February 2000 (total K = 79 mg/L) and July 2002 (total K = 78 mg/L) each contained nearly 1 mg/L of K-40. Furthermore, the sample collected in July 2002 was analyzed for K-40 activity and the result was about 90 pCi/L. The presence of K-40 in the well would account for the strong correlation between the monitoring results for gross beta activity and total potassium (Figure 2). Thus, elevated gross beta activity may be an artifact of the grout contamination in well. Consequently, this well is not ideally suited for groundwater quality monitoring designed to detect or monitor a release of beta-emitting radiological contaminants from the UNCS.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Brownlow, A.H. 1979. *Geochemistry.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision*. IRC No. 910704.0092, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

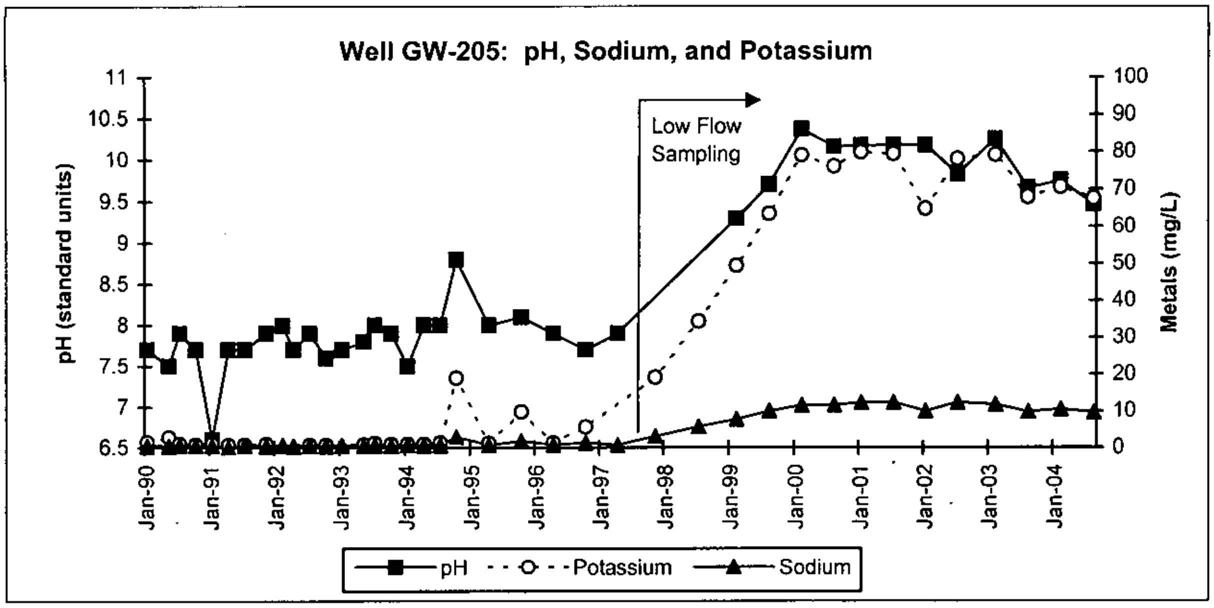


Figure 1

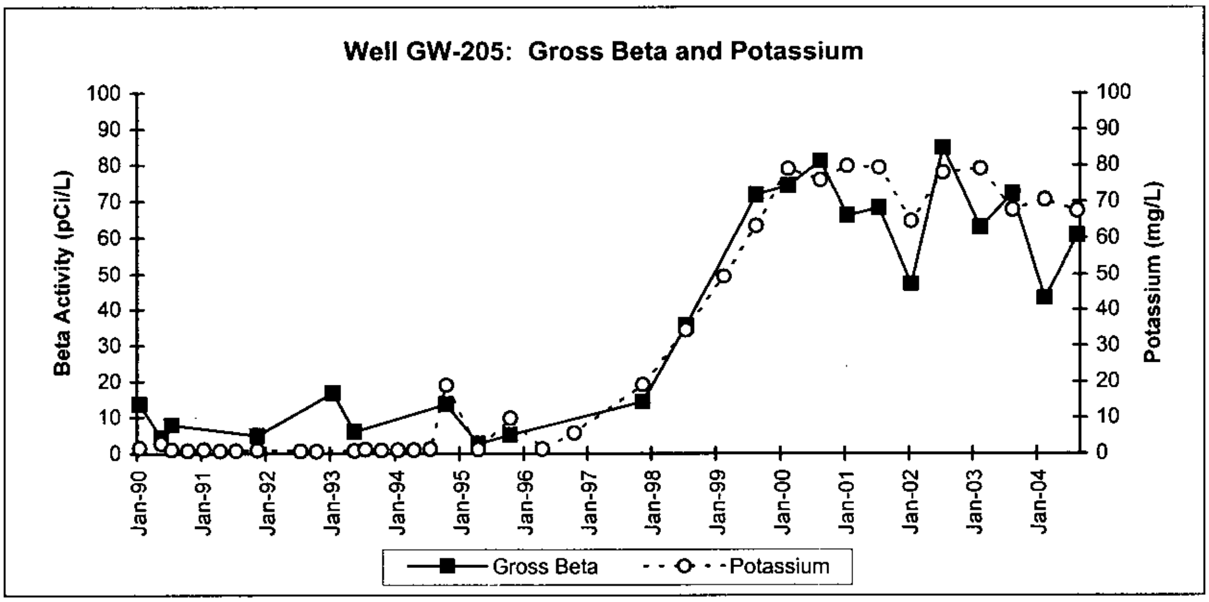


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-207

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Along Scarboro Road
Y-12 GRID EAST COORDINATE: 64,023.39
Y-12 GRID NORTH COORDINATE: 31,596.45
SURFACE ELEVATION: 894.38 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/25/85 PAIRED/CLUSTERED WITH: GW-208 GW-816
TAG DEPTH (measured): 114.73 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 899.40 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 7.87 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: . Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	100.0	794.38
BOTTOM (filter pack or open hole):	109.6	784.78
MIDPOINT (filter pack or open hole):	104.8	789.58
PUMP INTAKE:	104.48	789.90
WATER LEVEL (average):	-2.11	896.49

GEOLOGIC FORMATION: Rome
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	43		
CONVENTIONAL SAMPLING METHOD:	28 samples	06/01/90	04/08/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/02/97	11/09/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/25/04	.	11/09/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-207

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1985, completed with an open-hole monitored interval from 100 to 109.6 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing. The well forms a cluster with wells GW-208 and GW-816 and is located near Scarboro Road northeast of Y-12, about 50 ft east of the section of Upper East Fork Poplar Creek that passes through a gap in Pine Ridge.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 28 samples between June 1990 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from intermediate bedrock interval (>100 ft bgs) in the Rome Formation. The average static groundwater level in the well is 2.1 ft above the ground surface, indicating artesian conditions. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<7 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 310 – 438 mg/L;
- pH (field measurements) of 6.9 – 7.8;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 40 groundwater samples collected from the well since January 1991.

5.1 NITRATE

One groundwater sample had a nitrate concentration above the applicable analytical reporting limit, and this result (0.04 mg/L in September 1996) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in two groundwater samples: 4-methyl-2-pentanone (4 μg/L) in January 1992 and methylene chloride (4 μg/L) in June 1995. These results are considered to be outliers because each compound was detected only once.

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.48 pCi/L in November 1995) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.1 pCi/L in October 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-208

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Along Scarboro Road
Y-12 GRID EAST COORDINATE: 64,007.55
Y-12 GRID NORTH COORDINATE: 31,612.65
SURFACE ELEVATION: 894.55 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/14/86 PAIRED/CLUSTERED WITH: GW-207 GW-816
TAG DEPTH (measured): 416.62 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 898.05 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6.62 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: . Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	404.0	490.55
BOTTOM (filter pack or open hole):	412.8	481.75
MIDPOINT (filter pack or open hole):	408.4	486.15
PUMP INTAKE:	407.00	487.55
WATER LEVEL (average):	-0.02	894.57

GEOLOGIC FORMATION: Rome
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	44			
CONVENTIONAL SAMPLING METHOD:	29	samples	06/01/90	04/10/97
LOW-FLOW SAMPLING METHOD:	15	samples	12/02/97	11/09/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/25/04	.	11/09/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.34 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	2	9 μg/L	01/30/92	Outliers
GROSS ALPHA (15 pCi/L):	1	102 pCi/L	01/30/92	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-208

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1986, completed with an open-hole monitored interval from 404 to 412.8 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well forms a cluster with wells GW-207 and GW-816 and is located near Scarboro Road northeast of Y-12, about 50 ft east of the section of Upper East Fork Poplar Creek that passes through a gap in Pine Ridge.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 29 samples between June 1990 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (>400 ft bgs) in the Rome Formation. The average static groundwater level in the well is 0.02 ft above the ground surface, indicating artesian conditions. Presampling depth-to-water measurements for the well indicate moderate (<7 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 372 – 498 mg/L;
- pH (field measurements) of 6.9 – 8.0;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 40 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.827 mg/L in December 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the analytical reporting limit and the maximum result (0.004 mg/L in May 1994) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples: 1,2-dichloropropane (2 μg/L) and chloroform (7 μg/L) in January 1992, 2-butanone (4 μg/L) in December 1997, and acetone (9 μg/L) in June 1998. These results are considered outliers because these compounds are common laboratory reagents that were detected only once.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (102 pCi/L in January 1992) being substantially above the MCL for gross alpha activity (15 pCi/L). However, this gross alpha result was identified as an outlier (none of the other results exceed 10 pCi/L) and is probably an analytical artifact.

5.5 GROSS BETA ACTIVITY

Seventeen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (17 pCi/L in January 1992) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-217

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill IV
Y-12 GRID EAST COORDINATE: 53,019.91
Y-12 GRID NORTH COORDINATE: 28,757.85
SURFACE ELEVATION: 1,174.29 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/13/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 179.13 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,177.03 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	165.2	1009.09
BOTTOM (filter pack or open hole):	180.0	994.29
MIDPOINT (filter pack or open hole):	172.6	1001.69
PUMP INTAKE:	172.06	1002.23
WATER LEVEL (average):	107.40	1066.89

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	48		
CONVENTIONAL SAMPLING METHOD:	33 samples	02/17/88	07/17/97
LOW-FLOW SAMPLING METHOD:	15 samples	01/07/98	07/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/14/04	.	07/14/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 22.9 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	120 µg/L	01/07/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-217

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1987, completed with a screened monitored interval from 165 to 180 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the crest of Chestnut Ridge southwest of the west end of Y-12, about 100 ft directly east (hydraulically downgradient) of the unlined portion (about 22,500 ft^2) of the eastern end of Industrial Landfill IV. This landfill began operating in 1989 in accordance with a permit issued by the TDEC-DSWM that allows for the disposal of nonhazardous, nonradioactive industrial wastes (including cardboard, plastics, rubber, scrap metal, wood, and paper) and special wastes (e.g., asbestos and beryllium oxide) generated from DOE operations at Y-12 and elsewhere on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 33 samples between February 1988 and July 1997, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is 107 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10-25ft) water-level fluctuations. However, the difference between the presampling groundwater elevations may be at least partially attributable to the hydraulic performance of the well. Whenever the conventional sampling method is used, the well typically purges dry and the water level is very slow to recover back to the presampling level. Slow recovery of the water level suggests that the monitoring interval intercepts groundwater flowpaths with relatively low hydraulic conductivity. The average result of several falling head permeability tests performed in well GW-217 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.2×10^{-5} cm/s (0.034 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 106 – 200 mg/L;
- pH (field measurements) of 5.2 – 8.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Also, as noted in Section 4.0, elevated boron concentrations potentially reflect groundwater contamination. The following discussion of contaminant concentrations in the well is based on the analytical results reported for 37 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.1 mg/L in January 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in July 1991, October 1991, and January 1993) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in five groundwater samples. Acetone was detected in samples collected from the well in July 1991 (18 μg/L), January 1998 (120 μg/L), and February 2000 (9.4 μg/L). A trace of xylene (0.51 μg/L) was reported for the sample collected in July 2003. The acetone and xylene results are probably analytical artifacts and are considered to be outliers. Trace levels of PCE (0.47 μg/L), TCE (0.41 μg/L), and c12DCE (0.49 μg/L) were detected in the sample collected from the well in January 2004. The significance of these results is questionable because the compounds were not detected in the subsequent sample (July 2004).

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.61 pCi/L in October 1991) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (45.1 pCi/L in April 1992) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). However, the historical maximum gross beta activity is clearly an outlier value (none of the other gross beta results exceed 16 pCi/L).

5.6 Other

Historical monitoring results show that total boron concentrations in the groundwater at the well consistently exceeded the boron UTL (0.028 mg/L) for groundwater in the Knox Group (HSW 1995) and were more than an order-of-magnitude higher than evident in most wells in the Knox Group. Available data show that boron concentrations in the well steadily increased through October 1994 (0.22 mg/L) and slowly decreased thereafter, dropping below 0.1 mg/L in July 2000 for the first time since January 1993 (Figure 1). This pattern suggests a "pulse" of elevated boron transported via the groundwater flowpaths intercepted by the well. This well is hydraulically down gradient along geologic strike from the eastern (unlined) section of Industrial Landfill IV and groundwater in the Knox Group exhibits preferred flow along strike-parallel flowpaths. Because boron solute species are uncharged, they are probably not extensively absorbed onto mineral surfaces and are, therefore, highly mobile in groundwater (Hem 1985). Also, results of falling head permeability tests in the well (see Section 3.0) support advective transport of boron to the well within the time period between initial disposal of wastes in the landfill (October 1989) and a conspicuous concentration "spike" (0.69 mg/L) in January 1992. Moreover, historical data show that three of the four lowest boron concentrations (≤0.0074 mg/L) were reported for groundwater samples collected from the well before mid-1989, when the Industrial Landfill IV began receiving waste.

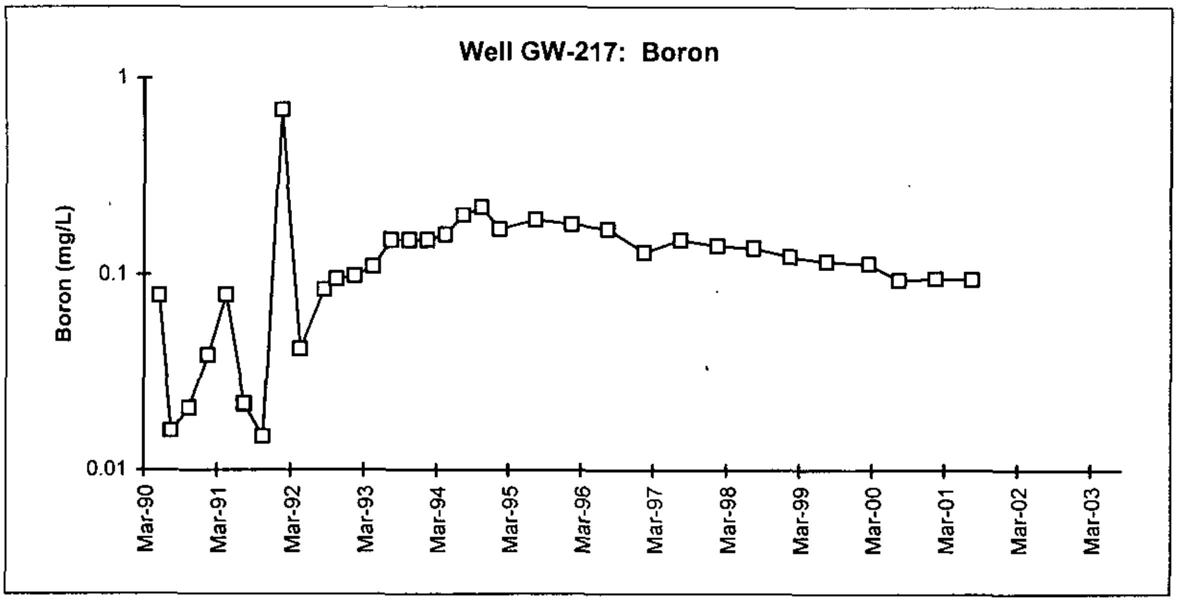
6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hem, J.D. 1985. *Study and Interpretation of the Chemical Characteristics of Natural Water*. U.S. Geological Survey Water-Supply Paper 2254.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision*. IRC No. 910704.0092, Office of Environmental Protection, Oak Ridge, TN.



Note: Only detected results are shown; all results obtained since July 2001 are < 0.1 mg/L (detection limit increased).

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	0.3 - 3.0	ND	15 - 150	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-219

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Uranium Oxide Vault
Y-12 GRID EAST COORDINATE: 58,928.95
Y-12 GRID NORTH COORDINATE: 29,163.24
SURFACE ELEVATION: 931.27 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/30/87 PAIRED/CLUSTERED WITH: GW-218
TAG DEPTH (measured): 15.59 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 935.83 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.3	926.97
BOTTOM (filter pack or open hole):	11.3	919.97
MIDPOINT (filter pack or open hole):	7.8	923.47
PUMP INTAKE:	8.94	922.33
WATER LEVEL (average):	6.16	925.11

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	2 samples	03/24/97	04/24/97
LOW-FLOW SAMPLING METHOD:	12 samples	09/04/98	11/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/26/04	.	11/11/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.47 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	13	0.6 mg/L	11/06/01	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	13	585 pCi/L	03/24/97	Indeterminate
GROSS BETA (50 pCi/L):	11	837 pCi/L	03/24/97	Indeterminate

WELL GW-219

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 4.3 to 11.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) at the northeast corner of the Bldg. 9418-3 Uranium Vault, which is in the south-central section of Y-12, adjacent to Upper East Fork Poplar Creek (UEFPC) near the intersection of Chromium Drive and Third Street. Constructed of concrete, the subsurface vault is 16 ft wide, 4 ft deep, and 20 ft long, with a 3-ft square floor drain in one corner and a pair of 2-ft diameter manholes in the concrete cap. Between 1960 and 1964, the vault was filled with an estimated 224 tons of uranium oxide dross (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain samples in March and April 1997, and the low-flow sampling method used to obtain 12 samples between September 1998 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements for the well show that the static groundwater level in the well occurs at an average depth of about 6 ft bgs and exhibits seasonal fluctuations of about 4 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-219 indicate flow primarily to the east, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 275 - 375 mg/L;
- pH (field measurements) of 6.7 – 7.4;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total concentrations trace metals (except uranium) that are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The Y-12 GWPP requested biological testing to assess microbial activity in groundwater at this well in April 2004. The results (shown below) are qualitative counts of bacterial colonies of four specific bacteria types, estimates based on the appearance of the sample after an eight- to ten-day growth period.

Date Sampled	Bacteria Activity (colony forming units/milliliter)			
	Heterotrophic Aerobic	Iron-Related	Slime Forming	Sulfate- Reducing
04/27/04	1,000	5,000	1,000	1,000

These results indicate the presence of various bacteria in the groundwater at this well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, uranium, gross alpha, and gross beta are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Five of the groundwater samples had nitrate (as N) at or above the analytical reporting limit, with all of the results being less than 1 mg/L and substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Each groundwater sample had total uranium concentrations above the applicable analytical reporting limit (Table 1), with ten of the results, including the historical maximum concentration (0.6 mg/L in November 1991), being more than an order-of-magnitude above the MCL for total uranium (0.03 mg/L). The most likely source of the uranium in the groundwater at this well is the Bldg. 9418-3 Uranium Vault (DOE 1998). Also, under the neutral pH of the groundwater samples, uranium tends to complex with inorganic anions (e.g., carbonate) which may facilitate transport in the groundwater system (Fetter 1993).

A time-series plot of the uranium results for each groundwater sample shows a fairly indeterminate long term trend (Figure 1), as illustrated by the uranium concentrations reported for the samples collected in December 1999 (0.599 mg/L) and November 2004 (0.525 mg/L). The indeterminate trend for uranium in the well suggests long-term and continued influx from an active source of uranium. Also, the uranium concentrations exhibit proportionally large temporal fluctuations, as illustrated by the 65% concentration increase between May 2002 (0.359 mg/L) and November 2002 (0.584 mg/L), followed by the 50% concentration decrease through June 2003 (0.285 mg/L), a 70% concentration increase through November 2003 (0.485 mg/L), and a 30% concentration decrease through April 2004 (0.338 mg/L). Assuming advective transport of uranium (complexes) in the groundwater, the temporal changes in uranium concentrations potentially reflect corresponding changes in the relative flux of the uranium along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Very low (estimated) concentrations of acetone (3 µg/L), PCE (0.3 µg/L), and TCE (2 µg/L) were detected in the samples collected in March 1997, September 1997, and May 2001, respectively; these results are probably sampling or analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for each groundwater sample (Table 1), and all of these gross alpha results exceed the MCL for gross alpha activity (15 pCi/L). Most of the results exceed 100 pCi/L, with the historical maximum (585 pCi/L in March 1997) and historical minimum (26 pCi/L in October 2000) values being suspected outliers compared to the other gross alpha results, which range between about 80 and 200 pCi/L. Historical data indicate that uranium isotopes (U-234 and U-238) are the likely source of the gross alpha activity in the groundwater (Table 1).

A time-series plot of gross alpha activity for each groundwater sample shows a fairly indeterminate long term trend (Figure 2), as illustrated by the results reported for the samples collected in June 2000 (100 pCi/L) and November 2004 (110 pCi/L). The indeterminate trend for gross alpha activity suggests long-term and continued flux of uranium isotopes via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for each groundwater sample (Table 1), and all but two of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity). Most of the results exceed 100 pCi/L, with the historical maximum value (837 pCi/L in March 1997) and historical minimum value (24 pCi/L in October 2000) being suspected outliers compared to the other gross beta results. Uranium isotopes (U-234 and U-238) and related decay products are the primary source of the gross beta activity in the groundwater samples (Table 1). In addition to uranium isotopes, five of the samples were analyzed for technetium-99 (Tc-99), which also is a beta-emitting radionuclide, with the Tc-99 activity below the MDA for three samples and slightly above the MDA for two samples.

A time-series plot of gross beta activity for each groundwater sample shows an indeterminate long-term trend (Figure 2), as illustrated by the results reported for the samples collected in June 2000 (89 pCi/L) and November 2004 (97 pCi/L). Relatively unchanged levels of gross beta activity support long-term and continued flux of uranium isotopes via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-219: summary of results for uranium and uranium isotopes, gross alpha activity, and gross beta activity

Date Sampled	Total Uranium (mg/L)	Uranium Isotopes (pCi/L)		Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
		U-234	U-238		
03/24/97	0.211	53.9	293	585	837
09/04/98	0.229	14	98	90	48
12/02/99	0.599	31	220	180	140
06/06/00	0.494	36	170	100	89
10/30/00	0.449	20	140	26	24
05/24/01	0.569	29	190	200	150
11/06/01	0.6	22	150	140	77
05/06/02	0.359	18	120	120	77
11/07/02	0.594	27	190	170	91
06/16/03	0.285	NA	NA	91	60
11/11/03	0.485	NA	NA	120	110
04/26/04	0.338	NA	NA	79	82
11/11/04	0.525	NA	NA	110	97
MCL	**0.03 mg/L**	**Not Applicable**		**15 pCi/L**	**50 pCi/L***

Note: NA = Not applicable; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

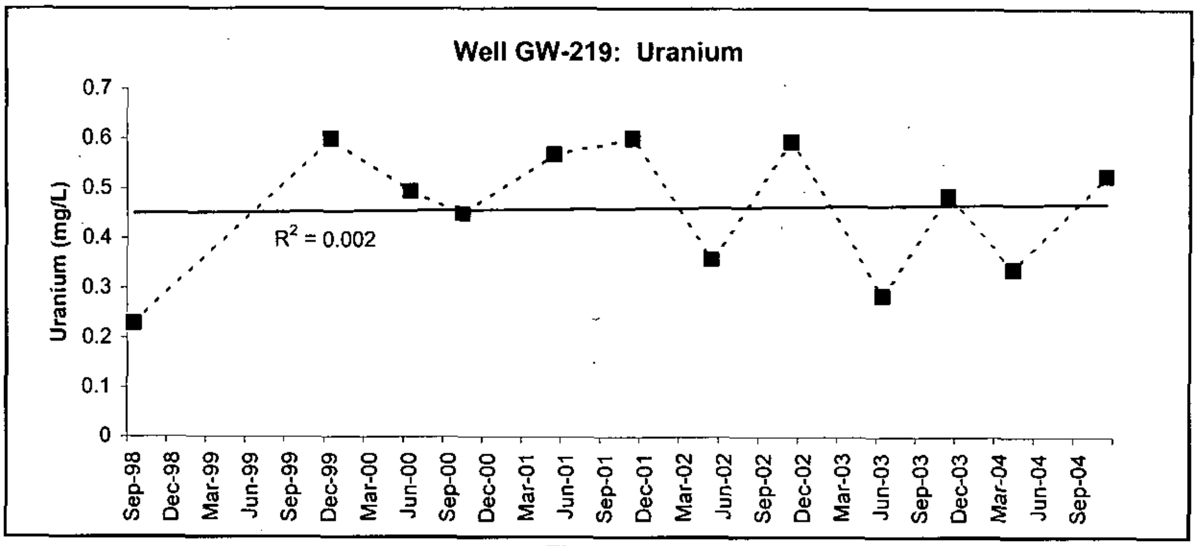


Figure 1

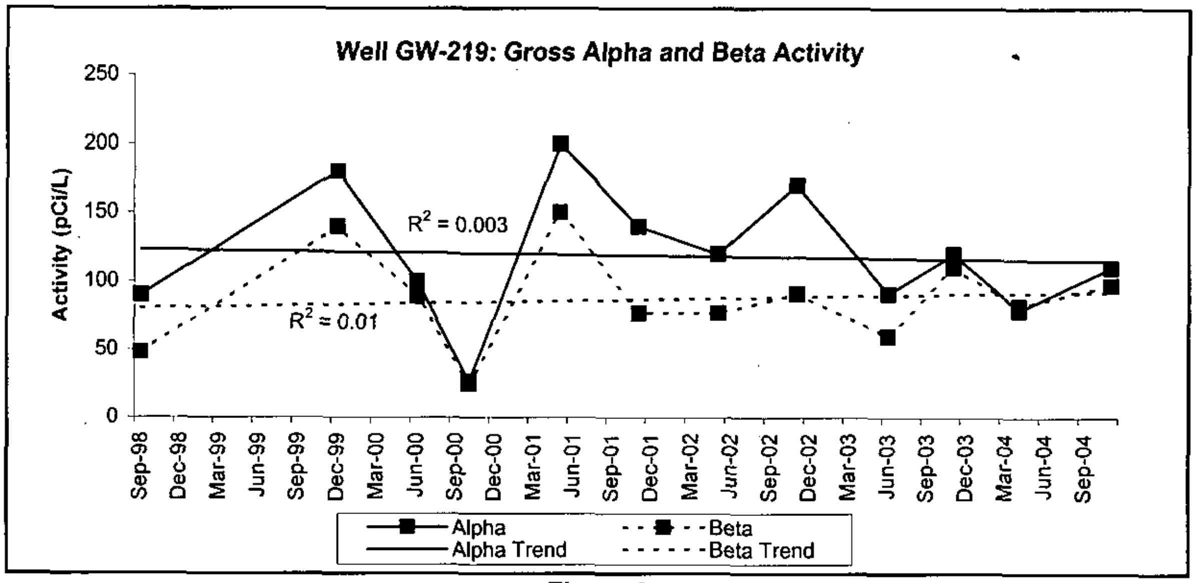


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	500 - 5,000	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-220

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,225.00
Y-12 GRID NORTH COORDINATE: 28,949.00
SURFACE ELEVATION: 912.74 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/22/85 PAIRED/CLUSTERED WITH: GW-150 GW-151
TAG DEPTH (measured): 49.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 916.47 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	31.0	881.74
BOTTOM (filter pack or open hole):	45.2	867.54
MIDPOINT (filter pack or open hole):	38.1	874.64
PUMP INTAKE:	40.27	872.47
WATER LEVEL (average):	11.97	900.77

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	65		
CONVENTIONAL SAMPLING METHOD:	45 samples	02/20/86	05/22/97
LOW-FLOW SAMPLING METHOD:	20 samples	12/08/97	11/15/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/27/04	.	11/15/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 13.34 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	42	2,139 µg/L	11/06/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-220

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 31 to 45.2 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). This well forms a cluster with wells GW-150 and GW-151 and is located in Bear Creek Valley near the east end of Y-12, immediately east of the Upper East Fork Poplar Creek (UEFPC) distribution channel on the east side (hydraulically downgradient) of New Hope Pond (NHP). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC bypasses Lake Reality and is directed through the concrete-lined distribution channel,, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 45 samples between February 1986 and May 1997, and the low-flow sampling method used to obtain 20 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits seasonal fluctuations of 4 to 14 ft. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are about 0.8 ft lower in well GW-220 than well GW-151, which is completed at a greater depth (95 ft bgs) in the Maynardville Limestone. Based on the distance (52 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.004 - 0.046) during seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-220 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 500 ft south-southeast of well GW-220 and is treated on-site to remove VOCs, particulates, iron, and manganese. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 190 – 366 mg/L;
- pH of 4.0 – 7.8 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate was detected in 42 groundwater samples (three samples were not analyzed for nitrate), with the highest concentration (3.3 mg/L in August 2000) being substantially below the drinking water MCL for nitrate (10 mg/L). Moreover, the historical maximum nitrate concentration appears to be an outlier because only two of the remaining nitrate values exceed 1 mg/L.

5.2 URANIUM

Only six groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest values (0.001 mg/L in April 1991, April 1993, November 1993, and May 1994) being an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in 42 groundwater samples (Table 1): CTET, chloroform, PCE, TCE, trichlorofluoromethane (TCFM), 12DCE, and 11DCE. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 500 ft south-

southeast (across geologic strike) of well GW-220; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The primary compound in each groundwater sample is CTET (Table 1), with a concentration of 1,000 μg/L or more reported for seven of the samples collected since August 2000. Secondary constituents are PCE, TCE, and chloroform. The most recent (low-flow sampling) results for TCE and chloroform show concentrations above 100 μg/L and 50 μg/L, respectively. Concentrations of 12DCE remain below 50 μg/L and only trace levels (2 μg/L or less) of TCFM have been detected. Also, the most recent sampling results show that the concentrations of CTET, PCE, and TCE substantially exceed respective drinking water MCLs (Table 1).

A time-series plot of summed VOC concentrations for each groundwater sample shows a cyclic but clearly increasing long-term trend (Figure 1). Monitoring (conventional sampling) results obtained through May 1997 show cyclic temporal fluctuations in VOC concentrations, with the highest concentrations typically detected in samples obtained during seasonally low groundwater flow conditions (summer and fall). Similar temporal fluctuations are less evident from subsequent (low-flow sampling) VOC results, which instead show a steadily increasing concentration trend that appears to continue in response to the full-time operation of groundwater extraction well GW-845 (Figure 1). Also, concurrently increasing concentration trends are evident for each individual VOC (except TCFM), which suggests an overall increase in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval for the well.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.55 pCi/L in August 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Sixteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (36.9 pCi/L in August 1992) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Furthermore, this result is a suspected outlier because all but one (18.8 pCi/L in April 1993) of the other detected results are less than 10 pCi/L.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

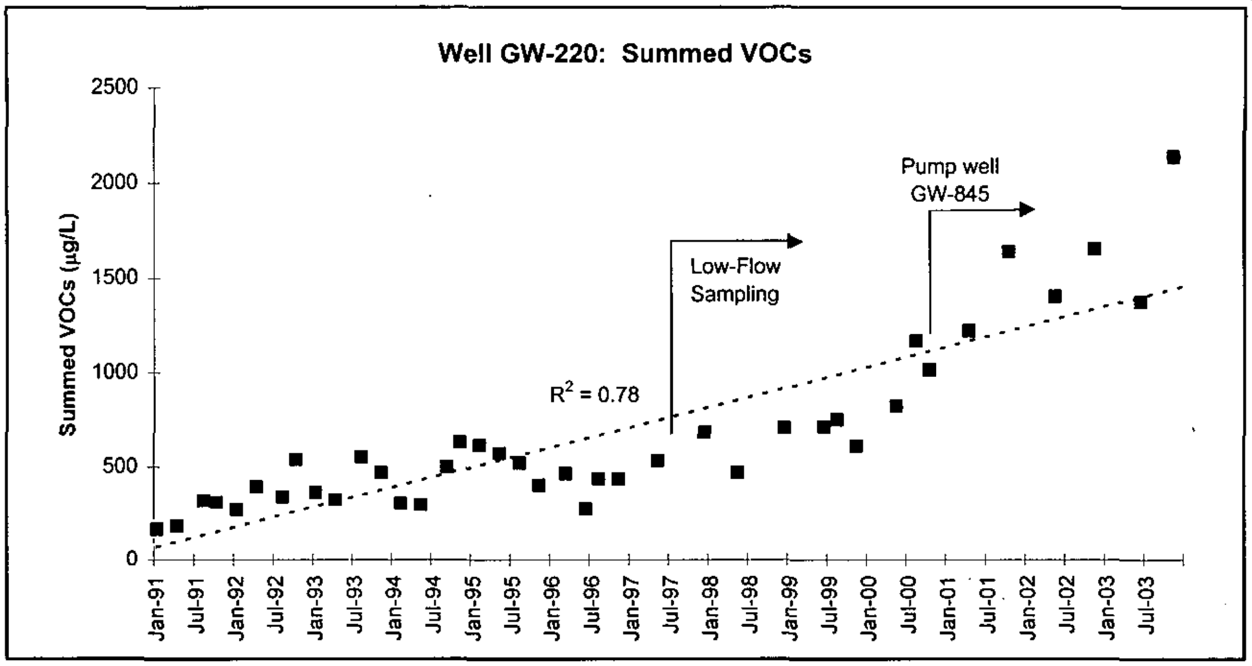
Table 1. Well GW-220: summary of VOC results

Date Sampled	VOC Concentration (µg/L)		
	CTET	Chloroform	TCFM
01/29/91	150	8	.
04/26/91	160	8	.
08/24/91	280	19	.
10/22/91	270	20	.
01/25/92	250	FP	.
04/21/92	350	18	.
08/01/92	290	21	.
10/18/92	470	25	.
01/25/93	320	17	.
04/22/93	280	14	.
08/06/93	490	23	.
11/01/93	400	21	.
02/05/94	260	15	.
05/12/94	250	17	.
09/22/94	430	23	.
11/16/94	540	29	.
02/27/95	540	23	.
05/24/95	500	21	.
08/29/95	520	.	.
11/30/95	340	18	.
03/20/96	410	21	.
06/13/96	230	13	.
08/26/96	370	19	.
11/20/96	350	24	.
05/22/97	450	24	.
12/08/97	610	29	1 J
05/28/98	410	23	1 J
12/07/98	600	38	2 J
06/02/99	610	33	.
08/16/99	620	43	.
11/10/99	490	40	.
05/15/00	700	35	.
08/22/00	1,000	44	.
10/12/00	850	53	.
04/30/01	1,000	55	.
10/23/01	1,200	76	2 J
05/14/02	1,000	54	.
11/21/02	1,200	59	.
06/24/03	860	60	1 J
11/06/03	1,400	80	.
05/27/04	920	75	.
11/15/04	1,100	72	1 J
MCL	**5**	**80***	**NA**

Table 1. (continued)

Date Sampled	VOC Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	11DCE
01/29/91	7	.	.	NR	.
04/26/91	10	2 J	.	NR	.
08/24/91	15	3 J	.	NR	.
10/22/91	16	3 J	.	NR	.
01/25/92	14	3 J	.	NR	.
04/21/92	18	4 J	.	NR	.
08/01/92	19	5	.	NR	.
10/18/92	35	7	.	NR	.
01/25/93	19	4 J	.	NR	.
04/22/93	23	4 J	.	NR	.
08/06/93	32	6	.	NR	.
11/01/93	39	7	.	NR	.
02/05/94	23	4 J	.	NR	.
05/12/94	20	5	1 J	NR	.
09/22/94	38	8	.	NR	.
11/16/94	53	9	.	NR	.
02/27/95	41	9	2 J	NR	.
05/24/95	42	8	.	NR	.
08/29/95	.	.	.	NR	.
11/30/95	36	7	.	NR	.
03/20/96	32	.	.	NR	.
06/13/96	24	5	.	NR	.
08/26/96	37	7	2 J	NR	.
11/20/96	49	9	2 J	NR	.
05/22/97	45	10	3 J	3 J	.
12/08/97	33	6	3 J	3 J	.
05/28/98	26	5	2 J	2 J	.
12/07/98	53	13	4 J	4 J	.
06/02/99	53	12	4 J	4 J	.
08/16/99	70	13	5	5	.
11/10/99	64	13	4 J	4 J	.
05/15/00	69	14	5	5	.
08/22/00	95	20	6	6	.
10/12/00	86	20	6	6	.
04/30/01	120	35	11	11	.
10/23/01	280	55	22	22	.
05/14/02	270	56	21	21	.
11/21/02	310	61	21	21	.
06/24/03	350	73	29	29	.
11/06/03	510	110	39	39	.
05/27/04	320	100	39	39	.
11/15/04	480	100	43	43	1 J
MCL	**5**	**5**	**NA**	**70**	

Note: "." = Not detected; FP = False positive; J = Estimated value; NR = Not reported; NA = Not applicable; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane



Well GW-220: Summed VOCs
Summed VOCs (µg/L)
2500
2000
1500
1000
500
0
Pump well
GW-845
Low-Flow
Sampling
R² = 0.78
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	.	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-221

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE: 54,388.57
Y-12 GRID NORTH COORDINATE: 28,359.44
SURFACE ELEVATION: 1,103.36 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 159.34 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,106.16 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	146.0	957.36
BOTTOM (filter pack or open hole):	158.0	945.36
MIDPOINT (filter pack or open hole):	152.0	951.36
PUMP INTAKE:	149.20	954.16
WATER LEVEL (average):	75.31	1028.05

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	55		
CONVENTIONAL SAMPLING METHOD:	41 samples	02/07/86	04/15/97
LOW-FLOW SAMPLING METHOD:	14 samples	11/12/97	08/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/25/04	.	08/04/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 21.69 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-221

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 146 to 158 ft bgs, and constructed with 4.5-inch diameter PVC (#40) riser casing and screen (0.01 slot). The well is located on the crest of Chestnut Ridge south of Y-12, about 100 ft southeast (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge, radiologically-contaminated soils, and demolition debris. A multilayer, low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 41 samples between February 1986 and April 1997, and the low-flow sampling method used to obtain 14 samples between November 1997 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 75 ft bgs and exhibit substantial (10 - 25 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 106 – 270 mg/L;
- pH (field measurements) of 6.0 – 8.0;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 36 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2.4 mg/L in August 2000) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, and results for each sample (0.001 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the 21 groundwater samples analyzed for VOCs between January 1991 and April 1997.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (13.31 pCi/L in August 2004) being slightly below the MCL for gross alpha activity (15 pCi/L). This result may be an outlier because the next highest value (4.42 pCi/L in October 1992) is much lower.

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10.5 pCi/L in October 1992) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision.* Information Resource Center No. F.0612.031.0008.

MAXIMUM CONCENTRATION: 2004

<5	0.03 - 0.3	5 - 50	15 - 150	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-222

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 63,324.00
Y-12 GRID NORTH COORDINATE: 28,954.00
SURFACE ELEVATION: 908.82 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/24/85 PAIRED/CLUSTERED WITH: GW-154 GW-223
TAG DEPTH (measured): 28.55 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 911.82 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	18.0	890.82
BOTTOM (filter pack or open hole):	25.0	883.82
MIDPOINT (filter pack or open hole):	21.5	887.32
PUMP INTAKE:	23.0	885.82
WATER LEVEL (average):	6.53	902.29

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	30 samples	02/23/86	11/18/96
LOW-FLOW SAMPLING METHOD:	4 samples	06/13/00	11/30/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	06/10/04	.	11/30/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: X
WATER LEVEL FLUCTUATION: 1.96 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	15	0.28 mg/L	03/19/96	Indeterminate
SUMMED VOCs (5 µg/L):	14	515 µg/L	11/29/95	Indeterminate
GROSS ALPHA (15 pCi/L):	15	100 pCi/L	10/26/00	Indeterminate
GROSS BETA (50 pCi/L):	3	74 pCi/L	10/26/00	Indeterminate

WELL GW-222

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 18 to 25 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-154 and GW-223 and is located in Bear Creek Valley (BCV) at the east end of Y-12, near the former Oil Skimmer Basin (OSB) immediately west (hydraulically upgradient) of the New Hope Pond (NHP)/Lake Reality. Located near the inlet to NHP, the OSB was a 25 x 40 ft sediment-accumulation basin and oil/water separator; visual evidence of a direct hydraulic connection with the OSB was observed during installation of wells GW-154 and GW-223 (Geraghty & Miller, Inc. 1989). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through a concrete-lined diversion channel bordering the south and east sides of NHP/Lake Reality. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was diverted through the Lake Reality spillway, which discharges into the mainstream of UEFPC directly north (downstream) of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 30 samples between February 1986 and November 1996, and the low-flow sampling method used to obtain four samples between June 2000 and November 2004. This sampling history encompasses three time gaps when samples were not collected from the well: May 1991 – November 1994; November 1996 – June 2000; and October 2000 – June 2004.

The well infrequently yields slightly turbid unfiltered groundwater samples containing elevated total (unfiltered sample) iron concentrations compared to other wells, which suggests that groundwater sampling activities disturb silt, clay, and other similarly fine-grained material distributed within the filter pack surrounding the well screen and/or settled onto the bottom of the well. The filter pack may be the source of the suspended material because the low-flow sampling procedure would not typically be expected to disturb sediments on the bottom of the well. However, the intake for the sampling pump in this well is located about 1.5 ft from the bottom of the screen, and collection of samples with elevated iron concentrations may reflect sediment from the bottom of the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7 ft bgs and does not exhibit wide seasonal fluctuations (<2 ft since 1991). Also, presampling water-level measurements recorded during contemporaneous sampling events (i.e., within 24 hours) performed before NHP was closed and capped show that groundwater elevations in well GW-222 were consistently higher than evident in well GW-154, which is completed at a shallower depth in the Maynardville Limestone (11 ft bgs), and were usually slightly lower than evident in well GW-223, which is completed deeper (90.5 ft bgs) in the Maynardville Limestone (Figure 1). The relationships between the groundwater elevations before closure of NHP indicate strongly upward vertical hydraulic gradients from the bedrock interval (GW-222 and GW-223) to the water table interval (GW-154). In contrast, the presampling groundwater elevations determined from contemporaneous sampling events performed after the NHP was closed and capped show groundwater elevations in well GW-154 being consistently higher than evident in wells GW-222 and GW-223 (Figure 1). The relationships between these groundwater elevations reflect downward gradients (0.014 – 0.067) from the water table interval (GW-154) to the shallow bedrock interval (GW-222) and lesser downward vertical hydraulic gradients (0.001 - 0.008) within the bedrock interval from GW-222 to GW-223. Thus, the closure of NHP (and the OSB) and installation of the low-permeability cap at the site appears to have reversed the local vertical hydraulic gradients in the Maynardville Limestone.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-222 indicate east-northeasterly flow toward the UEFPC drainage system. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near NHP, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2000, groundwater has been pumped from a well (GW-845) located about 1,200 ft southeast of well GW-222 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002). However, there are insufficient data to determine if groundwater elevations in well GW-222 show any response to the operation of well GW-845.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 248 – 652 mg/L, excluding a suspected outlier (130 mg/L) in March 1996;
- pH (field measurements) of 6.8 – 7.4;
- strongly negative oxidation-reduction potential (REDOX) and low dissolved oxygen (DO) indicative of reducing conditions (e.g., REDOX = -132 mV and DO = 0.12 ppm in November 2004);
- elevated concentrations of chloride (>20 mg/L), sodium (>20 mg/L), and sulfate (>30 mg/L) compared to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of fluoride, nitrate, and potassium (<10% of total anions/cations);
- unusually high total iron concentrations (e.g., 5.15 mg/L in November 2004); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated chloride, sodium, and sulfate concentrations typical of the groundwater samples indicate contamination from one or more sources hydraulically upgradient of the well or if they reflect the range natural geochemical variability in the Maynardville Limestone. Also, the groundwater from this well contains a mixture of chlorinated hydrocarbons (see Section 5.3) and elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (reductive dechlorination) of these compounds (Hinchee et al. 1995). In any case, the sampling results reflect a general reduction in TDS that is primarily attributable to substantially reduced levels of chloride and sulfate, as illustrated by the chloride results reported for the groundwater samples collected in October 1990 (141 mg/L), August 1995 (55 mg/L), October 2000 (29.7 mg/L), and November 2004 (13 mg/L).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, the principal contaminants present in the groundwater at this well are uranium, VOCs, and gross alpha activity.

5.1 NITRATE

Seven of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.71 mg/L in February 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit (Table 1), with results for 21 of the samples being greater than or equal to the drinking water MCL for uranium (0.03 mg/L). The specific source of the uranium in the groundwater at this well has not been identified, but is probably the former OSB, which is believed to have retained uranium-contaminated oils (DOE 1998). Considering the fairly neutral pH of the groundwater in the well, the uranium is probably present as uranyl cations combined with available anions in the groundwater (Fetter 1993), including carbonate dissolved from the Maynardville Limestone.

Total uranium concentrations reported for the groundwater samples collected to date range between the historical minimum value of 0.009 mg/L in October 1987 and April 1999, and the historical maximum value of 0.364 mg/L in August 1990 (Table 1). However, there is a clear distinction between the uranium results reported for samples collected before and after NHP (and the OSB) was closed and capped. Indeed, all of the uranium concentrations that are less than the drinking water MCL were reported for groundwater samples collected before closure of the site. After closure of NHP, the uranium concentrations are higher, most being above the MCL, and the uranium results show substantially greater temporal variation (Figure 2), with notably sharp concentration "spikes" indicated by results for the samples collected in May 1990 (0.354 mg/L), August 1990 (0.364 mg/L), February 1995 (0.26 mg/L), and March 1996 (0.28 mg/L). Also, the increased uranium concentrations evident after closure of NHP generally coincide with the concurrent change from an upward vertical hydraulic gradient to a downward vertical hydraulic gradient (see Section 3.0).

Total uranium concentrations detected in unfiltered groundwater samples from well GW-222 typically are higher than reported for samples of the deeper groundwater from well GW-223 (e.g., 0.0412 mg/L in February 2004), but are lower than uranium concentrations reported for the samples of the shallower groundwater in well GW-154 (e.g., 0.477 mg/L in February 2004). Considering the downward vertical hydraulic gradients indicated by presampling groundwater elevations recorded following closure of NHP (and the former OSB) and installation of the low-permeability cap at the site (see Section 3.0), increased recharge of uranium-contaminated groundwater from the shallow flow system may help maintain the (elevated) uranium concentrations in the deeper groundwater.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): CTET, chloroform (CLF), PCE, TCE, 12DCE (c12DCE) and VC. These compounds are components of an essentially contiguous commingled plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide separating the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). As noted in Section 3.0, full-time operation of a groundwater extraction and treatment system began in October 2000 to intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near NHP.

Historical data show CTET, PCE, and 12DCE as the primary VOCs in the groundwater samples, with each compound having at least one concentration above 100 μg/L (Table 2). However, the most recent data (June and November 2004) show substantially lower concentrations of these and other VOCs, with the highest concentration (5 μg/L) reported for PCE and c12DCE. These results confirm the sharp decrease in VOC concentrations indicated by the VOC levels detected in the sample collected in October 2000. The recent decrease in VOC concentrations in the groundwater samples from this well coincides with the full-time operation of groundwater extraction well GW-845 (see Section 3.0).

Historical data show that VOCs are not present in the shallow groundwater at well GW-154 and, as illustrated by the selected data summarized below, similar levels of VOCs are evident in the groundwater at wells GW-222 and GW-223.

VOC	Concentration (µg/L)					
	June 2000		October 2000		Nov. 2004	Aug.2004
	GW-222	GW-223	GW-222	GW-223	GW-222	GW-223
PCE	110	110	6	25	5	18
TCE	29	31	3 J	13	2 J	9
12DCE	45	38	15	95	5	39
CTET	28	.	.	.	.	
CLF	5	.	.	.	.	
VC	.	.	1 J	3 J	2 J	25
Summed VOCs	217	178	25	136	14	91

Note: "." = Not detected; J = Estimated value below analytical reporting limit

The lack of VOCs in the shallow groundwater from well GW-154 essentially eliminates the OSB as a likely source of the VOCs and shows that the presence of VOCs in the deeper groundwater from wells GW-222 and GW-223 does not result from local vertical infiltration of VOC-contaminated groundwater from the shallow flow system. Instead, the VOCs in the groundwater from these wells probably result from lateral migration from upgradient sources (west of the well) via strike-parallel groundwater flow/transport pathways in the Maynardville Limestone.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples, which includes a combination of quarterly and semiannual sampling results and encompasses several gaps in the sampling history for the well (see Section 2.0), shows an indeterminate long-term concentration trend dominated by wide temporal concentration fluctuations (Figure 3). Summed VOC concentrations were below 50 µg/L before closure of NHP but increased above 500 µg/L immediately after closure. Since that time, concentrations have varied, possibly showing an overall decrease with the lowest summed VOC concentration in the June 2004 sample (Table 2).

5.4 GROSS ALPHA ACTIVITY

All of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE; with values above the drinking water MCL (15 pCi/L) reported for each of these samples (Table 1). Comparable levels of gross alpha activity were reported for samples collected before January 1990, but these results are considered qualitative because the sample-specific MDA and corresponding CE are not available for these samples. Uranium isotopes are the source of the elevated gross alpha activity, as indicated by analytical results for seven of the samples collected from the well to date, which show U-234 and U-238 levels ranging between from less than 5 pCi/L to slightly above 100 pCi/L (Table 1). As with total uranium (see Section 5.2), contamination associated with the historical operation of the OSB is the suspected source of the uranium isotopes in the shallow groundwater at this well (DOE 1998).

Analytical results for the groundwater samples collected since January 1990 show gross alpha activity ranging between the 18 pCi/L and 118 pCi/L (Table 1), with the most recent values for gross alpha activity (e.g., 30 pCi/L in November 2004) exceeding the drinking water MCL. Also, the samples from this well typically have levels of gross alpha activity that are substantially lower than reported for samples of the shallower groundwater in well GW-154 (e.g., 698 pCi/L in August 2004), but are generally higher than typically evident in samples of the deeper groundwater in GW-223 (e.g., 21 pCi/L in August 2004). With the downward vertical hydraulic gradients evident since the closure of NHP (and the former OSB), these results suggest somewhat limited vertical flux of the uranium isotopes present in the shallow groundwater (water table interval) in the Maynardville Limestone.

A time-series plot of the gross alpha activity reported for groundwater samples collected since January 1990 (i.e., excluding the qualitative results noted above) encompasses several significant gaps in the sampling history for the well (see Section 2.0) and shows an indeterminate trend dominated by wide temporal fluctuations (Figure 4). Because the gross alpha activity of samples collected before 1990 are not shown, the impact from closuring the NHP (and the former OSB) and reversal of the vertical horizontal gradient are unknown. However, the gross alpha concentration trend since 1990 generally mirrors the total uranium trend (Figure 2), and the gross alpha activity trend before 1990 is most likely similar to the uranium trend before 1990.

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE (Table 1); with results for five samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Note, that gross beta activity results for samples collected before January 1990 are qualitative (the sample-specific MDA and CE are not available). As with gross alpha activity, uranium isotopes released from the former OSB are the source of the gross beta activity in the shallow groundwater at this well.

Analytical results for the groundwater samples collected since January 1990 show gross beta activity ranging between the 10 pCi/L and 116 pCi/L (Table 1), with the most recent sampling results (e.g., 41 pCi/L in November 2004) being slightly below the SDWA screening level. Also, as noted previously with gross alpha activity, the samples from this well typically have levels of gross beta activity that are substantially lower than reported for samples of the shallower groundwater in well GW-154 (e.g., 288 pCi/L in August 2004), but are generally higher than typically evident in samples of the deeper groundwater in GW-223 (e.g., 18 pCi/L in August 2004). These results support the similar results for gross alpha activity and reflect the fairly limited vertical flux of the uranium isotopes present in the shallow groundwater (water table interval) in the Maynardville Limestone. A time-series plot of the gross beta activity reported for groundwater samples collected since January 1990 (i.e., excluding the qualitative results noted above) mirrors that of gross alpha activity (Figure 4).

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Geraghty & Miller, Inc. 1989. *Groundwater Quality Assessment Report for New Hope Pond at the Y-12 Plant, 1988.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/89-002-6C/5).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-222: summary of results for uranium, gross alpha activity, gross beta activity, and uranium isotopes

Date Sampled	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)	Uranium Isotopes (pCi/L)	
				U-234	U-238
02/23/86	0.029	20.5*	8.7*	.	.
04/23/86	0.029	9.89*	8.2*	.	.
07/30/86	0.012	9*	8*	.	.
11/04/86	0.026	27*	24*	.	.
01/28/87	0.036	22*	10*	.	.
05/04/87	0.019	16.6*	14.7*	.	.
08/12/87	0.012	6.1*	<5*	.	.
10/22/87	0.009	6.1*	12.7*	.	.
03/08/88	0.019	1*	17*	.	.
06/09/88	0.014	8*	15*	.	.
08/17/88	0.013	5*	3*	.	.
10/26/88	0.013	12*	14*	.	.
01/09/89	0.012	11*	10*	.	.
04/08/89	0.009	3*	10*	.	.
10/13/89	0.09	29.1*	138.1*	.	.
01/23/90	0.099	24	34	.	.
05/24/90	0.354	89.07	90.79	33.23	100.15
08/17/90	0.364	118.46	115.93	28.76	88.03
10/30/90	0.093	36.08	48.58	3.05	< CE
02/01/91	0.141	38.63	41.48	10.9	30.1
05/02/91	0.115	23.05	38.53	4.1	6.16
11/15/94	0.051	19.7	23.7	.	.
02/23/95	0.26	63.3	72.5	.	.
05/22/95	0.13	38.9	39.4	.	.
08/23/95	0.075	19.9	22.7	.	.
11/29/95	0.17	53.8	54.3	.	.
03/19/96	0.28	95.8	37.6	.	.
06/12/96	0.078	24.7	<MDA	.	.
08/22/96	0.083	19.7	10	.	.
11/18/96	0.045	18	14.8	.	.
06/13/00	0.136	35	21	.	.
10/26/00	0.0812	100	74	.	.
06/10/04	0.0777	18	15	8.2	23
11/30/04	0.0654	30	26	7.6	21
MCL	**0.03**	**15**	**50****	**Not Applicable**	

Note: "." = Not analyzed; * Data are qualitative (sample-specific MDAs and counting errors are not available); ** SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-222: summary of VOC results

Date Sampled	Concentration (µg/L)						
	PCE	TCE	12DCE (Total)	c12DCE	VC	CTET	CLF
02/23/86	9	.	.	NR	.	.	14
04/23/86	.	.	.	NR	.	12	6
07/30/86	2 J	.	.	NR	.	.	9
11/04/86	5	1 J	.	NR	.	.	6
01/28/87	24	4 J	.	NR	.	16	8
05/04/87	13	2 J	1 J	NR	.	8	7
08/12/87	5	2 J	1 J	NR	.	3 J	4 J
10/22/87	6	1 J	.	NR	.	2 J	4 J
03/08/88	390	75	9	NR	.	320	29
06/09/88	220	45	11	NR	.	150	24
08/17/88	170	34	6	NR	.	96	19
10/26/88	52	9	.	NR	.	18	10
01/09/89	130	22	29	NR	.	190	27
04/08/89	160	38	110	NR	9	470	44
10/13/89	44	8	39	NR	.	2 J	2 J
01/23/90	99	16	23	NR	.	20	6
05/24/90	17	3 J	24	NR	.	.	1 J
08/17/90	.	5	35	NR	.	.	.
10/30/90	2 J	0.7 J	26	NR	.	.	.
02/01/91	11	3 J	8	NR	.	.	.
05/02/91	15	3 J	5	NR	.	.	.
11/15/94	6	2 J	6	NR	.	.	.
02/23/95	30	5	10	NR	.	4 J	.
05/22/95	270	49	20	NR	.	120	11
08/23/95	42	9	23	NR	1 J	.	1 J
11/29/95	280	48	30	NR	.	150	7
03/19/96	13	3 J	9	NR	.	3 J	.
06/12/96	31	7	8	NR	.	4 J	.
08/22/96	16	3 J	7	NR	.	1 J	.
11/18/96	110	28	18	NR	.	14	5
06/13/00	110	29	45	45	.	28	5
10/26/00	6	3 J	15	15	1 J	.	.
06/10/04	2 J	.	2 J	2 J	.	.	.
11/30/04	5	2 J	5	5	2 J	.	.
MCL	**5**	**5**	**NA**	**70**	**2**	**5**	**80***

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported; * MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

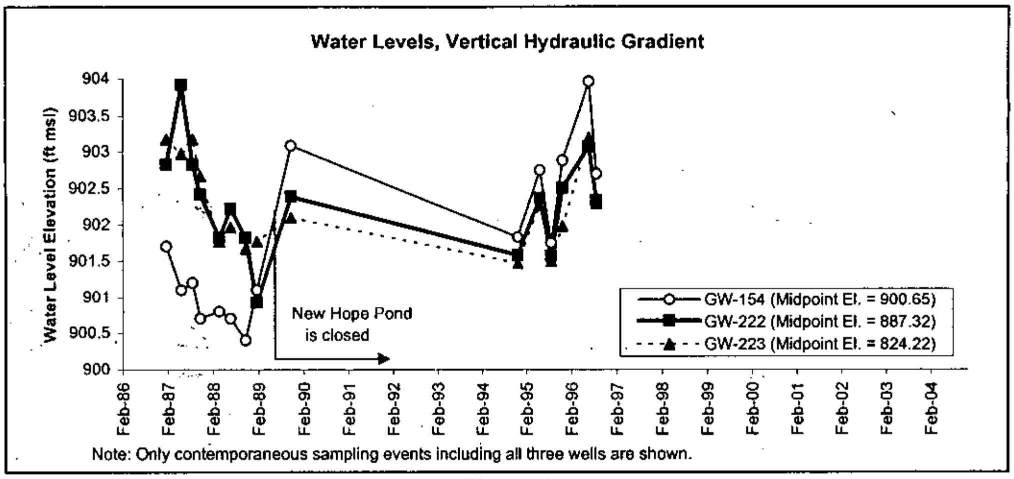


Figure 1

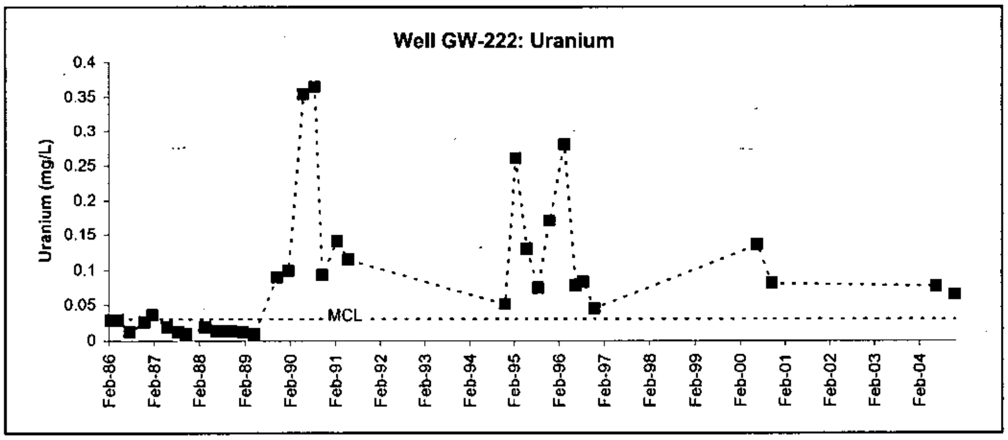


Figure 2

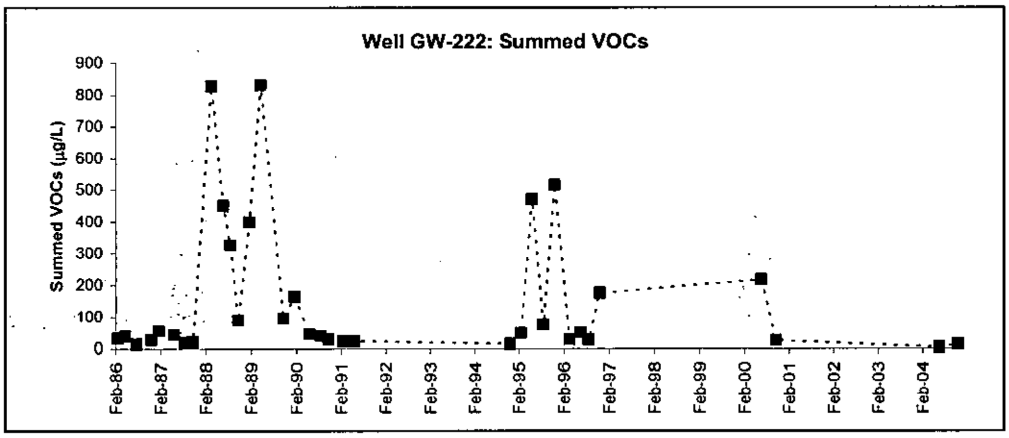


Figure 3

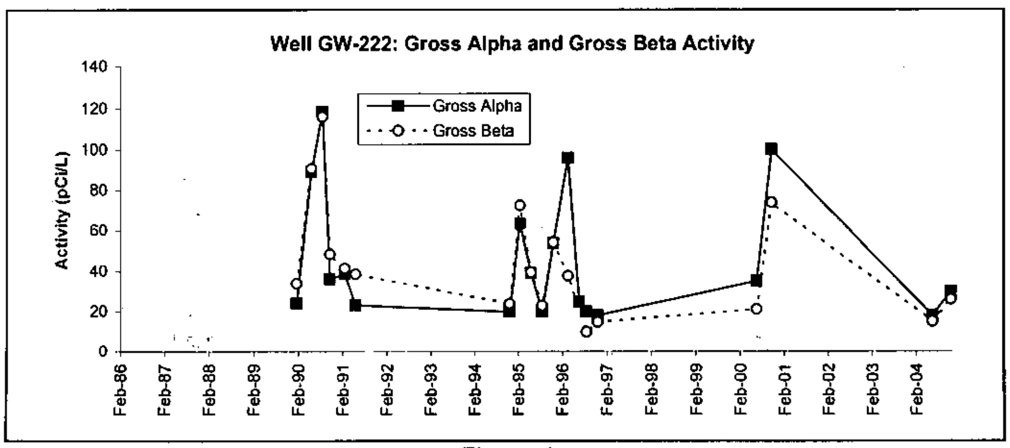


Figure 4

GW-222

MAXIMUM CONCENTRATION: 2004

ND	0.03 - 0.3	50 - 500	15 - 150	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-223

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 63,311.00
Y-12 GRID NORTH COORDINATE: 28,938.00
SURFACE ELEVATION: 908.97 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/21/85 PAIRED/CLUSTERED WITH: GW-154 GW-222
TAG DEPTH (measured): 93.57 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 911.62 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	79.0	829.97
BOTTOM (filter pack or open hole):	90.5	818.47
MIDPOINT (filter pack or open hole):	84.15	824.82
PUMP INTAKE:	84.15	824.82
WATER LEVEL (average):	6.97	902.00

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	41		
CONVENTIONAL SAMPLING METHOD:	30 samples	02/25/86	11/18/96
LOW-FLOW SAMPLING METHOD:	11 samples	09/07/99	08/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/18/04	.	08/10/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.29 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	7	0.0465 mg/L	08/10/04	Increasing
SUMMED VOCs (5 µg/L):	22	619 µg/L	11/18/96	Decreasing
GROSS ALPHA (15 pCi/L):	4	24.05 pCi/L	02/18/04	Increasing
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-223

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1985, completed with a screened monitored interval from 79 to 90.5 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well forms a cluster with wells GW-154 and GW-222 and is located in Bear Creek Valley (BCV) at the east end of Y-12, near the former Oil Skimmer Basin (OSB) immediately west (hydraulically upgradient) of the New Hope Pond (NHP)/Lake Reality. Located near the inlet to NHP, the OSB was a 25 x 40 ft sediment-accumulation basin and oil/water separator; visual evidence of a direct hydraulic connection with the OSB was observed during installation of wells GW-154 and GW-223 (Geraghty & Miller, Inc. 1989). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through a concrete-lined diversion channel bordering the south and east sides of NHP/Lake Reality. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was diverted through the Lake Reality spillway, which discharges into the mainstream of UEFPC directly north (downstream) of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 30 samples between February 1986 and November 1996, and the low-flow sampling method used to obtain 11 samples between September 1999 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits minor (<3 ft) seasonal fluctuations, although a particularly sharp "spike" in the groundwater elevation is indicated by presampling water-level measurement recorded in July 2001 (Figure 1). Also, presampling water-level measurements recorded during contemporaneous sampling events (i.e., within 24 hours) performed after the closure of NHP (and the OSB) show groundwater elevations in well GW-223 being consistently lower than evident in well GW-154 and GW-222, which are completed at shallower depths in the Maynardville Limestone (11 ft and 25 ft bgs, respectively). Based on the distance between the monitored interval midpoint (elevation) in the wells, the relationships between the groundwater elevations indicate: (1) downward vertical hydraulic gradients (0.014 - 0.067) from the water table interval (GW-154) to the shallow bedrock (GW-222) and (2) lesser downward vertical hydraulic gradients (0.001 - 0.008) within the bedrock interval between GW-222 and GW-223. Presampling groundwater elevations determined from contemporaneous sampling events performed before the closure of NHP show higher groundwater elevations in well GW-223 (and GW-222) relative to well GW-154 and indicate upward hydraulic gradients (Figure 1). Thus, the closure of NHP (and the OSB) and installation of the low-permeability cap at the site appears to have reversed local vertical hydraulic gradients.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-223 indicate east-northeasterly flow toward the UEFPC drainage system. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near NHP, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2000, groundwater has been pumped from a well (GW-845) located about 1,200 ft southeast of well GW-223 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002). Groundwater elevations in well GW-223 do not appear to exhibit any direct response to the operation of well GW-845 (Figure 1).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 303 – 510 mg/L;
- pH (field measurements) of 6.13 – 7.31, excluding a suspected outlier (5) in August 1996;
- elevated concentrations of sulfate (>30 mg/L) and chloride (>20 mg/L) compared to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of sodium, potassium, and nitrate (<10% of total anions/cations);
- total concentrations of trace metals (excluding uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated sulfate and chloride concentrations typical of the groundwater samples reflect natural geochemical characteristics in the Maynardville Limestone, or if the elevated concentrations are the result of contamination from one or more sources hydraulically upgradient of the well. Also, the groundwater contains a mixture of chlorinated hydrocarbons (see Section 5.3) and elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the groundwater samples collected from the well since January 1991, the principal contaminants present in the groundwater at this well are uranium, VOCs, and gross alpha activity.

5.1 NITRATE

Only five of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.35 mg/L in November 1994) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

All but one of the groundwater samples had uranium concentrations above the applicable analytical reporting limit (Table 1); including seven results that slightly exceed the MCL for uranium (0.03 mg/L). The specific source of the uranium in the groundwater at this well has not been identified, but is probably the former OSB, which is believed to have retained uranium-contaminated oils (DOE 1998), particularly in light of the direct hydraulic connection observed during installation of the well (see Section 1.0). Considering the relatively neutral pH of the samples, the uranium is probably present as uranyl cations combined with available anions in the groundwater (Fetter 1993), including carbonate dissolved from the Maynardville Limestone, which may greatly increase the relative mobility of uranium in the groundwater flow system.

Excluding the non-detect result reported for the groundwater sample collected in November 1994, total uranium concentrations range between the historical minimum value of 0.005 mg/L in February 1991 and the historical maximum value of 0.0465 mg/L in August 2004 (Table 1). Indeed, all of the uranium concentrations that exceed the MCL have been reported for groundwater samples collected since July 2001 (0.0353 mg/L). These results also illustrate the clearly increasing long-term concentration trend for uranium in the well since closure of NHP (Figure 2). The increasing trend may reflect a corresponding increase in the relative flux of uranium along the groundwater flow/transport pathways intercepted by the monitored interval in the well, possibly in response to the testing and full-time operation of groundwater extraction well GW-845 (see Section 3.0). Additionally, uranium concentrations detected in samples from well GW-223 typically are an order-of-magnitude lower than reported for samples of the shallower groundwater from well GW-154 (e.g., 0.411 mg/L in August 2003). Considering the downward vertical hydraulic gradients indicated by presampling groundwater elevations recorded following closure of NHP (and the former OSB) and installation of the low-permeability cap at the site (see Section 3.0), increased recharge of uranium-contaminated groundwater from the shallow flow system may help maintain the (elevated) uranium concentrations in the deeper groundwater.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): CTET, chloroform (CLF), PCE, TCE, 12DCE (c12DCE) and VC. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide separating the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). As noted in Section 3.0, full-time operation of a groundwater extraction and treatment system began in October 2000 to intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near NHP.

The primary VOCs in the groundwater samples are PCE, TCE, and 12DCE (c12DCE), each of which were detected in each sample (Table 2), with the most recent sampling results (February and August 2004) showing PCE and TCE concentrations above respective MCLs (5 µg/L).

Historical maximum concentrations of PCE (420 µg/L in November 1996), TCE (110 µg/L in November 1996), and 12DCE (95 µg/L in October 2000) substantially exceed the highest concentrations of secondary VOCs in the samples; CTET (30 µg/L in May 1991), CLF (11 µg/L in August 1996), and VC (6 µg/L in January 2001). Also, the secondary VOCs are detected infrequently, with CTET and CLF detected (excluding false positive results) in only one of the samples collected since September 1999 and June 1996, respectively, and VC detected only in samples collected since October 2000 (3 µg/L), including the sample collected most recently (2 µg/L in August 2004). The bulk of the results for the secondary VOCs are estimated values below 5 µg/L, although the low levels of VC equal or slightly exceed the MCL (2 µg/L).

As illustrated by the selected data summarized below, none of the VOCs detected in the groundwater samples from well GW-223 have been detected in samples of the shallower groundwater from well GW-154, which does not yield VOC-contaminated groundwater.

VOC	Concentration (µg/L)					
	August 1991		August 1996		August 2004	
	GW-154	GW-223	GW-154	GW-223	GW-154	GW-223
PCE	.	190	.	170	.	18
TCE	.	42	.	37	.	9
12DCE	.	30	.	29	.	39
CTET	.	26	.	16	.	.
CLF	.	FP	.	FP	.	.
VC	.	.	.	.	.	2 J
Summed VOCs	0	288	0	252	0	68
Note: "." = Not detected; J = Estimated value below analytical reporting limit						

The lack of VOCs in the shallow groundwater from well GW-154 essentially eliminates the OSB as a likely source of the VOCs and shows that the presence of VOCs in the deeper groundwater from well GW-223 does not result from local vertical infiltration of VOC-contaminated groundwater from the shallow flow system. Instead, the VOCs in the samples from well GW-223 indicate lateral migration from upgradient sources (west of the well) via strike-parallel groundwater flow/transport pathways at depth in the Maynardville Limestone.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples encompasses the gaps in the sampling history for the well (May 1991 – November 1994 and November 1996 – September 1999) and shows a clearly decreasing long-term concentration trend (Figure 2). Continued reductions in the levels of PCE and TCE account for the bulk of the concentration decrease, as illustrated by the data summarized above, although the 12DCE levels remain relatively unchanged over the same time period. Note that the decreasing levels of PCE and TCE predate the full-time operation of groundwater extraction well GW-845. Thus, decreasing levels of VOCs probably correspond with an overall reduction in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Additionally, decreasing concentrations may be attributable to biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater. Selected results for some of the indicator parameters, particularly the very low REDOX conditions (Table 3), suggest that the geochemical conditions in the groundwater at this well are within the optimum range for biotic degradation (dechlorination) of chlorinated hydrocarbons. Degradation of PCE and TCE may account for both the decreasing concentrations of these compounds and the relatively unchanged levels of 12DCE, because the REDOX conditions do not suggest the strongly reducing (methanongenic) conditions necessary to transform 12DCE to VC (Chapelle 1996).

5.4 GROSS ALPHA ACTIVITY

All but one of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), including two results that are slightly above the MCL for gross alpha activity (15 pCi/L). Uranium isotopes are the source of the gross alpha activity in the groundwater at this well; each of the samples collected between January 2001 and August 2004 had U-234 and U-238 levels ranging between 3.53 pCi/L and 15.84 pCi/L (Table 1). As with total uranium (see Section 5.2), contamination associated with the historical operation of the OSB is the suspected source of the uranium isotopes in the shallow groundwater at this well (DOE 1998).

Excluding the non-detect gross alpha activity (i.e., <MDA) reported for the groundwater sample collected in March 1996 (Table 1), the other samples define a fairly limited range of gross alpha activity, with the historical maximum value of 24.09 pCi/L in February 2004 and a historical minimum value of 2.05 pCi/L in August 1995. Also, the gross alpha activity reported for each sample is at least an order-of-magnitude lower than reported for samples of the shallower groundwater from well GW-154 (e.g., 698 pCi/L in August 2004). Considering the downward vertical hydraulic gradients indicated by presampling groundwater elevations recorded following closure of NHP (and the former OSB), the relatively low levels of gross alpha activity in the deeper groundwater suggest limited vertical flux of the uranium isotopes present in the shallow groundwater.

A time-series plot of the gross alpha activity (excluding the non-detect result noted above) encompasses the previously mentioned gaps in the sampling history for the well and shows a variable but generally increasing trend (Figure 4). Concurrent increases in U-234 and U-238 levels support this trend (Table 1). This suggests an increase in the relative flux of uranium isotopes via the groundwater flow/transport pathways intercepted by the monitored interval in the well, perhaps in response to the full-time operation of groundwater extraction well GW-845.

5.5 GROSS BETA ACTIVITY

Sixteen of the groundwater samples collected since January 1991 had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (17.92 pCi/L in August 2004) being substantially below the SDWA screening level (50 pCi/L) for gross beta activity. Although below the screening level, the results for gross beta activity indicate an increasing long-term trend (Table 1), which generally corresponds with the trends for gross alpha activity and uranium isotopes.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Geraghty & Miller, Inc. 1989. *Groundwater Quality Assessment Report for New Hope Pond at the Y-12 Plant, 1988.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/89-002-6C/5).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: <u>Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water</u>. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-223: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)	Uranium Isotopes (pCi/L)	
					U-234	U-238
02/01/91	.	0.005	2.51	4.19	<CE.	<CE.
05/03/91	0.2	0.008	4.79	< CE	<CE	<CE
11/15/94	0.35	.	4.25	5.07	NA	NA
02/23/95	.	0.0096	3.76	6.53	NA	NA
05/22/95	.	0.011	3.52	6.61	NA	NA
08/23/95	.	0.0092	2.05	5.49	NA	NA
11/28/95	.	0.012	7.03	5.57	NA	NA
03/14/96	.	0.012	<MDA	<MDA	NA	NA
06/11/96	.	0.017	8.46	<MDA	NA	NA
08/21/96	0.03	0.02	3.68	<MDA	NA	NA
11/18/96	.	0.014	5.81	<MDA	NA	NA
09/07/99	0.05308	0.0236	16	9.4	NA	NA
06/12/00	.	0.0221	8.1	<MDA	NA	NA
10/31/00	.	0.0221	13	8.3	NA	NA
01/11/01	0.11	0.0283	11.28	7.93	4.34	9.97
07/31/01	0.02	0.0353	9.87	1.61	3.53	9.26
01/31/02	.	0.0343	12.19	6.13	3.88	9.17
08/05/02	0.038	0.0305	14	15.24	5.02	9.2
02/11/03	.	0.0325	22.79	15.04	5.74	11.66
08/12/03	.	0.0342	11.91	11.83	5.2	10.59
02/18/04	.	0.0412	24.05	20.95	6.76	14.49
08/10/04	.	0.0465	10.25	17.92	7.34	15.84
MCL	**10**	**0.03**	**15**	**50***	**Not Applicable**	

Note: "." = Not detected; NA = Not analyzed; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-223: summary of VOC results

Date Sampled	Concentration (µg/L)						
	PCE	TCE	12DCE (Total)	c12DCE	VC	CTET	CLF
02/01/91	190	42	30	NR	.	26	FP
05/03/91	160	35	26	NR	.	30	3 J
11/15/94	15	4 J	15	NR	.	1 J	.
02/23/95	250	54	33	NR	.	27	4 J
05/22/95	270	51	32	NR	.	23	5
08/23/95	260	60	40	NR	.	15	4 J
11/28/95	210	43	35	NR	.	4 J	2 J
03/14/96	280	51	36	NR	.	28	5
06/11/96	170	35	24	NR	.	16	.
08/21/96	170	37	29	NR	.	16	FP
11/18/96	420	110	49	NR	.	29	11
09/07/99	140	41	62	62	.	.	.
06/12/00	110	31	38	38	.	.	.
10/31/00	25	13	95	95	3 J	.	.
01/11/01	44	18	86	86	6	.	.
07/31/01	67	17	60	60	2 J	.	.
01/31/02	45	15	44	44	2 J	.	.
08/05/02	40	15	52	52	.	.	.
02/11/03	42	13	40	40	3 J	4 J	.
08/12/03	11	6	42	42	.	.	.
02/18/04	13	6	41	41	.	.	.
08/10/04	18	9	39	39	2 J	.	.
MCL	**5**	**5**	**NA**	**70**	**2**	**5**	**80***

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported; * MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

Table 3. Well GW-223: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	June 2000	Jan. 2001	Aug. 2002	Feb. 2003	Aug. 2004
Nitrate < 1 mg/L	<0.02	0.11	0.038	<0.02	<0.02
Iron (II) > 1 mg/L	0.565*	0.25	0.11	0.03	0.18
Sulfate < 20 mg/L	36.1	34.5	35.7	35.7	35.7
Dissolved Oxygen < 0.5 ppm	0.73**	.**	1.08**	1.13**	0.59**
REDOX < 50 mV	-32**	-25**	2**	5**	-39**
pH >5 and < 9 st. units	6.13 **	6.4 **	7.02**	6.94**	6.88**

Note: *Result is for total iron; **Field measurement.

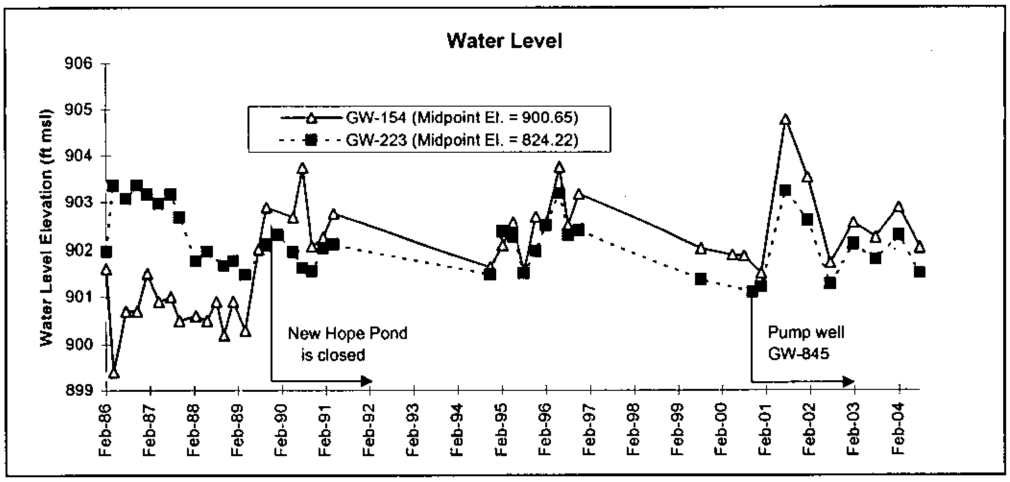


Figure 1

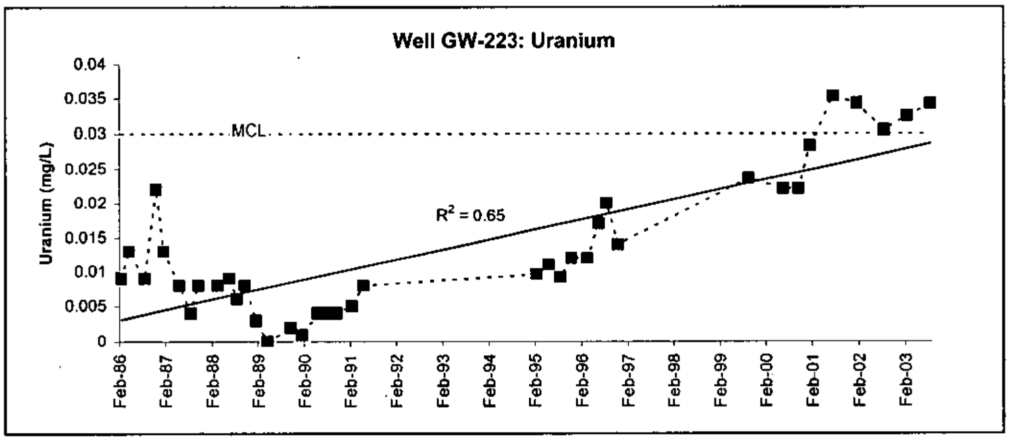


Figure 2

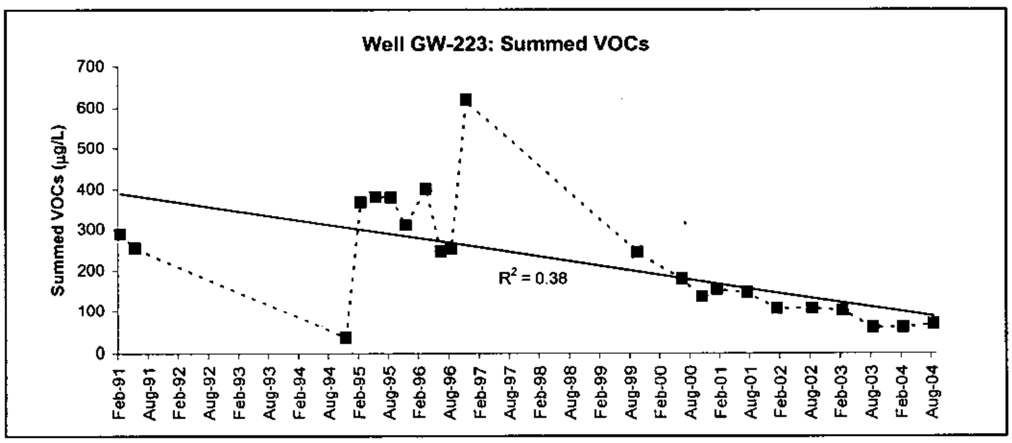


Figure 3

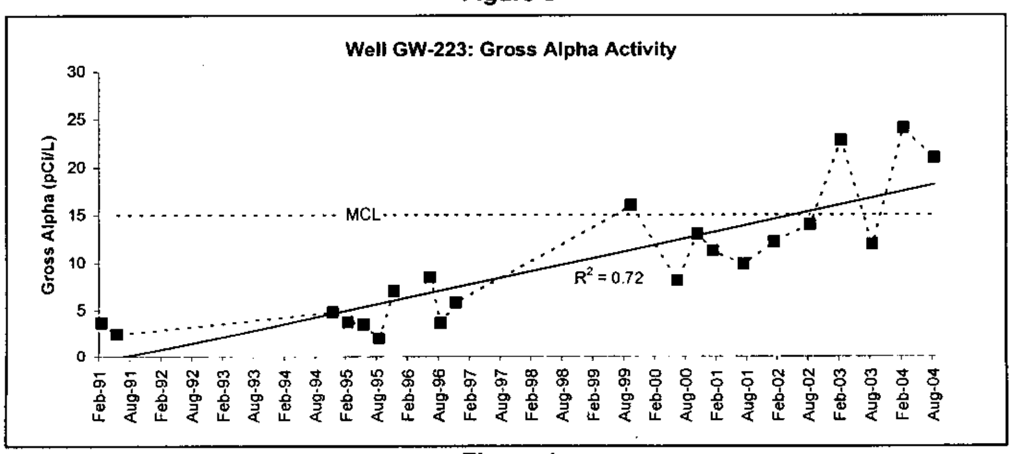


Figure 4

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	50 - 500	ND	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-225

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,461.00
Y-12 GRID NORTH COORDINATE: 29,155.00
SURFACE ELEVATION: 940.21 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/08/85 PAIRED/CLUSTERED WITH: GW-226
TAG DEPTH (measured): 203.30 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 943.11 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	150.0	790.21
BOTTOM (filter pack or open hole):	200.0	740.21
MIDPOINT (filter pack or open hole):	175.0	765.21
PUMP INTAKE:	190.10	750.11
WATER LEVEL (average):	11.39	928.82

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	30 samples	01/12/86	08/14/03
LOW-FLOW SAMPLING METHOD:	8 samples	03/19/01	07/29/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/17/04	.	07/29/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.72 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	16	88 mg/L	02/21/91	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	17	426 μg/L	02/21/91	Indeterminate
GROSS ALPHA (15 pCi/L):	1	16.7 pCi/L	09/13/92	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-225

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from about 150 to 200 ft bgs, and constructed with nominal 4.5-inch diameter steel (SF25) riser casing. The well is paired with well GW-226 and is located in Bear Creek Valley (BCV) approximately 5,000 ft west of Y-12, on the south side of the main channel of Bear Creek, about 100 ft directly south of Sanitary Landfill I and the Oil Landfarm waste management area (WMA).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 30 samples between January 1986 and August 2003, and the low-flow sampling method used to obtain eight samples between March 2001 and July 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher nitrate concentrations than samples obtained with the low-flow sampling method (AJA 2001). However, results of "paired sampling" performed during March and August 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, do not confirm the apparent sampling-method bias (Table 1). The samples obtained with the conventional sampling method had higher, but not substantially higher summed nitrate concentrations than the samples obtained with the low-flow sampling method. Also, as illustrated by the data summarized on Table 1, there is little if any difference between the conventional and low-flow sampling results for other analytes (e.g., calcium and strontium). Thus, the apparent difference between the historical conventional sampling results for nitrate and the more recent low-flow sampling results for nitrate probably reflect an overall decrease in the relative nitrate concentration in the groundwater at this well (see Section 5.1).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits seasonal fluctuations up to about 18 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-225 are typically equal to or slightly higher than evident in well GW-226, which is completed at a shallower depth (55 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (about 125 ft), the contemporaneous groundwater elevations indicate very slightly upward vertical hydraulic gradients (0.0003 – 0.005) from the deeper bedrock (GW-225) to the shallow bedrock interval (GW-226) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of well GW-225 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 216 – 792 mg/L;
- pH of 6 – 7.35 (field measurements);
- nitrate concentrations above 25 mg/L;
- elevated concentrations of chloride, (>70 mg/L), strontium (>1 mg/L), and sulfate (>40 mg/L) relative to other wells completed at shallower depths in the Maynardville Limestone;
- low molar proportions of potassium and sodium (<10% of total anions/cations); and
- total concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the chloride, strontium, and sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

The relative percent difference (RPD) between respective summed millequivalent concentrations determined from the analytical results for the principal anions and cations (i.e., the ion charge-balance) reported for the groundwater sample obtained with the conventional sampling method in March 2003 (RPD = +54.4%) does not meet the data quality objective (RPD < 20%). The source of the charge-balance error is probably the unusually low nitrate concentration (0.213 mg/L) reported for this sample (see Section 5.1). Because of the charge-balance error, this nitrate result (and the results for all the major anions and cations) is considered qualitative.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate, uranium, and VOCs are the contaminants present at elevated levels in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected since January 1986 had nitrate concentrations above the analytical reporting limit (Table 2), and all but two of these samples had concentrations above the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 4,500 ft east-northeast of well GW-225, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, all but two of the groundwater samples collected since January 1986 had nitrate concentrations above the MCL (Table 2), including the historical maximum value (105 mg/L in November 1990), with no apparent difference between the results for samples obtained with the conventional or low-flow sampling method (see Section 2.0). The lowest nitrate concentrations, 3.1 mg/L in November 1988 and 0.213 mg/L in March 2003, clearly are outliers (too low); the latter result is considered qualitative because of the ion charge-balance error determined for this sample (see Section 4.0). Also, the temporal fluctuations in concentration of nitrate show a somewhat inconsistent relationship with seasonal groundwater flow conditions, although six of the nine highest nitrate values (i.e., >80 mg/L) were reported for samples collected during seasonally low flow (summer and fall). This suggests seasonal (and episodic) recharge of less nitrate-contaminated groundwater along the flowpaths intercepted by the monitored interval in the well.

A time series plot of the nitrate concentrations reported for the groundwater samples collected since January 1986 (excluding the suspected outliers noted above) spans the nearly 10-year gap in the sampling history for the well (November 1992 – March 2001) and shows: (1) a widely variable, increasing trend between January 1986 (48.1 mg/L) and November 1990 (105 mg/L); (2) a widely variable, decreasing trend through September 1992 (72 mg/L); and (3) after the sampling gap, a fairly indeterminate trend at much lower concentrations, as illustrated by the nearly equal nitrate concentrations reported for the samples collected with the low-flow sampling method in March 2001 (35.4 mg/L) and February 2004 (34.2 mg/L). Substantially reduced flux of nitrate following the closure of the former S-3 Ponds in 1984 and installation of the low-permeability cap in 1989 probably explains the long-term decrease in nitrate concentrations in the groundwater at this well.

5.2 URANIUM

All of the groundwater samples collected since February 1991 had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.00372 mg/L) being almost an order-of-magnitude lower than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Based on the VOC results reported for the groundwater samples collected since February 1991 (previous VOC results generally do not meet all applicable data quality objectives), one or more of the following compounds were detected (excluding false positive results) in at least one of the samples (Table 3): CTET, chloroform, PCE, TCE, 11DCA, 11DCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the

Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), TCE becomes the primary contaminant in the plume, with major inputs of VOCs from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), the former Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater directly south (down dip) of the former HCDA, about 500 ft east-northeast (hydraulically upgradient) of well GW-225. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

TCE is the principal VOC in the groundwater samples, with concentrations above 100 reported for each sample, a historical maximum concentration of 400 µg/L in February 1991, and the most recent sampling results (February and July 2004) showing that the concentrations remain above 200 µg/L. Secondary compounds in the samples are chloroform, CTET, PCE, 11DCA, 11DCE, 12DCE (c12DCE), and 111TCA; one or more of which were detected in all but one of the samples (Table 3). Historical maximum values for each of these compounds are less than 10 µg/L, with most of the results being estimated values below 5 µg/L. The remaining VOCs were detected infrequently (only one or two samples) with most of the results being estimated values of 1 µg/L or less; these results are probably analytical artifacts.

As noted in Section 2.0, the results of "paired" sampling do not indicate substantial differences between the concentrations of VOCs in the groundwater samples obtained with the conventional sampling and low-flow sampling methods. This is illustrated by the data summarized below, which show equal or nearly equal concentrations of all VOCs except TCE, with the samples obtained with the conventional method each having 50 µg/L more TCE than the corresponding samples obtained with the low-flow method.

VOC	Concentration (µg/L)			
	Low-Flow Sampling March 24, 2003	**Conventional Sampling March 25, 2003**	**Low-Flow Sampling August 12, 2003**	**Conventional Sampling August 13, 2003**
PCE	.	2 J	2 J	2 J
TCE	230	280	200	250
c12DCE	3 J	3 J	2 J	3 J
11DCE	3 J	2 J	3 J	3 J
CTET	5 J	7	4 J	6
Chloroform	2 J	2 J	2 J	1 J
Summed VOCs	243	297	213	265

Assuming a heterogeneous mixture of dissolved VOCs in the groundwater at the well, it is not clear why the sampling method would only influence the concentration of TCE.

A time-series plot of TCE concentrations reported for the groundwater samples obtained with the low-flow sampling method shows an indeterminate long-term trend dominated by clearly seasonal concentration fluctuations (Figure 3), with temporal peak concentrations consistently evident during seasonally high groundwater flow conditions (winter and spring). This trend suggests seasonally (and episodically) variable movement of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well (and proximal to the sampling pump intake). As shown by the data summarized in Table 3, however, the concentrations of other VOCs detected in the samples do not exhibit similarly wide temporal fluctuations, as illustrated by the equal concentrations of chloroform reported for the samples collected in February 2004 (2 μg/L) and July 2004 (2 μg/L).

5.4 GROSS ALPHA ACTIVITY

Eight of the groundwater samples collected since February 1991 (previous results for gross alpha activity do not meet applicable data quality objectives) had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum value (16.7 pCi/L in September 1992) being slightly above the MCL for gross alpha activity (15 pCi/L). This result appears to be an outlier, all of the other results for gross alpha activity are less than 8 pCi/L.

5.5 GROSS BETA ACTIVITY

All but two of the groundwater samples collected since February 1991 (previous results for gross beta activity do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE (Table 4), and all of these results are less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-225: Consecutive daily sampling results for summed VOCs and other selected analytes, March and August 2003

Analyte	Units	March 24-25, 2003		August 12-13, 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	Std. units	5.74	7.36	7.15	7.02
Dissolved Solids	mg/L	597	180	537	684
Suspended Solids	mg/L	<1	22	<1	<1
Calcium	mg/L	106	[111]	109	118
Nitrate	mg/L	35.2	[0.213]	35.6	43
Barium	mg/L	0.168	0.182	0.168	0.16
Strontium	mg/L	1.96	1.21	1.81	1.14
Summed VOCs	μg/L	243	297	213	265
Gross Alpha Activity	pCi/L	<MDA	<MDA	4.2	<MDA
Gross Beta Activity	pCi/L	17	30	16	24

Table 2. Well GW-225: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
Conventional Sampling				
01/12/86	48.1		DQO	DQO
05/20/86	65.3		DQO	DQO
09/02/86	71.8		DQO	DQO
12/19/86	73.4		DQO	DQO
03/31/87	68		DQO	DQO
06/24/87	73.4		DQO	DQO
09/05/87	64		DQO	DQO
11/02/87	68		DQO	DQO
04/26/88	75.4		DQO	DQO
07/12/88	71		DQO	DQO
09/24/88	85		DQO	DQO
11/11/88	3.1		DQO	DQO
11/23/88	67		DQO	DQO
03/29/89	84		DQO	DQO
07/23/89	86		DQO	DQO
09/25/89	84		DQO	DQO
12/15/89	74		DQO	DQO
02/01/90	77		DQO	DQO
05/30/90	93		DQO	DQO
08/19/90	97		DQO	DQO
11/03/90	105		DQO	DQO
02/21/91	88	0.002	1.84	42.29
05/17/91	79	0.002	3.7	33.78
08/31/91	74.1	0.002	2.73	29.9
11/01/91	87	0.002	6.63	23.2
03/20/92	73	0.002	7.09	18.4
06/09/92	74.8	0.002	<CE	22.5
09/13/92	72	0.002	16.7	23.1
03/25/03	[0.213]	0.00168	<MDA	30
08/14/03	43	0.00358	<MDA	24
Low-Flow Sampling				
03/19/01	35.4	0.00346	<MDA	<MDA
08/08/01	37.3	0.00326	4.2	25
02/19/02	37.4	0.00372	<MDA	19
08/01/02	34.9	0.00356	<MDA	19
03/24/03	35.2	0.00354	<MDA	17
08/13/03	35.6	0.00304	4.2	16
02/17/04	34.2	0.00271	<MDA	12
07/29/04	37.6	0.00292	<MDA	<MDA
MCL	**10**	**0.03**	**15**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity); DQO = Result does not meet data quality objectives; [ ] = Result considered qualitative because of ion charge-balance error

Table 3. Well GW-225: summary of VOC results

Sampling Method and Date	Concentration (µg/L)			
	PCE	TCE	12DCE (Total)	c12DCE
Conventional Sampling				
01/12/86	.	500	NA	NR
05/20/86	.	520	NA	NR
09/02/86	.	350	NA	NR
12/19/86	4 J	500	2 J	NR
03/31/87	4	450	2 J	NR
06/24/87	5	500	2 J	NR
09/05/87	3 J	320	3 J	NR
11/02/87	5	440	3 J	NR
04/26/88	5	430	.	NR
07/12/88	5	400	.	NR
09/24/88	5	440	.	NR
11/11/88	.	11	.	NR
11/23/88	6	400	3 J	NR
03/29/89	5	400	3 J	NR
07/23/89	5	360	.	NR
09/25/89	5	360	.	NR
12/15/89	.	360	.	NR
02/01/90	7	410	4 J	NR
05/30/90	5	460	.	NR
08/19/90	7	300	.	NR
11/03/90	7	380	.	NR
02/21/91	6	400	.	NR
05/17/91	5	350	.	NR
08/31/91	5	300	.	NR
11/01/91	2 J	370	.	NR
03/20/92	.	370	.	NR
06/09/92	.	350	.	NR
09/13/92	3 J	360	3 J	NR
03/25/03	2 J	280	3 J	3 J
08/14/03	2 J	250	3 J	3 J
Low-Flow Sampling				
03/19/01	.	220	.	.
08/08/01	.	200	2 J	2 J
02/19/02	.	190	3 J	3 J
08/01/02	.	180	2 J	2 J
03/24/03	.	230	3 J	3 J
08/13/03	2 J	200	2 J	2 J
02/17/04	2 J	220	2 J	2 J
07/29/04	1 J	240	3 J	3 J
MCL	**5**	**5**	**.**	**5**

Table 3 (continued)

Sampling Method and Date	Concentration (µg/L)			
	11DCE	CTET	Chloroform	111TCA
Conventional Sampling				
01/12/86	5	11	.	5
05/20/86	9	.	.	.
09/02/86	.	13	6	.
12/19/86	8	14	5	6
03/31/87	6	10	2 J	4 J
06/24/87	6	13	2 J	6
09/05/87	3 J	9	4 J	4 J
11/02/87	6	9	2 J	4 J
04/26/88	5	11	2 J	5
07/12/88	5	11	2 J	5
09/24/88	5	12	2 J	5
11/11/88	.	.	.	.
11/23/88	7	7	2 J	3 J
03/29/89	5	9	2 J	4 J
07/23/89	6	7	2 J	3 J
09/25/89	.	6	.	3 J
12/15/89	.	.	.	.
02/01/90	6	9	2 J	3 J
05/30/90	.	8	.	.
08/19/90	6	9	2 J	4
11/03/90	6	8	2 J	3
02/21/91	5	8	4 J	3 J
05/17/91	5	7	FP	3 J
08/31/91	4 J	2 J	4 J	2 J
11/01/91	3 J	7	.	2 J
03/20/92	.	6	FP	.
06/09/92	5	8	.	3 J
09/13/92	6	5	5	2 J
03/25/03	3 J	7	2 J	.
08/14/03	3 J	6	1 J	.
Low-Flow Sampling			.	.
03/19/01	.	.		
08/08/01	2 J	4 J	.	.
02/19/02	2 J	4 J	.	.
08/01/02	.	2 J	.	.
03/24/03	3 J	5	2 J	.
08/13/03	3 J	4 J	2 J	.
02/17/04	3 J	5	2 J	.
07/29/04	3 J	4 J	2 J	.
MCL	**7**	**5**	**80***	**200**

Note: "." = Not detected; FP = False positive; J = Estimated value below analytical reporting limit; NA = Not analyzed; NR = Not reported; *MCL is for total trihalomethanes

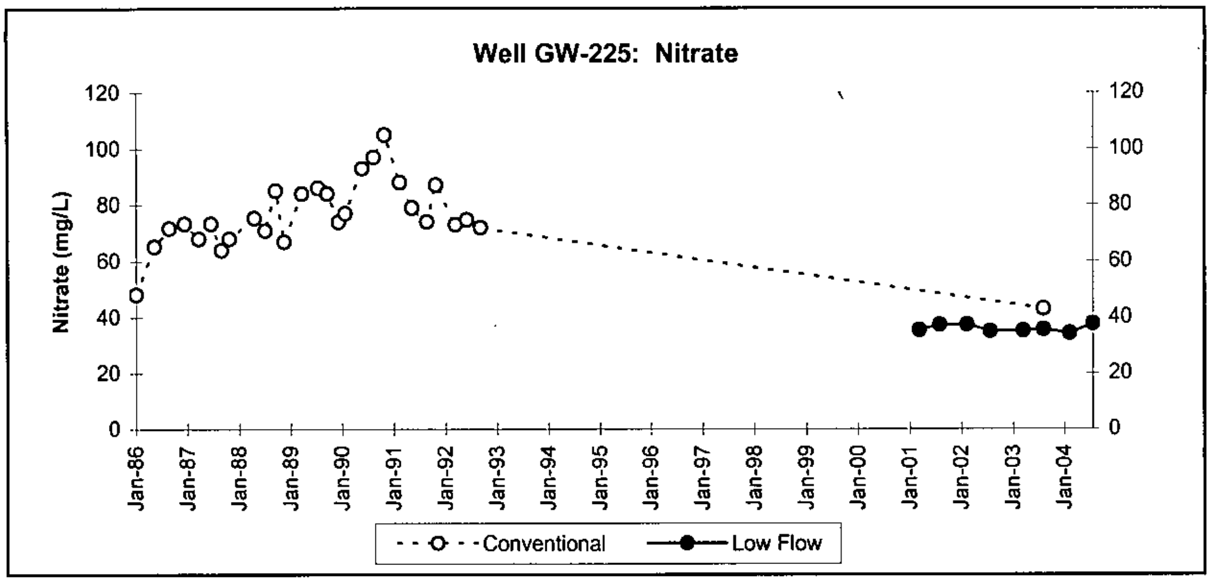


Figure 1

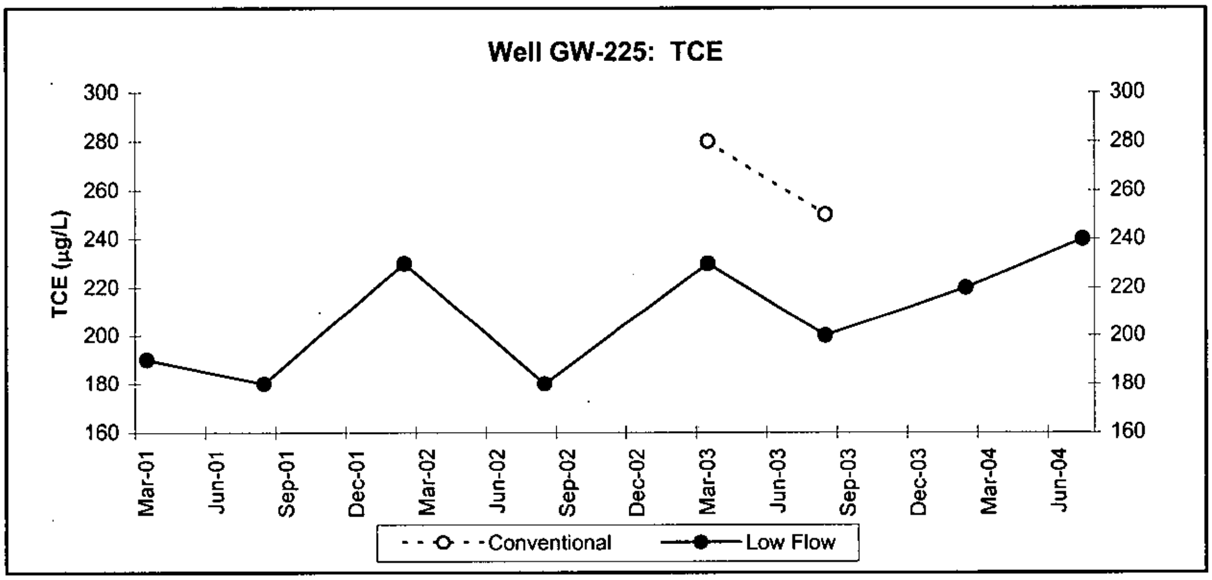


Figure 2

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	50 - 500	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-226

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,473.00
Y-12 GRID NORTH COORDINATE: 29,156.00
SURFACE ELEVATION: 940.56 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/14/85 PAIRED/CLUSTERED WITH: GW-225
TAG DEPTH (measured): 58.47 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 943.57 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	45.0	895.56
BOTTOM (filter pack or open hole):	55.0	885.56
MIDPOINT (filter pack or open hole):	50.0	890.56
PUMP INTAKE:	49.79	890.77
WATER LEVEL (average):	10.6	929.96

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	39		
CONVENTIONAL SAMPLING METHOD:	25 samples	01/12/86	08/13/03
LOW-FLOW SAMPLING METHOD:	14 samples	03/10/98	07/28/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/17/04	.	07/28/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 12.91 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	12	32.3 mg/L	02/17/04	Indeterminate
URANIUM (0.03 mg/L):	3	0.088 mg/L	02/08/91	Indeterminate
SUMMED VOCs (5 µg/L):	18	224 µg/L	02/17/04	Indeterminate
GROSS ALPHA (15 pCi/L):	4	33.86 pCi/L	05/13/91	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-226

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from about 45 to 55 ft bgs, and constructed with nominal 4.5-inch diameter steel (SF25) riser casing. The well is paired with well GW-225 and is located in Bear Creek Valley (BCV) approximately 5,000 ft west of Y-12, on the south side of the main channel of Bear Creek, about 100 ft directly south of Sanitary Landfill I and the Oil Landfarm waste management area (WMA).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 25 samples between January 1986 and August 2003, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method had substantially lower VOC concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during May and August 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias (Table 1); summed concentrations of VOCs detected in the samples obtained with the low-flow method are about 20 to 40% higher than the corresponding summed VOC concentrations for the samples obtained with the conventional sampling method. Conversely, the conventional sampling method appears to yield samples with higher levels of gross alpha activity and gross beta activity (Table 1). Also, the conventional sampling method appears to promote the inflow of more mineralized groundwater into the well, as illustrated by the higher calcium concentrations and TDS evident for both conventional sampling events, although samples obtained with either method have similar nitrate concentrations (Table 1).

Inherent differences in the manner in which each sampling method induces flow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce flow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. Conventional sampling also appears to disturb fine-grained particles in the bottom of the well or in the fractures intercepted by the open-hole interval, which frequently results in the collection of unfiltered samples with significant levels of total suspended solids (TSS), as illustrated by the extremely high TSS reported for the (unfiltered) samples collected in March 2003 (864 mg/L) and August 2003 (719 mg/L). In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method appears to induce inflow of more mineralized groundwater (with lower VOC concentrations) from water-producing features that are not proximal to the monitored interval, whereas low-flow sampling appears to primarily induce inflow of VOC-contaminated groundwater from the water producing feature(s) close to the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). Additionally, well GW-226 is located along a reach of the main channel of Bear Creek south of Sanitary Landfill I that loses substantial flow to the Maynardville Limestone and greatly facilitates the transfer of surface-water contaminants into Maynardville Limestone (DOE 1997).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits seasonal fluctuations up to about 13 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-226 are typically equal to or slightly lower than evident in well GW-225, which is completed deeper (200 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (about 125 ft), the contemporaneous groundwater elevations indicate very slightly upward vertical hydraulic gradients (0.0003 – 0.005) from the deeper bedrock (GW-225) to the shallow bedrock interval (GW-226) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of well GW-226 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 216 – 792 mg/L;
- pH of 6 – 7.35 (field measurements);
- aluminum and iron (total) concentrations that sporadically exceed 50 mg/L;
- elevated concentrations of chloride (>60 mg/L) and sulfate (>30 mg/L) relative to other wells completed at shallower depths in the Maynardville Limestone;
- low molar proportions of potassium and sodium (<10% of total anions/cations); and
- total concentrations of trace metals (except aluminum and iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the chloride and sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well. Also, the unusually high total aluminum and iron concentrations show a direct correlation with TSS, and are probable artifacts of the preservation of the unfiltered samples (i.e., acidification below a pH of 2).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on sampling results obtained since February 1991, three of these contaminants (nitrate, uranium, and VOCs) are present at elevated levels in the groundwater at this well.

5.1 NITRATE

Seventeen groundwater samples had nitrate concentrations at or above the analytical reporting limit (Table 2) and most of these samples had concentrations above the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 4,500 ft east-northeast of well GW-226, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, eleven of the groundwater samples had nitrate concentrations above the MCL (Table 2), including the historical maximum value (32.3 mg/L in February 2004), with no apparent difference between the results for samples obtained with the conventional or low-flow sampling method (see Section 2.0). Also, with high nitrate concentrations evident for samples collected during seasonally high flow (e.g., 28.6 mg/L in March 1999) and seasonally low flow (e.g., 19.1 mg/L in September 2000), there does not appear to be any consistent relationship between nitrate levels and seasonal groundwater flow conditions. Figure 1 is a time-series plot of the nitrate results, which shows an indeterminate trend with wide concentration fluctuations from March 1998 through March 2001, followed by a much less variable and increasing trend through February 2004, with a sharp concentration decrease in July 2004 (20.9 mg/L).

5.2 URANIUM

All of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the results for eight samples exceeding the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of well GW-226, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. Nevertheless, the CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 550 ft east-northeast of the well. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock served as a source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited mobility, considering the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area for uranium, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

As noted previously, total uranium concentrations reported for most of the groundwater samples, do not exceed the MCL (0.03 mg/L), with the most recent result (0.00694 in July 2004) being the lowest concentration reported for any groundwater sample collected since November 1988 (0.003 mg/L). Additionally, all of the samples with uranium concentrations above the MCL, including the historical maximum value (0.092 mg/L in October 1990), were obtained with the conventional sampling method. This suggests that the conventional sampling method tends to induce greater inflow of uranium-contaminated groundwater into the well, a finding supported by the results of paired low-flow and conventional sampling (see Section 2.0). If so, it is not clear which sampling method provides the most representative sampling results for total uranium.

A time-series plot of uranium concentrations reported for the groundwater samples collected since February 1998 (including the conventional sampling results obtained in 2003) shows an indeterminate trend (Figure 3), as illustrated by the similarity between the uranium concentrations evident in March 1998 (0.016 mg/L) and February 2004 (0.0125 mg/L). However, the uranium concentrations exhibit a clear correlation with seasonal flow conditions, with temporal peak concentrations reported for samples collected during seasonally high groundwater flow conditions (winter and spring), and temporal low concentrations reported for samples collected during seasonally low flow conditions (summer and fall). This suggests seasonal (and episodic) changes in advective flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, recent low-flow sampling data potentially reflect a decreasing concentration trend, with the uranium concentration evident in July 2004 being about 56% lower than evident in August 2001 (0.0157 mg/L), which may be attributable to the CERCLA remedial action at the BYBY.

5.3 VOLATILE ORGANIC COMPOUNDS

Based on the VOC results reported for the groundwater samples collected since February 1991 (previous VOC results generally do not meet all applicable data quality objectives), one or more of the following compounds were detected in one or more of the samples (Table 3): benzene, CTET, chloroethane, chloroform, chloromethane, TCE, 11DCA, 11DCE, and 12DCE (isomers). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), TCE becomes the primary contaminant in the plume, with major inputs of VOCs from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary

Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater directly south (down dip) of the former HCDA, about 500 ft east-northeast (hydraulically upgradient) of well GW-226.

The primary VOCs in the groundwater samples are TCE and 12DCE (c12DCE), both of which was detected in each sample (Table 3). The dominant compound is TCE, which has been detected in each sample, with concentrations above 100 µg/L reported for most of these samples, including the historical maximum concentration of 210 µg/L (March 1999 and February 2004). Conversely, most of the 12DCE concentrations are less than 10 µg/L and the historical maximum value (36 µg/L in February 1991) is substantially below the MCL (70 µg/L). Secondary compounds in the samples are chloroform, CTET, 11DCA, and 11DCE, which were detected in a total of twelve samples, but only three of the samples collected since August 1999 (Table 3). The remaining VOCs were detected infrequently (only one or two samples) with most of the results being estimated values below 5 µg/L.

As noted in Section 2.0, the summed concentrations of VOCs detected in the groundwater samples obtained with the conventional sampling method are lower than the summed VOC concentrations for samples obtained with the low-flow sampling methods. As illustrated by the "paired" sampling results summarized below, this is primarily attributable to substantial differences in the concentrations of TCE.

VOC	Concentration (µg/L)			
	Low-Flow Sampling March 24, 2003	**Conventional Sampling March 25, 2003**	**Low-Flow Sampling August 12, 2003**	**Conventional Sampling August 13, 2003**
TCE	200	110	160	120
c12DCE	8	10	7	9
11DCE	3 J	2 J	1 J	.
11DCA	1 J	.	.	.
CTET	.	.	2 J	2 J
Chloroform	.	1 J	1 J	1 J
Chloromethane	.	4 J	.	.
Summed VOCs	212	127	171	132

Aside from TCE, however, the respective sampling results do not show any significant difference between the concentrations of the other VOCs detected in the samples. Assuming a heterogeneous mixture of dissolved VOCs in the groundwater at the well, it is not clear why the sampling method influences the concentrations of some compounds and not others. Nevertheless, these findings suggest that the VOC results reflect the apparent tendency for the conventional sampling method to induce inflow of (nitrate- and uranium-contaminated) groundwater from water-producing features that are not proximal to the well (i.e., further into the formation), whereas low-flow sampling appears to primarily induce inflow of TCE-contaminated groundwater from the water producing feature(s) close to the well.

A time-series plot of TCE concentrations reported for the groundwater samples obtained with the low-flow sampling method shows an indeterminate long-term trend dominated by clearly seasonal concentration fluctuations (Figure 3), with temporal peak concentrations consistently evident during seasonally high groundwater flow conditions (winter and spring). This trend suggests seasonally (and episodically) variable advective flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well. As shown by the data summarized in Table 3, however, the concentrations of other VOCs detected in the samples do not exhibit similarly wide temporal fluctuations, as illustrated by the nearly equal concentrations of c12DCE reported for the samples collected in March 2003 (8 µg/L) and August 2003 (7 µg/L).

5.4 GROSS ALPHA ACTIVITY

All but four of the groundwater samples collected since February 1991 (previous results for gross alpha activity do not meet applicable data quality objectives) had gross alpha activity above the applicable MDA and corresponding CE, and four of these results exceed the drinking water MCL for gross alpha activity (Table 2). Uranium isotopes are the source of the gross alpha activity, as indicated by the analytical results for the samples collected in March 1998 (U-234 = 3.2 pCi/L and U-238 = 5 pCi/L), May 2001 (U-234 = 3.2 pCi/L and U-238 = 4.5 pCi/L), and August 2001 (U-234 = 3.4 pCi/L and U-238 = 5.2 pCi/L). The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the groundwater at the well GW-226 (DOE 1997). As with total uranium (see Section 5.2), U-234 and U-238 ions leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the limestone bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

As noted in Section 2.0, the conventional sampling method appears to induce inflow of groundwater with elevated gross alpha activity, and all of the results that exceed the MCL were reported for samples obtained with this sampling method (Table 2). Additionally, seasonal fluctuations in gross alpha activity are generally indicated, with the highest values reported for the samples collected during seasonally high groundwater flow conditions in May 1991 (33.86 pCi/L) and March 2003 (33 pCi/L). Substantially lower gross alpha activity was reported for the samples obtained with the low-flow sampling method, although like the conventional sampling results, the highest value was reported for a sample collected during seasonally high flow conditions (11 pCi/L in March 2003). These results suggest seasonally (and episodically) variable flux of alpha-emitting radionuclides (uranium isotopes) via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples collected since February 1991 (previous results for gross beta activity do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE (Table 4). Although uranium isotopes and related daughter products contribute to the gross beta activity in the groundwater at this well, Tc-99 may be another source, as indicated by the relatively low levels of this beta-emitting radionuclide detected (i.e., >MDA and CE) in samples collected March 1998 (28 pCi/L) and February 2001 (16 pCi/L). Technetium-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

Gross beta activity results that exceed the MDA and corresponding CE range between 8.5 pCi/L (July 2004) and 45 pCi/L (August 2003), and are all less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity).

The highest values reported for the groundwater samples obtained with the conventional sampling method in February 1991 (41.44 pCi/L) and August 2003 (45 pCi/L). These results suggest, as noted in Section 2.0, that the conventional sampling method induces greater relative inflow of contaminated groundwater.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-226: Consecutive daily sampling results for summed VOCs and other selected analytes, March and August 2003

Analyte	Units	March 24-25, 2003		August 12-13, 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	6.82	6.86	6.91	6.65
Dissolved Solids	mg/L	664	688	633	701
Suspended Solids	mg/L	3	864	33	719
Calcium	mg/L	148	165	123	171
Nitrate	mg/L	17.3	19.4	19.9	17
Barium	mg/L	0.208	0.53	0.173	0.433
Iron	mg/L	0.802	96.8	3.25	89.7
Uranium	mg/L	0.0172	0.0306	0.011	0.0225
Summed VOCs	µg/L	212	127	171	132
Gross Alpha Activity	pCi/L	11	33	8.5	24
Gross Beta Activity	pCi/L	24	<MDA	18	45

Table 2. Well GW-226: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
Conventional Sampling				
01/12/86	14.22	0.009	DQO	DQO
05/20/86	9.64	0.066	DQO	DQO
09/02/86	11.3	0.008	DQO	DQO
12/13/86	NA	0.002	NA	NA
03/31/87	4.1	0.007	DQO	DQO
06/30/87	3.27	0.004	DQO	DQO
09/01/87	2.12	0.006	DQO	DQO
10/30/87	2.66	0.008	DQO	DQO
04/25/88	3.4	0.034	DQO	DQO
07/08/88	2.2	0.004	DQO	DQO
09/20/88	4	0.007	DQO	DQO
11/21/88	2.8	0.003	DQO	DQO
03/29/89	2.1	0.009	DQO	DQO
07/24/89	2	0.01	DQO	DQO
09/19/89	2	0.017	DQO	DQO
12/14/89	0.9	0.014	DQO	DQO
02/08/90	2.8	0.014	DQO	DQO
05/29/90	1.4	0.04	DQO	DQO
08/16/90	0.5	0.055	DQO	DQO
10/31/90	0.7	0.092	DQO	DQO
02/08/91	0.7	0.088	29.19	41.44
05/13/91	<0.2	0.056	33.86	32.61
03/25/03	19.4	0.0306	33	<MDA
08/13/03	16.9	0.0225	24	45
Low-Flow Sampling				
03/10/98	17.2	0.016	5.5	13
09/02/98	8.92	0.0091	<MDA	16
03/18/99	28.6	0.0136	6.6	20
08/31/99	7.066	0.00765	<MDA	18
03/01/00	1.6	0.015	8.1	15
09/11/00	19.1	0.00751	4.6	23
02/06/01	8.02	0.0192	5.2	18
08/02/01	7.98	0.0157	7.7	24
02/19/02	10.3	0.0189	8.4	17
08/01/02	12.2	0.00828	4.5	17
03/24/03	17.3	0.0172	11	24
08/12/03	19.9	0.011	8.5	18
02/17/04	32.3	0.0125	<MDA	20
07/28/04	20.9	0.00694	<MDA	8.5
MCL	**10**	**0.03**	**15**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 3. Well GW-226: summary of VOC results

Sampling Method and Date	Concentration (µg/L)				
	TCE	12DCE (Total)	c12DCE	11DCA	11DCE
Conventional Sampling					
02/08/91	6	36	NR	.	2 J
05/13/91	3 J	29	NR	3 J	1 J
03/25/03	110	10	10	.	2 J
08/13/03	120	9	9	.	.
Low-Flow Sampling					
03/10/98	110	7	7	1 J	2 J
09/02/98	180	3 J	3 J	.	.
03/18/99	210	4 J	4 J	.	2 J
08/31/99	110	3 J	3 J	.	.
03/01/00	160	4 J	4 J	.	.
09/11/00	87	3 J	3 J	.	.
02/06/01	120	5	5	.	.
08/02/01	79	7	7	.	.
02/19/02	110	6	6	.	.
08/01/02	89	3 J	3 J	.	.
03/24/03	200	8	8	1 J	3 J
08/12/03	160	7	7	.	1 J
02/17/04	210	6	6	.	2 J
07/28/04	130	3 J	3 J	.	.
MCL	**5**	**NA**	**70**	**NA**	**7**

Sampling Method and Date	Concentration (µg/L)		
	CTET	Chloroform	OTHER
Conventional Sampling			
02/08/91	.	.	Benzene (1 J), Chloroethane (4 J)
05/13/91	.	.	Benzene (0.4 J)
03/25/03	.	1 J	Chloromethane (4 J)
08/13/03	2 J	1 J	.
Low-Flow Sampling			
03/10/98	2 J	FP	.
09/02/98	3 J	2 J	.
03/18/99	3 J	.	.
08/31/99	2 J	.	.
03/01/00	.	.	.
09/11/00	.	.	.
02/06/01	.	.	.
08/02/01	.	.	.
02/19/02	.	.	.
08/01/02	.	.	.
03/24/03	.	.	.
08/12/03	2 J	1 J	.
02/17/04	3 J	2 J	PCE (1 J)
07/28/04	.	.	PCE (1 J)
MCL	**5**	**80***	**.**

Note: "." = Not detected; FP = False positive; J = Estimated value below analytical reporting limit; NR = Not reported; NA = Not applicable; *MCL is for total trihalomethanes

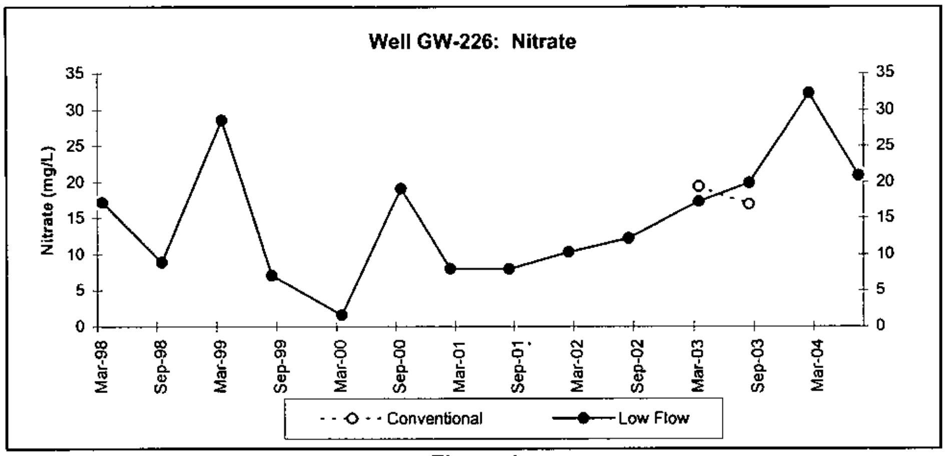


Figure 1

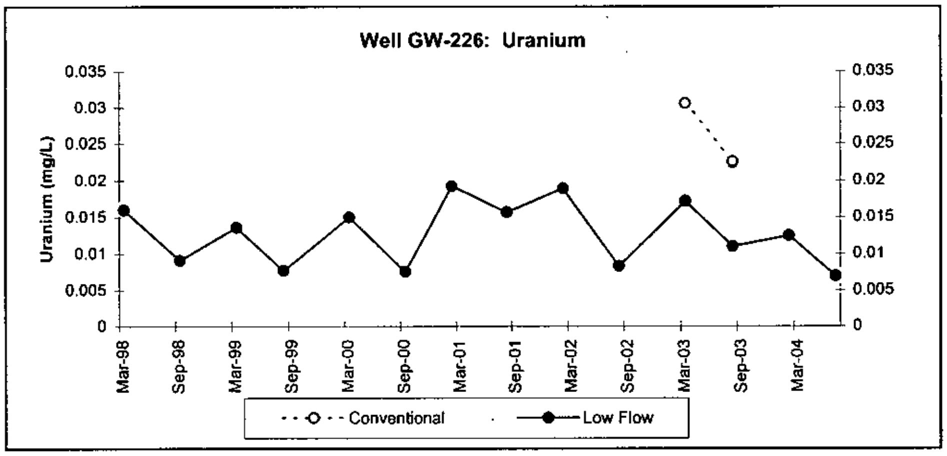


Figure 2

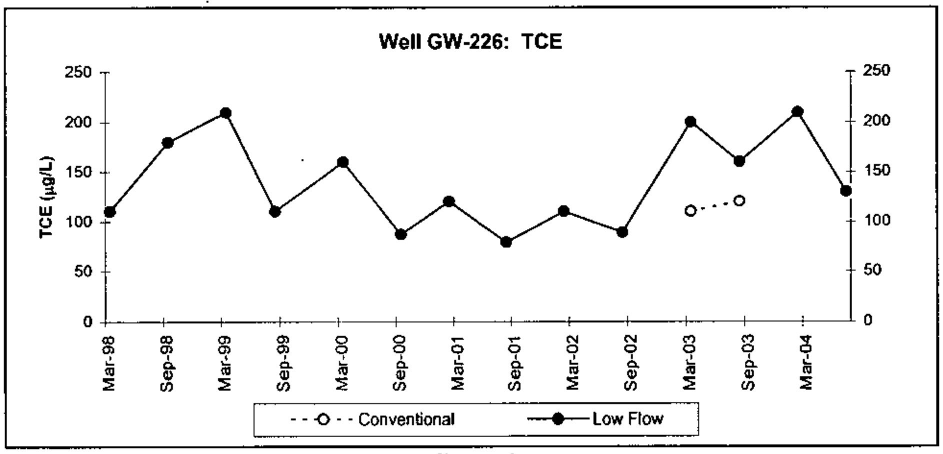


Figure 3

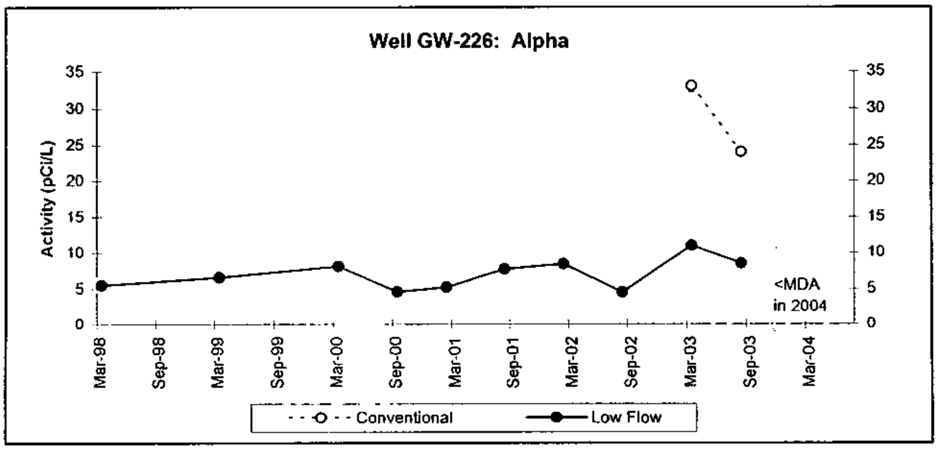


Figure 4

MAXIMUM CONCENTRATION: 2005

<5	0.03 - 0.3	5 - 50	15 - 150	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-227

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,802.00
Y-12 GRID NORTH COORDINATE: 29,172.00
SURFACE ELEVATION: 943.91 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/09/85 PAIRED/CLUSTERED WITH: GW-228
TAG DEPTH (measured): 42.64 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 946.46 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	30.0	913.91
BOTTOM (filter pack or open hole):	40.0	903.91
MIDPOINT (filter pack or open hole):	35.0	908.91
PUMP INTAKE:	34.9	908.96
WATER LEVEL (average):	12.71	931.20

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	29 samples	01/14/86	09/12/92
LOW-FLOW SAMPLING METHOD:	2 samples	03/21/05	09/08/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/21/05	.	09/08/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.64 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

	Results (since 1991) > Screening Level			
Contaminant (screening level)	**# Samp.**	**Maximum**	**Max. Date**	**Long-Term Trend**
NITRATE (10 mg/L):	5	45 mg/L	11/01/91	Decreasing
URANIUM (0.03 mg/L):	8	0.118 mg/L	02/08/91	Decreasing
SUMMED VOCs (5 µg/L):	9	94 µg/L	06/09/92	Indeterminate
GROSS ALPHA (15 pCi/L):	6	28.34 pCi/L	02/08/91	Indeterminate
GROSS BETA (50 pCi/L):	4	80.07 pCi/L	02/08/91	Decreasing

WELL GW-227

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1985, completed with an open-hole monitored interval from 30 to 40 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well is paired with well GW-228 and is located in Bear Creek Valley (BCV) approximately 4,500 ft west of Y-12, south of the main channel of Bear Creek approximately 100 ft directly south of the Oil Landfarm waste management area (WMA). The Oil Landfarm WMA encompasses several closed waste management facilities, including the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 29 samples between January 1986 and September 1992, and the low-flow sampling method used to obtain samples in March and September 2005. The sampling history includes a quarterly sampling frequency, followed by a nearly 13-year period (September 1992 – March 2005) when no samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 13 ft bgs and exhibits maximum seasonal fluctuations of approximately 8 ft. Also, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-227 are typically lower than those evident in well GW-228, which is completed deeper (100 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (55 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.011 – 0.048) within the shallow bedrock interval (from GW-228 to GW-227) during both seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-227 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located along a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 368 – 578 mg/L;
- pH of 6.48 – 7.1 (field measurements);
- elevated levels of chloride (>25 mg/L) and sulfate (>35 mg/L) compared to other wells completed at similarly shallow depths in the Maynardville Limestone;
- low molar proportions of potassium and sodium (<10% of total anions/cations);
- conspicuously high concentrations of iron (>2 mg/L) and manganese (>1 mg/L); and
- total concentrations of other trace metals, except for boron and uranium, that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Many geochemical characteristics of the shallow groundwater in this well differ substantially from those indicated for the groundwater from the deeper flowpaths intercepted by the monitored interval in well GW-228, as illustrated by the following summary of selected field measurements and laboratory analytes reported for groundwater samples collected on contemporaneous dates in March and September 2005. Considering the vertically upward hydraulic gradients noted in Section 3.0, upward migration from the deeper flow system may at least partially account for the elevated levels of chloride in the shallow groundwater, but not the elevated levels of boron and sulfate. Note also the substantial difference between total iron and manganese concentrations reported for the samples from each well. Both wells have steel riser casing and open-hole monitored intervals, and static water levels in each well typically occur within the casing. Thus, the disparity between the iron and manganese concentrations does not appear to be an artifact of well construction, but instead is probably a function of the unusually high levels of dissolved oxygen in the shallower groundwater.

Analyte/Units		**GW-227 (30-40 ft bgs)**		**GW-228 (80-100 ft bgs)**	
		03/21/05	**09/08/05**	**03/21/05**	**09/08/05**
Dissolved Oxygen	ppm	3.88	2.57	0.65	0.32
REDOX	mV	149	68	55	-61
pH	st. units	6.48	6.81	9.48	9.59
Chloride	mg/L	27	28.3	36.8	37.7
Sulfate	mg/L	39	37.7	15.8	15.4
Boron	mg/L	0.128	0.137	<0.01	<0.01
Iron	mg/L	1.88	1.58	0.042	0.57
Manganese	mg/L	1.09	1	0.0231	0.00691

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that each of the principal contaminants except VOCs are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations at or above the analytical reporting limit (Table 1) and most of these samples had concentrations above the drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 4,300 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

Nitrate concentrations detected in all but two of the groundwater samples collected between January 1986 (66.5 mg/L) and September 1992 (35 mg/L), including the historical maximum concentration (77 mg/L in September 1987), substantially exceed the drinking water MCL for nitrate (Table 1). Note that the nitrate result reported for the sample collected in February 1991 (18 mg/L) is considered qualitative because of the ion charge balance error (i.e., the percent difference between respective summed milliequivalent concentrations of the major cations and anions exceeds 20%). Also, the historical data show wide fluctuations in nitrate concentrations, with the highest levels typically observed during seasonally low-flow conditions (summer and fall), as illustrated by the “peak” concentrations evident in September 1987 (77 mg/L; the historical maximum value), July 1988 (61 mg/L), and November 1991 (45 mg/L). This relationship suggests that the changes in nitrate concentrations reflect the seasonal (and episodic) recharge of uncontaminated (or less nitrate-contaminated) groundwater via the flowpaths intercepted by the monitored interval in the well, which is consistent with the low nitrate concentrations evident in March 1987 (36.4 mg/L), February 1990 (9.4 mg/L), and March 1992 (9.77 mg/L). Note, however, that not only are the nitrate concentrations detected in the samples collected most recently (3.56 mg/L in March 2005 and 3.26 mg/L in September 2005) substantially lower than indicated by the previous sampling results, but these concentrations do not suggest substantial seasonal variation.

As noted previously, well GW-227 is paired with well GW-228 and, as illustrated by the selected sampling results summarized below, historical data show that nitrate concentrations were typically lower in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-228, although more recent sampling results show nearly equal concentrations for each well. Thus, considering the upward vertical hydraulic gradients indicated by contemporaneous presampling groundwater elevations in each well, as noted in Section 4.0, nitrate concentrations in the shallower groundwater at well GW-227 do not appear to have been significantly influenced by upward migration of nitrate from the deeper flow system in the Maynardville Limestone.

Nitrate (mg/L)			
GW-227 (30-40 ft bgs)		GW-228 (80-100 ft bgs)	
01/14/86	66.5	01/14/86	19.2
06/23/87	43.8	06/23/87	22.5
04/27/88	45	04/27/88	24
07/27/89	27	07/28/89	27
02/08/90	9.4	02/02/90	37
03/21/05	3.53	03/21/05	2.47

A time-series plot of nitrate concentrations detected in the groundwater samples collected to date shows a widely variable but clearly decreasing long-term trend that spans the nearly 13-year (September 1992 – March 2005) gap in the sampling history for the well (Figure 1). Also, note the decreasing concentrations evident in the deeper groundwater at well GW-228, as illustrated by the data summarized above. The overall decrease from the historical nitrate concentrations is directly attributable to the substantially reduced flux of nitrate in the Maynardville Limestone following the closure/capping of the former S-3 Ponds. Nevertheless, the rate of concentration decrease appears to have slowed considerably, with the most recent sampling results noted above suggesting that the nitrate concentrations may have reached asymptotic levels in the groundwater at this well.

5.2 URANIUM

All of the groundwater samples had uranium concentrations above the applicable analytical reporting limit (Table 1), with the results for all but one of the samples being at or above the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of the well, including the groundwater contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. Additionally, the CERCLA remedial investigation identified the former BYBY, which is located approximately 550 ft east-northeast of the well, as the primary source of uranium in Maynardville Limestone hydraulically downgradient (west) of the Oil Landfarm WMA (DOE 1997). Uranium-bearing wastes in the subsurface at the BYBY were below the seasonally high water table and carbonate dissolved from the limestone bedrock combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility, considering the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area for uranium, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site (above the seasonally high water table); and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site.

Aside from the historical minimum value (0.024 mg/L in November 1991), uranium concentrations reported for all the other groundwater samples collected to date meet or exceed the drinking water MCL (0.03 mg/L), although the historical maximum value (1.66 mg/L in March 1987) is a suspected outlier compared to the other uranium results (Table 1). The uranium concentrations also exhibit significant short-term variability, although the concentration fluctuations do not exhibit any consistent relationship with seasonal flow conditions, as illustrated by the low uranium concentrations reported for samples collected during seasonally high flow (e.g., 0.03 mg/L in February 1990) and seasonally low flow (e.g., 0.098 mg/L in July 1988). Interestingly, the fluctuations in uranium levels often exhibit an inverse relationship with concurrent changes in nitrate concentrations, as illustrated by the selected data summarized below, whereby a short-term increase in uranium is mirrored by a short-term decrease in nitrate. This relationship suggests that there are separate sources for the uranium and nitrate transported via the groundwater flow/transport pathways intercepted by the monitored interval in the well, with the BYBY the presumed principal source of the uranium and the former S-3 Ponds the sole source of nitrate.

Sampling Date	Nitrate (mg/L)	% Change	Uranium (mg/L)	% Change
10/30/87	68	.	0.078	.
04/27/88	45	-34%	0.205	+162%
07/08/88	61	+36%	0.098	-52%
11/11/88	49	-34%	0.238	+143%

As illustrated by the selected sampling results summarized below, total uranium concentrations are substantially lower in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-228. Thus, considering the upward vertical hydraulic gradients noted previously, the elevated concentrations of uranium in the shallower groundwater at well GW-227 probably do not result from upward migration of uranium from the deeper flow system in the Maynardville Limestone. Moreover, the lack of elevated uranium levels in the deeper groundwater, in light of the elevated nitrate concentrations indicated by historical data, again indicates that the uranium and nitrate in the shallow groundwater at well GW-227 do not share a common source area.

Uranium (mg/L)			
GW-227 (30-40 ft bgs)		GW-228 (80-100 ft bgs)	
05/20/86	0.07	05/20/86	0.003
04/27/88	0.205	04/27/88	0.005
02/08/90	0.03	02/02/90	0.005
03/21/05	0.0496	03/21/05	0.00056

A time-series plot of the uranium concentrations (excluding the suspected outlier) shows a decreasing long-term trend dominated by wide temporal fluctuations and the prolonged gap in the sampling history for the well (Figure 2). Additionally, compared to the uranium concentrations evident in June (0.038 mg/L) and September 1992 (0.033 mg/L), the uranium results reported for the samples collected in March (0.0496 mg/L) and September 2005 (0.056 mg/L) suggest a 30 to 70% increase. Assuming the higher concentrations correlate with increased flux of uranium, these results are in direct contrast to the decreasing levels of nitrate, which reflect substantially reduced flux, as noted in Section 5.1, and are somewhat surprising considering that bulk of the uranium-bearing wastes were excavated and removed from the BYBY during the CERCLA remedial action described above. Divergent trends in the relative flux of these contaminants may be at least partially attributable to differential transport in the Maynardville Limestone, but also indicates that the uranium and nitrate probably do not share a common source area.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, benzene, CTET, chloroethane, chloroform, ethylbenzene, methylene chloride (MC), styrene, PCE, toluene, TCE, vinyl acetate, xylenes, 12DCE, 111TCA, and 4-methyl-2-pentaone (4M2P). The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient (east) of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area. Farther downgradient, additional influx of VOCs into the Maynardville Limestone occurs from several potential sources within the Oil Landfarm WMA, including the Oil Landfarm, HCDA, and Sanitary Landfill I (DOE 1997); each of these potential source areas is hydraulically upgradient of well GW-227.

Based on frequency of detection and concentration magnitude, the primary VOC in the groundwater samples is TCE, which is the only VOC detected in all of the samples collected to date (Table 2). All but two of the TCE results exceed the drinking water MCL (5 µg/L) and, excluding a suspected outlier reported for the sample collected in June 1992 (88 µg/L), the results for three samples, including the historical maximum value (82 µg/L in September 1987), exceed 50 µg/L (Table 2). Secondary VOCs detected in the samples are CTET, chloroform, MC, PCE, and 12DCE; of these, only PCE and 12DCE were detected in the samples collected most recently (March and September 2005). The bulk of the analytical results for these compounds, most of which were detected only in the series of samples collected between December 1986 and December 1989, are estimated concentrations below 5 µg/L (Table 2). The remaining compounds were detected in no more than three of the samples, none of which were collected after November 1990, with the bulk of these results being estimated concentrations below 3 µg/L.

As illustrated by the selected sampling results summarized below, TCE concentrations are substantially higher in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-228. Thus, considering the upward vertical hydraulic gradients indicted by the presampling groundwater elevations (see Section 3.0), the concentration of TCE in the shallower groundwater may be at least partially attributable to upward migration of TCE from the deeper flow system in the Maynardville Limestone. Also, the sampling results for these wells indicate that a greater proportional decrease in TCE levels has occurred in the shallower groundwater, which suggests that the most contaminated groundwater has been flushed from the shallow flow system in the Maynardville Limestone.

TCE (µg/L)			
GW-227 (30-40 ft bgs)		**GW-228 (80-100 ft bgs)**	
05/20/86	34	05/20/86	82
04/27/88	22	04/27/88	76
02/08/90	14	02/02/90	78
03/21/05	16	03/21/05	63

Several of the VOCs detected in the groundwater samples collected to date, particularly 11DCA, 11DCE, and 12DCE isomers, are probably present in the groundwater as a result of biologically mediated degradation (sequential dechlorination) of related parent compounds (PCE and 111TCA). However, as illustrated by the data summarized in Table 3, results for selected indicator parameters (particularly dissolved oxygen) suggest that geochemical characteristics of the groundwater in this well generally are not within the optimum range for biotic degradation of chlorinated hydrocarbons. Instead, considering the upward vertical hydraulic gradients noted previously, the presence of the VOC-degradation products in the groundwater at this well may be at least partially attributable to upward migration from the deeper flow system, where geochemical conditions may promote more effective anaerobic degradation, as indicated by the low dissolved oxygen and REDOX values reported for the most recent samples collected from well GW-228 (see data summary included in Section 4.0).

A time-series plot of TCE concentrations detected in the groundwater samples collected to date (excluding the suspected outlier noted above) shows an indeterminate long-term trend dominated by "peak" concentrations in September 1987 (82 µg/L) and July 1988 (68 µg/L) and the prolonged gap in the sampling history for the well (Figure 2). Note that both these TCE results were reported for samples collected during seasonally low flow conditions (summer and fall), whereas low TCE concentrations, such as those reported for the samples collected in March 1987 (10 µg/L) and March 1989 (13 µg/L), often correlate with seasonally high flow conditions (winter and spring). This relationship suggests seasonally variable flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Interestingly, the concentrations of other VOCs detected in the samples do not show any similar fluctuations, as illustrated by the nearly equal PCE concentrations reported for the samples collected in September 1987 (2 µg/L) and March 1989 (1 µg/L). Moreover, the TCE concentrations detected in the samples collected in March 2005 (16 µg/L) and September 2005 (17 µg/L) are the highest since December 1989 (excluding the suspected outlier noted above) and suggest an overall increase from the historical minimum TCE concentration (3 µg/L) evident in February and May 1990 (Figure 3). Assuming a heterogeneous mixture of dissolved VOCs in the groundwater from the shallow karst network in the Maynardville Limestone, it is unclear why the VOC concentrations exhibit such divergent trends. Perhaps the TCE is not well mixed with other VOCs in the groundwater system, but instead occurs within separate, discreet transport pathways intercepted by the monitored interval in the well. As noted in Section 5.2 regarding the suspected sources of nitrate and uranium, the divergent VOC concentration trends potentially reflect separate transport of compounds from different upgradient source areas.

5.4 GROSS ALPHA ACTIVITY

All of the groundwater samples collected since February 1990 (previous results for gross alpha activity do not meet applicable DQOs) had gross alpha activity above the applicable MDA and corresponding CE, and all but four of these results exceed the drinking water MCL for gross alpha activity (Table 1). Uranium isotopes are the source of the gross alpha activity, as indicated by the analytical results for the samples collected in March 2005 (U-234 = 12 pCi/L and U-238 = 17 pCi/L) and September 2005 (U-234 = 11 pCi/L and U-238 = 16 pCi/L). The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the groundwater samples from this well (DOE 1997). As with total uranium (see Section 5.2), U-234 and U-238 ions leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the limestone bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater typical of the Maynardville Limestone (DOE 1997).

Most of the results for gross alpha activity that meet applicable DQOs exceed the drinking water MCL (15 pCi/L), including the historical maximum value (52 pCi/L in October 1990) and the most recent results reported for the samples collected in March (23 pCi/L) and September 2005 (28 pCi/L). Additionally, considering the inherent analytical variability commonly associated with the measurement of gross alpha activity, the results do not suggest wide temporal fluctuations or any consistent relationship with seasonal groundwater flow conditions, although most of the lowest levels of gross alpha activity were reported for samples collected during seasonally low flow conditions (e.g., 8.21 pCi/L in July 1991).

A time-series plot of these results shows a fairly indeterminate long-term trend dominated by the temporal "peak" levels evident in October 1990 (52 pCi/L) and March 1992 (26 pCi/L) and the 13-year gap in the sampling history for the well (Figure 4). Also, as with total uranium concentrations discussed in Section 5.2, the most recent sampling results show higher levels of gross alpha activity than evident during the early 1990s and likewise may indicate an increase in the relative flux of U-234 and U-238 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected since February 1990 (previous results for gross beta activity do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE, and about half of these results (six samples) exceed SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity) (Table 1). Uranium isotopes and associated daughters are the most likely source of the beta activity in the groundwater at the well, as indicated by the U-234 and U-236 results for the samples collected in March and September 2005 (Table 1). Note that the analytical results for several of the samples, including the samples collected in March and September 2005, indicate that Tc-99 may not be present in the groundwater flow/transport pathways intercepted by the monitored interval in the well. This is somewhat surprising in light of the elevated nitrate concentrations indicated by historical data for the well, as discussed in Section 5.1, because Tc-99, a beta-emitting radionuclide, is a "signature" component of the contaminant plume emplaced during operation of the former S-3 Ponds. Also, under the neutral pH conditions typical of groundwater in the Maynardville Limestone, the Tc-99 probably occurs as the pertechnetate anion (TcO_4^-) which, like nitrate, is highly soluble and mobile in the subsurface (Gee et al. 1983).

As noted above, about half of the results for gross beta activity that meet applicable DQOs exceed the SDWA screening level (50 pCi/L), including the historical maximum value (150 pCi/L in October 1990), which appears to be an outlier compared to the other results (Table 1). Also, the most recent results reported for the samples collected in March (16 pCi/L) and September 2005 (15 pCi/L) show substantially lower gross beta activity significantly below the SDWA screening level. A time-series plot of the results for gross beta activity, excluding the suspected outlier noted above, is similar to that of gross alpha activity but shows a decreasing long-term trend dominated by the temporal "peak" levels evident in February 1991 (80 pCi/L) and June 1992 (65 pCi/L) and the nearly 13-year gap in the sampling history for the well (Figure 5).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-227: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	Total Uranium	Gross Alpha	Gross Beta	Tc-99	U-234	U-238
01/14/86	66.5	0.173	DQO	DQO	.	.	.
05/20/86	48.3	0.07	DQO	DQO	.	.	.
09/05/86	67.3	0.086	DQO	DQO	.	.	.
12/16/86	41	0.247	DQO	DQO	.	.	.
03/28/87	36.4	{1.66}	DQO	DQO	.	.	.
06/23/87	43.8	0.152	DQO	DQO	.	.	.
09/01/87	77	0.072	DQO	DQO	.	.	.
10/30/87	68	0.078	DQO	DQO	.	.	.
04/27/88	45	0.205	DQO	DQO	.	.	.
07/08/88	61	0.098	DQO	DQO	.	.	.
09/22/88	54	0.187	DQO	DQO	.	.	.
11/11/88	49	0.238	DQO	DQO	.	.	.
11/21/88	31	0.175	DQO	DQO	.	.	.
03/30/89	28	0.133	DQO	DQO	.	.	.
07/27/89	27	0.124	DQO	DQO	.	.	.
09/25/89	19	0.09	DQO	DQO	.	.	.
12/14/89	22	0.093	DQO	DQO	.	.	.
02/08/90	9.4	0.03	3.16	28.75	< CE	.	.
05/29/90	13.4	0.059	22.45	45.39	.	.	.
08/16/90	16	0.075	23.34	51.91	.	.	.
10/31/90	28	0.196	52.42	{150.09}	.	.	.
02/08/91	[18]	0.118	28.34	80.07	.	.	.
05/12/91	17	0.085	17.04	64.7	.	.	.
08/31/91	20.8	0.034	8.21	49.8	< CE	.	.
11/01/91	45	0.024	9.42	51.7	.	.	.
03/20/92	9.77	0.047	26.1	32.6	.	.	.
06/09/92	33.2	0.038	9.91	64.6	1,600	< CE	2.59
09/12/92	35	0.033	16.8	23.4	< CE	< CE	< CE
03/21/05	3.53	0.0496	23	16	<MDA	12	17
09/08/05	3.26	0.056	28	15	<MDA	11	16
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: "." = Not analyzed; DQO = results do not meet data quality objectives; [ ] = Result considered qualitative because of charge balance; { } = suspected outlier; * = MCL is SDWA screening level for a 4 mrem/yr dose equivalent

Table 2. Well GW-227: summary of VOC results

Sampling Date	VOC (µg/L)					
	PCE	TCE	12DCE	CTET	Chloroform	MC
01/14/86	.	23	7	.	.	.
05/20/86	.	34	.	.	5	.
09/05/86	.	18	.	.	.	.
12/16/86	2 J	18	2 J	.	3 J	1 J
03/28/87	.	10	4 J	.	3 J	1 J
06/23/87	.	35	5	1 J	1 J	.
09/01/87	2 J	82	.	2 J	1 J	3 J
10/30/87	2 J	67	6	2 J	2 J	.
04/27/88	2 J	22	5	0.9	0.8	4 J
07/08/88	.	68	5.67	3 J	2 J	.
09/22/88	2 J	38	.	1 J	1 J	.
11/11/88	1 J	29	5	.	1 J	.
11/21/88	.	19	.	.	0.8	.
03/30/89	1 J	13	4 J	.	0.9	.
07/27/89	.	18	.	.	0.9	.
09/25/89	1 J	17	4 J	.	0.9	1 J
12/14/89	1 J	22	7	.	1 J	.
02/08/90	.	14	.	.	.	.
05/29/90	.	3 J	.	.	.	.
08/16/90	.	3 J	.	.	.	.
11/03/90	.	9	.	.	.	2 J
02/08/91	.	9	.	.	.	.
05/12/91	.	9	.	.	.	.
08/31/91	.	6	.	.	.	.
11/01/91	.	7	.	.	.	.
03/20/92	.	6	.	.	.	.
06/09/92	.	{88}	3 J	2 J	1 J	.
09/12/92	.	7	.	.	.	.
03/21/05	1 J	16	3 J	.	.	.
09/08/05	1 J	17	3 J	.	.	.
MCL	**5**	**5**	**NA**	**5**	**80***	**5**

Sampling Date	OTHER VOCs (µg/L)
12/16/86	Acetone (19), Toluene (2 J)
03/28/87	Chloroethane (1 J)
06/23/87	Toluene (1 J), 111TCA (1 J)
09/01/87	Acetone (10)
04/27/88	Ethylbenzene (2 J), Xylenes (1 J), Styrene (0.7 J), 4M2P (1 J)
09/22/88	111TCA (0.8 J)
07/27/89	Acetone (12), 11TCA (1 J)
11/03/90	Benzene (1 J), Vinyl acetate (2 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; { } = suspected outlier; NA = Not applicable; * = MCL is for total trihalomethanes

Table 3. Well GW-227: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	September 2005
Nitrate	mg/L	<1	3.53	3.26
Iron (II)	mg/L	>1	1.88*	1.58*
Sulfate	mg/L	<20	39	37.7
Dissolved Oxygen	ppm	<0.5	3.88**	2.57**
REDOX	mV	<50	149**	68**
pH	st. units	>5 and < 9	6.48**	6.81**

Note: *Results are for total iron; **Field measurement.

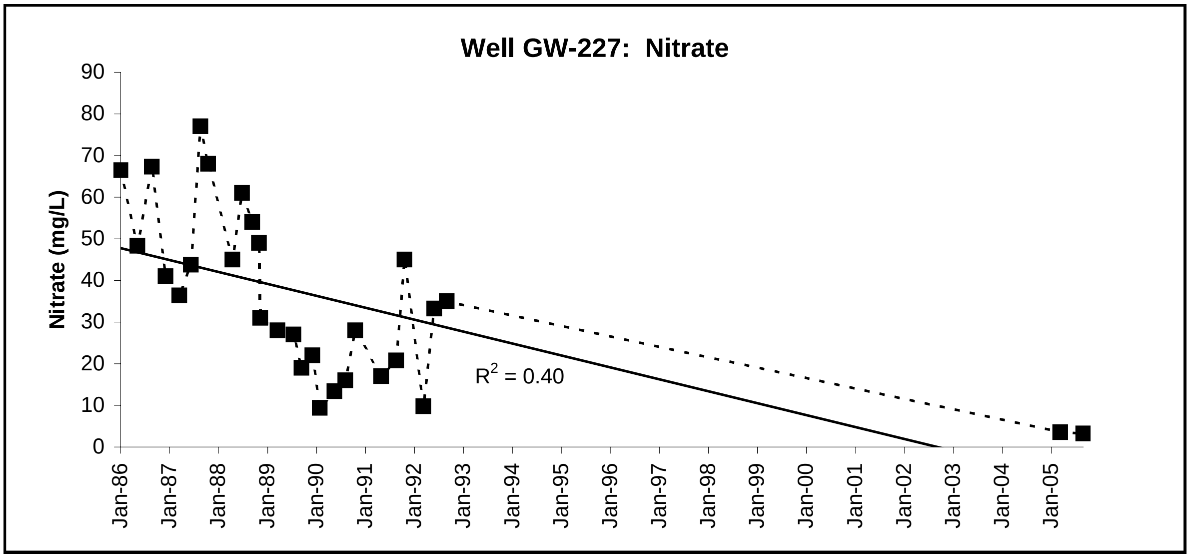


Figure 1

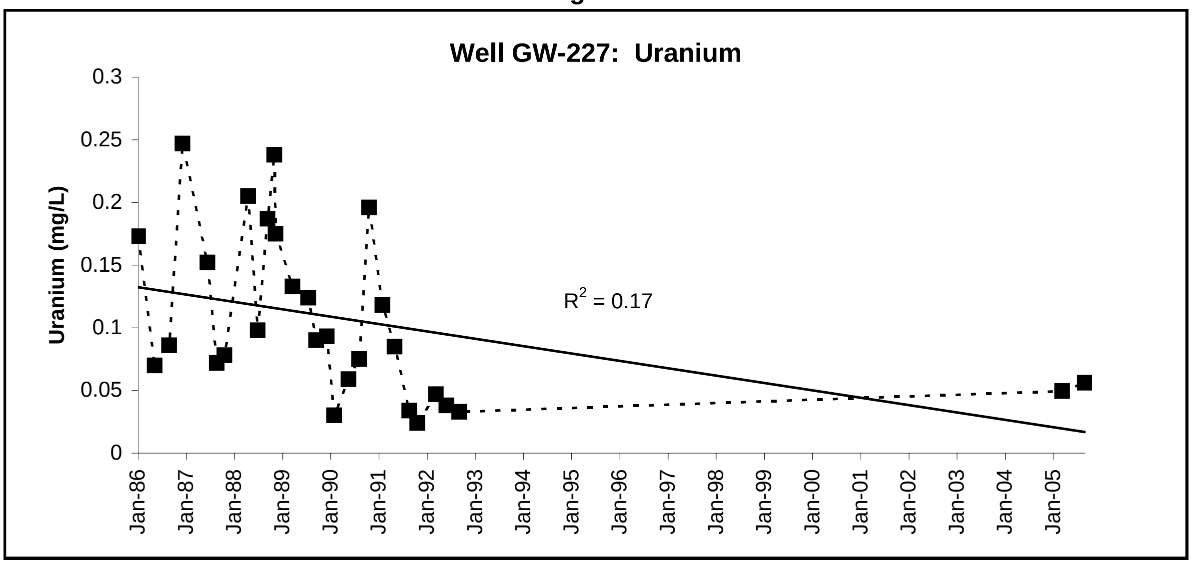


Figure 2

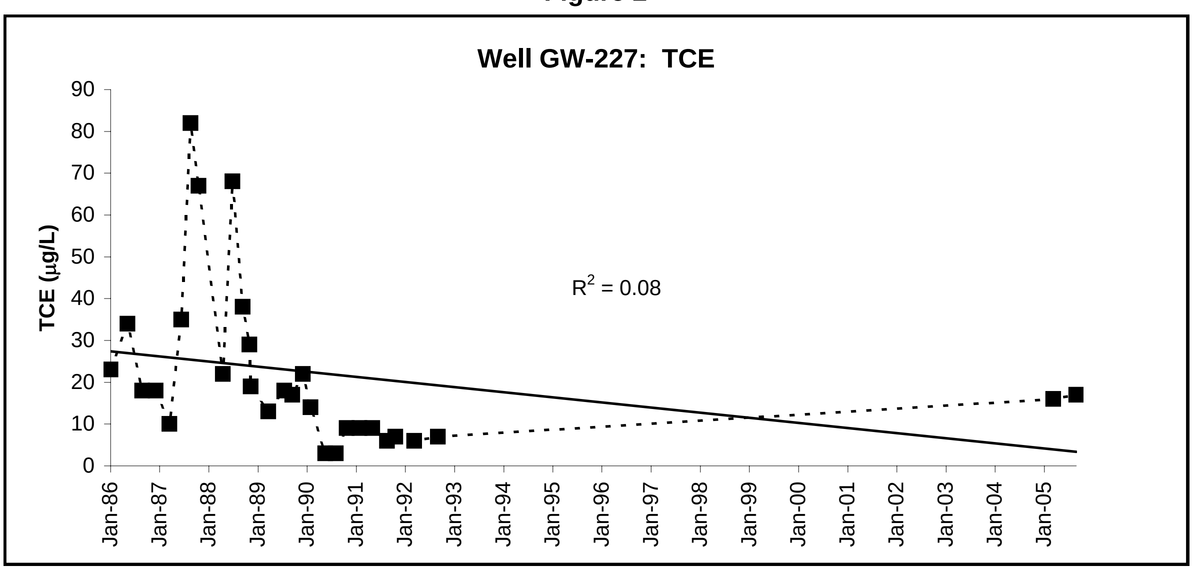


Figure 3

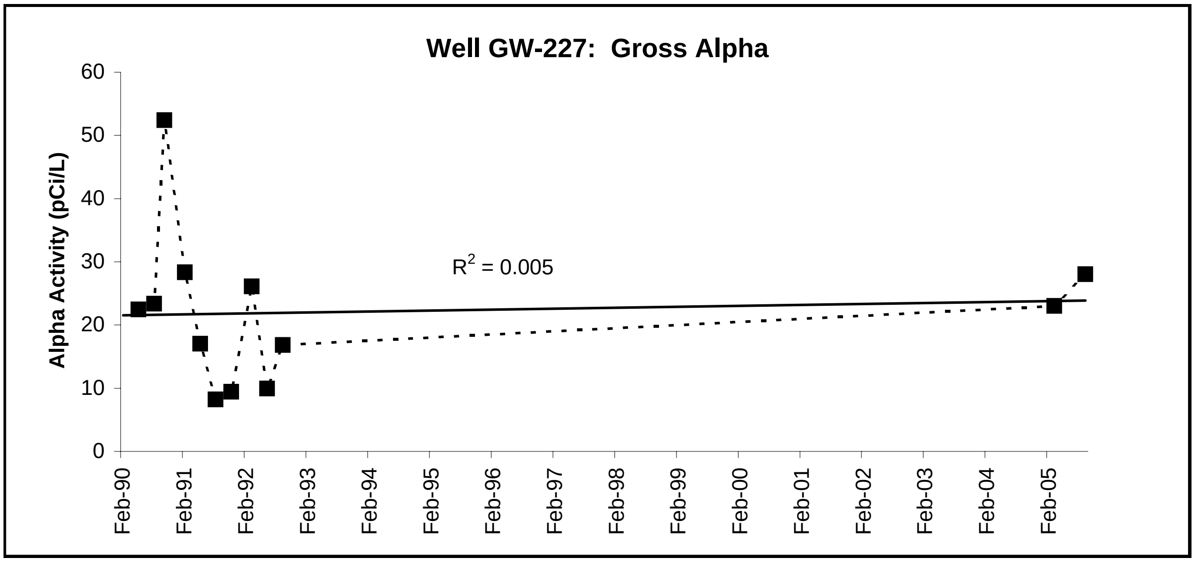


Figure 4

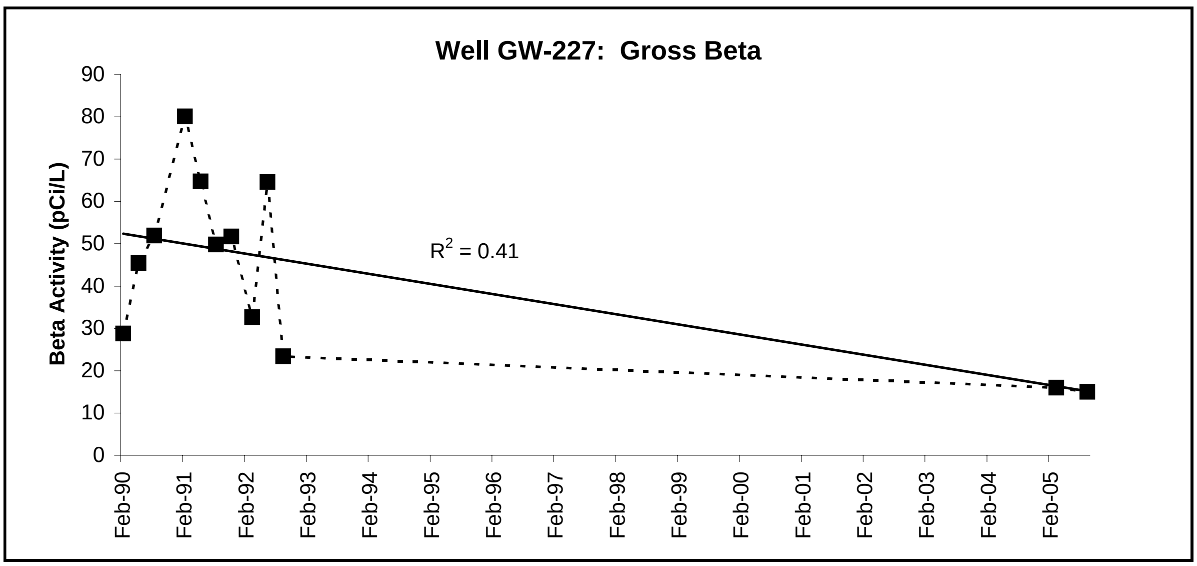


Figure 5

MAXIMUM CONCENTRATION: 2005

<5	<0.015	50 - 500	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-228

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,791.00
Y-12 GRID NORTH COORDINATE: 29,171.00
SURFACE ELEVATION: 943.85 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/23/85 PAIRED/CLUSTERED WITH: GW-227
TAG DEPTH (measured): 93.45 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 946.47 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	80.0	863.85
BOTTOM (filter pack or open hole):	100.0	843.85
MIDPOINT (filter pack or open hole):	90.0	853.85
PUMP INTAKE:	80.9	862.97
WATER LEVEL (average):	12.20	931.65

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	21		
CONVENTIONAL SAMPLING METHOD:	18 samples	01/14/86	09/17/95
LOW-FLOW SAMPLING METHOD:	3 samples	09/09/99	09/08/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/21/05	.	09/08/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.82 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	40 mg/L	09/17/95	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	4	80 μg/L	03/21/05	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-228

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from 80 to 100 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well is paired with well GW-227 and is located in Bear Creek Valley (BCV) approximately 4,500 ft west of Y-12, south of the main channel of Bear Creek approximately 100 ft directly south of the Sanitary Landfill I and the Oil Landfarm waste management area (WMA), which encompasses several closed waste management facilities, including the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between January 1986 and September 1995, and the low-flow sampling method used to obtain three samples between September 1999 and September 2005. The sampling history includes a quarterly sampling frequency followed by 5-year (February 1990 – September 1995) and 6-year (September 1999 – March 2005) periods when no samples were collected from the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of 12 ft bgs and exhibits maximum seasonal fluctuations of approximately 12 ft. Also, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-228 are typically higher than those evident in well GW-227, which is completed shallower (40 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (55 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.011 – 0.048) within the shallow bedrock interval (from GW-228 to GW-227) during seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-228 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located along a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show distinctly different geochemical characteristics coincident with the change from conventional sampling to low-flow sampling. As illustrated by the selected data summarized below, analytical results for the groundwater samples obtained with the conventional sampling method indicate that the well yields moderately mineralized (TDS >500 mg/L) and nitrate-contaminated calcium-magnesium-bicarbonate groundwater with the neutral pH common of most wells completed in the Maynardville Limestone. However, analytical results for the samples subsequently obtained with the low-flow sampling method indicate that the well yields substantially less mineralized groundwater with higher pH and substantially lower calcium, magnesium, and bicarbonate concentrations, but similar concentrations of other major ions, such as chloride and sodium, compared to the conventional sampling results. Moreover, the low TDS of the most recent samples indicates relatively low residence time for the groundwater and implies inflow from highly permeable flowpaths directly connected with shallow karst network in the Maynardville Limestone.

Sampling Method/Date	pH (st. units)	Concentration (mg/L)					
		TDS	Calcium	Magnesium	Bicarbonate	Chloride	Sodium
Conventional Sampling							
02/02/90	7	666	150	42	341	<100	17
09/17/95	7.8	668	110	40	230	43	19
Low-Flow Sampling							
09/09/99	9.16	262	11.7	14.4	26	37.44	18.9
03/21/05	9.48	124	9.44	12.4	52.8	36.8	17.7
09/08/05	9.59	142	8.77	11.3	62.2	37.7	17.7

It is not clear from the available data what may have caused the change in groundwater chemistry. Perhaps the difference in geochemical characteristics is related to inherent differences in the manner in which each sampling method induces flow of groundwater into the well. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce greater relative inflow from water-producing features (i.e., fractures, cavities, conduits) that may not be proximal to the intake for the dedicated sampling pump in the well. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the pump intake, which is located near the midpoint of the open-hole interval in the well. Thus, the low-flow sampling method may induce proportionally greater inflow from highly permeable flowpaths nearest to the pump intake, whereas conventional sampling may induce proportionally greater inflow of more mineralized groundwater from less permeable flowpaths intercepted throughout the monitored (open-hole) interval.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations at or above the analytical reporting limit (Table 1) and most of these samples had concentrations above the drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 4,300 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

Nitrate concentrations detected in all but two of the groundwater samples collected between January 1986 (19.2 mg/L) and September 1995 (40 mg/L; the historical maximum concentration) exceed the drinking water MCL for nitrate (Table 1). Indeed, the only two nitrate results that are below the MCL, reported for samples collected in December 1986 (5.4 mg/L) and November 1987 (1.29 mg/L, the historical minimum concentration), appear to be outliers compared to preceding and subsequent sampling results. Also, aside from these outlier results, the lowest nitrate concentrations were reported for samples obtained using the low-flow sampling method; all previous samples were collected using the conventional sampling method. Thus, the difference between the historical and more recent nitrate concentrations may be attributable to the manner in which each sampling method induces flow of groundwater into the well, as noted for major ions (calcium, magnesium, and bicarbonate) in Section 4.0, rather than a corresponding change in the relative flux of nitrate via the groundwater flowpaths intercepted by the open-hole interval in the well.

As noted previously, well GW-228 is paired with well GW-227 and, as illustrated by the selected sampling results summarized below, historical data show that nitrate concentrations were typically lower in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-228, although more recent sampling results show nearly equal concentrations for each well. Thus, considering the upward vertical hydraulic gradients indicated by contemporaneous presampling groundwater elevations in each well, as noted in Section 4.0, nitrate concentrations in the shallower groundwater at well GW-227 do not appear to have been significantly influenced by upward migration of nitrate from the deeper flow system in the Maynardville Limestone.

Nitrate (mg/L)			
GW-227 (30-40 ft bgs)		**GW-228 (80-100 ft bgs)**	
01/14/86	66.5	01/14/86	19.2
06/23/87	43.8	06/23/87	22.5
04/27/88	45	04/27/88	24
07/27/89	27	07/28/89	27
02/08/90	9.4	02/02/90	37
03/21/05	3.53	03/21/05	2.47

A time-series plot of the nitrate concentrations reported for the groundwater samples collected to date, excluding the suspected outliers noted previously, shows a generally increasing trend between January 1986 (19.2 mg/L) and September 1995 (40 mg/L), with substantially lower concentrations evident after the long gaps in the sampling history for the well (Figure 1). Interestingly, the nitrate concentrations apparently increased for several years after the former S-3 Ponds were closed and capped, whereas nitrate levels in the shallow flow system exhibit more direct responses to the closure/capping of the site (as illustrated by the nitrate results for well GW-227), which probably reflects the substantially higher permeability compared to the groundwater flowpaths in the deeper flow system

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with highest value (0.01 mg/L in January 1986) being less than the drinking water MCL for uranium (0.03 mg/L). Moreover, the most recent results show uranium concentrations only slightly above (0.00056 mg/L in March 2005) or below the analytical reporting limit (September 2005).

As illustrated by the selected sampling results summarized below, total uranium concentrations are substantially lower in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-228. Thus, considering the upward vertical hydraulic gradients noted previously, the elevated concentrations of uranium in the shallower groundwater at well GW-227 probably do not result from upward migration of uranium from the deeper flow system in the Maynardville Limestone. Moreover, the lack of elevated uranium levels in the deeper groundwater, in light of the elevated nitrate concentrations indicated by historical data, again indicates that the uranium and nitrate in the shallow groundwater at well GW-227 do not share a common source area.

Uranium (mg/L)			
GW-227 (30-40 ft bgs)		**GW-228 (80-100 ft bgs)**	
05/20/86	0.07	05/20/86	0.003
04/27/88	0.205	04/27/88	0.005
02/08/90	0.03	02/02/90	0.005
03/21/05	0.0496	03/21/05	0.00056

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, CTET, chloroethane, chloroform, ethylbenzene, methylene chloride (MC), styrene, PCE, toluene, TCE, vinyl acetate, xylenes, 11DCE, 11DCA, 12DCA, 12DCE, 111TCA, and 4-methyl-2-pentaone (4M2P). The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient (east) of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area. Farther downgradient, additional influx of VOCs into the Maynardville Limestone occurs from several potential sources within the Oil Landfarm WMA, including the Oil Landfarm, HCDA, and Sanitary Landfill I (DOE 1997); each of these potential source areas is hydraulically upgradient of well GW-228.

Based on frequency of detection and concentration magnitude, the primary VOC in the groundwater samples is TCE, which is the only VOC that was detected in all of the samples collected to date (Table 2). All but one of the analytical results for TCE exceed 50 µg/L and the most recent results reported for samples collected in March (63 µg/L) and September 2005 (60 µg/L) show that the TCE concentrations remain substantially above the drinking water MCL (5 µg/L). Also, apparent fluctuations in TCE concentrations do not exhibit any clear correlation with seasonal groundwater flow conditions, although many of the lowest TCE concentrations, including the historical minimum concentration (28 µg/L in September 1995), were reported for samples collected during seasonally low flow conditions (summer and fall). However, this may be an artifact of the sampling history for the well, which includes a greater proportion of samples collected during summer and fall. Moreover, both the historical minimum (28 µg/L in September 1995) and maximum (160 µg/L in January 1986) TCE concentrations are suspected outliers compared to the other TCE results, which range between 55 µg/L (September 1995) and 98 µg/L (March 1987).

As shown by the selected sampling results summarized below, historical and recent TCE concentrations detected in the groundwater samples collected to date are substantially higher than evident in the shallower groundwater flow/transport pathways intercepted by the monitored interval in well GW-227. Thus, considering the upward vertical hydraulic gradients indicted by the presampling groundwater elevations, as noted in Section 4.0, the presence of TCE in the shallower groundwater may be at least partially attributable to upward migration of TCE from the deeper flow system in the Maynardville Limestone.

TCE (µg/L)			
GW-227 (30-40 ft bgs)		**GW-228 (80-100 ft bgs)**	
05/20/86	34	05/20/86	82
04/27/88	22	04/27/88	76
02/08/90	14	02/02/90	78
03/21/05	16	03/21/05	63

Secondary VOCs detected in the groundwater samples collected to date, listed in order of decreasing detection frequency, are 12DCE, PCE, 11DCA, chloroform, and 111TCA; of these, only PCE and 12DCE were detected in the samples collected most recently (Table 2). Concentrations of 12DCE are all less than 20 µg/L, although the most recent results (16 µg/L in March and September 2005) show concentrations just slightly below the historical maximum (17 µg/L in July 1988) and demonstrate that the concentrations of 12DCE generally do not exhibit wide seasonal variations. All but seven of the analytical results for chloroform, PCE, 11DCA, and 111TCA are estimated values below 5 µg/L, with the historical maximum concentration of PCE (36 µg/L in January 1986) an obvious outlier compared to the other PCE results (Table 2). The remaining compounds were detected in at least one of a series of samples collected between December 1986 and September 1988, with the bulk of these results being estimated concentrations less than 5 µg/L.

Several of the VOCs detected in the groundwater samples collected to date, particularly 11DCA and 12DCE isomers, are probably present in the groundwater as a result of biologically mediated degradation (sequential dechlorination) of related parent compounds (PCE and 111TCA). As illustrated by the data summarized in Table 3, results for several indicator parameters (particularly the very low dissolved oxygen and negative REDOX conditions) suggest that geochemical characteristics of the groundwater in this well are generally within the optimum ranges for biotic degradation of chlorinated hydrocarbons. Thus, considering the upward vertical hydraulic gradients noted previously, upward migration from the deeper flow system, where geochemical conditions promote more effective anaerobic degradation, is indicated by the low dissolved oxygen and REDOX values reported for the most recent samples collected from well GW-228 (see data summary included in Section 4.0).

A time-series plot of TCE concentrations detected in the groundwater samples collected to date, excluding the suspected outlier results noted above, shows a slightly decreasing long-term concentration trend (Figure 2). Interestingly, other compounds detected in groundwater samples from the well show little change (e.g., PCE) or a slight increase (12DCE) in concentrations over time (Table 2). Assuming a heterogeneous mixture of dissolved VOCs in the groundwater from the shallow karst network in the Maynardville Limestone, it is unclear why the VOC concentrations exhibit divergent trends. Perhaps the TCE is not well mixed with other VOCs in the groundwater system, but instead occurs within separate, discreet transport pathways intercepted by the monitored interval in the well. As noted in Section 5.2 regarding the suspected sources of nitrate and uranium, the somewhat divergent VOC concentration trends potentially reflect separate transport of compounds from different upgradient source areas

5.4 GROSS ALPHA ACTIVITY

Two groundwater samples collected since February 1990 (previous results do not meet applicable data quality objectives) had gross alpha activity above the applicable MDA and corresponding CE, and both of these results (6.36 pCi/L in February 1990 and 7.11 pCi/L in September 1995) are below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Two groundwater samples collected February 1990 (previous results do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE, with these results (48.01 pCi/L in February 1990 and 33.6 pCi/L in September 1995) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-228: summary of results for nitrate and uranium

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)
01/14/86	19.2	0.01
05/20/86	24.4	0.003
09/05/86	15.4	0.002
12/16/86	[5.4]	0.002
03/28/87	17.2	0.007
06/23/87	22.5	0.005
09/02/87	21.6	0.006
11/03/87	[1.29]	0.004
04/27/88	24	0.005
07/18/88	29	0.004
09/22/88	30	0.007
11/21/88	27	0.002
03/07/89	25	0.005
07/28/89	27	0.006
09/25/89	30	0.005
12/14/89	28	0.009
02/02/90	37	0.005
09/17/95	40	0.0077
09/09/99	6.112	<0.0005
03/21/05	2.47	0.00056
09/08/05	2.54	<0.0005
MCL	**10 mg/L**	**0.03 mg/L**
Note: [ ] = suspected outlier		

Table 2. Well GW-228: summary of VOC results

Sampling Date	VOC (µg/L)					
	PCE	**TCE**	**12DCE**	**111TCA**	**11DCA**	**Chloroform**
01/14/86	[36]	[160]	6	.	.	6
05/20/86	.	82	5	.	.	.
09/05/86	.	62	.	.	.	.
12/16/86	1 J	72	5	.	4 J	3 J
03/28/87	2 J	98	4 J	2 J	2 J	.
06/23/87	1 J	89	8	2 J	5	0.9
09/02/87	.	75	9	1 J	4 J	4 J
11/03/87	2 J	76	10	.	5	2 J
04/27/88	2 J	76	7	1 J	4 J	1 J
07/18/88	5	81	17	1 J	5	2 J
09/22/88	2 J	82	9	2 J	4 J	1 J
11/21/88	.	68	.	.	3 J	.
03/07/89	2 J	79	9	1 J	5	2 J
07/28/89	2 J	77	9	1 J	4 J	2 J
09/25/89	1 J	61	8	0.7	3 J	1 J
12/14/89	1 J	60	9	0.8	.	1 J
02/02/90	1 J	78	12	.	4 J	1 J
09/17/95	.	[28]	14	.	.	.
09/09/99	.	55	8	.	.	.
03/21/05	1 J	63	16	.	.	.
09/08/05	.	60	16	.	.	.
MCL	**5**	**5**	**NA**	**200**	**NA**	**80***

Sampling Date	OTHER VOCs (µg/L)
12/16/86	Acetone (15)
03/28/87	Chloroethane (0.9 J), Methylene chloride (1 J), 11DCE (5)
06/23/87	Acetone (16), Toluene (0.9 J)
09/02/87	Acetone (10), Chloroethane (1 J), MC (2 J), 2-Hexanone (1 J)
11/03/87	Acetone (16), Methylene chloride (5), 2-Hexanone (4 J)
04/27/88	CTET (0.6 J), Ethylbenzene (2 J), Xylenes (1 J), Styrene (0.7 J), 4M2P (1 J)
07/28/88	CTET (0.7 J), Toluene (0.6 J)
09/09/88	CTET (2 J), Methylene chloride (0.7 J), 11DCE (0.9 J), 12DCA (0.4 J)

Note: "." = Not detected; J = Estimated value; [ ] = suspected outlier; NA = Not applicable;
* = MCL is for total trihalomethanes

Table 3. Well GW-228: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	September 2005
Nitrate	mg/L	<1	2.47	2.54
Iron (II)	mg/L	>1	0.42*	0.57*
Sulfate	mg/L	<20	15.8	15.4
Dissolved Oxygen	ppm	<0.5	0.65**	0.32**
REDOX	mV	<50	55**	-61**
pH	st. units	>5 and < 9	9.46**	9.59**

Note: *Results are for total iron; **Field measurement.

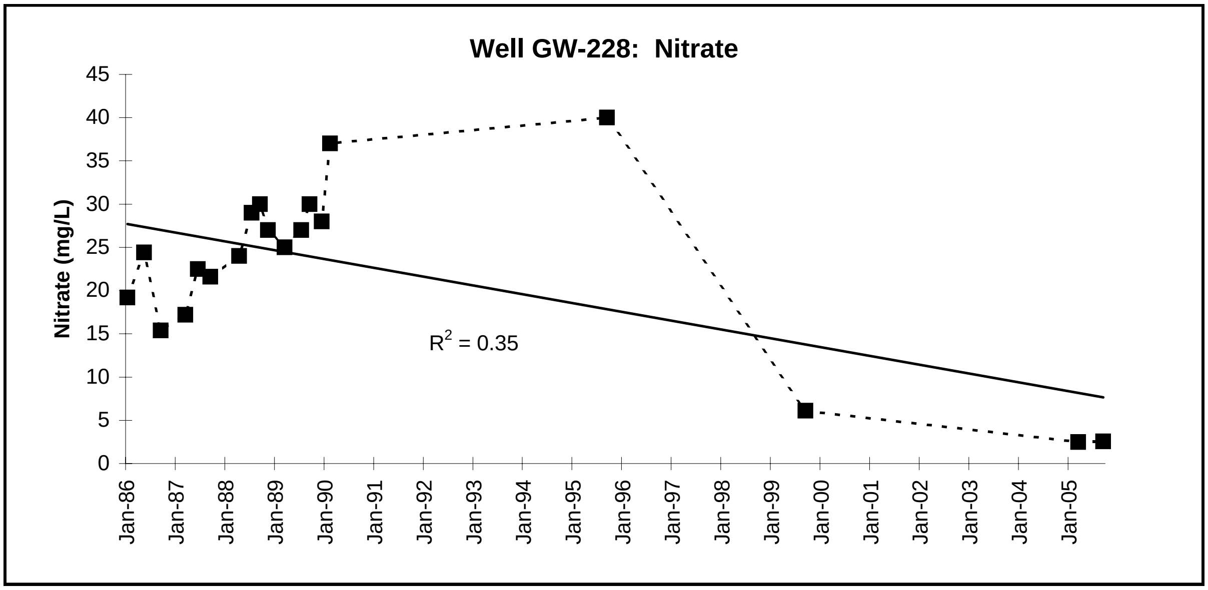


Figure 1

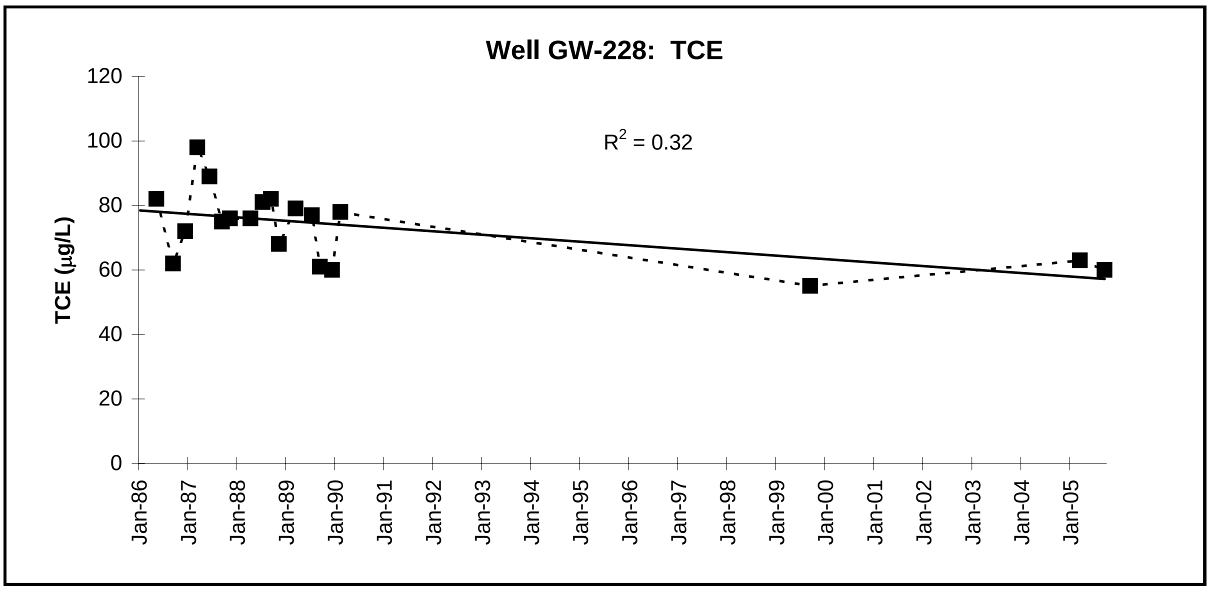


Figure 2

MAXIMUM CONCENTRATION: 2004

ND	0.03 - 0.3	50 - 500	15 - 150	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-229

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,017.00
Y-12 GRID NORTH COORDINATE: 29,256.00
SURFACE ELEVATION: 945.71 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/30/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 51.45 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 949.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	40.0	905.71
BOTTOM (filter pack or open hole):	55.0	890.71
MIDPOINT (filter pack or open hole):	47.5	898.21
PUMP INTAKE:	44.71	901.00
WATER LEVEL (average):	18.4	927.31

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	20 samples	01/14/86	07/29/04
LOW-FLOW SAMPLING METHOD:	6 samples	03/19/02	07/28/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/11/04	.	07/28/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 17.57 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	8	0.266 mg/L	08/12/02	Increasing
SUMMED VOCs (5 μg/L):	8	446 μg/L	07/29/04	Increasing, Indeterminate
GROSS ALPHA (15 pCi/L):	8	150 pCi/L	02/13/03	Increasing
GROSS BETA (50 pCi/L):	5	120 pCi/L	02/13/03	Increasing

WELL GW-229

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with an open-hole monitored interval from 40 to 55 ft bgs, and constructed with nominal 4.5-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) approximately 5,500 ft west of Y-12, near the southwest corner of Sanitary Landfill I and the Oil Landfarm waste management area (WMA), about 100 ft north of the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 20 samples between January 1986 and July 2004, and the low-flow sampling method used to obtain six samples between March 2002 and July 2004. Note the two substantial gaps in the sampling history: a five and one-half year gap between May 1990 and November 1995 and a six and one half-year gap between November 1995 and March 2002.

Monitoring data obtained through August 2003 indicated that groundwater samples obtained with the low-flow sampling method had substantially higher concentrations of several contaminants compared to groundwater samples obtained previously with the conventional sampling method. The higher contaminant concentrations indicated by the more recent low-flow sampling results could reflect a long-term increasing concentration trend (i.e., increased contaminant flux via the groundwater flow/transport pathways intercepted by the monitored interval in the well), but also potentially reflect the relative influence (bias) of each sampling method. In order to confirm if the higher contaminant concentrations are attributable to sampling method bias, "paired sampling" was performed during consecutive days in February and July 2004, whereby samples were collected one day using the low-flow sampling method and the next day using the conventional sampling method. These sampling results show little if any significant difference between conventional and low-flow sampling results for indicator parameters (e.g., pH), major ions, trace metals, and radioanalytes, along with substantial but conflicting differences between summed VOC concentrations (Table 1). Based on review of these results, including the VOC data (see Section 5.3), the higher contaminant concentration now evident in groundwater samples from the well do not appear to be an artifact of the change from conventional sampling to low-flow sampling.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). Additionally, well GW-229 is located northwest of a reach of the main channel of Bear Creek south of Sanitary Landfill I that loses substantial flow to the Maynardville Limestone and greatly facilitates the transfer of surface-water contaminants into Maynardville Limestone (DOE 1997).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 18 ft bgs and exhibits seasonal fluctuations up to about 18 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on

Chestnut Ridge, groundwater elevation isopleths in the vicinity of well GW-226 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 618 – 976 mg/L;
- pH of 6.43 – 6.65 (field measurements, excluding an outlier of 4.38 in February 2003);
- unusually high concentrations of several trace metals, notably barium (>1 mg/L), boron (>4 mg/L), iron (>25 mg/L), manganese (>7 mg/L);
- elevated concentrations of chloride (>100 mg/L) and sodium (>75 mg/L) relative to other wells completed at similarly shallow depths in the Maynardville Limestone;
- low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the chloride and sodium concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well. Also, the elevated chloride levels may be at least partially attributable to the biologically mediated degradation of chlorinated solvents in the groundwater (Hinchee et. al. 1995). Additionally, the unusually high iron and manganese concentrations frequently show a direct correlation with total suspended solids (TSS) in the corresponding samples; these results may be artifacts of the preservation (i.e., acidification below a pH of 2) of turbid unfiltered samples. Indeed, considering the extremely high total iron concentrations reported for several samples (e.g., 27.1 mg/L in February 2003), suspended materials in the unfiltered samples probably include rust particles from the corrosion of the steel riser casing in the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, uranium, VOCs, gross alpha activity, and gross beta activity are the contaminants present at elevated levels in the groundwater at this well.

5.1 NITRATE

None of the groundwater samples collected from the well since January 1986 had nitrate concentrations at or above the analytical reporting limit.

5.2 URANIUM

All of the groundwater samples had uranium concentrations above the applicable analytical reporting limit (Table 2), with the results for nine samples, including the samples collected most recently (February and July 2004), substantially exceeding the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of the well, including the contaminant plume originating from the former S-3 Ponds and recharge of uranium-contaminated surface water in Bear Creek. Nevertheless, the CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 1,200 ft east-northeast of the well. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

Total uranium concentrations reported for all but one of the groundwater samples collected between January 1986 and September 1995 (all of which were obtained with the conventional sampling method) are less than the MCL (0.03 mg/L), ranging from 0.01 mg/L in March 1989 to 0.026 mg/L in August 1987 (Table 2). Conversely, all of the samples obtained since March 2002 (0.238 mg/L), including samples obtained with the conventional sampling method in February and July 2004, substantially exceed the MCL. However, as noted in Section 2.0, the "paired sampling" results do not indicate any significant difference between uranium concentrations in samples obtained with low flow or conventional sampling methods. Thus, the higher uranium concentrations do not appear to be an artifact of the change from conventional sampling to low-flow sampling, but instead may reflect a long-term increase in the relative flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of the uranium results obtained since September 1995 spans a long gap in the sampling history (see Section 2.0), with a long-term increase in uranium concentrations reflected by the conventional sampling results (Figure 1), although the low-flow sampling results suggest a generally downward trend after the historical maximum concentration in August 2002 (0.266 mg/L). Decreasing concentrations of uranium in the groundwater at this well may be a direct response to the CERCLA remedial actions at the BYBY.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following compounds were detected in all of the groundwater samples collected since January 1986 (Table 3): acetone, benzene, chlorobenzene (CB), chloroethane, PCE, TCE, trichlorofluoromethane (TCFM), VC, 111TCA, 11DCA, 11DCE, 12DCE (isomers), 1,4-dichlorobenzene (14DCB), and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113 (F113). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Major plume constituents in the upper part of BCV are acetone, TCE, c12DCE, and PCE. Source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), TCE becomes the primary contaminant in the plume, with major inputs of VOCs from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 μg/L and occur in the deeper groundwater directly south (down dip) of the HCDA, about

1,000 ft east-northeast (hydraulically upgradient) of well GW-229. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing (influent) reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are 12DCE (c12DCE) and VC. Both compounds have been detected the most frequently and at the highest concentrations, with respective historical maximum concentrations of 280 μg/L and 42 μg/L (Table 3). Moreover, the most recent (February and July 2004) sampling results show that concentrations of c12DCE and VC remain substantially above their drinking water MCLs (70 μg/L and 2 μg/L, respectively). Secondary compounds in the samples are benzene, CB, 14DCB, chloroethane, 11DCA, TCE, and 11DCE, which have been detected in all of the samples collected since March 2002. Of these compounds, the highest concentrations have been reported for 11DCE (41 μg/L), TCE (16 μg/L) and CB (14 μg/L), with the most recent sampling results show benzene and 11DCE concentrations above respective MCLs (5 μg/L and 7 μg/L). Other VOCs, including PCE, TCFM, and 111TCA have been detected infrequently and most of the results are estimated values below 5 μg/L (Table 3). Additionally, the most recent sampling results indicate that F113 is present in the groundwater, with three of the four samples analyzed for this compound showing concentrations as high as 44 μg/L.

Biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater probably explains the dominance of c12DCE and VC in the groundwater samples from this well. As illustrated by the data summarized in Table 4, results for several indicator parameters suggest that the geochemical conditions in the groundwater at this well are within the optimum range for biotic degradation (dechlorination) of chlorinated hydrocarbons. The REDOX conditions, for instance, suggest the reducing (methanogenic) conditions necessary to transform 12DCE to VC (Chapelle 1996). Additionally, dissolved hydrocarbons (e.g., benzene) in the groundwater may serve as electron donors necessary to co-metabolic transformation of the chlorinated hydrocarbons in the groundwater (McCarty 1996).

As noted in Section 2.0, "paired" sampling results obtained during February and July 2004 show large proportionate differences between the summed concentrations of VOCs detected in the groundwater samples obtained with the conventional and low-flow sampling methods. As shown in the following data summary, this is primarily attributable to the concentrations of c12DCE, with the highest concentration reported for the sample obtained with the low-flow sampling method in February 2004 and the conventional sampling method in July 2004.

VOC	Concentration (µg/L)			
	Low-Flow Sampling February 11, 2004	Conventional Sampling February 12, 2004	Low-Flow Sampling July 28, 2004	Conventional Sampling July 29, 2004
PCE	.	.	1 J	1 J
TCE	6	3 J	10	16
c12DCE	130	67	140	280
t12DCE	.	.	.	1 J
11DCE	13	6	24	41
VC	42	23	31	18
111TCA	.	.	1 J	6
11DCA	7	4 J	9	8
Chloroethane	2 J	1 J	.	2 J
Benzene	7	9	7	8
Chlorobenzene	13	14	14	11
14DCB	3 J	3 J	4 J	3 J
Acetone	.	.	3	7
F113	6	2 J	15	44
TCFM	6	3 J	.	.
Summed VOCs	235	135	259	446

Note that the "paired" sampling results for other VOCs, with the possible exception of F113, show similar concentrations in samples obtained with low-flow and conventional sampling methods. Assuming a heterogeneous mixture of dissolved VOCs in the groundwater, it is not clear why the sampling method does not similarly influence the concentrations of all VOCs. Moreover, there are insufficient data to ascertain which sampling method provides the most representative monitoring results for VOCs. Nevertheless, the relatively high summed VOC concentrations indicated by the "paired" sampling results confirm the substantial increase from VOC levels evident during the mid-1980s and are primarily attributable to the order-of-magnitude increase in the concentration of 12DCE (Table 3). This suggests a corresponding increase in the relative flux of 12DCE (isomers) via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

Although limited by the intermittent sampling history for this well (see Section 2.0) and the large differences between conventional sampling and low-flow sampling results for 12DCE, respective time-series plots of summed VOC concentrations show increasing trends (Figure 2). Also, the low-flow sampling results do not appear to show any clear response to the CERCLA remedial actions at the BYBY, with the increasing concentration trend evident before and after the remedial actions.

5.4 GROSS ALPHA ACTIVITY

Available data for gross alpha activity, excluding results reported for the groundwater samples collected before September 1995, which do not meet applicable data quality objectives (the MDAs and corresponding CEs were not reported for these results), indicate elevated levels that exceed the drinking water MCL for gross alpha activity (15 pCi/L). Radiochemical results for samples collected in February and July 2004 confirm that uranium isotopes are the most likely source of the gross alpha activity in the groundwater at this well (Table 2). The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the groundwater at the well GW-229

(DOE 1997). As with total uranium (see Section 5.2), U-234 and U-238 ions leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the limestone bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

Results for gross alpha activity that exceed the applicable MDA and corresponding CE range between the historical minimum of 6.13 pCi/L in September 1995 and the historical maximum of 150 pCi/L in February 2003 (Table 2). Also, the "paired" sampling results from February and July 2004 do not indicate any consistent and significant difference between the gross alpha activity detected in samples collected with the conventional and low-flow sampling methods (see Section 2). Additionally, the results for gross alpha activity suggest significant temporal (seasonal) fluctuations, with the lowest values (including the historical minimum) reported for samples collected during seasonally high groundwater flow conditions (winter and spring) and the highest values (including the historical maximum) reported for samples collected during seasonally low groundwater flow (summer and fall). This suggests seasonally increased flux of uranium isotopes along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of the results for gross alpha activity reported for samples collected since September 1995 is similar to that for total uranium (see Section 5.2): the trend spans a long gap in the sampling history with the conventional sampling results demonstrating the overall increase in gross alpha activity and the low-flow sampling results indicating a general decrease from the historical maximum value in February 2003 (Figure 3). Decreasing levels of gross alpha activity potentially correspond to the reduced flux of uranium isotopes as a result of the CERCLA remedial actions at the BYBY.

5.5 GROSS BETA ACTIVITY

There are limited data for gross beta activity because the applicable MDAs and corresponding CEs were not reported for the samples collected before September 1995 (Table 2). Of the nine results for gross beta activity that meet DQOs, five exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). Results of radiological analyses of the groundwater samples collected in February and July 2004 (Table 2) confirm that uranium isotopes (and related beta-emitting daughter products) are the source of the elevated gross beta activity, with the BYBY being the closest and most likely source area. These sampling results also indicate that Tc-99, which is a beta particle-emitting radionuclide considered the "signature" component of the contaminant plume emplaced during operation of the former S-3 Ponds (DOE 1997), is not present in the groundwater at this well (Tc-99 levels were below the applicable MDA for each sample). This is consistent with the lack of nitrate in the groundwater samples from the well (see Section 5.1) because available data indicate that nitrate and Tc-99 from the former S-3 Ponds share similar transport characteristics and nearly identical distribution patterns the Maynardville Limestone west of Y-12 (DOE 1997).

Results for gross beta activity that exceed the applicable MDA and corresponding CE range between the historical minimum of 11 pCi/L in September 1995 and the historical maximum of 120 pCi/L in February 2003 (Table 2). Also, the "paired" sampling results from February and July 2004 do not indicate any consistent and significant difference between the gross beta activity detected in samples collected with the conventional and low-flow sampling methods (see Section 2). Additionally, the results for gross beta activity suggest significant temporal (seasonal) fluctuations that generally mirror those evident for gross alpha activity, with the lowest values (including the historical minimum) reported for samples collected during seasonally high groundwater flow conditions (winter and spring) and the highest values (including the historical maximum) reported for samples collected during seasonally low groundwater flow (summer and fall). This relationship suggests seasonally increased flux of uranium isotopes along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of the results for gross beta activity reported for samples collected since September 1995 generally mirrors that for gross alpha activity (Figure 3): the trend spans a long gap in the sampling history, with the conventional sampling results demonstrating the an overall increase in gross beta activity and the low-flow sampling results suggesting a general decrease from the historical maximum value in February 2003. Decreasing levels of gross beta activity likewise may correspond to the reduced flux of uranium isotopes as (and beta particle-emitting daughter products) a result of the CERCLA remedial actions at the BYBY.

6.0 REFERENCES

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and H. J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-229: Consecutive daily sampling results for summed VOCs and other selected analytes, March and August 2003

Analyte	Units	February 11-12, 2004		July 28-29, 2004	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	Std. units	6.61	6.57	6.71	6.4
Dissolved Solids	mg/L	846	738	941	911
Suspended Solids	mg/L	16	9	22	25
Chloride	mg/L	129	92.3	152	151
Sodium	mg/L	72.1	55.5	82.4	76.4
Barium	mg/L	1.31	1.24	1.41	1.32
Iron	mg/L	25.2	29.6	25.6	27.3
Uranium	mg/L	0.182	0.131	0.206	0.208
Summed VOCs	µg/L	235	135	259	446
Gross Alpha Activity	pCi/L	83	65	71	87
Gross Beta Activity	pCi/L	57	33	53	47

Table 2. Well GW-229: summary of results for gross alpha activity and uranium isotopes

Sampling Method and Date	Concentration (pCi/L)				
	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)	Uranium Isotopes (pCi/L)	
				U-234	U-238
Conventional Sampling					
01/14/86	0.015	<DQO	<DQO	.	.
05/21/86	0.011	<DQO	<DQO	.	.
09/02/86	0.011	<DQO	<DQO	.	.
12/16/86	0.021	<DQO	<DQO	.	.
03/24/87	0.021	<DQO	<DQO	.	.
06/19/87	0.025	<DQO	<DQO	.	.
08/31/87	0.026	<DQO	<DQO	.	.
10/30/87	0.025	<DQO	<DQO	.	.
04/26/88	0.017	<DQO	<DQO	.	.
07/08/88	0.021	<DQO	<DQO	.	.
09/20/88	0.042	<DQO	<DQO	.	.
11/28/88	0.014	<DQO	<DQO	.	.
03/21/89	0.01	<DQO	<DQO	.	.
07/22/89	0.017	<DQO	<DQO	.	.
09/19/89	0.021	<DQO	<DQO	.	.
12/08/89	0.015	<DQO	<DQO	.	.
02/01/90	0.013	<DQO	<DQO	.	.
09/17/95	0.014	6.13	11	.	.
02/12/04	0.131	65	33	19	39
07/29/04	0.208	87	47	34	67
Low-Flow Sampling					
03/19/02	0.238	110	84	.	.
08/12/02	0.266	73	87	.	.
02/13/03	0.248	150	120	.	.
08/12/03	0.214	74	46	.	.
02/12/04	0.182	83	57	25	53
07/29/04	0.206	71	53	25	52
MCL	**15**	**15**	**50***	**NA**	

Note: "." = Not analyzed; NA = Not applicable; <DQO = results do not meet data quality objectives * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 3. Well GW-229: summary of VOC results

Sampling Method and Date	Concentration (µg/L)					
	PCE	TCE	12DCE (total)	c12DCE	11DCE	VC
Conventional Sampling						
01/14/86	.	.	10	NR	.	.
05/21/86	.	.	14	NR	.	17
09/02/86	.	.	30	NR	.	19
12/16/86	.	.	37	NR	.	28
03/24/87	.	4 J	26	NR	1 J	14
06/19/87	.	.	36	NR	.	25
08/31/87	.	3 J	38	NR	1 J	31
10/30/87	.	3 J	52	NR	3 J	16
04/26/88	.	.	.	NR	1 J	25
07/08/88	.	.	53.5	NR	.	18
09/20/88	.	2 J	0.6	NR	4 J	15
11/28/88	.	2 J	0.7	NR	3 J	14
03/21/89	.	.	38	NR	.	19
07/22/89	.	.	27	NR	.	17
09/19/89	.	.	29	NR	.	20
12/08/89	.	.	29	NR	.	35
02/01/90	.	.	20	NR	.	14
09/17/95	.	.	.	NR	.	.
02/12/04	.	3 J	67	67	6	23
07/29/04	1 J	16	281	280	41	18
Low-Flow Sampling						
03/19/02	.	.	110	110	11	37
08/12/02	.	.	100	100	10	40
02/13/03	.	10	170	170	20	29
08/12/03	.	9	160	160	18	21
02/11/04	.	6	130	130	13	42
07/28/04	1 J	10	140	140	24	31
MCL	**5**		**NA**	**70**	**7**	**2**
Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = Not reported						

Table 3 (continued)

Sampling Method and Date	Concentration (µg/L)							
	Benzene	CB	14DCB	11DCA	111TCA	Chloro-ethane	F113	TCFM
Conventional Sampling								
01/14/86	.	.	NR	.	.	.	NR	NR
05/21/86	.	.	NR	.	.	.	NR	NR
09/02/86	.	.	NR	.	.	.	NR	NR
12/16/86	.	.	NR	.	.	.	NR	NR
03/24/87	.	.	NR	.	.	.	NR	NR
06/19/87	.	.	NR	.	.	.	NR	NR
08/31/87	.	.	NR	.	.	.	NR	NR
10/30/87	.	.	NR	.	.	.	NR	NR
04/26/88	.	.	NR	.	.	.	NR	NR
07/08/88	.	.	NR	.	.	.	NR	NR
09/20/88	.	.	NR	.	.	.	NR	NR
11/28/88	.	.	NR	.	.	.	NR	NR
03/21/89	.	.	NR	.	.	.	NR	NR
07/22/89	.	.	NR	.	.	.	NR	NR
09/19/89	.	.	NR	.	.	.	NR	NR
12/08/89	.	.	NR	.	.	.	NR	NR
02/01/90	.	.	NR	.	.	.	NR	NR
09/17/95	.	.	NR	.	.	.	NR	NR
02/12/04	9	14	3 J	4 J	.	1 J	2 J	2 J
07/29/04	8	11	3 J	8	6	2 J	44	.
Low-Flow Sampling								
03/19/02	8	8	.	6	.	2 J	NR	.
08/12/02	6	7	3 J	6	.	2 J	NR	.
02/13/03	9	10	3 J	7	2 J	2 J	NR	.
08/12/03	7	11	4 J	6	2 J	2 J	NR	.
02/11/04	7	13	3 J	7	.	2 J	6	6
07/28/04	7	14	4 J	9	1 J	.	15	.
MCL	**5**	**NA**	.					

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = Not reported

Table 4. Well GW-229: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	February 2004		July 2004	
			LF	CONV	LF	CONV
Nitrate	mg/L	<1	<0.02	<0.02	<0.02	<0.02
Iron (II)	mg/L	>1	25.2*	29.6*	25.6*	27.3*
Sulfate	mg/L	<20	15.7	10.7	16.6	19.4
Dissolved Oxygen	ppm	<0.5	<0.4**	0.55**	1.21**	0.43**
REDOX	mV	<50	-75**	-56**	-85**	-48**
pH	st. units	>5 and < 9	6.61**	6.57**	6.71**	6.4**

Note: LF = Low flow sampling method; CONV = Conventional sampling method; *Results are for total iron; **Field measurement.

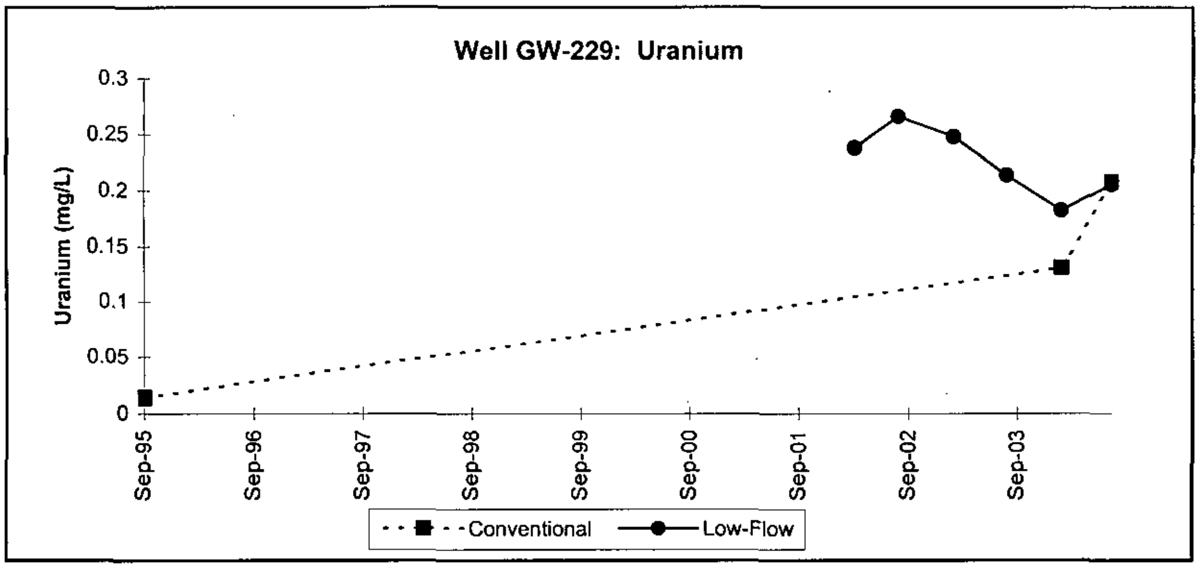


Figure 1

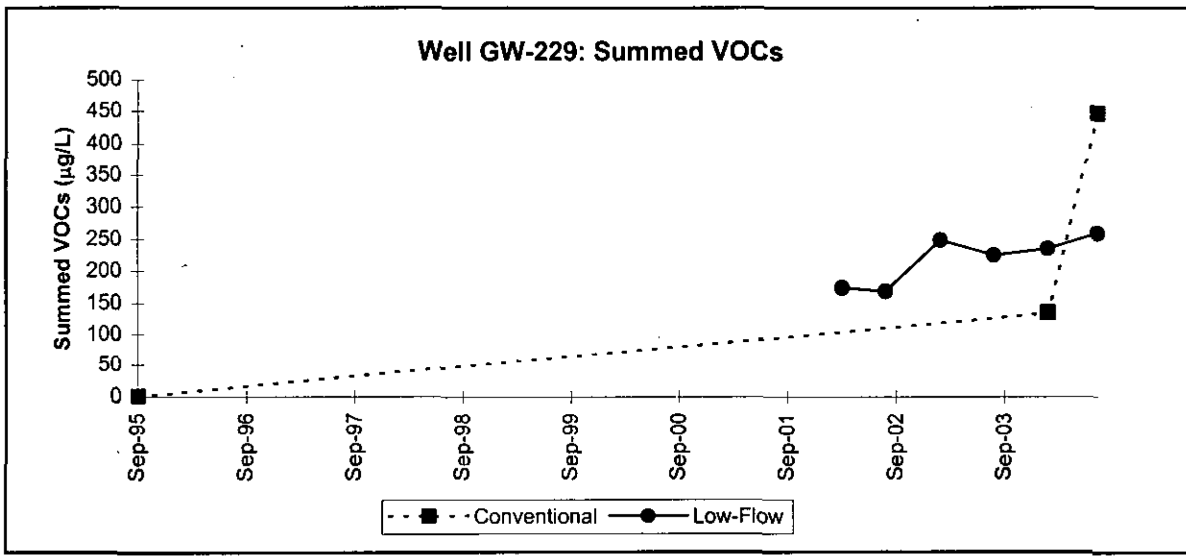


Figure 2

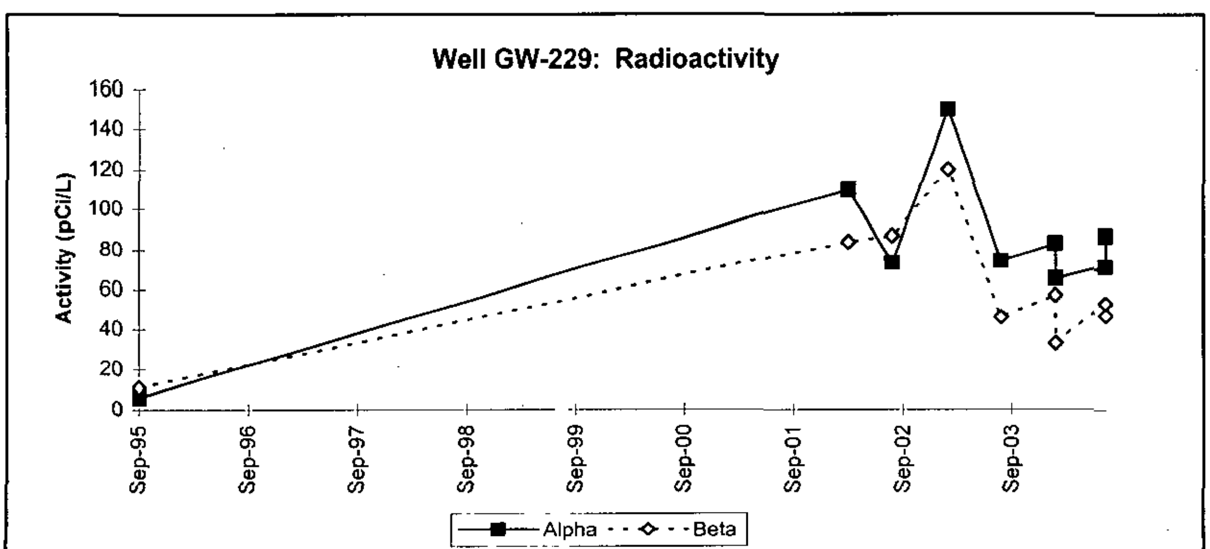


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	5 - 50	.	.

GW-230

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 69,616.86
Y-12 GRID NORTH COORDINATE: 28,388.20
SURFACE ELEVATION: 919.57 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/12/86 PAIRED/CLUSTERED WITH: GW-171 GW-172
TAG DEPTH (measured): 409.48 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 923.11 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 5.5 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	341.0	578.57
BOTTOM (filter pack or open hole):	406.4	513.17
MIDPOINT (filter pack or open hole):	373.7	545.87
PUMP INTAKE:	383.46	536.11
WATER LEVEL (average):	11.63	907.94

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	24		
CONVENTIONAL SAMPLING METHOD:	10 samples	06/06/90	04/15/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/17/98	08/09/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/10/04	.	08/09/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.09 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	22	29 µg/L	01/29/01	Indeterminate
GROSS ALPHA (15 pCi/L):	1	46.34 pCi/L	08/07/02	Outlier
GROSS BETA (50 pCi/L):	2	2,560.37 pCi/L	08/07/02	Outlier

WELL GW-230

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1986, completed with an open-hole monitored interval from 341 to about 406 ft bgs, and constructed with nominal 5.5-inch diameter steel (SF25) riser casing. The well forms a cluster with wells GW-171 and GW-172 and is located in Union Valley east of Y-12, about 4,300 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between June 1990 and April 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the deep bedrock interval in the Conasauga Group (Maynardville Limestone). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits moderate (<14 ft) seasonal fluctuations. Presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically less than 1 to 4 ft lower in well GW-230 than in wells GW-171 and GW-172, both of which are completed at shallower depths (31 ft bgs and 105 ft bgs, respectively) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate primarily downward vertical hydraulic gradients (0.01 - 0.05) during seasonally high and low flow conditions.

There are insufficient monitoring wells located in the vicinity of well GW-230 to ascertain the groundwater flow direction(s). Local topography and the characteristics of groundwater flow in the Maynardville Limestone suggest flow towards drainage features located east and west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 380 – 649 mg/L;
- pH of 6.2 – 7.4 (field measurements);
- high chloride concentrations (>100 mg/L);
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Considering the depth of the well, the high chloride concentrations in the groundwater samples may reflect the natural geochemical changes related to greater residence time as a consequence of increased fracture spacing and decreased fracture aperture at depth (Solomon et al. 1992). Additionally, the elevated chloride levels may be at least partially attributable to biologically mediated degradation (dechlorination) of dissolved chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). Moreover, as illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical characteristics of the groundwater, particularly the REDOX conditions, are conducive to biotic degradation of VOCs (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Ten groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (1.7 mg/L in August 2000) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Only eight of the groundwater samples were analyzed for uranium; none had concentrations above the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in at least one of the groundwater samples: acetone, benzene, bromomethane, chloromethane, total xylene, toluene, chlorobenzene, 12DCE (total), c12DCE, and VC (Table 2). Most of these compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 800 ft west of Scarboro Road; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The principal VOCs in the groundwater samples are c12DCE and VC; one or both compounds were detected in all but one of the samples since 1994 (Table 2). Relatively low concentrations of both compounds have been reported, with historical maximum values of only 22 μg/L for (total) 12DCE and 7 μg/L for VC. Also, the most recent monitoring results show that the c12DCE concentrations remain substantially below the drinking water MCL, and VC was detected only once (2 μg/L in February 2004) in the last four samples (Table 2). Secondary VOCs include chlorobenzene and petroleum hydrocarbons (benzene, total xylene, and toluene). Trace levels (1 μg/L) have been detected in 5 samples, including the most recent samples. Petroleum hydrocarbons have been detected in seven of the samples; all results for the petroleum hydrocarbons are estimated values below analytical reporting limits. The persistent detection of these compounds in the groundwater samples is surprising because petroleum hydrocarbons are not principal components of the dissolved VOC plume in the Maynardville Limestone hydraulically upgradient (west) of the well. Also, residual contamination during installation and construction of the well may be a source of the petroleum hydrocarbons, but this seems somewhat unlikely considering the age of the well and the likelihood for residual contamination to have been "flushed" from the well during subsequent well development and sampling.

A plot of the summed concentrations of VOCs detected each groundwater sample shows a fluctuating, indeterminate trend (Figure 1). This indeterminate trend probably reflects limited flux at this depth (>400 ft bgs) in Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (46.34 pCi/L in August 2002) exceeds the drinking water MCL for gross alpha activity (15 pCi/L). However, gross alpha activity reported for this sample is considered to be an outlier. The inconsistent detection of gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0)

5.5 GROSS BETA ACTIVITY

Fourteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, and the results for two of these samples (57.5 pCi/L in August 2001 and 2,560 pCi/L in August 2002) exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). However, the gross beta activity reported for these samples are suspected outliers compared to the other gross beta results, only one of which exceeds 10 pCi/L. As with the gross alpha activity, the inconsistent detection and widely variable results for gross beta activity may be related to analytical interference associated with the high TDS of the (unfiltered) groundwater samples (see Section 4.0)

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee,* DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

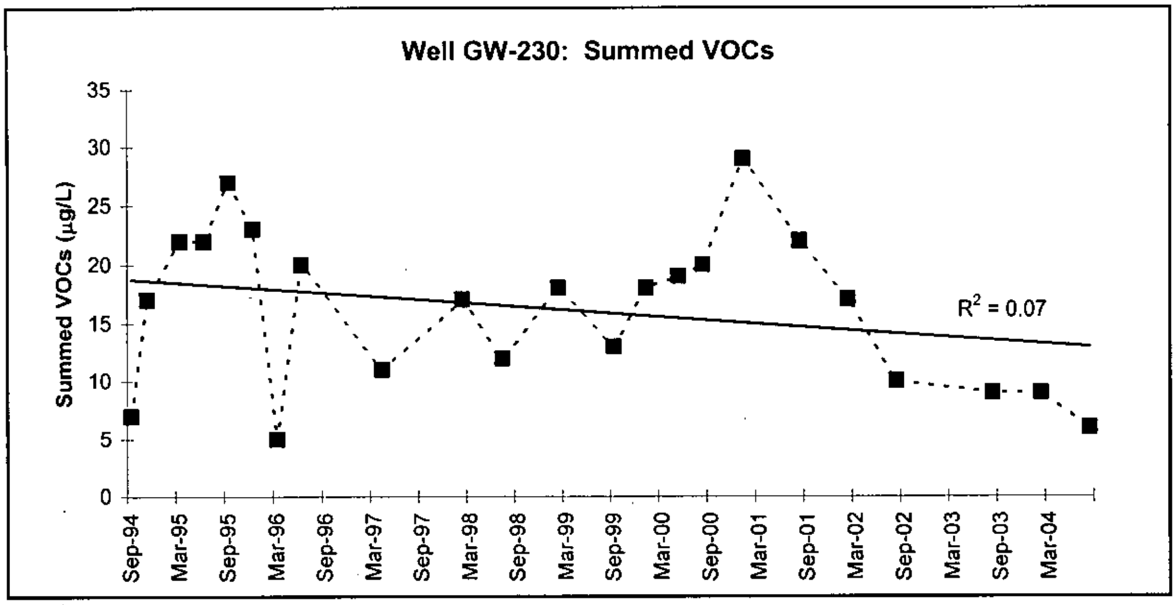
Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-230: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		February 2002	July 2002	August 2003
Nitrate	<1 mg/L	0.024	0.2	0.6
Iron (II)	>1 mg/L	3.83*	1.42*	0.3*
Sulfate	<20 mg/L	1.3	1	<0.2
Dissolved Oxygen	<0.5 ppm	0.5*	1.38*	0.2*
REDOX	<50 mV	-94*	-122*	-228*
pH	>5 and <9 st. units	6.97*	6.7*	7.41*
Note: * Field measurement				

Table 2. Well GW-230: summary of VOC results

Date Sampled	VOC Concentration (µg/L)					
	Total 12DCE	**c12DCE**	**VC**	**Toluene**	**Benzene**	**Chlorobenzene**
09/28/94	6	NR	.	1 J	.	.
11/15/94	17	NR	.	.	.	.
03/15/95	18	NR	4 J	.	.	.
06/15/95	17	NR	5	.	.	.
09/20/95	22	NR	5	.	.	.
12/13/95	19	NR	4 J	.	.	.
03/11/96	.	NR	5	.	.	.
06/18/96	13	NR	4 J	3 J	.	.
04/15/97	11	NR	.	.	.	.
02/17/98	15	NR	.	2 J	.	.
07/22/98	11	NR	.	1 J	.	.
02/11/99	12	12	2 J	1 J	.	.
09/01/99	4 J	4 J	1 J	.	.	.
01/20/00	13	13	4	.	1 J	.
05/17/00	15	15	4	.	.	.
08/08/00	13	13	4	1 J	1 J	1 J
01/29/01	22	22	7	.	.	.
08/01/01	17	17	5	.	.	1 J
02/05/02	13	13	4	.	.	1 J
08/07/02	10	10	.	.	.	.
08/19/03	9	9	.	.	.	.
02/10/04	6	6	2	.	.	1 J
08/09/04	5 J	5 J	.	.	.	1 J
MCL	**NA**	**70**	**2**	**1,000**	**5**	**100**
Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported						



Well GW-230: Summed VOCs
Summed VOCs (µg/L)
35
30
25
20
15
10
5
0
$R^2 = 0.07$
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	<7.5	<25

GW-231

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Kerr Hollow Quarry
Y-12 GRID EAST COORDINATE: 63,410.00
Y-12 GRID NORTH COORDINATE: 24,725.00
SURFACE ELEVATION: 846.90 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/02/85 PAIRED/CLUSTERED WITH: GW-147
TAG DEPTH (measured): 37.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 849.67 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	22.8	824.10
BOTTOM (filter pack or open hole):	35.0	811.90
MIDPOINT (filter pack or open hole):	28.9	818.00
PUMP INTAKE:	28.73	818.17
WATER LEVEL (average):	11.87	835.03

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	97		
CONVENTIONAL SAMPLING METHOD:	53 samples	03/07/86	08/07/97
LOW-FLOW SAMPLING METHOD:	44 samples	11/10/97	10/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/08/04	.	10/11/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.36 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

	Results (since 1991) > Screening Level			
Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	10 µg/L	11/06/95	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-231

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 22.8 to 35 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and screen (0.01 slot). The well forms a cluster with well GW-147 and is located on the southern flank of Chestnut Ridge directly south of the east end of Y-12, about 100 ft west-northwest (hydraulically upgradient) of Kerr Hollow Quarry (KHQ). KHQ is an inactive, water-filled quarry formerly used for disposal of various hazardous and nonhazardous wastes generated from historical DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ninety-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 53 samples between March 1986 and August 1997, and the low-flow sampling method used to obtain 44 samples between November1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group (Mascot Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibit moderate (<10 ft) water level fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically higher in well GW-231 than in well GW-147, which is completed at a greater depth (69 ft bgs) in the Knox Group. Based on the distance (30 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.004 – 0.033) from well GW-231 to GW-147 during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 90 – 322 mg/L;
- pH (field measurements) of 6.4 – 8.1;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 78 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Forty-two groundwater samples collected between March 1991 and April 1999 had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.79 mg/L in April 1996) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Seven groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.004 mg/L in October 2001) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples: 2-butanone (10 μg/L) in November 1995, TCE (3 μg/L) in April 1998, and chloromethane (1 μg/L) in October 2000. These results are considered outliers because each compound was detected only once.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.45 pCi/L in October 2000) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty-four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.53 pCi/L in October 2003) being substantially below the SDWA for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	.	<5	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-232

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Union Valley
Y-12 GRID EAST COORDINATE: 66,863.00
Y-12 GRID NORTH COORDINATE: 28,546.00
SURFACE ELEVATION: 929.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/27/86 PAIRED/CLUSTERED WITH: GW-169 GW-170
TAG DEPTH (measured): 412.88 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 931.39 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 6.62 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 4.38 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	401.0	528.52
BOTTOM (filter pack or open hole):	411.7	517.82
MIDPOINT (filter pack or open hole):	406.4	523.17
PUMP INTAKE:	404.13	525.39
WATER LEVEL (average):	30.68	898.84

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	22 samples	06/08/90	04/15/97
LOW-FLOW SAMPLING METHOD:	24 samples	02/26/98	10/25/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	04/20/04	08/09/04	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.37 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	45 µg/L	05/16/91	Outlier
GROSS ALPHA (15 pCi/L):	1	81.3 pCi/L	11/07/01	Outlier
GROSS BETA (50 pCi/L):	1	365.61 pCi/L	11/07/01	Outlier

WELL GW-232

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1986, completed with an open-hole monitored interval from 401 to 411.7 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well forms a cluster with wells GW-169 and GW-170, and is located in Union Valley east of Y-12, about 1,500 ft east of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 22 samples between June 1990 and April 1997, and the low-flow sampling method used to obtain 24 samples between February 1998 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (>400 ft bgs) in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 31 ft bgs and exhibit moderate (<10 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 430 – 620 mg/L, excluding a suspected outlier (176 mg/L) in August 1994;
- pH (field measurements) of 8.1 – 11.7;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 45 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Nine groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.6 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.001 mg/L in August 1993 and February 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples: acetone (45 μg/L) in May 1991, toluene (0.6 μg/L) in November 2002, and acetone (2 μg/L) in October 2004. These VOCs are common laboratory reagents and the results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (81.3 pCi/L in November 2001) being substantially above the MCL for gross alpha activity (15 pCi/L). However, this gross alpha result is considered an outlier (none of the other results exceed 10 pCi/L) and is probably an analytical artifact.

5.5 GROSS BETA ACTIVITY

Sixteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (365.61 pCi/L in November 2001) being substantially above the SDWA screening level for gross beta activity (50 pCi/L). However, this gross beta result is considered an outlier (none of the other results exceed 15 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	<5	ND	50 - 500
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-236

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 50,453.00
Y-12 GRID NORTH COORDINATE: 29,712.00
SURFACE ELEVATION: 980.39 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/16/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 21.14 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 983.21 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	10.0	970.39
BOTTOM (filter pack or open hole):	18.5	961.89
MIDPOINT (filter pack or open hole):	14.3	966.14
PUMP INTAKE:	15.68	964.71
WATER LEVEL (average):	8.49	971.91

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	11		
CONVENTIONAL SAMPLING METHOD:	8 samples	04/05/88	09/16/95
LOW-FLOW SAMPLING METHOD:	3 samples	09/08/99	08/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/08/04	.	08/18/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.53 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

	Results (since 1991) > Screening Level			
Contaminant (screening level)	**# Samp.**	**Maximum**	**Max. Date**	**Long-Term Trend**
NITRATE (10 mg/L):	4	65 mg/L	09/16/95	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	1	7 µg/L	09/16/95	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	4	97.5 pCi/L	09/16/95	Decreasing

WELL GW-236

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1985, completed with a screened monitored interval from 10 to about 19 ft bgs, and constructed with nominal 4.5-inch outside diameter PVC (#40) riser casing and well screen (0.01 slot spiral-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, on the north side of Bear Creek approximately 1,700 ft west-southwest of the former S-3 Ponds. This site consists of four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplace a large heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains one of the primary sources of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eleven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eight samples between April 1988 and September 1995, and the low-flow sampling method used to obtain samples in September 1999, March 2004, and August 2004. The sampling history includes quarterly, semiannual, and annual sampling frequencies that encompass three extended non-sampling periods: March 1990 – September 1995; October 1995 – September 1999; and October 1999 – March 2004.

Low pH is a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and (along with elevated nitrate concentrations) are a consequence of contamination associated with historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). Based on the depth of the well and its location relative to the (projected) geologic contact between the Maynardville Limestone and the underlying Nolichucky Shale, the monitored interval in the well potentially intercepts groundwater flow/transport pathways within the highly permeable zone near the bottom of the formation.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits minor seasonal fluctuations (<4 ft). Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the well indicate flow to the west, parallel with geologic strike of the Maynardville Limestone and the main channel of Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the samples collected from the well indicate that the well yields acidic, moderately mineralized, nitrate- and sulfate-enriched (contaminated) calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 422 – 1476 mg/L;
- pH (field measurements) of 4.2 – 5.6;
- elevated concentrations of nitrate and sulfate (e.g., 63.5 and 83 mg/L, respectively, in March 2004);
- low molar proportions of chloride, potassium, and sodium (<15% of total anions/cations);
- unusually high total concentrations of manganese (>2 mg/L);
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate and gross beta activity are principal contaminants currently in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1). Concentrations above 300 mg/L were reported for all but one of the samples collected between April 1986 (1,470 mg/L) and April 1991 (421 mg/L). Note that the latter result is qualitative because of an unacceptably high charge balance error (-36.4%), as determined by the percent difference between the summed millequivalent concentrations of the primary anions and cations. The source of the nitrate is the contaminant plume emplaced during historical operation of the former S-3 Ponds. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds. Based on the existing network of monitoring wells in the Maynardville Limestone in BCV west of Y-12, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater indicate: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) than the deeper bedrock and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations in the groundwater samples range from the historical maximum value (1,470 mg/L), which was reported for the initial groundwater sample collected from the well in April 1988, and the historical minimum value (33 mg/L in March 1989), which appears to be an outlier compared to the nitrate concentrations reported samples collected in November 1988 (362 mg/L) and May 1989 (805 mg/L). Additionally, the nitrate results reflect a clearly decreasing long-term concentration trend, with a significant decrease evident between March 1990 (421 mg/L [qualitative]) and September 1995 (65 mg/L) and fairly stable concentrations since September 1995 (Table 1). The decreasing trend follows installation of the low-permeability cap at the former S-3 Ponds during RCRA closure of the site in 1988, and reflects the substantial reduction in the relative flux of nitrate along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

All but one of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with four results, including the historical maximum concentration (0.051 mg/L in June 1988), being above the MCL for uranium (0.03 mg/L). Elevated levels of uranium in the groundwater samples from this well result from downgradient migration/transport of uranium from the contaminant plume emplaced during historical operation of the former S-3 Ponds. Uranium was entrained in the nitric acid wastes disposed at the site and is a primary component of the S-3 Ponds contaminant plume. The extent of uranium migration/transport from the plume is largely controlled by the pH of the groundwater. Within the acidic groundwater near the former surface impoundments, uranium is probably present as uranyl cations that tend to form complexes with a wide variety of inorganic anions (Fetter 1993). This well yields groundwater samples with low pH (see Section 4.0), and the pH has generally increased since the late 1980s. For example, the lowest value (3.8, field measurement) was obtained in September and November 1988 and the range of pH in the CY 2004 samples was 5.16 to 5.57.

As with the nitrate, the uranium results have shown a clearly decreasing long-term trend, with a significant decrease evident between March 1990 (0.045 mg/L) and September 1995 (0.0096 mg/L) and fairly stable concentrations since September 1995 (Table 1). None of the samples collected since March 1990 have exceeded the MCL for uranium. The decreasing trend reflects the substantial reduction in the relative flux of uranium along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: PCE, toluene, 11DCA, 11DCE, and 111TCA (Table 2). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the several source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV, where well GW-236 is located, are TCE, c12DCE, and PCE. Potential source areas of the VOCs in groundwater at the well include Spoil Area I and the former S-3 Ponds.

Based on the frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples are PCE, 11DCA, and 111TCA (Table 2), although only trace levels of PCE and 11DCA have been detected since September 1999 and 111TCA has not been detected in samples collected after March 1990. Toluene was detected in only the sample collected in March 1989 (0.3 μg/L) and 11DCE was detected only in the samples collected in March 1989 (5 μg/L) and March 1990 (1 μg/L). None of the sampling results for toluene, PCE, 11DCE, or 111TCA exceed the respective drinking water MCL (Table 2). Also, the VOCs results reflect a clearly decreasing long-term concentration trend that appears to have reached somewhat asymptotic levels, as illustrated by the summed concentrations of VOCs detected in the samples collected in September 1988 (41 μg/L), September 1995 (7 μg/L), September 1999 (2 μg/L), and August 2004 (3 μg/L). The overall decrease in VOC concentrations suggests a corresponding reduction in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Two of the groundwater samples collected since March 1990 had gross alpha activity above the applicable MDA and corresponding CE: the sample collected in September 1995 (3.26 pCi/L) and the sample collected in September 1999 (5.9 pCi/L). Both results are substantially below the drinking water MCL for gross alpha activity (15 pCi/L). Gross alpha activity results reported for previous samples are qualitative (the sample-specific MDA and CE are not available). Low levels of gross alpha activity in the groundwater at this well are supported by the similarly low levels of U-234 (<2 pCi/L) and U-238 (<5 pCi/L) that were detected (i.e., >MDA and CE) in the samples collected in March and August 2004.

5.5 GROSS BETA ACTIVITY

Four of the groundwater samples collected since March 1990 had gross beta activity above the applicable MDA and corresponding CE (Table 1), and all of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which is a beta particle-emitting radionuclide that was detected (i.e., >MDA and CE) in the samples collected in March 2004 (88 pCi/L) and August 2004 (79 pCi/L). Note that these Tc-99 concentrations are substantially less than the corresponding SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent. Tc-99 is considered a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity (i.e., >50 pCi/L) in the Maynardville Limestone suggest that the transport of Tc-99 in the groundwater closely mirrors that of nitrate.

As shown on Table 1, the highest levels of gross beta activity were reported for the groundwater samples collected before September 1995, including the historical maximum value (923 pCi/L in September 1988), although these results are considered qualitative. Gross beta activity reported for the samples collected since September 1995 are less than 100 pCi/L, with the sample collected in August 2004 having the lowest gross beta activity (52 pCi/L) evident since November 1988 (49 pCi/L). The overall decrease in gross beta activity is attributable to the reduced flux of Tc-99 from the former S-3 Ponds following closure of the site and installation of the low-permeability cap.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-236: summary of results for nitrate and gross beta activity

Date Sampled	Concentration		
	Nitrate (mg/L)	Uranium (mg/L)	Gross Beta Activity (pCi/L)
04/05/88	1,470	0.02	[-247]
06/20/88	385	0.051	[344]
09/01/88	409	0.009	[923]
11/04/88	361	<0.001	[49]
03/03/89	33	0.032	[319]
05/15/89	805	0.031	[180]
03/15/90	[421]	0.045	[203.34]
09/16/95	65	0.0096	97.5
09/08/99	47.73	0.00696	85
03/08/04	63.5	0.00979	73
08/18/04	42.5	0.0116	52
MCL	**10**	**0.03**	**50***
Note: [ ] = Result considered qualitative because of ion charge-balance error (nitrate) or lack of sample-specific MDA and CE (gross beta activity); * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)			

Table 2. Well GW-236: summary of VOC results

Date Sampled	Concentration (µg/L)			
	PCE	111TCA	11DCA	OTHER
04/05/88	0.9 J	8	.	.
06/20/88	.	10	2 J	.
09/01/88	2 J	36	3 J	.
11/04/88	1 J	43	5	.
03/03/89	2 J	23	.	Toluene (0.3 J), 11DCE (5)
05/15/89	.	21	5	.
03/15/90	1 J	19	8	11DCE (1 J)
09/16/95	2 J	FP	5	.
09/08/99	.	.	2 J	.
03/08/04	1 J	.	1 J	.
08/18/04	2 J	.	1 J	.
MCL	**5**	**200**	**NA**	**.**
Note: "." = Not detected; J = Estimated value below the analytical reporting limit; FP = False positive result; NA = Not applicable				

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-237

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 44,125.11
Y-12 GRID NORTH COORDINATE: 29,244.02
SURFACE ELEVATION: 918.16 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/01/85 PAIRED/CLUSTERED WITH: GW-096, GW-375, GW-119
TAG DEPTH (measured): 17.26 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 921.02 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	6.5	911.66
BOTTOM (filter pack or open hole):	13.7	904.46
MIDPOINT (filter pack or open hole):	10.1	908.06
PUMP INTAKE:	13.64	904.52
WATER LEVEL (average):	8.08	910.09

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	1 samples	04/15/88	04/15/88
LOW-FLOW SAMPLING METHOD:	2 samples	03/03/04	09/20/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/03/04	.	09/20/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 0.61 pre-sampling measurements (ft)

TDS: L (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-237

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1985, completed with a screen monitored interval from 6.5 to 13.7 ft bgs, and constructed with nominal 2.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, approximately 200 ft northeast of the confluence of the main channel of Bear Creek and a northern tributary (NT) of the creek (NT-6) that drains the eastern sections of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Three groundwater samples have been collected to date, with the conventional sampling method used to collect a sample in April 1988 and the low-flow sampling method used to obtain samples in March and September 2004.

Unusually low levels of TDS (<150 mg/L) are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0). The low TDS of the samples suggests relatively low residence time for the groundwater in the well, which indicates that the monitored interval for the well intercepts highly permeable groundwater flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths and groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). The depth of the well and its location relative to the geologic contact between the Maynardville Limestone and the underlying Nolichucky Shale suggest that the monitored interval is completed within Zone 6.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-237 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- unusually low TDS of 115 – 135 mg/L;
- pH (field measurements) of 6 – 6.2;

- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that none of the principal contaminants are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

Each groundwater sample had nitrate concentrations above the applicable analytical reporting limit, and the results are all less than 1 mg/L and are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

ND	ND	50 - 500	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-242

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,144.00
Y-12 GRID NORTH COORDINATE: 31,004.00
SURFACE ELEVATION: 974.78 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/20/85 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 20.18 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 978.69 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	9.0	965.78
BOTTOM (filter pack or open hole):	17.0	957.78
MIDPOINT (filter pack or open hole):	13.0	961.78
PUMP INTAKE:	13.1	961.69
WATER LEVEL (average):	3.20	971.58

GEOLOGIC FORMATION: Pumpkin Valley Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	10 samples	11/12/87	02/06/90
LOW-FLOW SAMPLING METHOD:	5 samples	06/19/98	10/05/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	.	06/14/05	.	10/05/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.11 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	5	135 µg/L	03/08/99	Indeterminate
GROSS ALPHA (15 pCi/L):	1	23.04 pCi/L	06/19/98	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-242

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1985, completed with a screened monitored interval from 9 to 17 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the southern flank of Pine Ridge west of Y-12, immediately east of Burial Ground-D in the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between November 1987 and February 1990, and the low-flow sampling method used to obtain five samples between June 1998 and October 2005. This sampling history includes an eight-year period (February 1990 to June 1998) and a six-year period (March 1999 to June 2005) when no groundwater samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Pumpkin Valley Shale). The bulk of the groundwater flow in the Conasauga Group occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Pumpkin Valley Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits seasonal fluctuations of about 1 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-242 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Pumpkin Valley Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-242 may be primarily eastward (parallel with geologic strike) toward discharge areas in NT-7.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 214 – 237 mg/L;
- pH of 6.12 – 6.6 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<15% of total anions/cations);
- elevated total concentrations of iron (>5 mg/L) and manganese (> 2mg/L); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

One groundwater sample had nitrate concentrations above the analytical reporting limit, with that concentration (0.045 mg/L in March 1999) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Eight groundwater samples collected to date had uranium concentrations above the analytical reporting limit, with the highest concentration (0.012 mg/L in April 1988) being below the drinking water MCL for uranium (0.03 mg/L). Notably, uranium concentrations have been below the reporting limits in all groundwater samples collected from the well since February 1990.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 2): PCE, TCE, 12DCE, VC, 111TCA, 11DCA, dichlorodifluoromethane (DCFM), and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as freon-113 (Table 1). Waste disposal sites within Burial Ground (BG)-C East or BG-D are the likely source of the dissolved VOCs in the shallow groundwater at this well.

The primary compounds in the groundwater samples are 12DCE and VC, which have been detected in nearly every sample and have historical maximum concentrations that exceed 50 µg/L (Table 1). These primary compounds are probably present in the groundwater as a consequence of the biotic degradation of PCE and TCE (Wilson et al. 1996); most of the geochemical characteristics of the groundwater in the well are conducive to anaerobic biotic degradation (Table 2). Secondary compounds in the samples are PCE, TCE, and 11DCA, which generally have historical maximum values below 10 µg/L. The historical maximum concentrations of PCE, TCE, c12DCE, and VC have exceeded respective drinking water MCLs, and the most recent results (June and October 2005) show that only VC concentrations continue to exceed the MCL (Table 1).

A time-series plot of the summed VOC concentrations shows a highly variable, indeterminate long-term trend that encompasses the two time gaps (February 1990–June 1998 and March 1999–June 2005) in the sampling history for the well (Figure 1). The indeterminate trend, also evident in concentration trends of the individual VOCs (Table 1), suggests little long-term change in the relative flux of dissolved VOCs along the shallow groundwater flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum (23.04 pCi/L in June 1998) exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, the historical maximum value is an outlier compared to the other results for gross alpha activity, none of which exceed 4 pCi/L. Results reported for samples obtained before 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the maximum level (44.54 pCi/L in June 1998) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). As with gross alpha activity, the historical maximum value is an outlier compared to the other gross beta results, none of which exceeded 8 pCi/L. Results reported for samples obtained before 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-242: summary of VOC results

Sampling Date	Concentration (μg/L)			
	PCE	TCE	12DCE	c12DCE
11/12/87	5	.	98	NR
04/08/88	8	3 J	90	NR
06/30/88	3 J	.	62	NR
09/10/88	.	1 J	.	NR
11/15/88	.	.	42	NR
03/16/89	.	3 J	76	NR
08/06/89	.	31	100	NR
09/26/89	.	3 J	75	NR
12/20/89	.	4 J	120	NR
02/06/90	.	5	130	NR
06/19/98	.	.	27	NR
07/27/98	.	1 J	49	NR
03/08/99	.	3 J	82	82
06/14/05	1 J	2 J	48	48
10/05/05	.	2 J	49	49
MCL	**5**	**5**	**NA**	**70**

Sampling Date	Concentration (μg/L)		
	VC	11DCA	OTHER
11/12/87	.	.	MC (6)
04/08/88	39	5	.
06/30/88	37	4 J	MC (3 J)
09/10/88	5	4 J	111TCA (1 J)
11/15/88	19	2 J	.
03/16/89	53	4 J	.
08/06/89	73	8	Acetone (17)
09/26/89	57	4 J	.
12/20/89	60	6	.
02/06/90	27	6	.
06/19/98	23	1 J	.
07/27/98	42	3 J	.
03/08/99	45	5	.
06/14/05	23	4 J	Freon-113 (9)
10/05/05	32	4 J	DCFM (8), Freon-113 (12)
MCL	**2**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
NR = Not reported

Table 2. Well GW-242: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005	October 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	6.62*	5.87*
Sulfate	< 20 mg/L	14.4	16.6
Dissolved Oxygen	< 0.5 ppm	2.52**	0.62**
REDOX	< 50 mV	25**	-35**
pH	>5 and < 9 st. units	6.45**	6.49**

Note: *Results are for total iron; **Field measurements.

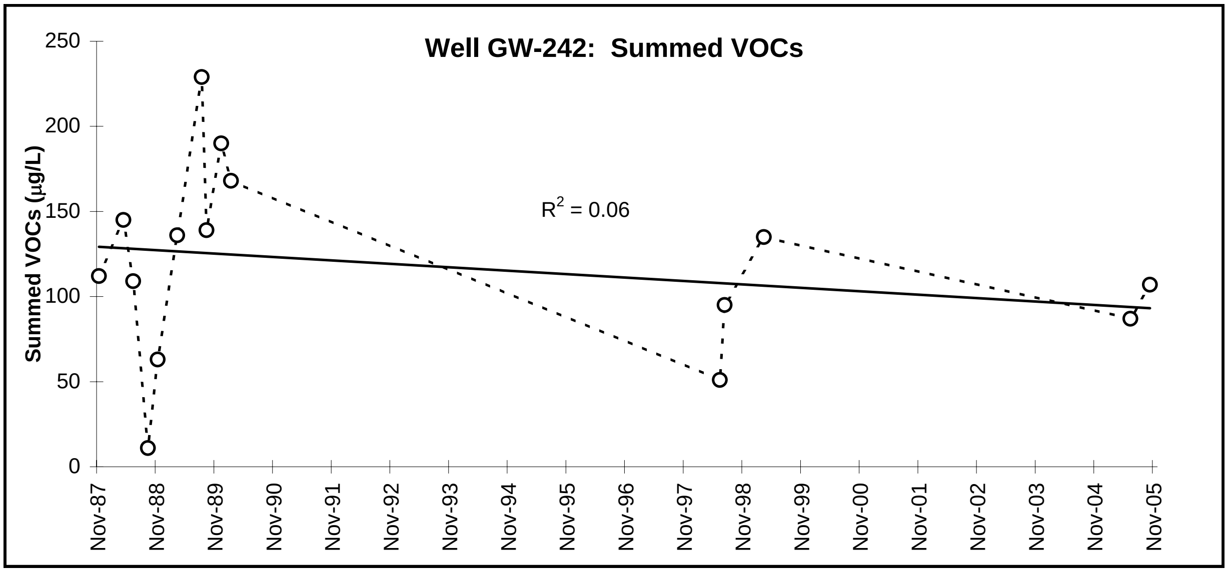

Well GW-242: Summed VOCs
Summed VOCs (µg/L)
250
200
150
100
50
0
R^2 = 0.06
Nov-87
Nov-88
Nov-89
Nov-90
Nov-91
Nov-92
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Nov-98
Nov-99
Nov-00
Nov-01
Nov-02
Nov-03
Nov-04
Nov-05

Figure 1

MAXIMUM CONCENTRATION: 2005

>1,000	<0.015	5 - 50	ND	500 - 5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-244

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,974.16
Y-12 GRID NORTH COORDINATE: 30,060.35
SURFACE ELEVATION: 1,006.88 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/10/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 77.30 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.24 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 6.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.03
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	43.0	963.88
BOTTOM (filter pack or open hole):	77.0	929.88
MIDPOINT (filter pack or open hole):	60.0	946.88
PUMP INTAKE:	60.6	946.24
WATER LEVEL (average):	12.43	994.45

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	13 samples	03/13/87	01/18/90
LOW-FLOW SAMPLING METHOD:	2 samples	06/23/05	10/24/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/23/05	.	10/24/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.98 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	4350 mg/L	06/23/05	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	2	36 µg/L	06/23/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	2	4300 pCi/L	10/24/05	Indeterminate

WELL GW-244

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1986, completed with a screened monitored interval from 43 to 77 ft bgs, and constructed with nominal 6.5-inch diameter PVC (#40) riser casing and screen (0.03 slot). The well is one of a series of wells completed at similar depths along the western (GW-243 and GW-244) and southern (GW-245, GW-246, and GW-247) boundaries of the former S-3 Ponds (hereafter referenced as the S-3 Site), with well GW-244 being approximately 100 ft northwest of the southwest corner of the site. The S-3 Site, which is located near the western end of Y-12, directly north of the headwaters of Bear Creek, encompasses four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between March 1987 and January 1990 and the low-flow sampling method used to obtain samples in June and October 2005. The sampling history includes almost two years of quarterly sampling, followed by a 15-year period (January 1990 – June 2005) when no groundwater samples were collected from the well.

Extremely high total dissolved solids (TDS) is a distinguishing characteristics of the groundwater samples from this well (see Section 4.0), and is a direct consequence of contamination resulting from historical operation of the S-3 Site (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º-55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Moreover, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Groundwater flow in the bedrock intervals

(shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 12.5 ft bgs and exhibits minor (<1 ft) seasonal fluctuations. As indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements from nearby monitoring wells, directions of groundwater flow near the S-3 Site are to the west, parallel with the trend (strike) of bedding in Nolichucky Shale, and to the south-southwest, across geologic-strike toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic flow via strike-parallel flowpaths (i.e., bedding-plane fractures) that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Also, possible dissolution of carbonate strata by the acidic seepage from the S-3 Site may locally enhance strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Additionally, directions of groundwater flow (and contaminant transport) now evident are undoubtedly different from the flow patterns that occurred during historical operations of the S-3 Site, which created a local "mound" in the water table that enabled groundwater flow (and contaminant transport) to the east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected in June and October 2005 show that the well yields acidic, highly mineralized and contaminated groundwater from the Nolichucky Shale beneath the S-3 Site that is generally characterized by:

- TDS of 26,300 –27,200 mg/L;
- pH (field measurements) of 5.5 – 5.6;
- very high concentrations of calcium (>5,000 mg/L), nitrate (>4,000 mg/L), magnesium (>800 mg/L), sodium (>400 mg/L), chloride (>250 mg/L), potassium (>40 mg/L), and fluoride (>4 mg/L) relative to other wells;
- very high total concentrations of several trace metals, notably aluminum (>10 mg/L), barium (>130 mg/L), cadmium (>1 mg/L), manganese (>170 mg/L), nickel (>2 mg/L), and strontium (>15 mg/L), that are orders of magnitude above corresponding background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Note that some of the inorganic compounds and trace metals in the groundwater at this well, such as nitrate and uranium, were entrained in the acidic wastes disposed at the S-3 Site, whereas other inorganics, such as calcium and barium, were dissolved from bedrock minerals by the highly acidic seepage from the site. Also, the very high concentrations of TDS and specific trace metals (e.g., aluminum) may cause analytical interferences for some laboratory analytes, including trace metals, gross alpha activity, and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate, VOCs, and gross beta activity are the principal contaminants of the groundwater at this well. Note, however, that the bulk of the historical the analytical results for VOCs, gross alpha activity, and gross beta activity do not meet all applicable DQOs. The QA/QC sample data needed to identify false positive VOC results are not available for groundwater samples collected before January 1991. Similarly, gross alpha activity and gross beta activity reported for the groundwater samples collected before January 1990 are considered unusable because the sample-specific MDA and CE are not available for these analytes.

5.1 NITRATE

Eight of the groundwater samples collected to date were analyzed for nitrate and all of these results exceed 4,000 mg/L, with the nitrate concentration detected in the sample collected most recently (4,290 mg/L in October 2005) being the lowest detected in the well (Table 1). Nitrate is a primary component of the contaminant plume emplaced during historical operations of the S-3 Site, is chemically stable and mobile in groundwater, and effectively traces the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997).

A time-series plot of the nitrate concentrations detected in the groundwater samples collected to date is dominated by the long gap in the sampling history for the well, but shows a generally decreasing long-term trend (Figure 1). As illustrated by the data summarized below, this decreasing trend is generally mirrored by the decreasing nitrate concentration trends indicated by the data for other wells (GW-245, GW-246, and GW-247) located adjacent to the S-3 Site. These data also show that wells GW-243 and GW-244, both of which are located on the west side of the site (parallel with geologic strike), monitor groundwater with the highest levels of nitrate, as indicated by both the historic and the most recent sampling results for each well.

Well No./Monitored Interval Depth (ft bgs)		**Nitrate (mg/L)**				**% Change**
		June 1988	**August 2002**	**August 2004**	**June 2005**	
GW-243	62 – 77	6,160	8,840	.	.	+ 44%
GW-244	43 – 77	6,200	.	.	4,350	-37%
GW-245	25 – 76	3,660	.	.	2,210	-40%
GW-246	34 – 76	5,590	.	2,850	.	-49%
GW-247	31 – 78	3,500	.	.	3,260	-7%
Note: "." = Not sampled						

The decreasing nitrate concentration trend evident for well GW-244 (and wells GW-245, GW-246, and GW-247) suggest a corresponding decrease in the relative flux of nitrate in the shallow groundwater flow system in the Nolichucky Shale nearest to the S-3 Site. Decreased flux of nitrate via the groundwater flowpaths intercepted by the monitored interval in these wells occurred in response to the closure of the site and the subsequent installation of the low-permeability cap. Conversely, the increasing concentration trend indicated by the nitrate data for well GW-243 seems conspicuous relative to the decreasing trends evident for the other wells and may be an artifact of one or more inaccurate sampling results. Also, a relatively minimal decrease in the flux of nitrate is indicted by the sampling results for well GW-247, which may be completed in a comparably less permeable interval in the Nolichucky Shale than well GW-244 (and wells GW-245 and GW-246).

5.2 URANIUM

Seven of the 11 groundwater samples collected to date that were analyzed for uranium had concentrations above the applicable analytical reporting limit (Table 1), including one value (0.111 mg/L in June 1987) that exceeds the drinking water MCL for uranium (0.03 mg/L). However, this maximum result is a suspected outlier because all other results are below 0.02 mg/L. As noted previously, uranium was entrained in the wastewaters disposed at the S-3 Site, and the uranium in the acidic seepage probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium are generally restricted to the acidic groundwater in the Nolichucky Shale within approximately 500 ft of the S-3 Site (DOE 1987).

As shown in the following data summary, the uranium concentrations evident in the groundwater at this well do not appear to ever have been significantly elevated and are substantially lower than evident in the other wells located along the southern boundary of the S-3 Site (GW-245, GW-246, and GW-247), with the highest uranium concentrations evident for wells GW-243 and GW-246, which appear to monitor the most acidic groundwater. Considering that uranium was entrained in the wastewaters disposed throughout the operation of the site, the relatively low levels of uranium in the groundwater from of well GW-244 is somewhat surprising.

Well No. / Monitored Interval Depth (ft bgs)		**June 1988**		**August 2002**		**August 2004**		**June 2005**	
		Total U	**pH**	**Total U**	**pH**	**Total U**	**pH**	**Total U**	**pH**
GW-243	62 - 77	60.5	3.6	0.653	5.42	.	.	.	.
GW-244	43 – 77	<0.001	5.5	.	.	.		0.00209	5.5
GW-245	25 – 76	0.115	5.3	.	.	.		0.0478	6.01
GW-246	34 – 76	0.661	4.8	.	.	0.591	4.63	.	.
GW-247	31 – 78	0.036	6.0	.	.	.		0.0241	5.93
Note: "." = Not sampled; Total uranium concentrations in mg/L; pH from field measurements (in standard pH units)									

Interestingly, the groundwater in well GW-244 has never been especially acidic and the pH appears to have changed very little since the S-3 Site was closed and capped, as illustrated by the results summarized above. Perhaps the monitored interval in this well is completed within a stratigraphic section of the Nolichucky Shale that contains proportionally more carbonate than shale. Dissolution of the carbonate by the acidic seepage during the operation of the S-3 Site would buffer the pH of the groundwater, increase the hydraulic conductivity of the permeable flowpaths (e.g., enlarge bedding-plane fractures), and provide dissolved carbonate available to complex with any uranyl cations in the groundwater.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs was detected in each of the groundwater samples collected to date: acetone, chloroform, ethylbenzene, MC, PCE, TCE, toluene, 2-hexanone, and 12DCE (Table 2). Chlorinated solvents and organic chemicals were not substantial components of the waste stream for the S-3 Site and, consequently, VOCs are fairly minor constituents within the contaminant plume emplaced during historical operation of the site and are typically present at substantially lower concentrations compared to inorganic components of the plume (e.g., nitrate).

Based on frequency of detection and maximum concentration, chloroform and MC are the primary VOCs in the groundwater samples collected to date (Table 2). Both compounds were detected in all but one sample, with a historical maximum concentration of 24 µg/L for chloroform and 10 µg/L for MC. The maximum value for chloroform, which was reported for the sample collected in June 2005, is substantially below the drinking water MCL for total trihalomethanes (80 µg/L). Of the other compounds, only PCE was detected in any sample collected since February 1989, with the highest concentrations reported for acetone (e.g., 32 µg/L in March 1987), and the results for several compounds (e.g., 2-hexanone) being likely analytical artifacts (see Section 5.0). Also, although PCE has been detected infrequently, but the most recent sampling result (6 µg/L in October 2005) indicates concentrations slightly above the MCL for PCE (5 µg/L).

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date (excluding false positive results) spans the prolonged gap in the sampling history for the well, with the VOC results reported for the samples collected in June and October 2005 suggesting an indeterminate or slightly increasing long-term VOC concentration trend (Figure 2). This trend is attributable to higher PCE and chloroform concentrations, fairly stable MC concentrations, and lower acetone concentrations compared to historical levels. For instance, the concentration of chloroform increased from 14 µg/L in June 1987 to 24 µg/L in June 2005, while acetone concentrations decreased from 21 µg/L to below the detection limit (Table 2). It is not clear from the available data if the divergent concentration trends for individual compounds are significant with regard to the corresponding flux of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

As illustrated by the chloroform (CLF) and summed (Tot.) VOC concentrations shown in the following data summary, VOC levels in the groundwater at this well are generally comparable to respective levels detected in groundwater samples from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246. Both of these wells monitor groundwater with substantially higher PCE concentrations than evident in well GW-244, with the most recent sampling results for each well showing PCE levels above 3,000 µg/L and 100 µg/L, respectively.

Well No. / Monitored Interval Depth (ft bgs)		**June 1988**		**Aug. 2002**		**Aug. 2004**		**June 2005**	
		CLF	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**
GW-243	62 - 77	27	2,153	29	4,076	.	.	.	.
GW-244	43 – 77	13	33	.	.	.	.	24	36
GW-245	25 – 76	8	30.9	.	.	.	.	7	18
GW-246	34 – 76	20	76	.	.	30	177	.	.
GW-247	31 – 78	7	19	.	.	.	.	10	25
Note: "." = Not sampled; All results in µg/L									

These data also illustrate the divergent long-term trends in the concentrations of VOCs in the groundwater from the other wells, which appear to have remained fairly unchanged (GW-244 and GW-247), decreased (GW-245), or increased (GW-243 and GW-246) in response to the closure/capping of the S-3 Site. However, considering the relatively low concentrations of the VOCs in most of the wells, it is not clear from the available data if the various long-term concentrations trends are significant with respect to the overall flux of dissolved VOCs through the shallow groundwater flow system in the Nolichucky Shale nearest to the site.

5.4 GROSS ALPHA ACTIVITY

As noted in Section 5.0, only the gross alpha activity reported for the groundwater samples collected from the well since January 1990 meet applicable DQOs, and these results are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples (see Section 4.0). Nevertheless, none of these samples had gross alpha activity above the applicable MDA and/or corresponding CE (Table 1). Low levels of gross alpha activity (i.e., <15 pCi/L drinking water MCL) are supported by analytical results for the primary alpha-emitting radionuclides entrained in the wastes disposed at the S-3 Site, U-234 and U-238, which were detected (i.e., >MDA and CE) at low levels in the groundwater samples collected most recently (Table 1).

5.5 GROSS BETA ACTIVITY

As noted in Section 5.0, only the gross beta activity reported for the groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of analytical interferences associated with the high TDS of the samples (see Section 4.0). Although considered qualitative, the gross beta activity detected in the samples collected in January 1990 (3,240 pCi/L), June 2005 (3,700 pCi/L), and October 2005 (9,000 pCi/L) substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

Uranium decay products (e.g., Th-234) and other beta-emitting radionuclides known to be included in the waste stream for the S-3 Site (e.g., Np-237) probably contribute to the high level of gross beta activity in the groundwater from this well. However, technetium-99 (Tc-99) is the principal source of beta activity and is the “signature” component of the contaminant plume emplaced during historical operation of the S-3 Site, which is the only site at Y-12 known to have received significant volumes of waste that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the groundwater downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater.

The Tc-99 activity reported for the samples collected in January 1990 (5,000 pCi/L), June 2005 (9,400 pCi/L), and October 2005 (9,000 pCi/L) substantially exceed the SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Although there are insufficient data to adequately characterize the long-term trend for Tc-99 activity, the most recent sampling results suggest a significant increase from the Tc-99 levels evident shortly after the installation of the low-permeability cap over the S-3 Site. This may reflect a corresponding increase in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, considering that the mobility of Tc-99 is similar to that of nitrate, and the nitrate concentrations in the well decreased substantially since the S-3 Site was closed and capped, it is possible that difference between the historical and recent sampling results for Tc-99 is attributable to inherent analytical variability.

As illustrated by the following summary of results for gross beta (GB) and Tc-99 activity, comparable levels of both analytes are evident in the groundwater from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246, which appear to monitor groundwater with substantially higher levels of gross beta and Tc-99 activity.

Well No. / Monitored Interval Depth (ft bgs)		**January 1990**		**August 2002**		**August 2004**		**June 2005**	
		GB	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**
GW-243	62 - 77	49,100	60,800	17,000	14,000	.	.	.	.
GW-244	43 – 77	3,240	5,000	.	.	.	.	3,700	9,400
GW-245	25 – 76	1,680	4,580	.	.	.	.	1,200	2,800
GW-246	34 – 76	13,900	23,100	.	.	9,800	26,000	.	.
GW-247	31 – 78	4,240	8,800	.		.	.	2,300	9,100
Note: “.” = Not sampled; All results in pCi/L									

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-244: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	Total Uranium	Gross Alpha	Gross Beta	Tc-99	U-234	U-238
03/13/87	.	0.017	DQO	DQO	.	.	.
06/04/87	.	0.111	DQO	DQO	.	.	.
09/17/87	.	0.015	DQO	DQO	.	.	.
11/17/87	5,521	0.004	DQO	DQO	.	.	.
03/25/88	5,364	<0.001	DQO	DQO	.	.	.
06/15/88	6,200	<0.001	DQO	DQO	.	.	.
08/27/88	6,170	<0.001	DQO	DQO	.	.	.
02/18/89	5,200	<0.001	DQO	DQO	.	.	.
05/11/89	4,530	0.005	DQO	DQO	.	.	.
01/18/90	.	.	< CE	3,240	5,000	.	.
06/23/05	4,350	0.00209	<MDA	3,700	9,400	6.7	0.56
10/24/05	4,290	0.00256	<MDA	9,000	9,000	<MDA	0.7
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**
Note: "." = Not analyzed; DQO = results do not meet data quality objectives; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent							

Table 2. Well GW-244: summary of VOC results

Sampling Date	Primary VOCs (µg/L)	
	Chloroform	MC
03/13/87	14	8
06/04/87	14	7
09/17/87	13	8
11/17/87	8	Not detected
03/25/88	16	6
06/15/88	13	10
08/27/88	15	7
02/18/89	17	7
05/11/89	17	7
06/23/05	24	7
10/24/05	22	7
MCL	**80***	**5**
Sampling Date	**Other VOCs (µg/L)**	
03/13/87	Acetone (32), PCE (3 J), Toluene (1 J)	
06/04/87	Acetone (21), PCE (6)	
09/17/87	Acetone (18)	
11/17/87	Acetone (8), TCE (2 J), 12DCE (2 J), 2-Hexanone (3 J)	
03/25/88	Ethylbenzene (0.8 J), PCE (0.5 J)	
06/15/88	Acetone (9), Toluene (1 J)	
02/18/89	Acetone (23)	
06/23/05	PCE (5)	
10/24/05	PCE (6)	
Note: J = Estimated value below analytical reporting limit; * MCL is for total trihalomethanes		

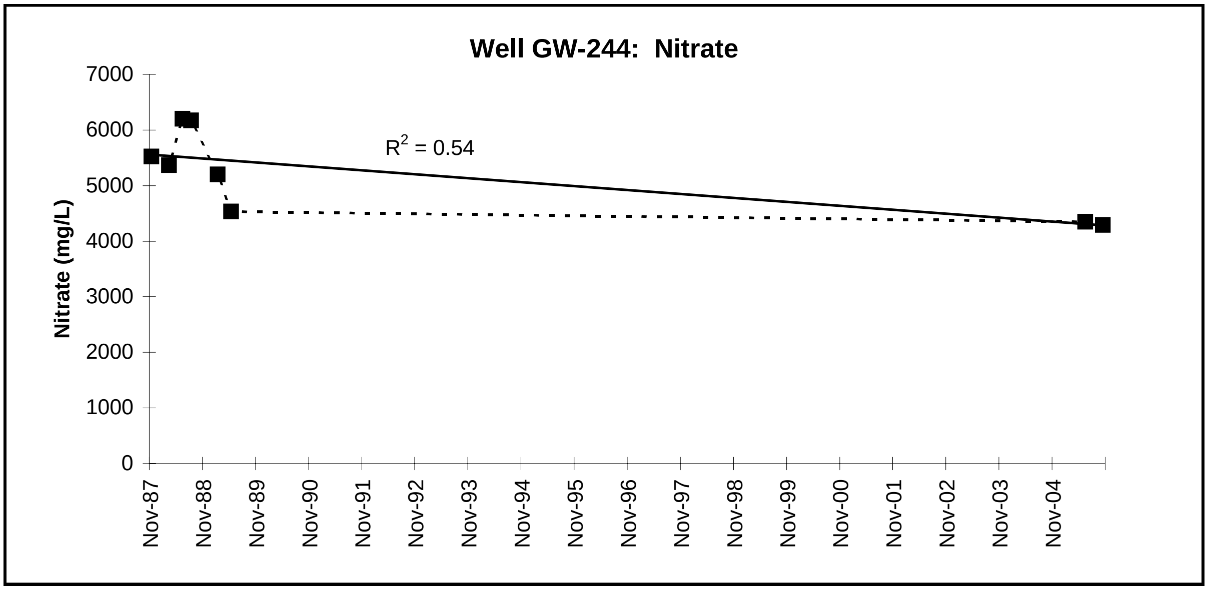


Figure 1

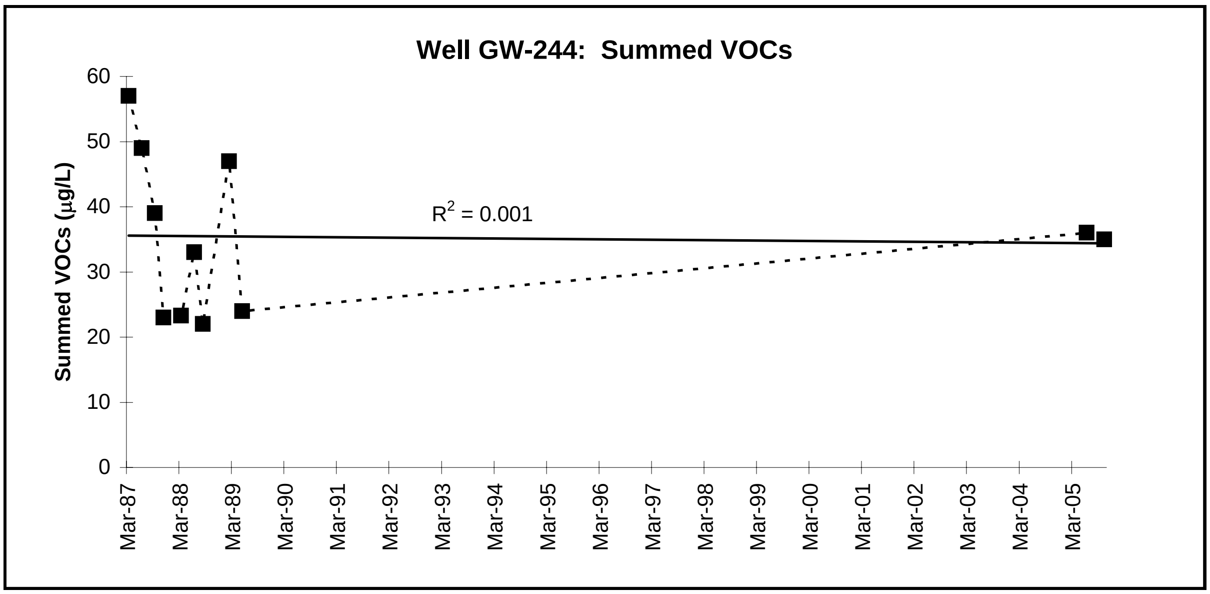


Figure 2

MAXIMUM CONCENTRATION: 2005

>1,000	0.03 - 0.3	5 - 50	ND	500 - 5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-245

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,992.00
Y-12 GRID NORTH COORDINATE: 29,977.06
SURFACE ELEVATION: 1,006.06 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/06/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 73.87 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.08 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 6.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.03
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	25.3	980.76
BOTTOM (filter pack or open hole):	76.0	930.06
MIDPOINT (filter pack or open hole):	50.7	955.41
PUMP INTAKE:	57.0	949.08
WATER LEVEL (average):	11.95	994.12

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	11 samples	03/10/87	01/17/90
LOW-FLOW SAMPLING METHOD:	2 samples	06/23/05	10/25/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	.	06/23/05	.	10/25/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.69 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	2210 mg/L	06/23/05	Decreasing
URANIUM (0.03 mg/L):	1	0.0478 mg/L	06/23/05	Decreasing
SUMMED VOCs (5 µg/L):	2	18 µg/L	06/23/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	2	1200 pCi/L	06/23/05	Decreasing

WELL GW-245

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1986, completed with a screened monitored interval from 25.3 to 76 ft bgs, and constructed with nominal 6.5-inch diameter PVC (#40) riser casing and screen (0.03 slot wire-wound). The well is one of a series of wells completed at similar depths along the western (GW-243 and GW-244) and southern (GW-245, GW-246, and GW-247) boundaries of the former S-3 Ponds (hereafter referenced as the S-3 Site), with well GW-245 being near the southwest corner of the site. The S-3 Site, which is located near the western end of Y-12, directly north of the headwaters of Bear Creek, encompasses four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well, with the conventional sampling method used to obtain 11 samples between March 1987 and January 1990 and the low-flow sampling method used to obtain samples in June and October 2005. The sampling history includes almost two years of quarterly sampling, followed by a 15-year period (January 1990 – June 2005) when no groundwater samples were collected from the well.

Extremely high total dissolved solids (TDS) is a distinguishing characteristic of the groundwater samples from this well (see Section 4.0), and is a direct consequence of contamination resulting from historical operation of the S-3 Site (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º-55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Moreover, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Groundwater flow in the bedrock intervals

(shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 12 ft bgs and exhibits minor (<1 ft) seasonal fluctuations. As indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements from nearby monitoring wells, directions of groundwater flow near the well are to the west, parallel with the trend (strike) of bedding in Nolichucky Shale, and to the south-southwest, across geologic-strike toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic flow via strike-parallel flowpaths (i.e., bedding-plane fractures) that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Also, possible dissolution of carbonate strata by the acidic seepage from the S-3 Site may locally enhance strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Additionally, directions of groundwater flow (and contaminant transport) now evident are undoubtedly different from the flow patterns that occurred during historical operations of the S-3 Site, which created a local “mound” in the water table that enabled groundwater flow (and contaminant transport) to the east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected in June and October 2005 show that the well yields highly contaminated groundwater from the Nolichucky Shale beneath the S-3 Site that is generally characterized by:

- TDS of 14,000 –15,968 mg/L;
- pH (field measurements) of 6 – 6.19;
- extremely high concentrations of calcium (>2,700 mg/L), chloride (>250 mg/L), magnesium (>430 mg/L), nitrate (>2,100 mg/L), and sodium (>180 mg/L);
- low molar proportions of sulfate and potassium (<10% of total anions/cations);
- high concentrations of several trace metals, notably barium (>10 mg/L), cadmium (>0.01 mg/L), manganese (>10 mg/L), nickel (>0.2 mg/L), strontium (>10 mg/L), and uranium (>0.04 mg/L), that are significantly above corresponding background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995)

Note that some of the inorganic compounds and trace metals in the groundwater at this well, such as nitrate and uranium, were entrained in the acidic wastes disposed at the S-3 Site, whereas other inorganics, such as calcium and barium, were dissolved from bedrock minerals by the highly acidic seepage from the site. Also, the high levels of TDS may cause analytical interferences for some laboratory analytes, including gross alpha activity and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants except gross alpha activity are present in the groundwater at this well. Note, however, that the bulk of the historical the analytical results for VOCs, gross alpha activity, and gross beta activity do not meet all applicable DQOs. The QA/QC sample data needed to identify false positive VOC results are not available for groundwater samples collected before January 1991. Similarly, gross alpha activity and gross beta activity reported for the groundwater samples collected before January 1990 are considered unusable because the sample-specific MDA and CE are not available for these analytes.

5.1 NITRATE

Nine of the groundwater samples collected to date were analyzed for nitrate and all had nitrate concentrations that exceed 2,000 mg/L (Table 1), including the samples collected most recently (June and October 2005), which confirm the nitrate levels in the shallow groundwater near the S-3 Site remain several orders-of-magnitude above the drinking water MCL for nitrate (10 mg/L). Nitrate is the principal component of the contaminant plume emplaced during historical operations of the site, is chemically stable and mobile in groundwater, and is believed to effectively trace the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997).

Excluding the historical maximum nitrate concentration evident in January 1990 (4,240 mg/L), which is considered qualitative because of the ion charge balance error (i.e., the percent difference between respective summed milliequivalent concentrations of the major cations and anions exceeds 20%), a time-series plot of the nitrate concentrations detected in the groundwater samples collected to date shows a generally decreasing long-term trend (Figure 1). This trend spans the long gap in the sampling history for the well and, as illustrated by the data summarized below, generally is mirrored by the concentration trends for other wells located adjacent to the S-3 Site. These data also show that wells GW-243 and GW-244, both of which are located on the west side of the site (parallel with geologic strike), monitor groundwater with the highest levels of nitrate, as indicated by both the historic and the most recent sampling results for each well.

Well No./Monitored Interval Depth (ft bgs)		Nitrate (mg/L)				% Change
		June 1988	August 2002	August 2004	June 2005	
GW-243	62 – 77	6,160	8,840	.	.	+ 44%
GW-244	43 – 77	6,200	.	.	4,350	-37%
GW-245	25 – 76	3,660	.	.	2,210	-40%
GW-246	34 – 76	5,590	.	2,850	.	-49%
GW-247	31 – 78	3,500	.	.	3,260	-7%
Note: "." = Not sampled						

The decreasing nitrate concentration trend evident for well GW-245 (and wells GW-244, GW-246, and GW-247) suggest a corresponding decrease in the relative flux of nitrate in the shallow groundwater flow system in the Nolichucky Shale near to the S-3 Site. Decreased flux of nitrate via the groundwater flowpaths intercepted by the monitored interval in these wells occurred in response to the closure of the site and the subsequent installation of the low-permeability cap. Conversely, the increasing concentration trend indicated by the nitrate data for well GW-243 seems conspicuous relative to the decreasing trends evident for the other wells and may be an artifact of one or more inaccurate sampling results. Also, a relatively minimal decrease in the flux of nitrate is indicted by the sampling results for well GW-247, which may be completed in a comparably less permeable interval in the Nolichucky Shale than well GW-245 (and wells GW-244 and GW-246).

5.2 URANIUM

All but one of the groundwater samples collected to date had uranium concentrations above the MCL for uranium (0.03 mg/L), with the historical maximum concentration (0.188 mg/L) evident in March 1988 (Table 1). As noted previously, uranium was entrained in the wastewaters disposed at the S-3 Site, and the uranium in the acidic seepage probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium are generally restricted to the acidic groundwater in the Nolichucky Shale within approximately 500 ft of the site (DOE 1987).

A time-series plot of the uranium results reported for the groundwater samples collected to date shows a variable but generally increasing concentration trend between March 1987 (0.07 mg/L) and May 1989 (0.161 mg/L), with a subsequently decreasing trend spanning the prolonged gap in the sampling history for the well (Figure 2). The overall decrease in uranium concentrations is generally mirrored by the uranium data for the other wells completed in the Nolichucky Shale adjacent to the S-3 Site, as illustrated by the data summarized below, which also indicates that the highest uranium concentrations have been reported for wells GW-243 and GW-246, which appear to monitor the most acidic groundwater.

Well No. / Monitored Interval Depth (ft bgs)		**June 1988**		**August 2002**		**August 2004**		**June 2005**	
		Total U	**pH**	**Total U**	**pH**	**Total U**	**pH**	**Total U**	**pH**
GW-243	62 - 77	60.5	3.6	0.653	5.42	.	.	.	.
GW-244	43 – 77	<0.001	5.5	.	.	.		0.00209	5.5
GW-245	25 – 76	0.115	5.3	.	.	.		0.0478	6.01
GW-246	34 – 76	0.661	4.8	.	.	0.591	4.63	.	.
GW-247	31 – 78	0.036	6.0	.	.	.		0.0241	5.93

Note: "." = Not sampled; Total uranium concentrations in mg/L; pH from field measurements (in standard pH units)

The lower concentrations of uranium indicated by the most recent sampling results probably reflect a corresponding reduction in the relative flux of uranium via the groundwater transport at shallow depths in the Nolichucky Shale nearest the S-3 Site. Additionally, the total concentration of uranium within the groundwater flowpaths intercepted by the monitored interval in this well may have decreased in response to the concurrent increase in the pH of the groundwater, as indicated by the data summarized above, which would be expected to promote sorption of uranyl cations, as noted above.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs was detected in each of the groundwater samples collected to date: acetone, chloroform, MC, PCE, toluene, xylenes, 2-hexanone, and 111TCA (Table 2). Chlorinated solvents and organic chemicals were not substantial components of the waste stream for the S-3 Site (DOE 1997). Consequently, VOCs are fairly minor constituents within the contaminant plume emplaced during historical operation of the site, and are typically present at substantially lower concentrations compared to other plume constituents (e.g., nitrate).

Based on the frequency of detection and relative concentrations, the primary VOCs in the groundwater samples are chloroform, MC, PCE, and 111TCA (Table 2). Historical data show the highest concentrations for PCE, with the historical maximum concentration (19 µg/L) evident in January 1990, but the most recent sampling results show PCE concentrations are now below the drinking water MCL (5 µg/L). Both chloroform and MC were detected in each sample collected to date, with maximum concentrations of 11 µg/L and 9 µg/L, respectively. Trace levels of 111TCA (3 µg/L or less) were detected in all but four of the samples collected through January 1990. Other VOCs were not detected in any of the samples collected after February 1989 (Table 2), with the highest concentrations reported for acetone (e.g., 14 µg/L in March 1987) and many of these historical results are probably analytical artifacts (see Section 5.0).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample collected to date is dominated by the prolonged gap in the sampling history for the well, although the most recent sampling results (June and October 2005) suggest a long-term decreasing concentration trend (Figure 3). The decreasing trend is primarily attributable to the reduced levels of PCE, as illustrated by the PCE concentrations evident in March 1987 (12 µg/L) and October 2005 (1 µg/L). Conversely, the most recent sampling results suggest minimal long-term change in the concentrations of other VOCs, as illustrated by the equal concentrations of MC detected in the samples collected in March 1987 (5 µg/L) and October 2005 (5 µg/L). It is not clear from the available data if the divergent concentration trends for individual compounds are significant relative to the corresponding flux of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

As illustrated by the chloroform (CLF) and summed (Tot.) VOC concentrations shown in the following data summary, VOC levels in the groundwater at this well are generally comparable to respective levels detected in groundwater samples from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246. Both of these wells monitor groundwater with substantially higher PCE concentrations than evident in well GW-244, with the most recent sampling results for each well showing PCE levels above 3,000 µg/L and 100 µg/L, respectively.

Well No. / Monitored Interval Depth (ft bgs)		**June 1988**		**August 2002**		**August 2004**		**June 2005**	
		CLF	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**
GW-243	62 - 77	27	2,153	29	4,076	.	.	.	.
GW-244	43 – 77	13	33	.	.	.	.	24	36
GW-245	25 – 76	8	30.9	.	.	.	.	7	18
GW-246	34 – 76	20	76	.	.	30	177	.	.
GW-247	31 – 78	7	19	.	.	.	.	10	25
Note: "." = Not sampled; All results in µg/L									

These data also illustrate the divergent long-term trends in the concentrations of VOCs in the groundwater from the other wells, which appear to have remained fairly unchanged (GW-244 and GW-247) or increased (GW-243 and GW-246) in response to the closure/capping of the S-3 Site. However, considering the relatively low concentrations of the VOCs in most of the wells, it is not clear from the available data if the various long-term concentration trends are significant with respect to the overall flux of dissolved VOCs through the shallow groundwater flow system in the Nolichucky Shale nearest to the site.

5.4 GROSS ALPHA ACTIVITY

As noted in Section 5.0, only the gross alpha activity reported for the groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples (see Section 4.0). Nevertheless, none of these samples had gross alpha activity above the applicable MDA and/or corresponding CE (Table 1). Low levels of gross alpha activity (i.e., <15 pCi/L drinking water MCL) are supported by analytical results for the primary alpha-emitting radionuclides entrained in the wastes disposed at the S-3 Site, U-234 and U-238, which were detected (i.e., >MDA and CE) at low levels in the groundwater samples collected most recently (Table 1).

5.5 GROSS BETA ACTIVITY

As noted in Section 5.0, only the gross beta activity reported for the groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of analytical interferences associated with the high TDS of the samples (see Section 4.0). Although considered qualitative, the gross beta activity detected in the samples collected in January 1990 (1,680 pCi/L), June 2005 (1,200 pCi/L), and October 2005 (890 pCi/L) substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

Uranium decay products (e.g., Th-234) and other beta-emitting radionuclides known to be included in the waste stream for the S-3 Site (e.g., Np-237) probably contribute to the high level of gross beta activity in the groundwater from this well. However, Tc-99 is the principal source of beta activity and is the "signature" component of the contaminant plume emplaced during historical operation of the S-3 Site, which is the only site at Y-12 known to have received significant volumes of waste that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the groundwater downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater.

The Tc-99 activity reported for the groundwater samples collected in January 1990 (4,580 pCi/L) and June 2005 (2,800 pCi/L) substantially exceed the SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99, and the Tc-99 activity reported for the sample collected in and October 2005 (860 pCi/L) is slightly below the SWDA screening level. Compared to the much higher Tc-99 level evident in June 2005 (and January 1990), it is not clear from the available data if the much lower level evident in October 2005 reflects natural temporal variability, or if the latter result is an analytical artifact. Also, there are insufficient data to adequately characterize the long-term trend for Tc-99, although the more recent sampling results suggest a general decrease from the activities evident shortly after the installation of the low-permeability cap over the S-3 Site. Considering that the mobility of Tc-99 is similar to that of nitrate and the substantially reduced nitrate concentrations in the well reflect a corresponding reduction in the overall flux of nitrate after the S-3 Site was closed and capped, the lower levels of Tc-99 likewise probably reflect a corresponding decrease in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

As illustrated by the following summary of results for gross beta (GB) and Tc-99 activity, comparable levels of both analytes are evident in the groundwater from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246, which appear to monitor groundwater with substantially higher levels of gross beta and Tc-99 activity.

Well No. / Monitored Interval Depth (ft bgs)		**January 1990**		**August 2002**		**August 2004**		**June 2005**	
		GB	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**
GW-243	62 - 77	49,100	60,800	17,000	14,000	.	.	.	.
GW-244	43 – 77	3,240	5,000	.	.	.	.	3,700	9,400
GW-245	25 – 76	1,680	4,580	.	.	.	.	1,200	2,800
GW-246	34 – 76	13,900	23,100	.	.	9,800	26,000	.	.
GW-247	31 – 78	4,240	8,800	.		.	.	2,300	9,100
Note: "." = Not sampled; All results in pCi/L									

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-245: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	Total Uranium	Gross Alpha	Gross Beta	Tc-99	U-234	U-238
03/10/87	.	0.07	DQO	DQO	.	.	.
06/05/87	.	0.096	DQO	DQO	.	.	.
09/28/87	.	0.106	DQO	DQO	.	.	.
11/23/87	2,916	0.1	DQO	DQO	.	.	.
03/24/88	3,509	0.188	DQO	DQO	.	.	.
06/13/88	3,660	0.115	DQO	DQO	.	.	.
08/27/88	3,810	0.125	DQO	DQO	.	.	.
02/18/89	3,000	0.14	DQO	DQO	.	.	.
05/12/89	2,690	0.161	DQO	DQO	.	.	.
01/17/90	[4,240]	0.108	< CE	1,680	4,580	.	.
06/23/05	2,210	0.0478	<MDA	1,200	2,800	6.4	12
10/25/05	2,150	0.0252	<MDA	890	860	3.9	6.1
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: "." = Not analyzed; [] = Result considered qualitative because of ion charge balance error;
DQO = results do not meet data quality objectives;
* = MCL is SDWA screening level for 4 mrem/yr dose equivalent

Table 2. Well GW-245: summary of VOC results

Sampling Date	Primary VOCs (µg/L)			
	PCE	111TCA	Chloroform	MC
03/10/87	12	2 J	10	5
06/05/87	12	2 J	9	7
09/28/87	9	.	6	7
11/23/87	.	3 J	8	9
03/24/88	16	2 J	11	6
06/13/88	12	1 J	8	9
08/27/88	11	.	7	7
02/18/89	15	1 J	8	6
05/12/89	16	2 J	8	8
01/17/90	19	1 J	7	7
06/23/05	4 J	.	7	7
10/25/05	1 J	.	5	5
MCL	**5**	**200**	**80***	**5**

Sampling Date	Other VOCs (µg/L)
03/10/87	Acetone (14), Toluene (1 J)
06/05/87	Acetone (8), Toluene (1 J), Xylenes (1 J)
09/28/87	Acetone (2 J), 2-Hexanone (1 J)
11/23/87	Toluene (1 J), 2-Hexanone (4 J)
06/13/88	Toluene (0.9 J)
02/18/89	Acetone (12)

Note: "." = Not detected; J = Estimated value below analytical reporting limit;
* MCL is for total trihalomethanes

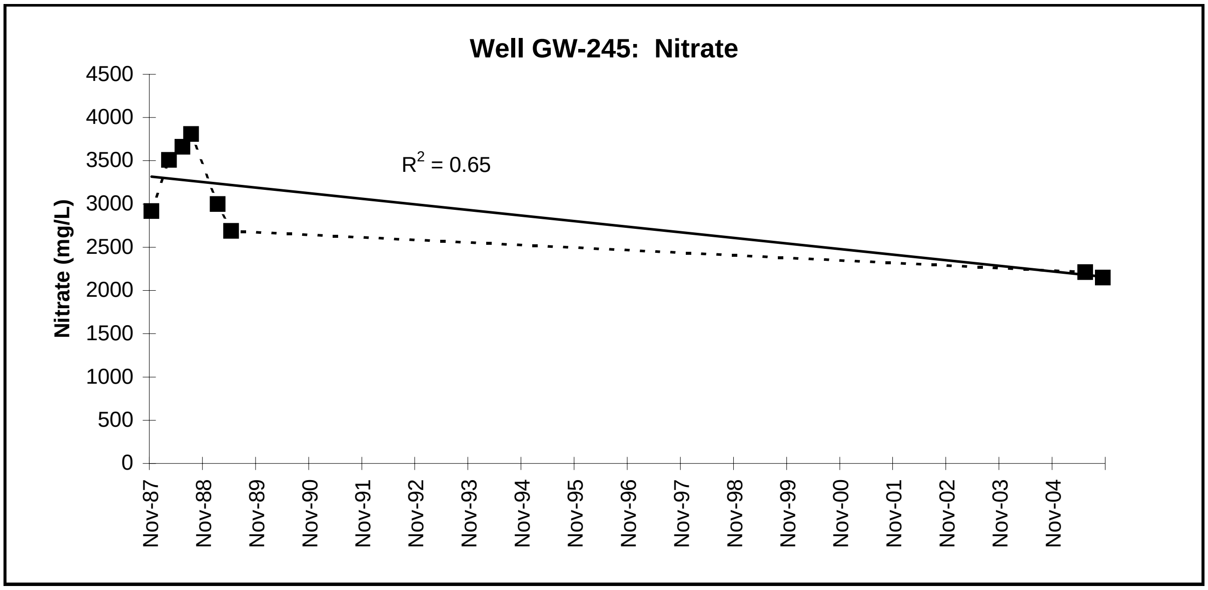


Figure 1

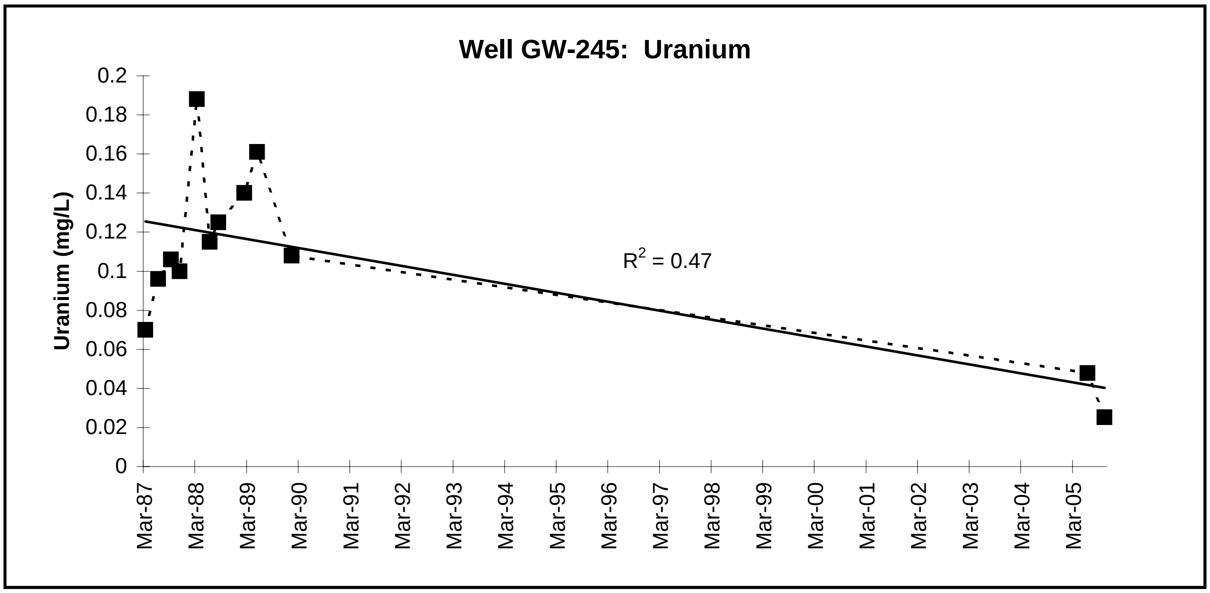


Figure 2

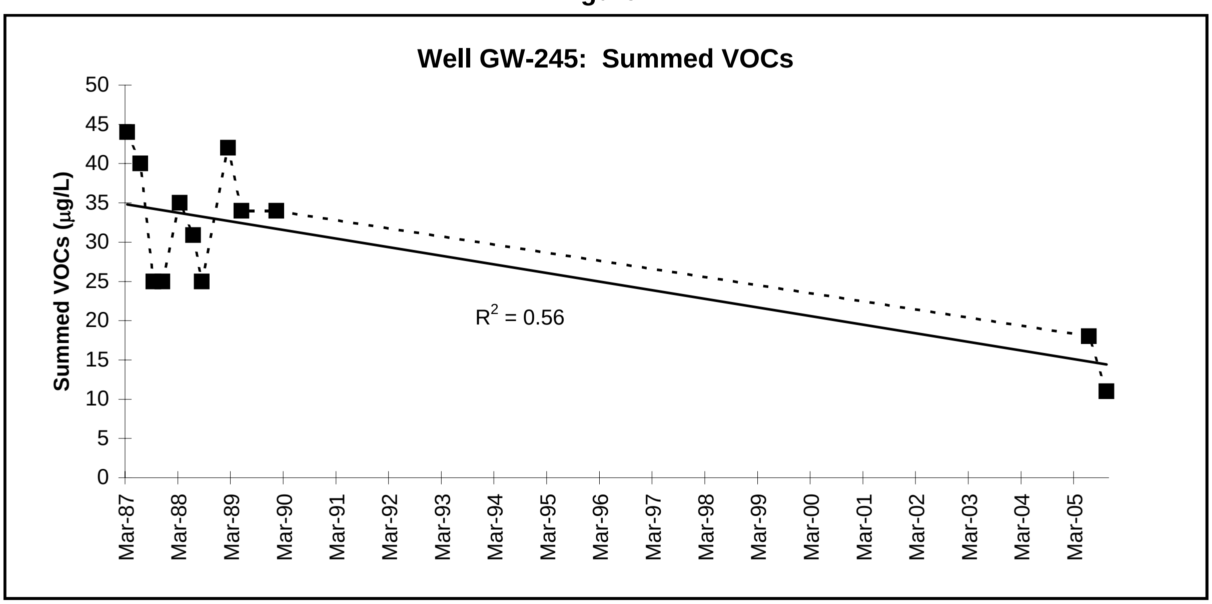


Figure 3

GW-245

MAXIMUM CONCENTRATION: 2004

>1,000	0.3 - 3.0	50 - 500	150 - 1,500	>5,000
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-246

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,098.35
Y-12 GRID NORTH COORDINATE: 29,992.24
SURFACE ELEVATION: 1,006.07 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/11/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 76.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.19 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 6.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.03
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	34.2	971.87
BOTTOM (filter pack or open hole):	76.0	930.07
MIDPOINT (filter pack or open hole):	55.1	950.97
PUMP INTAKE:	59.38	946.69
WATER LEVEL (average):	10.22	995.85

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	11 samples	03/16/87	01/17/90
LOW-FLOW SAMPLING METHOD:	2 samples	03/10/04	08/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/10/04	.	08/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.4 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	2980 mg/L	03/10/04	Indeterminate
URANIUM (0.03 mg/L):	2	0.595 mg/L	03/10/04	Indeterminate
SUMMED VOCs (5 µg/L):	2	290 µg/L	03/10/04	Increasing
GROSS ALPHA (15 pCi/L):	1	430 pCi/L	03/10/04	Indeterminate
GROSS BETA (50 pCi/L):	2	24000 pCi/L	03/10/04	Indeterminate

WELL GW-246

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1986, completed with a screened monitored interval from 34 to 76 ft bgs, and constructed with nominal 6.5-inch diameter PVC (#40) riser casing and screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, adjacent to the southwest corner of the former S-3 Ponds. This site consists of four contiguous, unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988 and completed with an asphalt-paved parking lot. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12. Operation of the ponds created a large mound in the water table that dissipated after the site was closed and capped, and emplaced a large, heterogeneous reservoir of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well, with the conventional sampling method used to obtain eleven samples between March 1987 and January 1990 and the low-flow sampling method used to obtain samples in March and August 2004. The sampling history includes quarterly, semiannual, and annual sampling frequencies and, as indicated by the sampling dates noted above, a 14-year period (January 1990 – March 2004); when no groundwater samples were collected from the well.

High total dissolved solids (TDS) and acidic pH (<5.5) are distinguishing characteristics of the groundwater samples from this well (see Section 4.0) and are a direct consequence of contamination resulting from historical operation of the former S-3 Ponds (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Also, the highly acidic wastes from the former S-3 Ponds dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these flowpaths. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops beneath the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits minor (<2 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-246 and the former S-3 Ponds indicate westward (strike-parallel) components of flow in Nolichucky Shale and cross-strike components of flow to the south-south west toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Dissolution of carbonate strata by the acidic seepage from the site also locally enhanced strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Moreover, present groundwater flow patterns differ substantially from those evident during the historical operations of the former S-3 Ponds, when the local mound created in the water table enabled groundwater flow to the east of the hydrologic divide near the west end of Y-12 that now separates the Bear Creek and Upper East Fork Poplar Creek drainage basins.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields acidic, highly contaminated groundwater from the Nolichucky Shale beneath the former S-3 Ponds that is generally characterized by:

- TDS of 17,552 –19,100 mg/L;
- pH (field measurements) of 4.4 – 4.7;
- extremely high concentrations (>2,500 mg/L) of nitrate and calcium;
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations);
- very high concentrations of several trace metals in the most recent sample (August 2004), notably aluminum (67.8 mg/L), barium (10.2 mg/L), manganese (103 mg/L), nickel (4.18 mg/L), and strontium (11.1 mg/L).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants are in the groundwater at this well.

5.1 NITRATE

All but three of the groundwater samples collected to date had nitrate concentrations above 2,500 mg/L (nitrate results were not reported for three samples). As noted previously, nitrate is a primary inorganic component of the contaminant plume emplaced during historical operations of the former S-3 Ponds. Nitrate is a primary component of the plume, is chemically stable and mobile in groundwater, and effectively traces the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (e.g., Tc-99). Based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) transport/migration in the unconsolidated zone (water table interval) directly south toward the headwaters of Bear Creek; (2) westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; (3) downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater and the hydraulic head created by the surface impoundments; and (4) substantially slower migration via much longer and less permeable strike-parallel flowpaths deeper in the bedrock, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997). Nitrate results reported for groundwater samples from this well are representative of concentrations within strike- and dip-parallel flowpaths in the Nolichucky Shale that, considering the location and depth of the well and assuming local geologic dip between 45° – 55°, potentially subcrop beneath the southwestern pond at the site.

The historical maximum nitrate concentration reported for the groundwater sample collected in May 1989 (10,800 mg/L) appears to be an outlier compared to the other nitrate results, all but two of which are less than 5,000 mg/L (Table 1). Also, the nitrate concentration (2,850 mg/L) reported for the sample collected most recently (August 2004) is slightly below the historical minimum value reported of the sample collected in November 1987 (2,860 mg/L). These "bookend" results reflect a generally indeterminate long-term concentration trend illustrated by a time-series plot of the nitrate concentrations (Figure 1), excluding the suspected outlier noted above. This trend spans the long gap in the sampling history for the well and shows a modest decrease in nitrate concentrations following installation of the low-permeability cap over the former S-3 Ponds, but does not indicate any significant overall reduction in the relative flux of nitrate along the groundwater flow/transport pathways intercepted by the monitored interval in the well, which seems unusual considering that wastewater disposal at the site ceased more than 20 years ago. The relatively steady nitrate concentrations over time probably reflect matrix diffusion from the reservoir of contaminants emplaced during operation of the site (see Section 1.0).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at least an order-of-magnitude above the MCL for uranium (0.03 mg/L), with concentrations above 0.5 mg/L reported for all but one of the samples (Table 1). As noted previously, the acidic groundwater in the Nolichucky Shale near the former S-3 Ponds contains elevated concentrations of numerous trace metals, some that were entrained in the wastewaters disposed at the site (e.g., uranium) and others that were dissolved from carbonate minerals in the bedrock underlying the site (e.g., barium). The uranium in the groundwater probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Thus, elevated uranium concentrations in the Nolichucky Shale near the former S-3 Ponds occurs primarily in the low-pH groundwater within about 500 ft of the site (DOE 1997).

As shown by the analytical results summarized on Table 1, widely variable uranium concentrations were reported for the groundwater samples collected between March 1987 (0.464 mg/L) and February 1989 (0.703 mg/L), including the historical maximum concentration (0.893 mg/L in March 1988), whereas more stable uranium concentrations are indicated by results reported for the samples obtained between May 1989 (0.534 mg/L) and August 2004 (0.591 mg/L). As with nitrate concentrations in the samples, these uranium results define an indeterminate long-term concentration trend spanning the long gap in the sampling history for the well and showing an initial concentration decrease at some time after installation of the low-permeability cap at the site (Figure 2). However, the close similarity between the uranium results reported for the groundwater samples collected since then suggests minimal long-term change in the relative flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: acetone, chloroform, ethylbenzene (ETB), xylenes, methylene chloride, PCE, TCE, 11DCE, 111TCA and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as freon-113 (Table 2). These compounds are components of the contaminant plume originating from the former S-3 Ponds, but are typically present at substantially lower concentrations compared to other components of the plume (e.g., nitrate). This is because wastewaters that contained chlorinated solvents and other organic chemical were not extensively disposed at the site (DOE 1997).

Based on the frequency of detection and relative concentrations, the primary VOCs in the groundwater samples are PCE, chloroform, and methylene chloride (Table 1). Each of these compounds was detected in all but two of the samples, with maximum historical maximum concentrations PCE (120 µg/L), chloroform (39 µg/L), and methylene chloride (21 µg/L) reported for the sample collected in March 2004 (i.e., the first sample collected from the well since January 1990). Note that the most recent sampling results show PCE concentrations at least an order-of-magnitude above the drinking water MCL (5 µg/L). The other VOCs have been detected more sporadically (e.g., acetone) and/or at very low levels, most results being estimated values of 2 µg/L or less, and only the historical maximum concentrations of acetone (15 µg/L in March 1987) and xylenes (16 µg/L in February 1989) exceed 5 µg/L (Table 2). Additionally, none of the VOC concentrations detected in the samples collected to date suggest the potential presence of DNAPL in the subsurface near the well.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date spans the 14-year gap in the sampling history for the well, with the most recent sampling results (March and August 2004) suggesting a long-term increase in VOC concentrations (Figure 3). This increasing trend is primarily attributable to sharply higher concentrations of PCE compared to historical levels. For instance, the PCE concentration reported for the sample collected in March 2004 (120 µg/L) is nearly three times higher than the previous historical maximum (48 µg/L in May 1989). Note that the samples collected most recently were obtained with the low-flow sampling method, whereas all previous samples were collected with the conventional sampling method, which suggests that the higher PCE concentrations may be an artifact of the change to the low flow sampling method. However, concentrations of other VOCs detected in the samples, including compounds that are significantly more soluble and mobile in the groundwater (e.g., chloroform) as well as compounds (e.g., TCE) with solubility/mobility comparable to that of PCE, do not appear to reflect any similar bias (higher or lower) coincident with the change in the sampling method. Perhaps the higher PCE concentrations reflect a corresponding change in the composition of organic wastes disposed at the former S-3 Ponds, whereby the volume and/or proportion of PCE-bearing organic wastewater increased over time relative to that of the other VOCs in the wastewater, such as chloroform.

5.4 GROSS ALPHA ACTIVITY

Only a few of the results for gross alpha activity reported for the samples collected to date are suitable for evaluation because sampling results obtained before January 1990 do not meet applicable data quality objectives (DQOs) (the sample specific MDA and CE are not available for these samples). Moreover, all gross alpha activity results for subsequent samples are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples. In any case, the sampling results for January 1990 (143 pCi/L) and March 2004 (430 pCi/L) show levels of gross alpha activity that exceed the drinking water MCL (15 pCi/L). The CY 2004 sample results show that uranium isotopes are the source of the gross alpha activity (Table 3). Other alpha-particle emitting radionuclides, such as americium-241, were included in the wastes disposed at the former S-3 Ponds and may be additional sources of gross alpha activity in the groundwater at this well (DOE 1997).

5.5 GROSS BETA ACTIVITY

As with gross alpha activity, few of the analytical results for gross beta activity reported for the groundwater samples collected to date meet DQOs and recent sampling results are considered qualitative because of analytical interferences associated with the high TDS of the groundwater samples. As shown on Table 3, radiological results for the three samples collected since January 1990 show gross beta activity substantially above the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The most recent sampling results (March and August 2004) show that the primary source of the beta activity is Tc-99, with possible contributions from beta-emitting uranium decay products (e.g., thorium-234). Note that Tc-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds because this was the only site at Y-12 to receive wastes that contained Tc-99. The concentrations of Tc-99 reported for these samples (33,000 pCi/L and 26,000 pCi/L) substantially exceed SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale west of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate, with transport in the water table interval south toward Bear Creek and more westward (strike-parallel) transport in the bedrock intervals toward discharge areas in NT-1 and NT-2 (DOE 1997).

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-246: summary of results for nitrate and uranium

Date Sampled	Concentration (mg/L)	
	Nitrate (as N)	Total Uranium
03/16/87	Not reported	0.464
06/08/87	Not reported	0.605
09/16/87	Not reported	0.58
11/20/87	2,860	0.644
03/25/88	3,634	0.893
06/11/88	5,590	0.661
08/30/88	3,160	0.817
02/20/89	5,400	0.703
05/06/89	10,800	0.534
01/17/90	3,530	0.552
03/10/04	2,980	0.595
08/19/04	2,850	0.591
MCL	**10**	**0.03**

Table 2. Well GW-246: summary of results for VOCs

Date Sampled	Concentration (µg/L)				
	PCE	Chloroform	TCE	11DCE	111TCA
03/16/87	26	17	.	1 J	4 J
06/08/87	38	20	1 J	1 J	4 J
09/16/87	25	14	1 J	.	4 J
11/20/87	41	18	1 J	.	3 J
03/25/88	40	20	0.9	.	4 J
06/11/88	37	20	1 J	2 J	3 J
08/30/88	46	22	1 J	1 J	4 J
02/20/89	.	.	.	.	.
05/06/89	48	22	1 J	2 J	3 J
01/17/90	33	18	0.9	.	2 J
03/10/04	120	39	2 J	4 J	.
08/19/04	88	30	1 J	3 J	.
MCL	5	NA	5	7	200

Date Sampled	Concentration (µg/L)		
	Methylene chloride	Acetone	Other
03/16/87	9	15	Toluene (1 J), Xylenes (1 J)
06/08/87	11	13	Toluene (1 J)
09/16/87	9	14	Toluene (1 J)
11/20/87	9	.	Toluene (0.8 J)
03/25/88	.	10	ETB (0.6 J)
06/11/88	13	.	.
08/30/88	10	.	CTET (0.7 J), Toluene (1 J)
02/20/89	.	.	ETB (4 J), Xylenes (16)
05/06/89	12	.	.
01/17/90	10	5	.
03/10/04	21	4 J	.
08/19/04	14	.	Freon-113 (41)
MCL	NA	NA	

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

Table 3. Well GW-246: summary of radiological results

Date Sampled	Concentration (pCi/L)					
	Gross Alpha Activity	Gross Beta Activity	Tc-99	U-234	U-235	U-238
01/17/90	143	13,900	.	.	.	.
03/10/04	430	24,000	33,000	87	4.5	210
08/19/04	<MDA	9,800	26,000	79	4.8	190
Note: "." = Not analyzed						

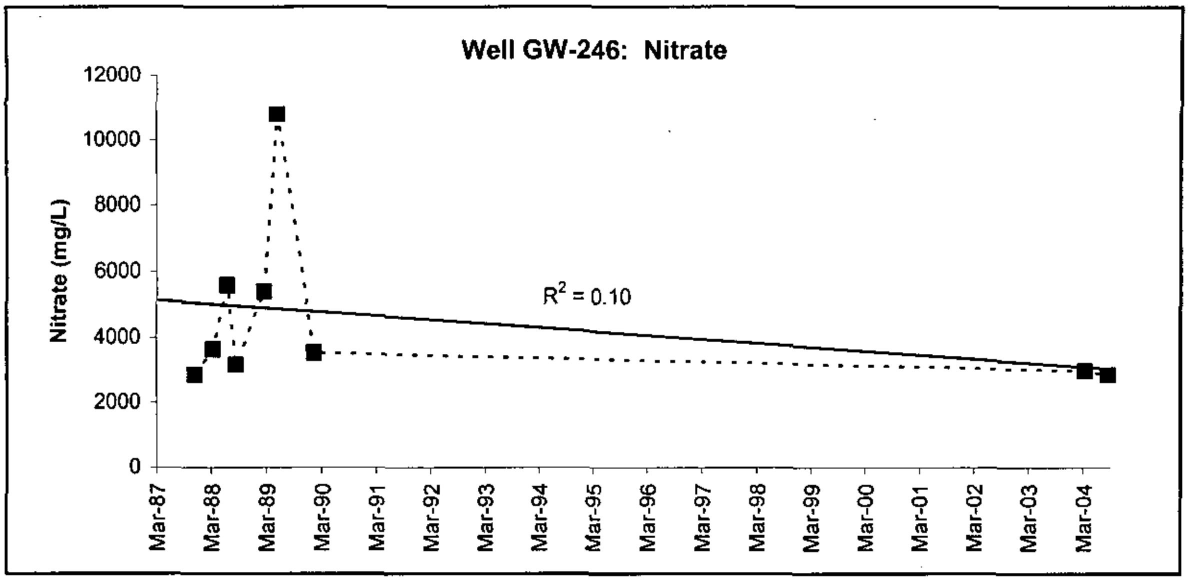


Figure 1

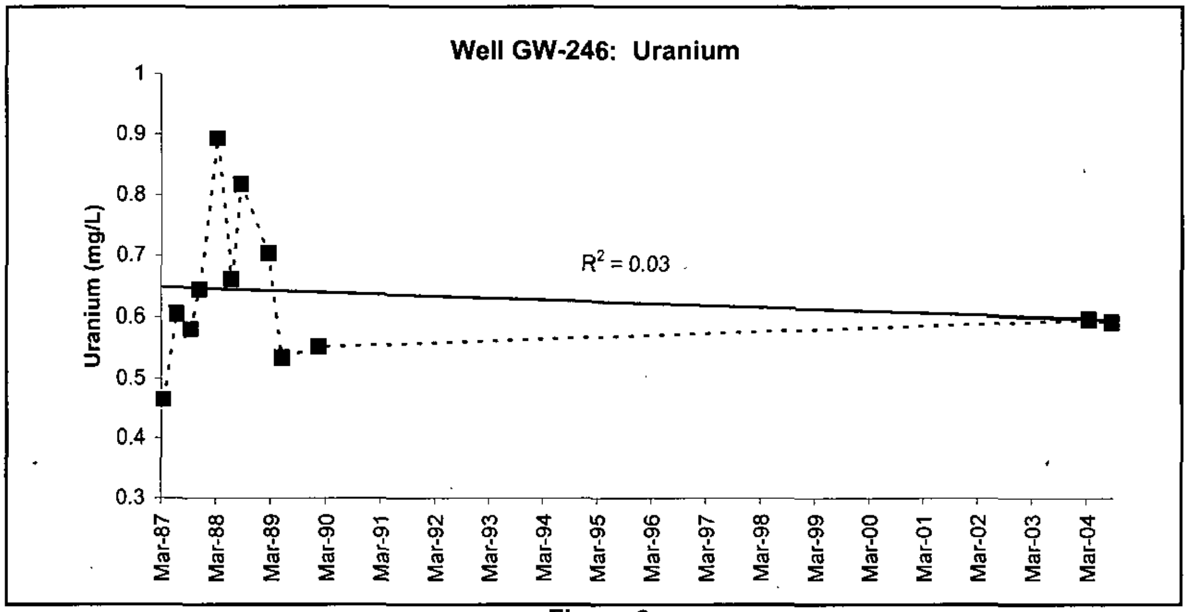


Figure 2

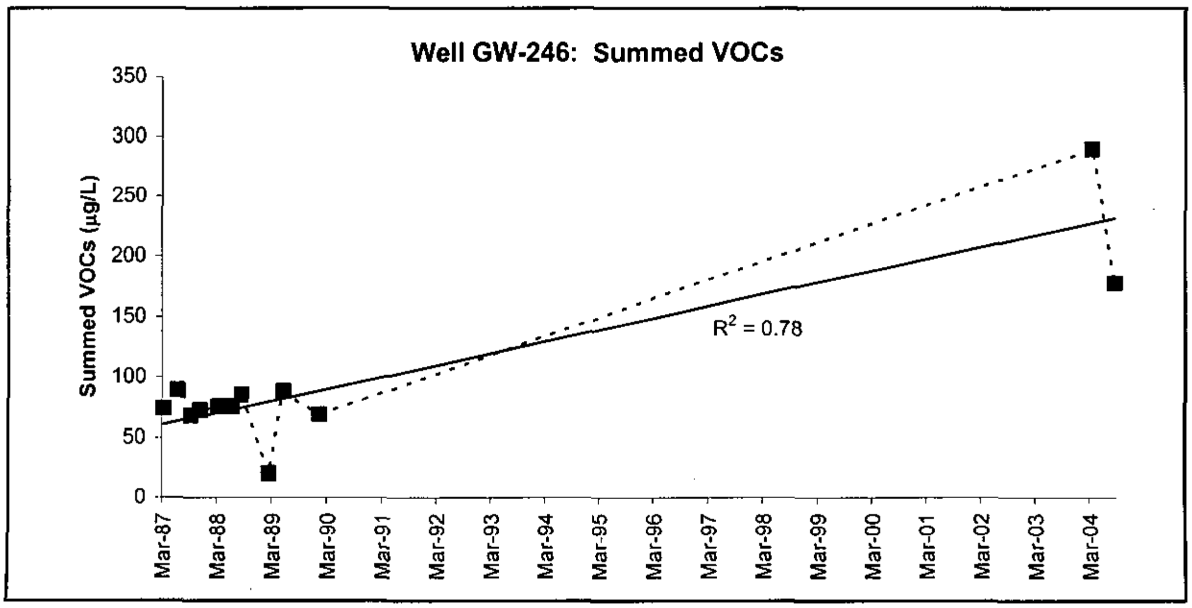


Figure 3

MAXIMUM CONCENTRATION: 2005

>1,000	0.015 - 0.03	5 - 50	ND	>5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-247

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,181.21
Y-12 GRID NORTH COORDINATE: 30,004.72
SURFACE ELEVATION: 1,006.73 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/13/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 76.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.61 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 11 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 6.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	31.5	975.23
BOTTOM (filter pack or open hole):	78.0	928.73
MIDPOINT (filter pack or open hole):	54.8	951.98
PUMP INTAKE:	59.6	947.11
WATER LEVEL (average):	12.38	994.35

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	11 samples	03/16/87	01/17/90
LOW-FLOW SAMPLING METHOD:	2 samples	06/23/05	10/25/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/23/05	.	10/25/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.8 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	3260 mg/L	06/23/05	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	2	25 µg/L	06/23/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	2	5500 pCi/L	10/25/05	Indeterminate

WELL GW-247

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1986, completed with a screened monitored interval from 31.5 to 78 ft bgs, and constructed with nominal 6.5-inch diameter PVC (#40) riser casing and screen (0.01 slot wire-wound). The well is one of a series of wells completed at similar depths along the western (GW-243 and GW-244) and southern (GW-245, GW-246, and GW-247) boundaries of the former S-3 Ponds (hereafter referenced as the S-3 Site), with well GW-247 being on the southern side, approximately 200 ft east of the southwest corner of the site. The S-3 Site, which is located near the western end of Y-12, directly north of the headwaters of Bear Creek, encompasses four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between March 1987 and January 1990 and the low-flow sampling method used to obtain samples in June and October 2005. The sampling history includes almost two years of quarterly sampling, followed by a 15-year period (January 1990 – June 2005) when no groundwater samples were collected from the well.

Extremely high total dissolved solids (TDS) is a distinguishing characteristics of the groundwater samples from this well (see Section 4.0), and is a direct consequence of contamination resulting from historical operation of the S-3 Site (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group) which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º-55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst unit that provides the principal pathway for subsurface contaminant migration in BCV. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Moreover, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 12.5 ft bgs and exhibits minor (<1 ft) seasonal fluctuations. As indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements from nearby monitoring wells, directions of groundwater flow near the well are to the west, parallel with the trend (strike) of bedding in Nolichucky Shale, and to the south-southwest, across geologic-strike toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic flow via strike-parallel flowpaths (i.e., bedding-plane fractures) that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Also, possible dissolution of carbonate strata by the acidic seepage from the S-3 Site may locally enhance strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Additionally, directions of groundwater flow (and contaminant transport) now evident are undoubtedly different from the flow patterns that occurred during historical operations of the S-3 Site, which created a local "mound" in the water table that enabled groundwater flow (and contaminant transport) to the east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected in June and October 2005 show that the well yields slightly acidic, highly contaminated groundwater from the Nolichucky Shale beneath the S 3 Site that is generally characterized by:

- TDS of 19,040 –20,000 mg/L;
- pH (field measurements) of 5.93 – 6;
- high concentrations of calcium (>3,700 mg/L), chloride (>230 mg/L), magnesium (>690 mg/L), nitrate (>3,200 mg/L), and sodium (>240 mg/L);
- low molar proportions of chloride, sodium, sulfate, and potassium (<10% of total anions/cations);
- high molar proportions of nitrate (>90% of total anions/cations);
- high concentrations of several trace metals, notably barium (>40 mg/L), cadmium (>0.01 mg/L), manganese (>20 mg/L), nickel (>0.3 mg/L), strontium (>10 mg/L), and uranium (>0.02 mg/L), that are significantly above corresponding background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995)

Note that some of the inorganic compounds and trace metals in the groundwater at this well, such as nitrate and uranium, were entrained in the acidic wastes disposed at the S-3 Site, whereas other inorganics, such as calcium and barium, were dissolved from bedrock minerals by the highly acidic seepage from the site. Also, the high levels of TDS may cause analytical interferences for some laboratory analytes, including gross alpha activity and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants except gross alpha activity are present in the groundwater at this well. Note, however, that the bulk of the historical the analytical results for VOCs, gross alpha activity, and gross beta activity do not meet all applicable DQOs. The QA/QC sample data needed to identify false positive VOC results are not available for groundwater samples collected before January 1991. Similarly, gross alpha activity and gross beta activity reported for the groundwater samples collected before January 1990 are considered unusable because the sample-specific MDA and CE are not available for these analytes.

5.1 NITRATE

All of the groundwater samples collected to date that were analyzed for nitrate (nine samples), had nitrate concentrations that exceed 3,000 mg/L (Table 1), including the samples collected most recently (June and October 2005). These results show that nitrate concentrations in the shallow groundwater nearest the S-3 Site remain several orders-of-magnitude above the drinking water MCL for nitrate (10 mg/L). Nitrate is the principal component of the contaminant plume emplaced during historical operations of the site, is chemically stable and mobile in groundwater, and is believed to effectively trace the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997).

A time-series plot of the nitrate concentrations reported for the groundwater samples collected to date shows an indeterminate or slightly decreasing long-term trend (Figure 1). Note that the historic maximum (7,380 mg/L in January 2000) and minimum (1,900 mg/L in February 1989) results are excluded from the trend because these results are considered qualitative (Table 1): the ion charge balance error (i.e., the percent difference between respective summed milliequivalent concentrations of the major cations and anions) for these samples exceeds 20%. The nitrate trend spans the long gap in the sampling history for the well and, as illustrated by the data summarized below, contrasts with the more clearly decreasing nitrate concentrations indicated by the data for wells GW-244, GW-245 and GW-246. The increasing trend indicated for well GW-243 is conspicuous and may be an artifact of one or more inaccurate nitrate results. These data also show that wells GW-243 and GW-244, both of which are located on the west side of the site (parallel with geologic strike), monitor groundwater with the highest levels of nitrate, as indicated by both the historic and the most recent sampling results for each well.

Well No./Monitored Interval Depth (ft bgs)		Nitrate (mg/L)				% Change
		June 1988	August 2002	August 2004	June 2005	
GW-243	62 – 77	6,160	8,840	.	.	+ 44%
GW-244	43 – 77	6,200	.	.	4,350	-37%
GW-245	25 – 76	3,660	.	.	2,210	-40%
GW-246	34 – 76	5,590	.	2,850	.	-49%
GW-247	31 – 78	3,500	.	.	3,260	-7%
Note: "." = Not sampled						

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the corresponding reporting limit (Table 1), although only two concentrations exceed the drinking water MCL for uranium (0.03 mg/L). As noted previously, uranium was entrained in the nitric-acid wastewaters disposed at the S-3 Site, and uranium in the acidic seepage probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium in the Nolichucky Shale near the S-3 Site are generally restricted to the acidic groundwater within approximately 500 ft of the S-3 Site (DOE 1987).

The groundwater in well GW-247 has never been especially acidic, surprisingly, which may explain the relatively low levels of uranium in the well. Also, the pH of the groundwater appears to have changed very little since the S-3 Site was closed and capped, as illustrated by the results summarized below. These results also show that the highest levels of uranium occur in the wells adjacent to the S-3 Site that monitor more acidic groundwater, particularly well GW-243.

Well No. / Monitored Interval Depth (ft bgs)		June 1988		August 2002		August 2004		June 2005	
		Total U	pH	Total U	pH	Total U	pH	Total U	pH
GW-243	62 - 77	60.5	3.6	0.653	5.42	.	.	.	.
GW-244	43 – 77	<0.001	5.5	.	.	.		0.00209	5.5
GW-245	25 – 76	0.115	5.3	.	.	.		0.0478	6.01
GW-246	34 – 76	0.661	4.8	.	.	0.591	4.63	.	.
GW-247	31 – 78	0.036	6.0	.	.	.		0.0241	5.93
Note: "." = Not sampled; Total uranium concentrations in mg/L; pH from field measurements (in standard pH units)									

Perhaps the monitored interval in well GW-247 is completed within a stratigraphic section of the Nolichucky Shale that contains proportionally more carbonate than shale. The carbonate would tend to buffer the acidic seepage during the operation of the S-3 Site, although dissolution of the carbonate would be expected to increase the hydraulic conductivity of the permeable flowpaths (e.g., enlarge bedding-plane fractures).

A time-series plot of the uranium results reported for the groundwater samples collected to date is dominated by the prolonged gap in the sampling history for the well (Figure 2), and shows a variable but generally increasing concentration trend between March 1987 (0.026 mg/L) and June 1988 (0.036 mg/L), with a subsequently decreasing trend through October 2005 (0.0243 mg/L). Moreover, as shown in the preceding data summary, the overall decrease in uranium concentrations is generally mirrored by the uranium data for the other wells located adjacent to the S-3 Site, particularly well GW-243. The lower concentrations of uranium indicated by the most recent sampling results for these wells reflect the corresponding reduction in the relative flux of uranium via the shallow groundwater flow system in the Nolichucky Shale nearest the S-3 Site.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs was detected in each of the groundwater samples collected to date: acetone, chloroform, ethylbenzene, MC, PCE, toluene, and 2-hexanone (Table 2). Chlorinated solvents and organic chemicals were not substantial components of the waste stream for the S-3 Site and, consequently, VOCs are fairly minor constituents within the contaminant plume emplaced during historical operation of the site, and are typically present at substantially lower concentrations compared to other plume constituents (e.g., nitrate).

Based on the frequency of detection and relative concentrations, the primary VOCs detected in the groundwater samples collected to date are PCE, chloroform, and MC (Table 2). All of these compounds were detected in each of the samples, with the highest concentrations reported for chloroform (10 µg/L) and MC (11 µg/L). Also, the most recent sampling results (June and October 2005) show PCE and MC concentrations above the respective drinking water MCL (5 µg/L). Aside from the primary VOCs, other compounds were not detected in samples collected after February 1989 (Table 2).

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date is dominated by the prolonged gap in the sampling history for the well and shows an indeterminate long-term VOC concentration trend (Figure 3). Additionally, data for individual compounds show divergent concentration trends. For instance, MC concentrations changed very little between June 1987 (8 µg/L) and June 2005 (7 µg/L), whereas PCE concentrations increased between March 1987 (2 µg/L) and October 2005 (8 µg/L). It is not clear from the available data if the divergent concentration trends for individual compounds are significant relative to the corresponding flux of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

As illustrated by the chloroform (CLF) and summed (Tot.) VOC concentrations shown in the following data summary, VOC levels in the groundwater at this well are generally comparable to respective levels detected in groundwater samples from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246. Both of these wells monitor groundwater with substantially higher PCE concentrations than evident in well GW-247, with the most recent sampling results for each well showing PCE levels above 3,000 µg/L and 100 µg/L, respectively.

Well No. / Monitored Interval Depth (ft bgs)		**June 1988**		**Aug. 2002**		**Aug. 2004**		**June 2005**	
		CLF	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**	**CLF**	**Tot. VOC**
GW-243	62 - 77	27	2,153	29	4,076	.	.	.	.
GW-244	43 – 77	13	33	.	.	.	.	24	36
GW-245	25 – 76	8	30.9	.	.	.	.	7	18
GW-246	34 – 76	20	76	.	.	30	177	.	.
GW-247	31 – 78	7	19	.	.	.	.	10	25
Note: "." = Not sampled; All results in µg/L									

These data also illustrate the divergent long-term trends in the concentrations of VOCs in the groundwater from the other wells, which appear to have remained fairly unchanged (GW-244), decreased (GW-245), or increased (GW-243 and GW-246) in response to the closure/capping of the S-3 Site. However, considering the relatively low concentrations of the VOCs in most of the wells, it is not clear from the available data if the various long-term concentrations trends are significant with respect to the overall flux of dissolved VOCs through the shallow groundwater flow system in the Nolichucky Shale nearest to the site.

5.4 GROSS ALPHA ACTIVITY

Only a few of the results for gross alpha activity reported for the samples collected to date are suitable for evaluation because sampling results obtained before January 1990 do not meet applicable data quality objectives (DQOs) (the sample specific MDA and CE are not available for these samples). None of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE (Table 1). Note that these gross alpha activity results are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples (Section 4.0). However, the low levels of U-234 and U-238 (the primary alpha emitting isotopes) reported for the most recent samples collected from the well support the presence of low levels of gross alpha activity (Table 1).

5.5 GROSS BETA ACTIVITY

As with gross alpha activity, few of the analytical results for gross beta activity reported for the groundwater samples collected to date meet DQOs and recent sampling results are considered qualitative because of analytical interferences associated with the high TDS of the groundwater samples. As shown on Table 1, radiological results for the three samples collected since January 1990 show gross beta activity substantially above the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

Uranium decay products (e.g., Th-234) and other beta-emitting radionuclides known to be included in the waste stream for the S-3 Site (e.g., Np-237) probably contribute to the high level of gross beta activity in the groundwater from this well. However, Tc-99 is the principal source of beta activity and is the "signature" component of the contaminant plume emplaced during historical operation of the S-3 Site, which is the only site at Y-12 known to have received significant volumes of waste that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the groundwater downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater.

The Tc-99 activity reported for the samples collected in January 1990 (8,800 pCi/L), June 2005 (9,100 pCi/L), and October 2005 (9,100 pCi/L) substantially exceed the SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Although there are insufficient data to adequately characterize the long-term trend for Tc-99, the most recent sampling results suggest a slight increase from the Tc-99 activity evident shortly after the installation of the low-permeability cap over the S-3 Site. This may reflect a corresponding increase in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, considering that Tc-99 and nitrate share similar mobility in the groundwater, the lack of a concurrent increase in nitrate concentrations (which decreased slightly) suggests that the higher levels of Tc-99 indicated by the more recent results may simply reflect inherent analytical variability.

As illustrated by the following summary of results for gross beta (GB) activity and Tc-99, comparable levels of both analytes are evident in the groundwater from each of the other wells located adjacent to the S-3 Site except wells GW-243 and GW-246, which appear to monitor groundwater with substantially higher levels of gross beta activity and Tc-99.

Well No. / Monitored Interval Depth (ft bgs)		**January 1990**		**August 2002**		**August 2004**		**June 2005**	
		GB	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**	**GB**	**Tc-99**
GW-243	62 - 77	49,100	60,800	17,000	14,000	.	.	.	.
GW-244	43 – 77	3,240	5,000	.	.	.	.	3,700	9,400
GW-245	25 – 76	1,680	4,580	.	.	.	.	1,200	2,800
GW-246	34 – 76	13,900	23,100	.	.	9,800	26,000	.	.
GW-247	31 – 78	4,240	8,800	.		.	.	2,300	9,100
Note: "." = Not sampled; All results in pCi/L									

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-247: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	**Total Uranium**	**Gross Alpha**	**Gross Beta**	**Tc-99**	**U-234**	**U-238**
03/16/87	.	0.026	DQO	DQO	.	.	.
06/09/87	.	0.028	DQO	DQO	.	.	.
09/16/87	.	0.029	DQO	DQO	.	.	.
11/23/87	3,358	0.021	DQO	DQO	.	.	.
03/28/88	3,880	0.029	DQO	DQO	.	.	.
06/14/88	3,500	0.036	DQO	DQO	.	.	.
08/31/88	3,340	0.03	DQO	DQO	.	.	.
02/20/89	[1,900]	0.022	DQO	DQO	.	.	.
05/11/89	3,070	0.032	DQO	DQO	.	.	.
01/17/90	[7,380]	0.027	< CE	4,240	8,800	.	.
06/23/05	3,260	0.0241	<MDA	2,300	9,100	3.9	6.8
10/25/05	3,200	0.0243	<MDA	5,500	9,100	3.6	5.9
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: "." = Not analyzed; [ ] = Result considered qualitative because of ion charge balance error;
DQO = does not meet data quality objectives;
* = MCL is SDWA screening level for 4 mrem/yr dose equivalent

Table 2. Well GW-247: summary of VOC results

Sampling Date	Primary VOCs (µg/L)		
	PCE	**Chloroform**	**MC**
03/16/87	2 J	8	11
06/09/87	4 J	9	8
09/16/87	2 J	7	8
11/23/87	4 J	7	9
03/28/88	2 J	7	9
06/14/88	3 J	7	7
08/31/88	3 J	8	7
02/20/89	3 J	8	7
05/11/89	5	10	8
01/17/90	3 J	8	7
06/23/05	8	10	7
10/25/05	8	10	7
MCL	**5**	**80***	**5**

Sampling Date	Other VOCs (µg/L)
03/16/87	Acetone (5), Toluene (1 J)
06/09/87	Acetone (7), Toluene (1 J)
09/16/87	Acetone (2 J), Toluene (1 J), 111TCA (2 J)
11/23/87	Acetone (13), 2-Hexanone (2 J)
06/14/88	Toluene (2 J)
02/18/89	Acetone (12)

Note: "." = Not detected; J = Estimated value below analytical reporting limit;
* MCL is for total trihalomethanes

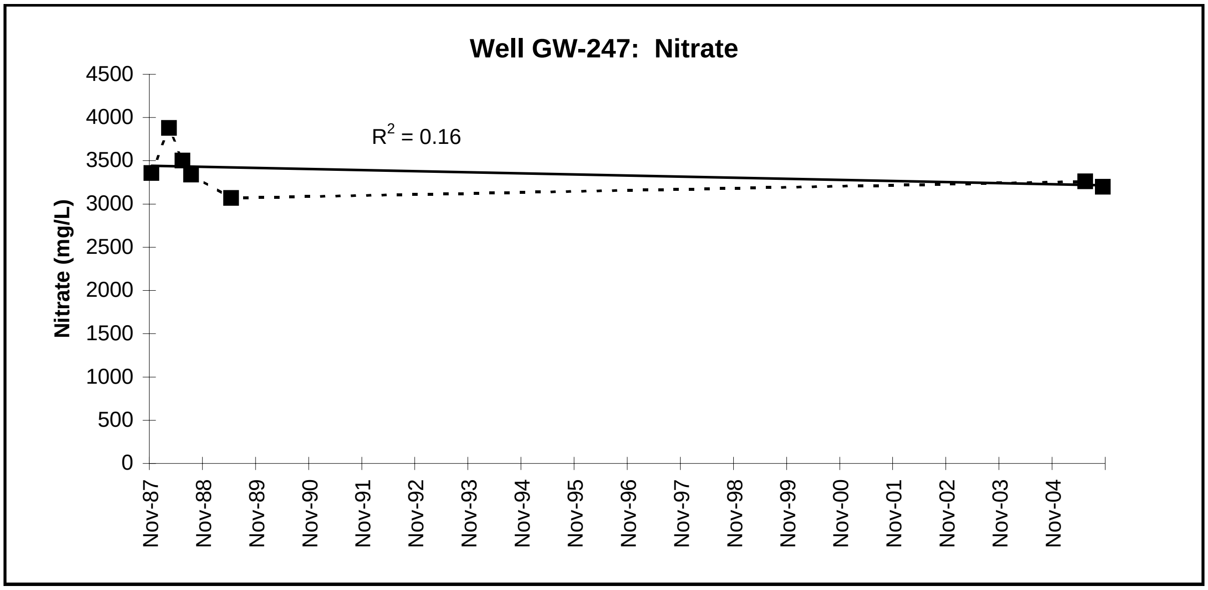


Figure 1

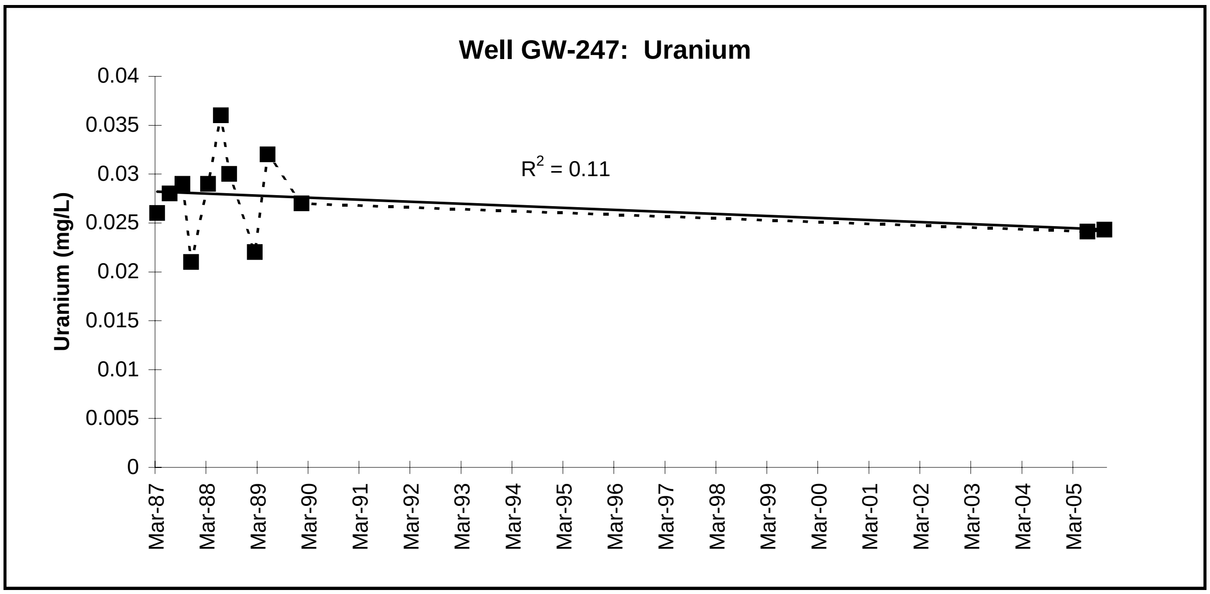


Figure 2

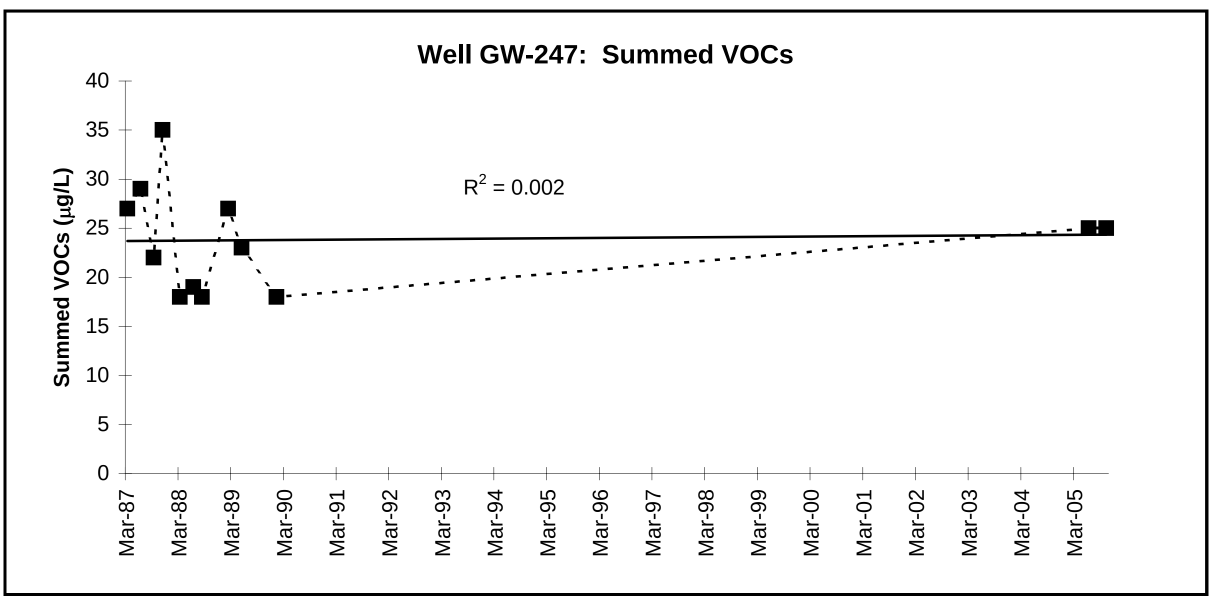


Figure 3

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	50 - 500	7.5 - 15	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-251

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-2 Site
Y-12 GRID EAST COORDINATE: 53,843.00
Y-12 GRID NORTH COORDINATE: 29,467.00
SURFACE ELEVATION: 1,001.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/08/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 50.04 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,003.80 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.25 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	35.0	966.60
BOTTOM (filter pack or open hole):	51.0	950.60
MIDPOINT (filter pack or open hole):	43.0	958.60
PUMP INTAKE:	42.80	958.80
WATER LEVEL (average):	14.8	986.80

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	59		
CONVENTIONAL SAMPLING METHOD:	42 samples	06/10/86	05/07/97
LOW-FLOW SAMPLING METHOD:	17 samples	11/05/97	10/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/29/04	.	10/21/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.37 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	33	92 mg/L	01/14/91	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	39	879 µg/L	05/07/97	Indeterminate
GROSS ALPHA (15 pCi/L):	6	27.8 pCi/L	04/22/92	Decreasing
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-251

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1986, completed with a screened monitored interval from 35 to 51 ft bgs, and constructed with nominal 4.5-inch diameter PVC (Schedule 40) riser casing and well screen (0.01 slot). The well is located near the base Chestnut Ridge in the southwest section of Y-12, about 50 ft west of the S-2 Site. The S-2 Site originally consisted of an unlined waste pit excavated into the northern flank of Chestnut Ridge. With an estimated capacity of 200,000 gallons, the S-2 Site was used from 1943 to 1951 for disposal of an unknown quantity of corrosive and toxic aqueous waste, primarily acidic solutions containing nitrates of heavy metals such as copper, nickel, and chromium (DOE 1998). When closed sometime in 1954, the wastes remaining in the S-2 Site were chemically neutralized and the site was backfilled, covered with topsoil, and seeded with grass.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 42 samples between June 1986 and May 1997, and the low-flow sampling method used to obtain 17 samples between November 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements for the well show that the static groundwater level in the well occurs at an average depth of about 15 ft bgs and exhibits substantial (>15 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-251 indicate easterly flow, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions in the Maynardville Limestone may be strongly influenced by subsurface process lines, utilities, and storm sewers (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 325 - 815 mg/L;
- pH (field measurements) of 5.7 – 7.1;
- high concentrations of nitrate (>50 mg/L) and fluoride (>1 mg/L) compared to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- elevated total concentrations of several trace metals, particularly manganese (>2 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirty-three of the groundwater samples were analyzed for nitrate (as N), with concentrations above the analytical reporting limit detected in all but four of the samples, and the most recent sampling results showing concentrations substantially above the MCL for nitrate (Table 1). The mass of inorganic contaminants emplaced in the Maynardville Limestone during historical operation of the S-2 Site is the source of the nitrate in the groundwater at this well. Also, sludge and soil backfill in the former waste pit contain metals, nitrate, and inorganic compounds (e.g., cyanide), are below the saturated zone, and the site is not covered with a low-permeability cap; these conditions effectively promote vertical leaching of contaminants directly into the shallow karst network in the Maynardville Limestone (DOE 1998).

Nitrate concentrations below 100 mg/L were reported for most of the groundwater samples (Table 1), with the recent sampling results showing that concentrations remain near 50 mg/L and substantially above the MCL (10 mg/L). The range of nitrate results encompass conspicuous non-detect results (<0.02 mg/L) for samples collected in December 1994 and February 1995; both results are probably sampling or analytical artifacts. Additionally, the nitrate results reported for the samples collected in July 1991, January 1992, September 1993, and August 1994 are considered qualitative because of the ion charge balance errors (i.e., the relative percent difference between respective summed millequivalent concentrations of the major cations and anions exceeds 20%);

A time-series plot of the nitrate results (excluding the non-detect values and qualitative results noted above) show a generally decreasing long-term concentration trend dominated by wide temporal fluctuations (Figure 1), although the "seesaw" fluctuations indicated by data obtained since May 1997 appear to be an artifact of the change from a quarterly to a semiannual sampling frequency. The slowly decreasing nitrate concentrations, as illustrated by the nitrate results reported for the samples collected in January 1991 (92 mg/L), May 1997 (80.2 mg/L), and April 2004 (61.9 mg/L), suggest an overall decrease in the flux from the source of the nitrate. The temporal concentration fluctuations correlate with seasonal groundwater flow conditions, with the highest nitrate concentrations reported for samples obtained during seasonally high flow and the lowest nitrate concentrations reported for samples obtained during seasonally low flow. This relationship suggests seasonally variable flux of nitrate along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

Thirty-nine groundwater samples were analyzed for total uranium and concentrations at or above the applicable analytical reporting limit were detected in all but one of the samples (Table 1). Total uranium concentrations reported for the samples range from 0.003 mg/L to 0.01 mg/L and are all less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each groundwater sample contained one or more of the following VOCs (Table 2): CTET, chloroform, dibromochloromethane, PCE, TCE, and 12DCE (c12DCE). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources within Y-12, including the S-2 Site, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The primary VOCs in the groundwater samples are PCE and TCE (Table 2), which were detected in each sample and have respective historical maximum concentrations above 600 μg/L and 240 μg/L. Also, the most recent sampling results show that PCE and TCE concentrations remain substantially above respective MCLs (5 μg/L). Secondary VOCs in the groundwater samples are CTET, chloroform, and 12DCE (Table 2), at least one of which was detected (excluding false positive results) in all but one of the samples. Respective maximum historical concentrations for these VOCs are less than 20 μg/L, with several results for each compound being estimated values below 5 μg/L, and the most recent sampling results showing CTET and c12DCE concentrations below corresponding MCLs (5 μg/L and 70 μg/L).

The relatively low concentrations of c12DCE suggest that the geochemical conditions in the groundwater at this well are not especially conducive to the anaerobic methanotropic organisms that are typically associated with the degradation (sequential dechlorination) of PCE and TCE. This is illustrated by the most recent results for several indicator parameters (Table 3), with the REDOX values in particular indicating that the groundwater does not exhibit the geochemical (methanogenic) conditions necessary for biotic degradation of chlorinated hydrocarbons.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows an indeterminate long-term concentration trend dominated by wide temporal fluctuations (Figure 1), although the "seesaw" fluctuations indicated by data obtained since May 1997 appear to be an artifact of the change from a quarterly to a semiannual sampling frequency. The indeterminate trend, illustrated by the similar summed VOC concentrations for the samples collected in January 1992 (327 mg/L), November 1996 (310 mg/L), and May 2003 (319 mg/L), potentially reflects continued influx from the source(s) of VOCs, which may include DNAPL (DOE 1998). The wide temporal concentration fluctuations closely correlate with seasonal groundwater flow conditions, with the highest summed VOC concentrations in samples obtained during seasonally high flow and the lowest summed concentrations in samples obtained during seasonally low flow. This relationship suggests seasonally variable flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Thirty-two groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), including results for five samples that exceed the MCL for gross alpha activity (15 pCi/L). The highest values for gross alpha activity were reported for samples collected in the early 1990s; none of the samples collected since November 1997 had gross alpha activity above 10 pCi/L. Uranium isotopes (U-234 and U-238) are the suspected source of the gross alpha activity in the groundwater and were detected (i.e., >MDA) in groundwater samples collected in March 1998 (U-234 = 10.81 pCi/L and U-238 = 2.32 pCi/L) and July 1998 (U-234 = 10.79 pCi/L and U-238 = 3.34 pCi/L).

A time-series plot of applicable results for gross alpha activity (i.e., results that exceed the MDA and corresponding CE) shows a generally decreasing long-term concentration trend that exhibits substantially less temporal fluctuations compared to nitrate and VOCs (Figure 3). Also, the gross alpha results obtained since November 1997 show generally steady levels below 10 pCi/L.

5.5 GROSS BETA ACTIVITY

Twenty-three groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the highest value (39.6 pCi/L in April 1992) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity). Also, gross beta activity above the applicable MDA was reported only for three of the samples collected since May 1996, with the most recent result (15 pCi/L in May 2000) being substantially below the SDWA screening level.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds*. Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-251: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/14/91	92	0.005	16.52	13.76
04/09/91	35.7	0.003	10.95	10.95
07/14/91	(21)	0.005	11.34	9.91
10/03/91	65	0.006	10.19	16.39
01/19/92	(16)	0.007	11.2	10.6
04/22/92	82.5	0.007	27.8	39.4
07/31/92	67	0.008	<CE	36.9
10/20/92	54	0.008	16.9	11.9
01/20/93	82	0.006	19.2	19.4
05/05/93	83	0.007	5.94	12.6
09/17/93	(244)	0.01	22.2	11.5
12/08/93	42.9	0.004	9.11	4.19
02/07/94	75.24	0.007	9.09	9.97
05/09/94	91	0.007	9.66	10.1
08/22/94	(146.9)	0.008	9.75	6.22
12/03/94	.	.	7.89	8.01
02/27/95	.	0.0054	11.2	16.7
05/25/95	76	0.005	10.1	9.37
09/13/95	61	0.0081	15.6	8.45
12/07/95	64	0.0055	7.32	8.78
02/21/96	79.2	0.006	NA	NA
05/23/96	75.2	0.0076	8.96	<MDA
11/07/96	44.7	0.0043	6.77	<MDA
05/07/97	80.2	0.0088	13	14
11/05/97	40.9	0.0036	8	<MDA
05/26/98	89.5	0.0063	8.5	8.7
12/02/98	31.6	0.0053	8.3	<MDA
05/27/99	73.33	0.0045	9.8	<MDA
11/02/99	25.5	0.00275	<MDA	<MDA
05/09/00	63.2	0.00375	10	15
10/09/00	26.3	0.00267	6	<MDA
04/24/01	55.7	0.00349	7.4	<MDA
10/18/01	20.4	0.00183	<MDA	<MDA
04/18/02	62.4	0.00395	7.5	<MDA
10/16/02	41.2	0.00385	8.3	<MDA
05/07/03	62.6	0.00528	<MDA	<MDA
10/01/03	52.2	0.00426	<MDA	<MDA
04/29/04	61.9	0.00333	<MDA	<MDA
10/21/04	51.5	0.00583	8	<MDA
MCL	**10 mg/L**	**0.03 mg/L**	**15 pCi/L**	**50 pCi/L***

Note: "." = Not detected; NA = Not analyzed; ( ) = Qualitative result; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-251: summary of VOC results

Date Sampled	Concentration (µg/L)			
	PCE	TCE	12DCE (Total)	c12DCE
01/14/91	180	81	.	NR
04/09/91	450	160	11	NR
07/14/91	270	94	7	NR
10/03/91	150	53	2 J	NR
01/19/92	190	110	12	NR
04/22/92	230	86	7	NR
07/31/92	130	45	2 J	NR
10/20/92	82	34	2 J	NR
01/20/93	24	7	.	NR
05/05/93	210	82	7	NR
09/17/93	47	18	.	NR
12/08/93	31	10	.	NR
02/07/94	27	8	.	NR
05/09/94	240	99	5	NR
08/22/94	130	49	.	NR
12/03/94	49	17	.	NR
02/27/95	63	27	2 J	NR
05/25/95	59	24	1 J	NR
09/13/95	100	40	1 J	NR
12/07/95	120	49	4 J	NR
02/21/96	160	76	5	NR
05/23/96	190	76	5	NR
11/07/96	130	40	.	NR
05/07/97	600	240	8	8
11/05/97	130	50	2 J	2 J
05/26/98	410	200	11	11
12/02/98	66	29	.	.
05/27/99	310	140	10	10
11/02/99	60	23	.	.
05/09/00	300	150	10	10
10/09/00	71	28	.	.
04/24/01	200	100	8	8
10/18/01	50	18	.	.
04/18/02	230	130	11	11
10/16/02	81	38	2 J	2 J
05/07/03	200	100	6	6
10/01/03	150	68	5	5
04/29/04	280	120	9	9
10/21/04	140	49	4 J	4 J
MCL	**5**	**5**	**NA**	**70**

Table 2. (continued)

Date Sampled	Concentration (µg/L)		
	CTET	Chloroform	Other
01/14/91	13	FP	.
04/09/91	15	FP	.
07/14/91	10	8	.
10/03/91	6	6	.
01/19/92	7	8	.
04/22/92	9	FP	.
07/31/92	6	6	.
10/20/92	5	5	.
01/20/93	.	2 J	.
05/05/93	11	8	.
09/17/93	2 J	6	.
12/08/93	1 J	4 J	.
02/07/94	0.9	2 J	.
05/09/94	13	9	.
08/22/94	6	8	.
12/03/94	.	4 J	.
02/27/95	2 J	3 J	.
05/25/95	1 J	4 J	.
09/13/95	5	7	.
12/07/95	4 J	7	.
02/21/96	5	9	.
05/23/96	5	8	.
11/07/96	.	FP	Dibromochloromethane (22)
05/07/97	18	13	.
11/05/97	2 J	9	.
05/26/98	19	14	.
12/02/98	.	7	.
05/27/99	8	13	.
11/02/99	.	5	.
05/09/00	6	10	.
10/09/00	.	5	.
04/24/01	4 J	10	.
10/18/01	.	4 J	.
04/18/02	6	11	.
10/16/02	.	7	.
05/07/03	3 J	10	.
10/01/03	.	9	.
04/29/04	4 J	11	
10/21/04	.	9	
MCL	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

Table 3. Well GW-251: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	*April* 2004	*October* 2004
Nitrate < 1 mg/L	61.9	51.5
Iron (II) > 1 mg/L	0.094*	0.232*
Sulfate < 20 mg/L	18.8	16.4
Dissolved Oxygen < 0.5 ppm	1.68**	0.43**
REDOX < 50 mV	163**	206**
pH >5 and < 9 st. units	6.2**	6.58**

Note: *Results are for total iron; **Field measurement.

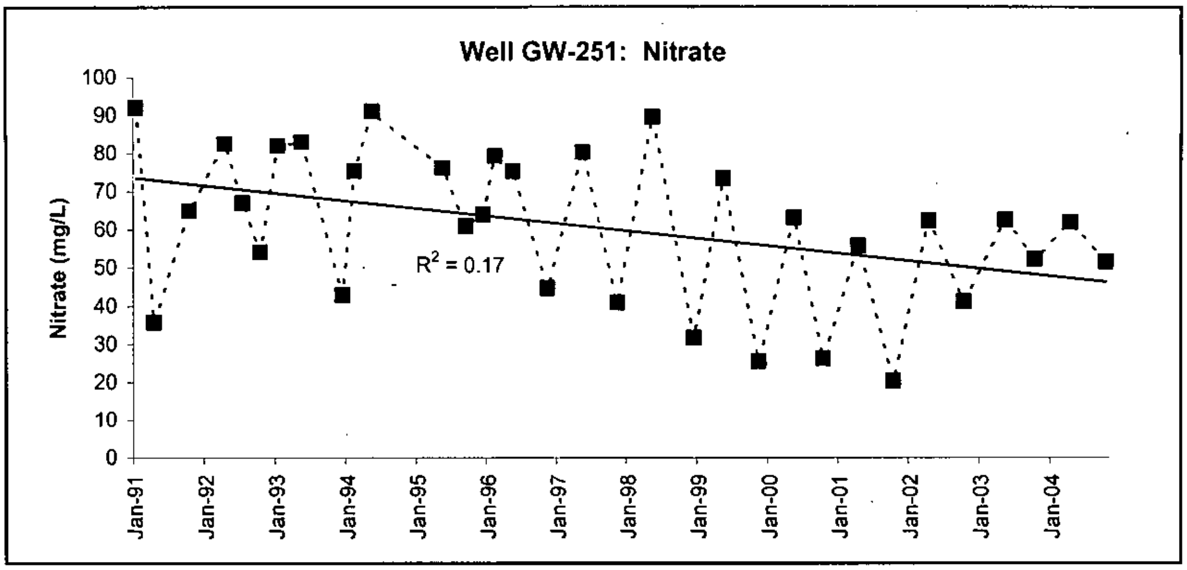


Figure 1

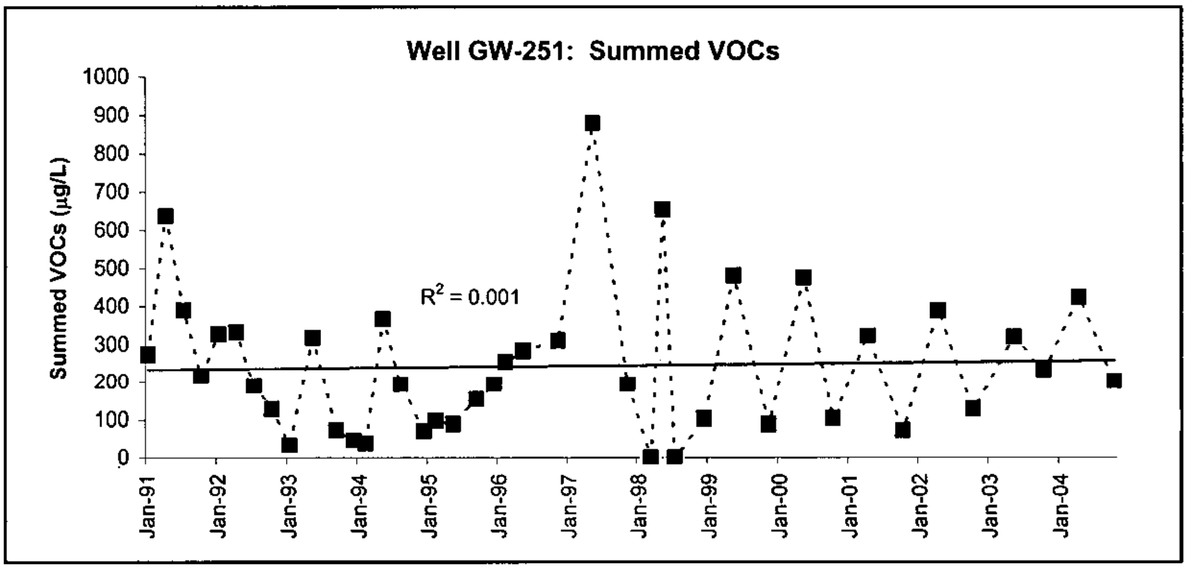


Figure 2

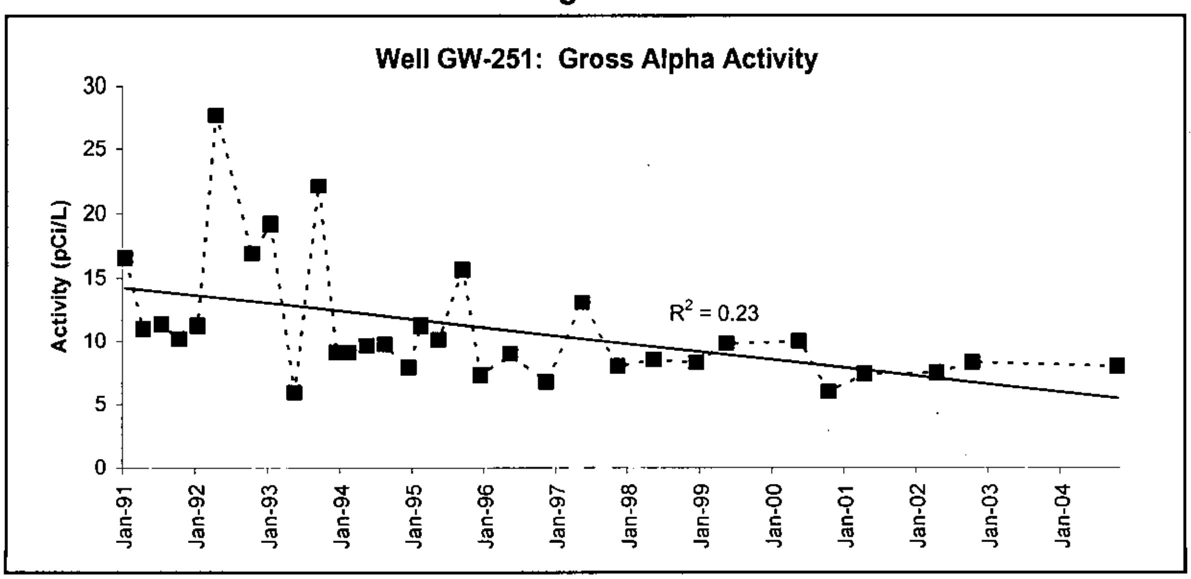


Figure 3

MAXIMUM CONCENTRATION: 2003

100 - 1,000	ND	500 - 5,000	15 - 150	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-253

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: S-2 Site
Y-12 GRID EAST COORDINATE: 54,057.00
Y-12 GRID NORTH COORDINATE: 29,404.00
SURFACE ELEVATION: 1,001.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/11/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 50.51 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,004.24 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.25 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	36.2	965.40
BOTTOM (filter pack or open hole):	50.0	951.60
MIDPOINT (filter pack or open hole):	43.1	958.50
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	8.33	993.27

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	18 samples	06/10/86	06/10/96
LOW-FLOW SAMPLING METHOD:	13 samples	06/23/98	10/21/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/28/03	.	10/21/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 26.97 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	8	1,140 mg/L	10/29/01	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	16	2,224 µg/L	02/08/99	Increasing, Indeterminate
GROSS ALPHA (15 pCi/L):	16	231.47 pCi/L	04/09/91	Indeterminate
GROSS BETA (50 pCi/L):	3	93.12 pCi/L	01/14/91	Indeterminate

WELL GW-253

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1986, completed with a screened monitored interval from about 36 to 50 ft bgs, and constructed with nominal 4.5-inch diameter. The well is located near the base of Chestnut Ridge in the southwest section of Y-12, about 30 ft east of the S-2 Site. The S-2 Site originally consisted of an unlined waste pit excavated into the northern flank of Chestnut Ridge. With an estimated capacity of 200,000 gallons, the S-2 Site was used from 1943 to 1951 for disposal of an unknown quantity of corrosive and toxic aqueous waste, primarily acidic solutions containing nitrates of heavy metals such as copper, nickel, and chromium (DOE 1998). When closed sometime in 1954, the wastes remaining in the S-2 Site were chemically neutralized and the site was backfilled, covered with topsoil, and seeded with grass.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between June 1986 and June 1996, and the low-flow sampling method used to obtain 13 samples between June 1998 and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements for the well show that the static groundwater level in the well occurs at an average depth of about 8 ft bgs, with a series of unusually large (>25 ft) water-level fluctuations evident between August 1999 and May 2002 (Figure 1). Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of the well indicate southeasterly flow, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 2,650 – 6,250 mg/L;
- pH (field measurements) of 4.8 – 5.8;
- very high concentrations of several inorganic contaminants, chloride (>100 mg/L), nitrate (>500 mg/L), sodium (>100 mg/L), and sulfate (>50 mg/L);
- ion charge balance errors (i.e., the relative percent difference between respective summed milliequivalent concentrations of major cations and anions) that often exceed 20%; and

- very high (total) concentrations of several trace metals, particularly aluminum (>3 mg/L), cadmium (>3 mg/L), copper (>40 mg/L), manganese (>40 mg/L), nickel (>2 mg/L), strontium (>1 mg/L), and zinc (>5 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

In addition to the acidic pH and high levels of TDS, the most recent monitoring results for several indicator parameters, particularly the REDOX values (Table 1), suggest that the geochemical conditions in the well are not especially conducive to biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the 16 groundwater samples collected from the well since January 1991, nitrate, VOCs, and gross alpha activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Fifteen of the groundwater samples were analyzed for nitrate (as N), with concentrations above 500 mg/L reported for all but one of the samples (Table 2). The mass of inorganic contaminants emplaced in the Maynardville Limestone during historical operation of the S-2 Site is the source of the nitrate in the groundwater at this well. Also, the site is not covered with a low-permeability cap and the sludge/soil backfill in the former waste pit contains nitrate, metals, and other inorganic compounds (e.g., cyanide) and is below the saturated zone during seasonally high and low groundwater flow conditions; these conditions effectively promote vertical leaching of contaminants directly into the shallow karst network in the Maynardville Limestone (DOE 1998).

Nitrate concentrations below 1,000 mg/L were reported for most of the groundwater samples, with the recent sampling results showing that concentrations remain substantially above the MCL (Table 2). However, the nitrate results reported for the samples collected in January 1991, April 1991, June 1996, May 2000, November 2000, November 2002, and October 2003 are considered qualitative because of unacceptably high ion charge balance errors (see Section 4.0).

A time-series plot of the nitrate concentrations (excluding the suspected outlier and qualitative results noted above) suggests an indeterminate concentration trend (Figure 2). However, the significance of the indeterminate trend is questionable because of the limited number of quantitative data points.

5.2 URANIUM

Thirteen groundwater samples were analyzed for total uranium and concentrations at or above the applicable analytical reporting limit were detected in only three samples, with the highest concentration (0.01 mg/L in January 1991) being less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each groundwater sample contained one or more of the following VOCs (Table 3): acetone, benzene, bromomethane, CT, chloroform, chloromethane, bromochloromethane, PCE, TCE, toluene, VC, xylenes, 11DCE, and 12DCE (c12DCE and t12DCE). Most of these compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources within Y-12, including the S-2 Site, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The primary VOCs in the groundwater samples are PCE, TCE, and 12DCE (c12DCE), which were detected in each sample and have historical maximum concentrations of 890 μg/L, 960 μg/L, and 280 μg/L, respectively. Also, the most recent sampling results show that the concentrations of each of these compounds remain substantially above respective MCLs (Table 3). Secondary VOCs in the groundwater samples are CT, chloroform, and VC, all three of which were detected in all but two of the samples. Respective maximum historical concentrations for these compounds exceed 50 μg/L, with and the most recent sampling results showing CT and VC concentrations substantially above corresponding MCLs (5 μg/L and 2 μg/L). Other VOCs were each detected in no more than two of the samples and the bulk of the results for these compounds are estimated values below 5 μg/L.

Biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater may explain the presence and relatively high concentrations of c12DCE and VC in the groundwater samples from this well. However, as noted in Section 4.0, results for several indicator parameters suggest that the geochemical conditions in the groundwater at this well are not within the optimum range for biotic degradation of chlorinated hydrocarbons. For instance, the REDOX values for the groundwater samples (see Table 1) do not indicate the strongly reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC (Chapelle 1996). Perhaps the monitored interval in the well intercepts groundwater flow/transport pathways for dissolved VOCs transported from a source (DNAPL) where conditions are better suited for biodegradation.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows a slightly increasing long-term trend (Figure 3), which is of questionable significance considering that only three samples were collected from the well between January 1991 and June 1998. The subsequent (low-flow sampling) results show concurrently fluctuating concentrations of dissolved chloroethenes (Figure 4) and chloromethanes (Figure 5) that exhibit indeterminate long-term trends. Additionally, neither concentration trend shows corresponding responses to the series of unusually wide water-level fluctuations in the well (Figure 1). These trends suggest minimal changes in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for each groundwater sample (Table 2), and all of these gross alpha results exceed the MCL for gross alpha activity (15 pCi/L). All but two of the results are less than 100 pCi/L, with the historical maximum value (231 pCi/L in April 1991) being a suspected outlier, and the historical minimum value (17 pCi/L) reported for a recently collected sample (November 2003). Analytical results for samples obtained between June 1996 and May 2002 show that uranium isotopes (U-234 and U-238) are a source of the gross alpha activity in the groundwater (Table 2), although the summed activity of these isotopes is usually much less than the corresponding gross alpha activity.

A time-series plot of applicable results for gross alpha activity (i.e., results that exceed the MDA and corresponding CE) shows a generally decreasing long-term concentration trend that is skewed downward by the historical maximum and minimum values (Figure 6). Nevertheless, the decreasing trend for gross alpha activity suggests a corresponding decrease in the relative flux of uranium isotopes, which is supported by the data shown in Table 2.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for each groundwater sample (Table 2), with results for the samples collected in January 1991 (93 pCi/L), April 1991 (72 pCi/L), and October 2001 (66 pCi/L) exceeding the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity). As with the gross alpha activity, the uranium isotopes (and related decay products) are the source of the gross beta activity in the samples.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-253: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	April 2003	October 2003
Nitrate < 1 mg/L	781	(83)
Iron (II) > 1 mg/L	0.05	0.04
Sulfate < 20 mg/L	66.9	66.2
Dissolved Oxygen < 0.5 ppm	0.55*	0.94*
REDOX < 50 mV	305*	339*
pH >5 and < 9 st. units	5.13*	5.2*
Note: *Field measurement; ( ) = Qualitative result		

Table 2. Well GW-253: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium Isotopes (pCi/L)		Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
		U-234	U-238		
01/14/91	(1,007)	NA	NA	95.44	93.12
04/09/91	(170)	NA	NA	231.47	72.14
06/10/96	(535)	15.1	4.53	47.1	34.4
06/23/98	662	10.36	2.6	50.77	29.18
07/27/98	928	12.79	2.82	34.36	18.96
02/08/99	952	7.55	2.11	37.2	22.2
08/24/99	788	14	3.43	41.92	18.7
11/08/99	NA	8.88	2.48	51.75	39.07
05/23/00	(1,010)	10.93	2.54	86.59	34.13
11/02/00	(1,280)	7.76	1.86	73.63	36.6
05/02/01	831	6.9	2.41	24.66	16.02
10/29/01	1,140	7.53	1.71	101.34	66.56
05/07/02	852	7.15	1.36	45.1	25.44
11/07/02	(3,100)	NA	NA	29.98	20.45
04/28/03	781	NA	NA	37.09	33.06
10/21/03	(83)	NA	NA	17	28.68
MCL	**10 mg/L**	**Not Applicable**		**15 pCi/L**	**50 pCi/L***

Note: "." = Not detected; NA = Not analyzed; ( ) Qualitative result; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 3. Well GW-253: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	VC
01/14/91	540	350	85	NR	.
04/09/91	660	360	88	NR	.
06/10/96	510	310	140	NR	16
06/23/98	190	180	120	NR	19
07/27/98	510	390	200	NR	48
02/08/99	890	960	220	220	31
08/24/99	600	540	220	220	35
11/08/99	760	710	250	250	53
05/23/00	660	580	230	230	71
11/02/00	690	660	190	190	35
05/02/01	680	580	240	240	53
10/29/01	810	700	270	270	54
05/07/02	680	600	260	260	63
11/07/02	580	610	150	150	39
04/28/03	530	420	230	230	65
10/21/03	570	450	280	280	87
MCL	**5**	**5**	**NA**	**70**	**2**

Date Sampled	Concentration (µg/L)			
	CT	Chloroform	11DCE	Toluene
01/14/91	20	FP	.	.
04/09/91	20	FP	.	.
06/10/96	18	30	.	.
06/23/98	14	27	.	2 J
07/27/98	22	39	.	1 J
02/08/99	57	66	.	.
08/24/99	30	44	2 J	2 J
11/08/99	37	55	.	.
05/23/00	38	54	3 J	2 J
11/02/00	43	50	2 J	2 J
05/02/01	32	49	2 J	2 J
10/29/01	38	61	.	2 J
05/07/02	35	46	2 J	1 J
11/07/02	19	32	.	.
04/28/03	28	38	3 J	1 J
10/21/03	31	47	4 J	2 J
MCL	**5**	**NA**	**7**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

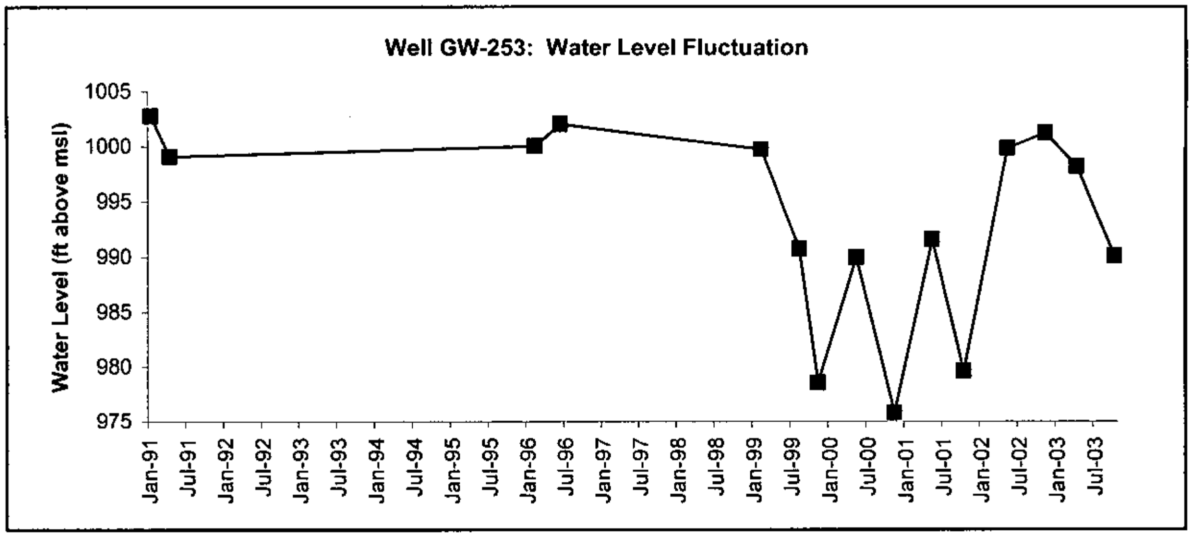


Figure 1

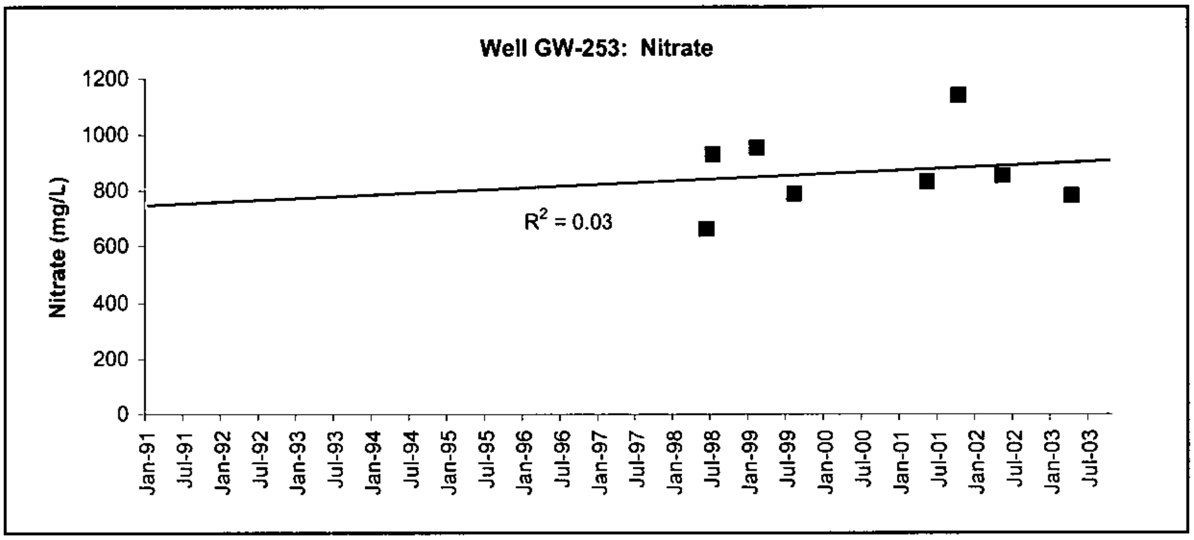


Figure 2

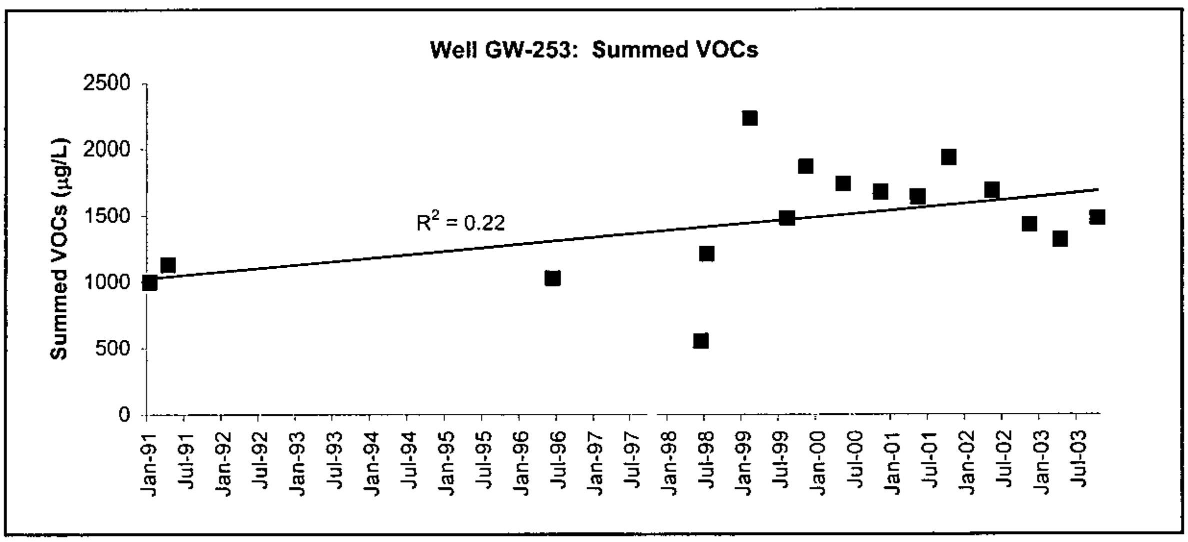


Figure 3

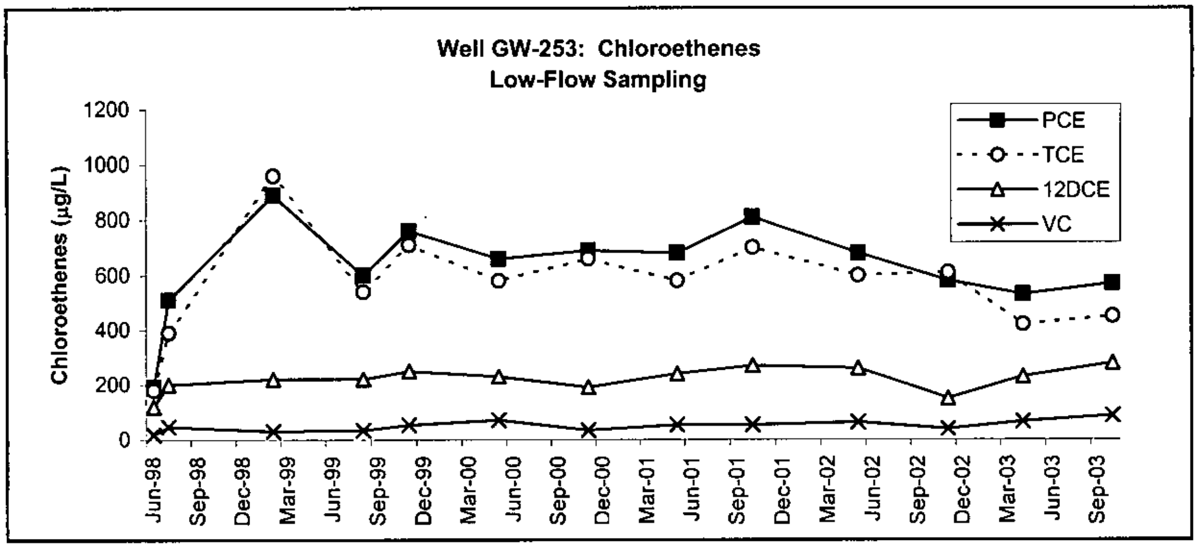


Figure 4

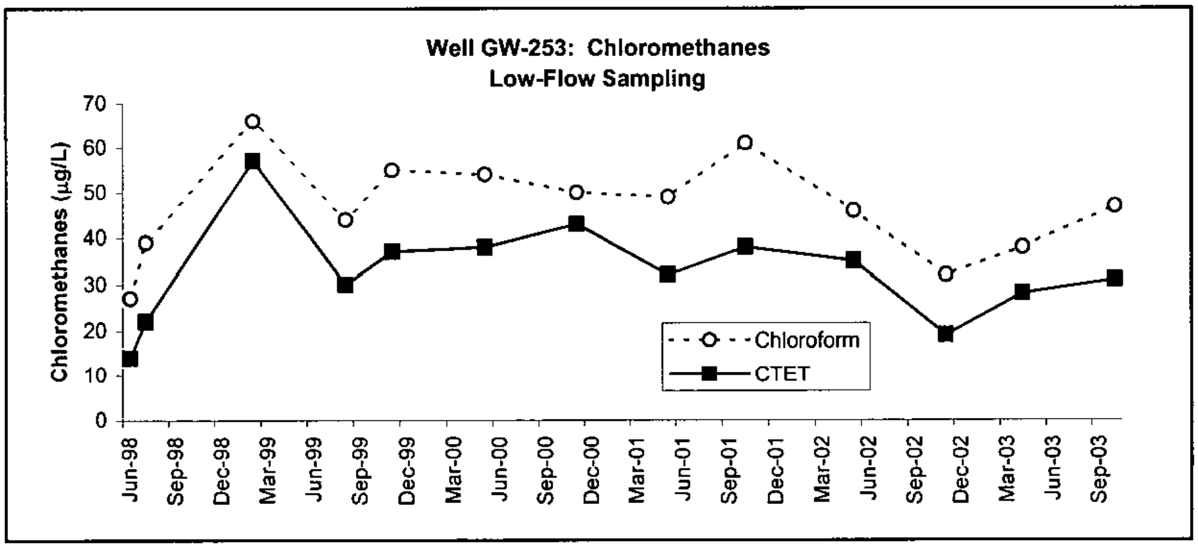


Figure 5

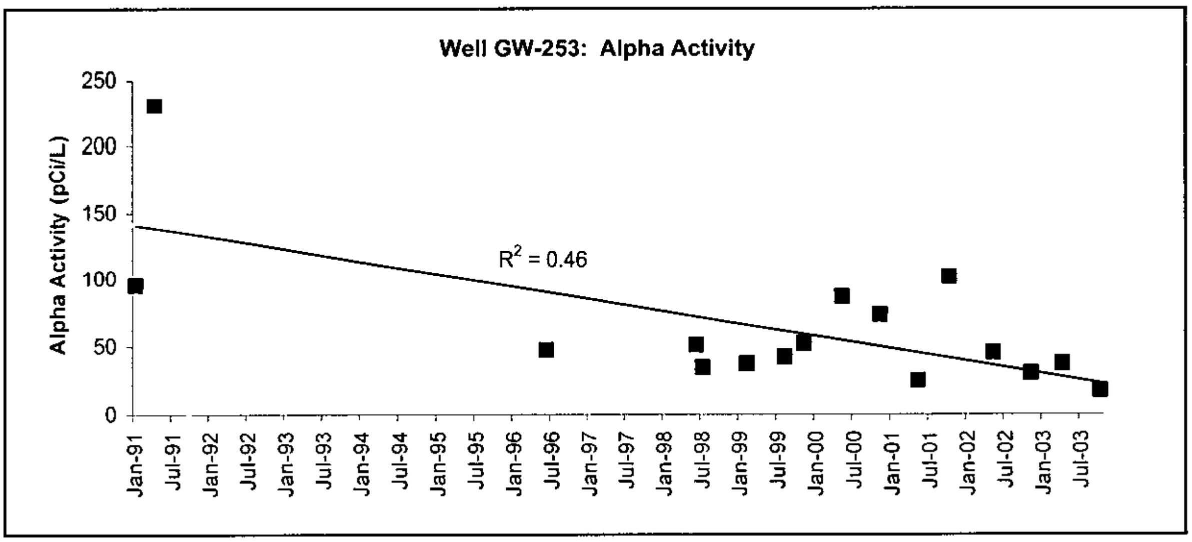


Figure 6

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-257

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,229.71
Y-12 GRID NORTH COORDINATE: 30,147.60
SURFACE ELEVATION: 959.21 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/03/87 PAIRED/CLUSTERED WITH: GW-248
TAG DEPTH (measured): 36.63 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 961.68 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.0	940.21
BOTTOM (filter pack or open hole):	33.7	925.51
MIDPOINT (filter pack or open hole):	26.4	932.86
PUMP INTAKE:	33.03	926.18
WATER LEVEL (average):	26.37	932.84

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	8		
CONVENTIONAL SAMPLING METHOD:	6 samples	05/09/88	08/08/95
LOW-FLOW SAMPLING METHOD:	2 samples	03/03/04	08/16/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/03/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.92 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	3	210 µg/L	08/16/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-257

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1987, completed with a screened monitored interval from 19 to 34 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-248 and is located in Bear Creek Valley (BCV), about 100 ft directly west of a northern tributary (NT) of Bear Creek (NT-7) that traverses the west-central section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain six samples between May 1988 and August 1995, and the low-flow sampling method used to obtain samples in March and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maryville Limestone (the Conasauga Group). The bulk of the groundwater flow in the Maryville Limestone occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 26 ft bgs and exhibits minor seasonal fluctuations (<3 ft). Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-257 are typically lower than evident in well GW-248, which is completed at a greater depth (62 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (29.6 ft), the contemporaneous groundwater elevations indicate an upward vertical hydraulic gradient (0.002) from the shallow bedrock interval (GW-248) to the water table interval (GW-257).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-257 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-257 may be primarily eastward (parallel with geologic strike) toward discharge areas in NT-7, which flows northeast-southwest across the BCBG approximately 100 ft east of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 130 – 187 mg/L;
- pH of 6.32 – 6.6 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations);
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Three groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (0.36 mg/L in August 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples collected to date had uranium concentrations above the analytical reporting limit, with the highest concentration (0.01 mg/L in August 1989) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Each groundwater sample that was analyzed for VOCs contained PCE, with trace levels (<1 μg/L) of TCE detected in two of the samples and chloromethane (8μg/L) detected in one sample (Table 1). The well is located approximately 350 ft east-southeast of the former BCBG Walk-In Pits (WIP), which are the source of a distinct plume of dissolved VOCs in the groundwater that is dominated by PCE. Historical data for other wells near the WIP show that PCE concentrations within the plume exceed 2000 μg/L, which is about 1% of maximum PCE solubility and possibly indicates that the PCE is present as DNAPL in the subsurface near this site (DOE 1997).

The PCE concentration detected in each groundwater sample generally decreased between June 1989 (210 μg/L) and March 1990 (130 μg/L) and subsequently increased through August 2004 (210 μg/L). These sampling results suggest little if any long-term change in the relative flux of PCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Moreover, the persistent lack of TCE and other PCE degradation products (e.g., c12DCE) in the samples suggest that there is minimal biotic or abiotic degradation of the PCE in the groundwater at this well. Conversely, data for other wells that monitor VOC-contaminated groundwater with similar geochemical characteristics elsewhere at the BCBG indicate active biotic degradation of PCE and related degradation products. It is not clear from the available data why similarly active biotic degradation of PCE apparently does not occur in the groundwater at this well, downgradient of the WIP.

5.4 GROSS ALPHA ACTIVITY

One of the groundwater samples collected since March 1990 had gross alpha activity above the applicable MDA and corresponding CE, and this result (1.62 pCi/L in August 1995) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L). Gross alpha activity results reported for samples obtained before 1990 are qualitative (the sample-specific MDA and CE are not available) and show similarly low levels of gross alpha activity.

5.5 GROSS BETA ACTIVITY

One of the groundwater samples collected since March 1990 had gross beta activity above the applicable MDA and corresponding CE, and this result (6.51 pCi/L in August 1995) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Gross beta activity results reported for samples before 1990 are qualitative (the sample-specific MDA and CE are not available) and show similarly low levels of gross beta activity.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-257: summary of VOC results

Sampling Date	VOC Concentration (µg/L)		
	PCE	TCE	Chloromethane
05/09/88	NA	NA	NA
06/23/89	210	.	8
08/24/89	190	.	.
11/10/89	190	.	.
03/05/90	130	0.8 J	.
08/08/95	140	3 J	.
03/03/04	200	.	.
08/16/04	210	.	.
MCL	**5**	**5**	**-**

Note: NA = Not analyzed; "." = Not detected; J = Estimated value below analytical reporting limit; "-" = Not applicable

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	50 - 500	ND	<25

GW-269

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,778.81
Y-12 GRID NORTH COORDINATE: 30,649.34
SURFACE ELEVATION: 1,025.38 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/16/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 33.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,027.81 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.02
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	21.9	1003.48
BOTTOM (filter pack or open hole):	30.0	995.38
MIDPOINT (filter pack or open hole):	26.0	999.43
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	14.31	1011.08

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	13 samples	10/28/86	03/17/97
LOW-FLOW SAMPLING METHOD:	2 samples	05/01/03	10/23/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/01/03	.	10/23/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.81 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	421 µg/L	05/01/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-269

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during June 1986, completed with a screened monitored interval from 21.9 to 30 ft bgs and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.02 slot). The well is located in Bear Creek Valley (BCV) near the west end of Y-12, on the east side of the Salvage Yard Oil/Solvent Drum Storage Area (OSDSA). The OSDSA includes two separate (East and West) gravel-covered areas within the northern section of the Y-12 Salvage Yard that were used from 1976 until 1989 for drummed storage of about 88,000 gallons of waste oils and solvents. Closure of the OSDSA was completed in stages, with the western area completed in 1986 and the eastern area completed in 1991, and involved excavation and removal of contaminated soils and replacement with clean backfill; the eastern area also was covered with an impermeable polyethylene membrane (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well, with the conventional sampling method used to obtain thirteen samples between October 1996 and March 1997 and the low-flow sampling method used to obtain samples in May and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maryville Limestone (Conasauga Group). The bulk of the groundwater flow in the Maryville Limestone occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 14 ft bgs and exhibits minimal (<3 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-269 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the low-permeability formations of the Conasauga Group, including the Maryville Limestone, exhibit strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- unusually low TDS of 60 – 135 mg/L, which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths;
- pH of 6 – 6.5 (field measurements);

- unusually high chloride concentrations (>70 mg/L) compared to other wells completed at similar depths in the Maryville Limestone;
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the unusually high chloride concentrations typical of the groundwater samples reflect natural geochemical characteristics or if the elevated concentrations are the result of contamination from one or more sources hydraulically upgradient of the well. Also, the groundwater contains a mixture of dissolved hydrocarbons (see Section 5.3) and elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995). Aside from the REDOX conditions, recent monitoring data suggest that the geochemical characteristics of the groundwater are conducive to biotic degradation of VOCs (Table 1).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Each groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.569 mg/L in May 2003) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one or more of the following VOCs was detected in each groundwater sample (Table 2): benzene, chloroform, ethylbenzene, toluene, PCE, TCE, trichlorofluoromethane (TCFM), VC, xylenes (total), 11DCA, 11DCE, 12DCE (c12DCE), and 111TCA. These compounds are components of a plume of dissolved VOCs in the groundwater that is believed to originate from one or more sources in the northern section of the Y-12 Salvage Yard, including the OSDSA and the Oil Storage Tank. Additionally, (soluble) contaminants leached from subsurface soils at both sites, which contain chlorinated hydrocarbons along with other organic and inorganic contaminants, continue to enter the shallow flow system (DOE 1998). Based on the characteristics of groundwater flow at shallow depths in the Maryville Limestone in BCV and the network of existing monitoring wells, the dissolved VOCs from the OSDSA that enter the groundwater are probably transported eastward, parallel with geologic strike, toward discharge areas for the shallow flow system, including buried storm drains and utilities, building basement sumps, and the buried northern tributaries of UEFPC (DOE 1998).

The primary VOCs in the groundwater samples are 11DCE, PCE, 12DCE (c12DCE) and 111TCA, which were detected in each sample and have historical maximum concentrations of 270 μg/L, 62 μg/L, 70 μg/L, and 56 μg/L respectively (Table 2). Note that the highest concentrations of these compounds (except 111TCA) were detected in groundwater samples collected with the low-flow sampling method since March 1997. Also, the most recent concentrations of 11DCE, PCE, and 12DCE (c12DCE) are substantially higher than indicated by the conventional sampling results obtained through March 1990, whereas there is little if any difference between recent and historical concentrations of other compounds (e.g., TCE = 4 μg/L in October 1986 and 4 μg/L in October 2003). Aside from the primary VOCs, other compounds (including TCE) are detected infrequently and typically at much lower concentrations, with the bulk of the results being estimated values below 5 μg/L (Table 2). Also, petroleum hydrocarbons were detected in each sample collected between March 1986 and March 1988, but only one of the samples collected since then (benzene = 3 μg/L in March 1997).

Biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater may explain the presence and high concentrations of 11DCE. However, the REDOX values for the groundwater samples (see Table 1) do not indicate the reducing (methanogenic) conditions necessary to transform parent compounds to DCE isomers (Chapelle 1996). Also, as noted in Section 4.0, the low TDS in the samples suggests relatively short residence time for groundwater produced from the flowpaths intercepted by the monitored interval in the well. Perhaps the monitored interval intercepts groundwater flow/transport pathways for dissolved VOCs transported from a source where conditions are better suited for biodegradation of chlorinated hydrocarbons, possibly involving co-metabolic degradation with petroleum hydrocarbons.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample spans two gaps in the sampling history (March 1990 – March 1997 and March 1997 – May 2003) and shows a clearly increasing long-term trend (Figure 1) attributable primarily to the large increases in the concentrations of 11DCE, PCE, and 12DCE (Table 2). Although the samples collected since March 1997 were obtained with the low-flow sampling method, the higher VOC concentrations do not appear to be an artifact of change from the conventional sampling method because, as noted previously, equivalent concentrations of individual VOCs (e.g., TCE) were detected in samples obtained with each method. Also, not all of the individual compounds exhibit increasing concentration trends. Assuming a heterogeneous mixture of VOCs from common source(s), it is not clear why the concentrations of individual compounds exhibit such divergent concentration trends or if the trends are significant with respect to the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for two groundwater samples, with the highest value (19.4 pCi/L in March 1997) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity).

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-269: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2003	October 2003
Nitrate < 1 mg/L	0.569	<0.02
Iron (II) > 1 mg/L	0.0654*	<0.01*
Sulfate < 20 mg/L	5.72	6.34
Dissolved Oxygen < 0.5 ppm	0.87**	0.32**
REDOX < 50 mV	197**	185**
pH >5 and < 9 st. units	6.02**	6.09**
Note: *Results are for total iron; **Field measurement.		

Table 2. Well GW-269: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	**TCE**	**12DCE (Total)**	**c12DCE**	**VC**
10/28/86	5	4 J	NA	NR	.
01/20/87	2 J	.	NA	NR	.
04/15/87	1 J	.	NA	NR	.
08/19/87	2 J	1 J	NA	NR	.
12/14/87	0.6 J	.	NA	NR	.
03/03/88	.	.	NA	NR	.
06/10/88	2 J	.	NA	NR	.
03/31/89	3 J	.	.	NR	.
07/24/89	6	.	.	NR	.
09/08/89	7	.	.	NR	.
12/08/89	7	.	.	NR	.
03/13/90	11	.	.	NR	.
03/17/97	62	4 J	45	45	2 J
05/01/03	35	4 J	70	70	1 J
10/23/03	30	4 J	57	57	.
MCL	**5**	**5**	**NA**	**70**	**2**

Table 2 (continued)

Date Sampled	Concentration (µg/L)			
	11DCE	**11DCA**	**111TCA**	**OTHER**
10/28/86	3 J	.	11	Acetone (17); Chloroform (4 J)
01/20/87	3 J	.	13	Acetone (3 J); Chloroform (2 J)
04/15/87	6	.	17	.
08/19/87	9	.	26	Chloroform (3 J)
12/14/87	7	.	18	.
03/03/88	7	.	16	.
06/10/88	10	.	18	.
03/31/89	17	.	34	.
07/24/89	30	.	56	.
09/08/89	23	.	40	.
12/08/89	31	.	52	.
03/13/90	30	.	43	.
03/17/97	140	3 J	42	.
05/01/03	270	6	28	Chloroform (4 J); TCFM (3 J)
10/23/03	220	6	26	Chloroform (4 J); TCFM (1 J)
MCL	**7**	**NA**	**200**	**NA**

Date Sampled	Concentration (µg/L)			
	Benzene	**Toluene**	**Ethylbenzene**	**Total Xylenes**
10/28/86	1 J	2 J	1 J	4 J
01/20/87	.	1 J	.	.
04/15/87	.	1 J	.	1 J
08/19/87	.	2 J	.	.
12/14/87	.	0.1 J	.	.
03/03/88	.	1 J	.	.
06/10/88	.	.	.	.
03/31/89	.	.	.	.
07/24/89	.	.	.	.
09/08/89	.	.	.	.
12/08/89	.	.	.	.
03/13/90	.	.	.	.
03/17/97	2 J	.	.	.
05/01/03	.	.	.	.
10/23/03	.	.	.	.
MCL	**5**	**NA**	**7**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

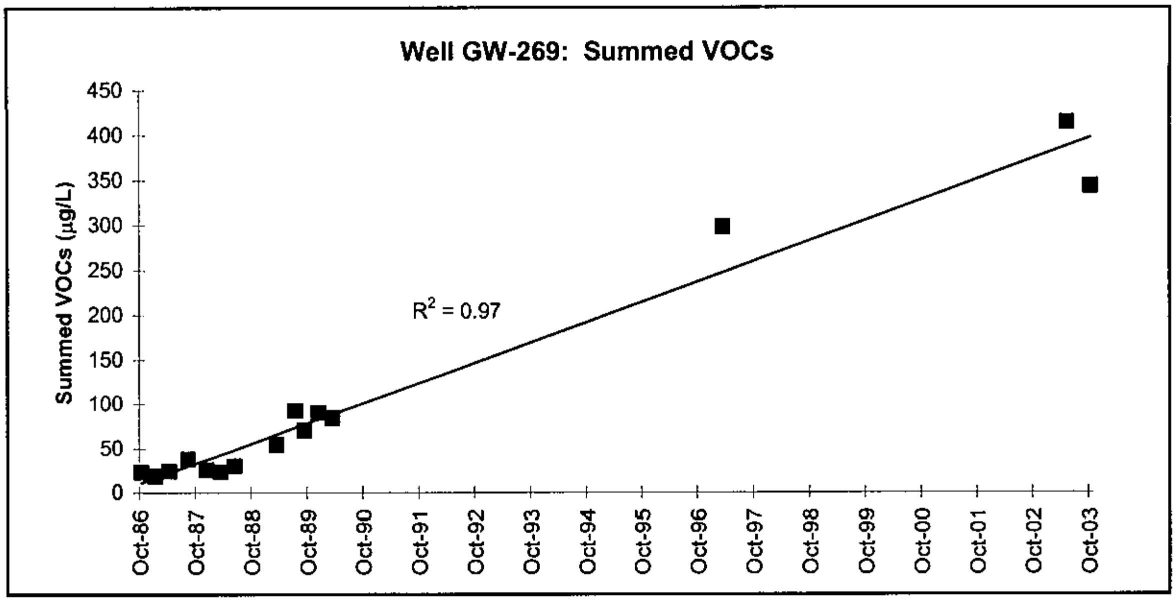

Well GW-269: Summed VOCs
Summed VOCs (µg/L)
450
400
350
300
250
200
150
100
50
0
R^2 = 0.97
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Oct-91
Oct-92
Oct-93
Oct-94
Oct-95
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03

Figure 1

MAXIMUM CONCENTRATION: 2003

100 - 1,000	<0.015	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-270

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,236.32
Y-12 GRID NORTH COORDINATE: 30,423.60
SURFACE ELEVATION: 1,006.35 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/09/86 PAIRED/CLUSTERED WITH: GW-271
TAG DEPTH (measured): 21.50 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,008.96 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.0	995.35
BOTTOM (filter pack or open hole):	18.5	987.85
MIDPOINT (filter pack or open hole):	14.8	991.60
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	-0.29	1006.64

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	10/30/86	01/19/90
LOW-FLOW SAMPLING METHOD:	2 samples	04/28/03	10/20/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/28/03	.	10/20/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	112 mg/L	10/20/03	Decreasing (pre-1991)
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-270

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1986, completed with a screened monitored interval from 11 to 18.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-271 and is located in Bear Creek Valley near the west end of Y-12. The well is within the Y-12 Salvage Yard about 750 ft directly east of the former S-3 Ponds. The S-3 Ponds site is a major source of groundwater contamination at Y-12 that was closed and capped in accordance with a RCRA closure plan in 1988. The S-3 site originally consisted of four unlined and contiguous surface impoundments that were used from 1951 to 1984 primarily for percolation/evaporation of nitric acid effluent (with depleted uranium in solution) discharged into the ponds via a pipeline (the Abandoned Nitric Acid Pipeline) connected to process buildings in the central Y-12 area. Operation of the site emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants into the Conasauga Group (Nolichucky Shale) and created a mound in the water table (which dissipated after disposal of wastes in the ponds ceased) that enabled transport/migration of contaminants into areas that now lie east and west of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between October 1986 and December 1989, and the low-flow sampling method used to obtain samples in April and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 0.3 ft above the ground surface, which indicates slightly artesian conditions. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-270 than in well GW-271, which is completed at a greater depth (56 ft bgs) in the Nolichucky Shale. Based on the distance (35.25 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.038-0.039) from the shallow bedrock to the water table interval during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- high TDS (>1, 000 mg/L);
- pH (field measurements) of 7.3 – 7.5;
- atypically high molar proportions of chloride, potassium, sulfate, and sodium (>10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations reported for samples obtained with the conventional sampling method all exceed 100 mg/L, with concentration "spikes" evident in October 1986 (549 mg/L), September 1988 (407 mg/L), and May 1989 (723 mg/L). A substantially lower nitrate concentration was evident from low-flow sampling in April 2003 (34.5 mg/L), but the nitrate level evident from low-flow sampling in October 2003 (112 mg/L) is comparable to the conventional sampling results (Figure 1). It is not clear from the available data if the lower nitrate concentrations evident from low-flow sampling during CY 2003 are an artifact of the sampling method or if they reflect a reduction in nitrate concentrations (and flux) in the groundwater transport/migration pathways intercepted by the monitored interval in the well. The source of the nitrate in the groundwater at this well is the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. Nitrate is chemically stable, does not readily partition to soils, is highly mobile in groundwater, and effectively traces the principal migration pathways followed by other (mobile) components of the plume. The pattern of elevated nitrate levels indicated by the network of wells in the Nolichucky Shale east of the site suggest two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstem of Upper East Fork Poplar Creek; and (2) substantially slower migration along much longer strike-parallel pathways deeper in the bedrock toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 (DOE 1998).

5.2 URANIUM

Uranium concentrations above the applicable analytical reporting limit were reported for all but two of the groundwater samples, with the highest value (0.012 mg/L) being less than the MCL for uranium (0.03 mg/L). Also, the available data show an indeterminate long-term concentration trend, with no distinct difference between conventional and low-flow sampling results for uranium, as illustrated by the similarity between the uranium levels reported for samples obtained with the conventional sampling method in March 1988 (0.001 mg/L) and April 2003 (0.0011 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples collected in CY 2003 show non-detect values for all VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater sample collected in October 2003 (5.2 pCi/L) exceeds the MDA and corresponding CE, but is substantially below the MCL for gross alpha activity (15 pCi/L).

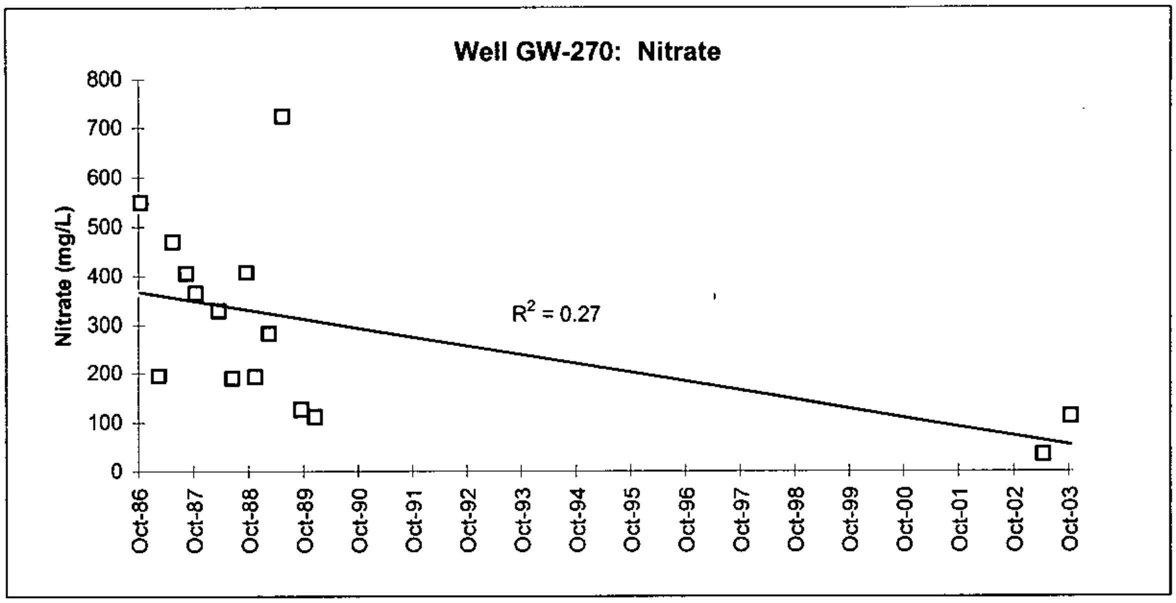
5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater sample collected in April 2003 (15 pCi/L) exceeds the MDA and corresponding CE, but is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.



Well GW-270: Nitrate
800
700
600
500
400
300
200
100
0
Nitrate (mg/L)
$R^2 = 0.27$
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Oct-91
Oct-92
Oct-93
Oct-94
Oct-95
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03

Figure 1

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	<7.5	25 - 50

GW-271

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,234.33
Y-12 GRID NORTH COORDINATE: 30,434.56
SURFACE ELEVATION: 1,006.49 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/05/86 PAIRED/CLUSTERED WITH: GW-270
TAG DEPTH (measured): 59.33 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.01 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	43.9	962.59
BOTTOM (filter pack or open hole):	56.3	950.19
MIDPOINT (filter pack or open hole):	50.1	956.39
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	-1.52	1008.01

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	10/30/86	01/18/90
LOW-FLOW SAMPLING METHOD:	2 samples	04/28/03	10/20/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	.	04/28/03	.	10/20/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.81 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-271

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1986, completed with a screened monitored interval from 43.9 to 56.3 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-270 and is located in Bear Creek Valley near the west end of Y-12. The well is within the Y-12 Salvage Yard about 750 ft directly east of the former S-3 Ponds, which are a primary source of groundwater contamination in Bear Creek Valley. Located at the headwaters of Bear Creek, the S-3 Ponds consisted of four unlined surface impoundments, each with a 2.5 million gallon capacity, that were used between 1951 and 1984 for the disposal of acidic, radioactive liquid wastes generated primarily at Y-12. The S-3 Ponds were covered with a multi-layer, low permeability cap (including asphalt paving) during RCRA closure of the site in 1988.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between October 1986 and January 1990, and the low-flow sampling method used to obtain samples in April and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is -1.5 ft above the ground surface, indicating artesian conditions. Presampling depth-to-water measurements for the well indicate minimal (<0.05 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 7.2 – 7.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for the groundwater samples collected during 2003.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (2.2 pCi/L in April 2003) is substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Two groundwater samples had gross beta activity above the applicable MDA and corresponding CE, and both results (13 pCi/L in April 2003 and 36 pCi/L in October 2003) are below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

100 - 1,000	0.03 - 0.3	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-272

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,736.95
Y-12 GRID NORTH COORDINATE: 30,485.04
SURFACE ELEVATION: 1,006.62 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/16/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 19.16 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.16 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	8.8	997.82
BOTTOM (filter pack or open hole):	16.2	990.42
MIDPOINT (filter pack or open hole):	12.5	994.12
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	4.42	1002.20

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	14 samples	10/30/86	01/23/90
LOW-FLOW SAMPLING METHOD:	3 samples	05/01/03	10/23/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/01/03	.	10/23/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.34 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	415 mg/L	10/23/03	Increasing
URANIUM (0.03 mg/L):	1	0.0377 mg/L	05/15/03	Increasing
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-272

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1986, completed with a screened monitored interval from 8.8 to 16.2 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley near the west end of Y-12, within the northeastern section of the Y-12 Salvage Yard, about 1,300 ft directly east of the former S-3 Ponds, a major source of groundwater contamination at Y-12 that was closed and capped in accordance with a RCRA closure plan in 1988. The S-3 site originally consisted of four unlined and contiguous surface impoundments that were used from 1951 to 1984 primarily for percolation/evaporation of nitric acid effluent (with depleted uranium in solution) discharged into the ponds via a pipeline (the Abandoned Nitric Acid Pipeline) connected to process buildings in the central Y-12 area. Operation of the site emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants into the Conasauga Group (Nolichucky Shale) and created a mound in the water table (which dissipated after disposal of wastes in the ponds ceased) that enabled transport/migration of contaminants into areas that now lie east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds. Additionally, the Y-12 Salvage Yard encompasses several former waste management units that are known sources of groundwater contamination (e.g., Salvage Yard Drum Deheader).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-two groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 20 samples between October 1986 and January 1990, and the low-flow sampling method used to obtain samples in May and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 4.4 ft below ground surface. Presampling depth-to-water measurements for the well indicate minor (<2 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields nitrate contaminated, calcium-magnesium-bicarbonate groundwater generally characterized by:

- high TDS (>1,200 mg/L);
- pH (field measurements) of 6.8 – 7.1;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except barium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations above the applicable analytical reporting limit were detected in each groundwater sample (Figure 1). Concentrations below the MCL for nitrate (10 mg/L) were reported for each sample collected between October 1986 (0.63 mg/L) and March 1989 (1.9 mg/L). Substantially higher nitrate levels were detected in the groundwater samples collected in April (335 mg/L) and October 2003 (415 mg/L). It is not clear from the available data if the higher nitrate concentrations are an artifact of the sampling method or if they reflect a substantial increase in nitrate concentrations (and flux) in the groundwater transport/migration pathways intercepted by the monitored interval in the well. The source of the nitrate is the contaminant plume emplaced in the Nolichucky Shale during historical operation of the former S-3 Ponds. Nitrate is chemically stable, does not readily partition to soils, is highly mobile in groundwater, and effectively traces the principal migration pathways followed by other (mobile) components of the plume. The pattern of elevated nitrate levels indicated by the network of wells in the Nolichucky Shale east of the site suggest two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstem of Upper East Fork Poplar Creek; and (2) substantially slower migration along much longer strike-parallel pathways deeper in the bedrock toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 (DOE 1998).

5.2 URANIUM

Eight groundwater samples contained uranium concentrations above the applicable analytical reporting limit (Figure 2). Uranium concentrations below the MCL (0.03 mg/L) were reported for six samples obtained with the conventional sampling method between October 1986 (0.008 mg/L) and December 1989 (0.005 mg/L). In contrast, substantially higher uranium concentrations slightly above and below the MCL were reported for the samples obtained with the low-flow sampling method in April (0.0377 mg/L) and October 2003 (0.0295 mg/L). As with the nitrate levels in the well, it is not clear from the available data if the higher uranium concentrations are an artifact of the sampling method or if they reflect a substantial increase in uranium levels (and flux) in the groundwater transport/migration pathways intercepted by the monitored interval in the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples collected in CY 2003 show non-detect values for all VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater samples collected in April and October 2003 does not exceed the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater samples collected in April and October 2003 does not exceed the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

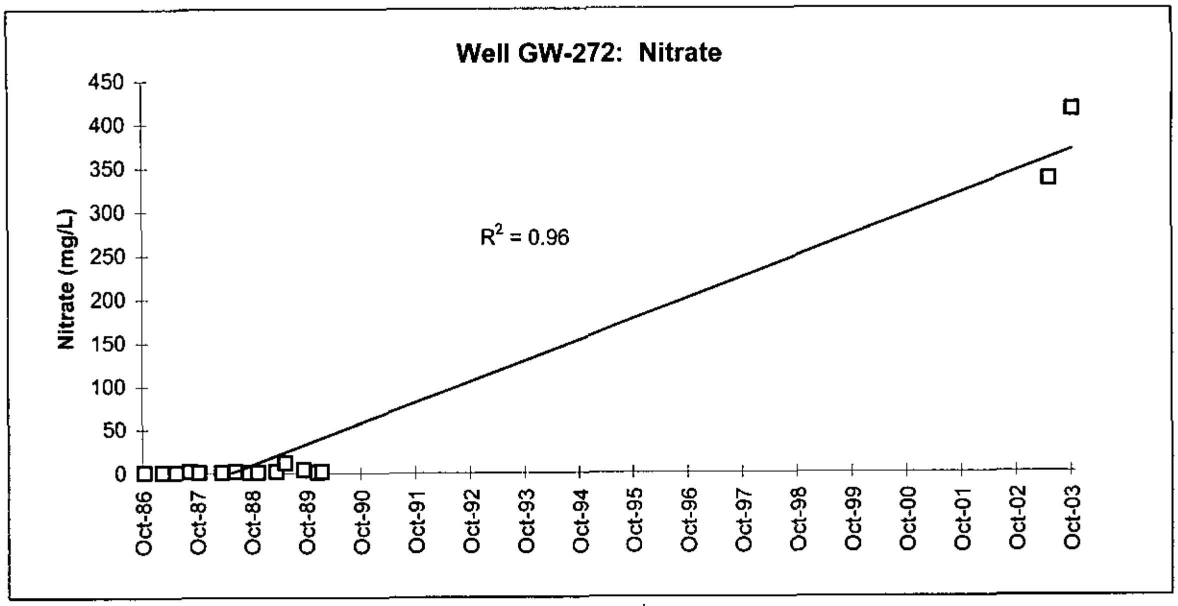


Figure 1

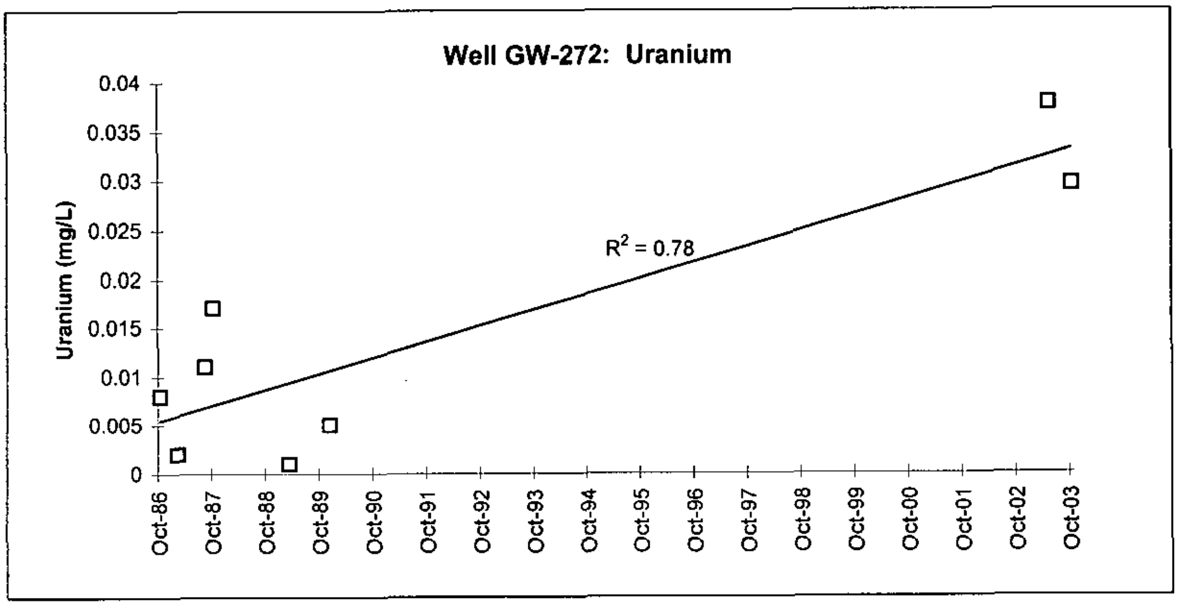


Figure 2

MAXIMUM CONCENTRATION: 2003

ND	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-273

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,261.34
Y-12 GRID NORTH COORDINATE: 30,201.24
SURFACE ELEVATION: 1,001.34 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/09/86 PAIRED/CLUSTERED WITH: GW-634
TAG DEPTH (measured): 35.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,003.52 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	22.9	978.44
BOTTOM (filter pack or open hole):	33.1	968.24
MIDPOINT (filter pack or open hole):	28.0	973.34
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	4.06	997.29

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	10		
CONVENTIONAL SAMPLING METHOD:	8 samples	10/31/86	03/17/97
LOW-FLOW SAMPLING METHOD:	2 samples	04/29/03	10/21/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/29/03	.	10/21/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.47 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		(Decreasing, pre-1991)
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	398.8 µg/L	03/17/97	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-273

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1986, completed with a screened monitored interval from 22.9 to 33.1 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley near the west end of Y-12, within the south-central section of the Y-12 Salvage Yard, about 750 ft directly east of the former S-3 Ponds, a major source of groundwater contamination at Y-12 that was closed and capped in accordance with a RCRA closure plan in 1988. The S-3 site originally consisted of four unlined and contiguous surface impoundments that were used from 1951 to 1984 primarily for percolation/evaporation of nitric acid effluent (with depleted uranium in solution) discharged into the ponds via a pipeline (the Abandoned Nitric Acid Pipeline) connected to process buildings in the central Y-12 area. Operation of the site emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants into the Conasauga Group (Nolichucky Shale) and created a mound in the water table (which dissipated after disposal of wastes in the ponds ceased) that enabled transport/migration of contaminants into areas that now lie east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds. Additionally, the Y-12 Salvage Yard encompasses several former waste management units that are known sources of groundwater contamination (e.g., Salvage Yard Drum Deheader).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Ten groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eight samples between October 1986 and March 1997, and the low-flow sampling method used to obtain samples in April and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 4.1 ft below ground surface. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- low TDS (<150 mg/L), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths;
- pH (field measurements) of 5.3;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations above 100 mg/L were detected in each groundwater sample collected between October 1986 (790 mg/L; qualitative) and December 1988 (185 mg/L). The sample collected in December 1997 was not analyzed for nitrate and nitrate was not detected (<0.028 mg/L) in the groundwater samples collected in April and October 2003. It is not clear from the available data if the lower nitrate concentrations are an artifact of the low-flow sampling procedure or if they reflect a substantial decrease in the nitrate levels (and flux) in the groundwater migration/transport pathways intercepted by the monitored interval in the well. Also, the lack of nitrate in the groundwater at this well seems surprising because very high nitrate concentrations (>100 mg/L) are evident in nearby wells to the north (e.g., GW-271), south (e.g., GW-108), east (e.g., GW-274), and west (e.g., GW-105). The source of the nitrate is the contaminant plume emplaced in the Nolichucky Shale during historical operation of the former S-3 Ponds. Nitrate is chemically stable, does not readily partition to soils, is highly mobile in groundwater, and effectively traces the principal migration pathways followed by other (mobile) components of the plume. The pattern of elevated nitrate levels indicated by the network of wells in the Nolichucky Shale east of the site suggest two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstem of Upper East Fork Poplar Creek; and (2) substantially slower migration along much longer strike-parallel pathways deeper in the bedrock toward basement sumps in Bldgs. 9204-4, 9201-5, and 9204-2 (DOE 1998).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

As shown below in Table 1, PCE, TCE, 12DCE, and benzene were detected in the groundwater samples, with the highest concentrations of each compound reported for samples obtained with the conventional sampling method.

Table 1. VOC Results for well GW-273

Sampling Date	Concentration (µg/L)			
	PCE	TCE	12DCE	Benzene
10/31/86	**19**	6	2 J	**16**
03/06/87	**43**	4 J	.	**68**
06/02/87	**35**	3 J	4 J	**60**
08/19/87	**46**	**22**	5	**73**
10/28/87	**39**	4 J	5	**72**
03/11/88	**36**	3 J	.	**77**
12/15/88	**27**	4 J	.	**170**
03/17/97	2 J	0.8 J	3 J	**390**
04/29/03	.	.	.	**7**
10/21/03	.	.	.	**6**

Note: Bold typeface denotes results that exceed the MCL; "." = not detected

It is not clear from the data if the lower VOC concentrations evident during CY 2003 are artifacts of the low-flow sampling method or if they reflect an overall decrease in VOC concentrations (and flux) in the groundwater transport/migration pathways intercepted by the monitored interval for the well. In either case, the intermingled plume of dissolved VOCs originating from historical operations of the former S-3 Ponds and several former waste management facilities within in the Y-12 Salvage Yard, including the Salvage Yard Drum Deheader and the Rust Garage Area, is the likely source of the compounds in the groundwater at this well (DOE 1998).

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

>1,000	0.015 - 0.03	500 - 5,000	ND	>5,000
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-274

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,672.75
Y-12 GRID NORTH COORDINATE: 30,151.84
SURFACE ELEVATION: 992.94 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/09/86 PAIRED/CLUSTERED WITH: GW-275
TAG DEPTH (measured): 36.12 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 995.60 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	25.8	967.14
BOTTOM (filter pack or open hole):	35.0	957.94
MIDPOINT (filter pack or open hole):	30.4	962.54
PUMP INTAKE:	31.01	961.93
WATER LEVEL (average):	1.75	991.19

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	20		
CONVENTIONAL SAMPLING METHOD:	16 samples	11/04/86	03/13/96
LOW-FLOW SAMPLING METHOD:	4 samples	05/30/00	10/22/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/30/03	.	10/22/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.63 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	5	5,410 mg/L	05/30/00	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	5	1,404 μg/L	10/22/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	5	13,000 pCi/L	04/30/03	Increasing

WELL GW-274

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during June 1986, completed with a screened monitored interval from 25.8 to 35 ft bgs. The well forms a cluster with well GW-275 and is constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) near the west end of Y-12, within the southeastern section of the Y-12 Salvage Yard about 1,200 ft directly east of the former S-3 Ponds. The Y-12 Salvage Yard encompasses several former waste management units that are known sources of groundwater contamination (e.g., Salvage Yard Drum Deheader). The former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty groundwater samples have been collected from the well, with the conventional sampling method used to obtain 16 samples between November 1986 and March 1996, and the low-flow sampling method used to obtain four samples between May 2000 and October 2003.

Extremely high levels of total dissolved solids (TDS) is a distinguishing characteristic of the groundwater samples and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 2 ft bgs and exhibits minimal (<2 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-274 than in well GW-275, which is completed at a greater depth (65.5 ft bgs) in the Nolichucky Shale. Based on the distance (28.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005-0.031) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-274 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in

directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields extremely mineralized, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 17,500 – 57,684 mg/L;
- pH of 5.3 – 5.98 (field measurements);
- high concentrations of several ions, notably calcium (>3,500 mg/L) and nitrate (>3,000) and;
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- elevated total concentrations of several trace metals, particularly barium (>20 mg/L), manganese (>80 mg/L), and strontium (>10 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, the principal contaminants present in the groundwater at this well are nitrate, VOCs, and gross beta activity.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 1,000 mg/L, including the samples collected most recently (Table 1). The source of the nitrate is the former S-3 Ponds, the historical operation of which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were entrained in the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume. Based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs (DOE 1998).

Nitrate concentrations reported for the groundwater samples range between the historical maximum concentration of 15,800 mg/L in October 1986 and the historical minimum concentration of 1,087 mg/L in March 1989 (Table 1). Under the conceptual model for contaminant transport from the former S-3 Ponds, the sampling results for this well are believed to be representative of concentrations within shallow (<30 ft bgs), fairly short groundwater flow/transport pathways that promote relatively rapid flow toward discharge areas in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within about 1,000 ft east of the former S-3 Ponds (DOE 1998). Additionally, as shown by the data summarized below, the nitrate concentrations in the shallow groundwater flow/transport pathways intercepted by the monitored interval in well GW-274 are significantly lower than the nitrate concentrations in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-275.

Well	Nitrate (mg/L)				
	October 1995	May 2000	October 2000	April 2003	October 2003
GW-274	4,270	5,410	3,890	3,010	2,950
GW-275	7,580	7,150	7,160	7,390	6,900

Under the conceptual model for contaminant transport from the former S-3 Ponds, sampling results for well GW-275 are representative of concentrations within long, strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, that promote much slower flow toward operating basement sumps located in Bldgs. 9204-4, 9201-5, 9201-4, and 9204-2, which are up to 4,000 ft east-southeast of the former S-3 Ponds (DOE 1998). Considering the upward hydraulic gradients indicated by presampling groundwater elevations in wells GW-274 and GW-275 (see Section 3.0), the nitrate concentrations in the shallower groundwater flow system are at least partially maintained by nitrate-contaminated groundwater upwelling from deeper in the Nolichucky Shale.

In addition to the lower nitrate concentrations evident in the shallow groundwater at well GW-274, the preceding data summary also illustrates the decreasing long-term nitrate concentration trend (Figure 1), with sampling results for well GW-275 suggesting a much slower decrease in the concentration of nitrate in the deeper groundwater flow/transport pathways. The decreasing nitrate concentrations indicated by the monitoring data for each well are primarily attributable to substantially reduced flux of nitrate (and other contaminants) following closure of the former S-3 Ponds in 1984 and the installation of the low-permeability cap in 1989; reduced flux of contaminants in the deeper bedrock (GW-275) also may be attributable to the continued eastward (strike parallel) migration of the nitrate mass emplaced during historical site operations (DOE 1998). Moreover, the more rapid decrease in nitrate concentrations in the shallow groundwater (GW-274) suggest the influence of natural attenuation processes, including inflow of uncontaminated (or less contaminated) recharge, that are limited to, or are more efficient in, the shallow flow system.

5.2 URANIUM

All of the groundwater samples collected since November 1986 had uranium concentrations above the analytical reporting limit, including results for eight samples that exceed the MCL for uranium (0.03 mg/L). The acidic groundwater in this well and elsewhere immediately downgradient of the former S-3 Ponds contains elevated concentrations of several trace metals, some entrained in the wastes disposed at the site (e.g., uranium) and others dissolved from minerals in the bedrock (Nolichucky Shale) underlying the site (e.g., barium). The uranium in the groundwater probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Thus, the distribution of elevated uranium concentrations in the Nolichucky Shale near the former S-3 Ponds is largely confined to the low-pH groundwater within about 500 ft of the site (DOE 1998).

Uranium concentrations reported for the groundwater samples range between the historical minimum value of 0.013 mg/L in October 1995 and the historical maximum value of 0.047 mg/L in November 1988 (Table 1). As with nitrate concentrations in the samples, these uranium results show a decreasing long-term concentration trend, with concentrations below the MCL (0.03 mg/L) reported for each sample collected form the well since January 1990. The decreasing uranium concentrations correspond with the substantially reduced flux of uranium in the shallow groundwater flow system following closure/capping of the former S-3 Ponds (DOE 1998).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected since October 1986 (Table 2): benzene, bromoform, chloroform, methylene chloride, PCE, TCE, and 12DCE (c12DCE). Although some of these compounds (e.g., PCE) are confirmed components of the contaminant plume originating from the former S-3 Ponds and the Y-12 Salvage Yard (Drum Deheader), others (e.g., benzene) are not, and their presence in the groundwater at well GW-274 indicates transport/migration from other potential sources of VOCs, such as the Rust Garage, which is a known source of petroleum hydrocarbons located about 500 ft west (hydraulically upgradient, parallel with geologic strike) of the well.

Based on frequency of detection, the primary VOCs in the groundwater samples are PCE and TCE, one or both of which were detected in all but three of the samples (Table 2), although the most recent sampling results (April and October 2003) show PCE concentrations are several orders-of-magnitude higher than TCE concentrations. Secondary compounds in the samples are benzene, bromoform, and 12DCE (c12DCE), with the concentrations of benzene exceeding 100 µg/L and the concentrations of bromoform and 12DCE remaining near 10 µg/L. Also, all of the VOCs have been detected more frequently in the samples collected since October 1995. Benzene, for instance, was detected in two of the 14 samples collected between November 1986 and January 1990, but was detected in all five of the samples collected between October 1995 and October 2003 (Table 2).

As noted in Section 5.1, the nitrate concentrations are substantially higher in the deeper groundwater at well GW-275. Vertically upward hydraulic gradients from well GW-275 to GW-274 suggest upwelling of nitrate-contaminated groundwater from the deeper flow system, which helps maintain the nitrate levels in the shallower groundwater (GW-274). Unlike the nitrate concentrations, however, the concentrations of VOCs in the shallow groundwater at well GW-274 are substantially higher than the concentrations of VOCs in the deeper groundwater at well GW-275, as illustrated by the data summarized below.

VOC	Concentration (µg/L)					
	October 1995		May 2000		October 2000	
	GW-274	GW-275	GW-274	GW-275	GW-274	GW-275
PCE	36	.	500	9	650	.
TCE	6	.	10	.	12	.
12DCE	4	.	5	.	7	.
Bromoform	.	.	6	.	6	.
Chloroform	17	1 J	25	.	28	.
MC	37	3 J	49	.	57	.
Benzene	.	.	35	.	50	.
Note: "." = Not detected; J = Estimated value below analytical reporting limit						

The data for well GW-274 also illustrate the substantial concentration increases evident for PCE and benzene (Table 2), with respective historical maximum values (1,200 µg/L for PCE and 120 µg/L for benzene) reported for the sample collected most recently (October 2003). Also, note the contrast between the increasing concentrations of PCE and benzene and the decreasing concentrations of nitrate. This relationship suggests that the contaminant plume emplaced during operation of the former S-3 Ponds may not be the primary source of the PCE (and other VOCs) in the shallow groundwater at this well, an interpretation supported by the overall lack of PCE (and other VOCs) in the samples of the deeper groundwater from well GW-275. Instead of the S-3 Site, areas in the Y-12 Salvage Yard (e.g., the Drum Deheader) may be the source of the chlorinated solvents. Moreover, the concurrent increase in the concentrations of PCE and benzene in the shallow groundwater at well GW-274 suggest a common source for these compounds, which also discounts the former S-3 Ponds because benzene and other petroleum hydrocarbons were not part of the waste stream disposed at the site. The increasing concentrations of the VOCs suggest a corresponding increase in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the well.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater samples collected before October 1995 do not meet data quality objectives (the MDA and corresponding CE were not for these results are not available), and gross alpha activity reported for the samples collected since then do not exceed the applicable MDA. However, the apparent lack of gross alpha activity (and associated alpha-emitting radionuclides) may be an artifact of the elevated MDAs reported for the applicable samples (e.g., MDA = 290 pCi/L in October 2003). The elevated MDAs are probably attributable to analytical interference related to the very high TDS of the (unfiltered) groundwater samples.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater samples collected before October 1995 do not meet data quality objectives (the MDA and corresponding CE were not for these results are not available). However, gross beta activity reported for all of the samples collected since then exceed 1,000 pCi/L, with the most recent sampling results (April and October 2003) indicating gross beta activity above 10,000 pCi/L (Table 1). Moreover, all of these results are at least two orders-of-magnitude higher than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The primary source of the gross beta activity is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99), and was detected at very high concentrations in the samples collected in May 2000 (15,000 pCi/L) and October 2000 (15,000 pCi/L). Note that both the Tc-99 results substantially exceed the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale east of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate (see Section 5.1), with the sampling results for well GW-274 being representative of gross beta/Tc-99 activity at shallow depths in relatively short groundwater flow/transport pathways that terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC (DOE 1998).

As noted in Section 5.1, nitrate concentrations in the groundwater samples from well GW-274 are substantially lower than evident in the groundwater samples from well GW-275. However, the opposite appears true for gross beta activity (and Tc-99). As shown by the data summarized below, sampling results for well GW-274 show substantially higher gross beta activity than the sampling results for well GW-275, which seems peculiar in light of the very high nitrate concentrations in the groundwater from this well.

Well	Gross Beta Activity (pCi/L)				
	October 1995	**May 2000**	**October 2000**	**April 2003**	**October 2003**
GW-274	4,230	7,800	12,200	13,000	10,000
GW-275	125	<MDA	<MDA	<MDA	<MDA

The preceding data summary also illustrates the increasing long-term trend indicated by the gross beta activity reported for the groundwater samples from well GW-274 (Figure 3). This trend suggests substantially increased flux of Tc-99 along the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, the substantially higher flux of Tc-99 is concurrent with the substantially lower flux of nitrate suggested by a decreasing long-term nitrate concentration trend (see Section 5.1). Divergent concentration trends (and differential flux) for nitrate and Tc-99 seem somewhat surprising considering that both contaminants share a common source (the former S-3 Ponds) and have similar groundwater transport characteristics. Perhaps the apparent differential flux of nitrate and Tc-99 is a consequence of waste disposal operations at the S-3 Ponds, whereby the routine disposal of nitrate wastes essentially emplaced a large contiguous mass of nitrate and the intermittent disposal of Tc-99 wastes emplaced more discontinuous "slugs" of Tc-99 within the mass of nitrate. Thus, the increasing Tc-99 concentrations indicted by the gross beta activity reported for well GW-274 may reflect a temporal "pulse" in the relative flux of Tc-99 emplaced during intermittent disposal of Tc-99 wastes at the site (AJA 2001).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA) 2001. *Calendar Year 2000, Annual Resource Conservation and Recovery Act Groundwater Monitoring Report for the Upper East Fork Poplar Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee.* Prepared for Bechtel Jacobs Company LLC, Oak Ridge, Tennessee. (BJC/OR-883).

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-274: summary of results for nitrate, uranium, and gross beta activity

Sampling Date	Concentration		
	Nitrate (mg/L)	Uranium (mg/L)	Gross Beta Activity (pCi/L)
11/04/86	15,800	0.034	DQO
03/06/87	15,128	0.036	DQO
06/02/87	13,700	0.034	DQO
08/22/87	11,200	0.031	DQO
10/29/87	12,500	0.028	DQO
03/28/88	10,000	0.028	DQO
06/17/88	11,800	0.022	DQO
09/27/88	9,350	0.031	DQO
11/11/88	1,780	0.047	DQO
03/03/89	1,087	0.046	DQO
05/23/89	11,100	0.028	DQO
09/27/89	13,400	0.04	DQO
12/08/89	13,800	0.046	DQO
01/23/90	10,900	0.024	DQO
10/30/95	4,270	0.013	4,230
05/30/00	5,410	0.0229	7,800
10/18/00	3,890	0.0177	12,200
04/30/03	3,010	0.0165	13,000
10/22/03	2,950	0.0181	10,000
MCL	**10**	**0.03**	**50***

Note: "." = Not detected; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-274: summary of VOC results

Sampling Date	Concentration (µg/L)					
	Benzene	Bromoform	PCE	TCE	12DCE	c12DCE
11/04/86	.	.	2 J	4 J	NR	NR
03/06/87	1 J	.	3 J	4 J	NR	NR
06/02/87	.	.	.	4 J	NR	NR
08/22/87	.	.	.	4 J	NR	NR
10/29/87	.	.	.	4 J	NR	NR
03/28/88	.	.	.	4 J	NR	NR
06/17/88	.	.	.	.	NR	NR
09/27/88	.	.	.	4 J	NR	NR
11/11/88	.	.	2 J	5	.	NR
03/03/89	0.4 J	.	2 J	6	.	NR
05/23/89	.	.	2 J	4 J	.	NR
09/27/89	.	.	.	.	.	NR
12/08/89	.	.	.	.	.	NR
01/23/90	.	.	1 J	6	.	NR
10/30/95	2 J	2 J	36	6	4 J	NR
05/30/00	35	6	500	10	5	5
10/18/00	50	6	650	12	7	7
04/30/03	120	8	1,100	12	13	13
10/22/03	120	8	1,200	10	12	12
MCL	**5**	**80***	**5**	**5**	**NA**	**70**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NR = Not reported
* MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + bromochloromethane)

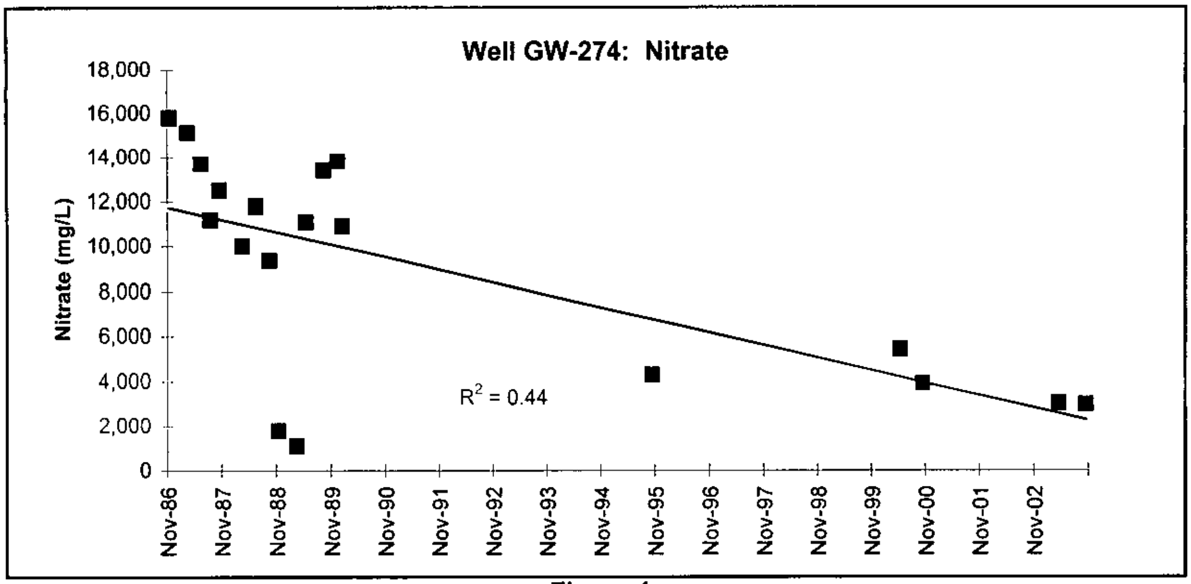


Figure 1

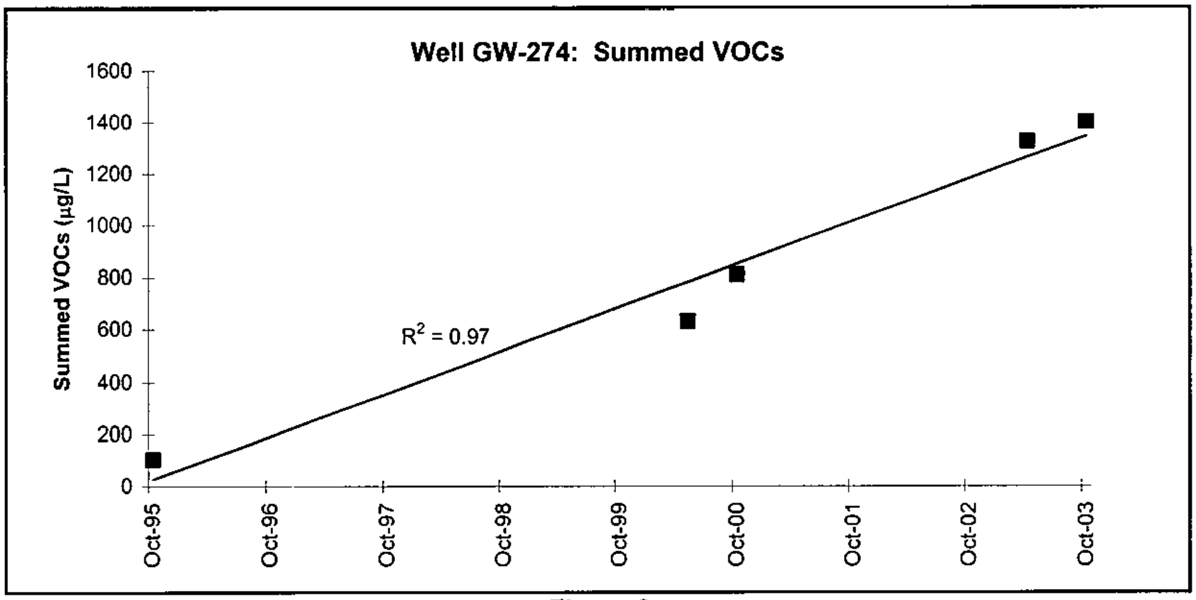


Figure 2

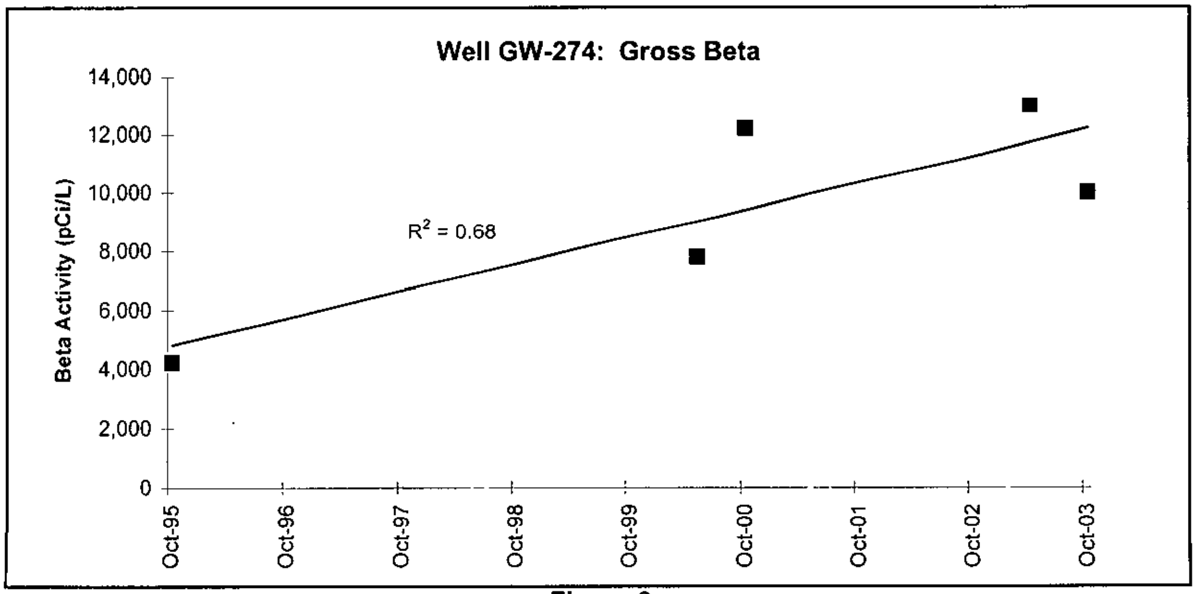


Figure 3

MAXIMUM CONCENTRATION: 2003

>1,000	<0.015	<5	150 - 1,500	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-275

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Y-12 Salvage Yard
Y-12 GRID EAST COORDINATE: 53,687.52
Y-12 GRID NORTH COORDINATE: 30,151.36
SURFACE ELEVATION: 993.08 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/30/86 PAIRED/CLUSTERED WITH: GW-274
TAG DEPTH (measured): 68.47 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 995.36 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	53.3	939.78
BOTTOM (filter pack or open hole):	65.5	927.58
MIDPOINT (filter pack or open hole):	59.4	933.68
PUMP INTAKE:	62.72	930.36
WATER LEVEL (average):	1.44	991.64

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	15 samples	11/04/86	10/30/95
LOW-FLOW SAMPLING METHOD:	4 samples	05/30/00	10/22/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/30/03	.	10/22/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.43 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	5	7,580 mg/L	10/30/95	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	9 μg/L	05/30/00	Decreasing
GROSS ALPHA (15 pCi/L):	1	154 pCi/L	10/22/03	Anomalous Result
GROSS BETA (50 pCi/L):	1	125 pCi/L	10/30/95	Anomalous Result

WELL GW-275

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1986, completed with a screened monitored interval from 53.3 to 65.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-274 and is located in Bear Creek Valley near the west end of Y-12, within the southeastern section of the Y-12 Salvage Yard, about 1,200 ft directly east of the former S-3 Ponds, a major source of groundwater contamination at Y-12 that was closed and capped in accordance with a RCRA closure plan in 1988. The S-3 site originally consisted of four unlined and contiguous surface impoundments that were used from 1951 to 1984 primarily for percolation/evaporation of nitric acid effluent (with depleted uranium in solution) discharged into the ponds via a pipeline (the Abandoned Nitric Acid Pipeline) connected to process buildings in the central Y-12 area. Operation of the site emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants into the Conasauga Group (Nolichucky Shale) and created a mound in the water table (which dissipated after disposal of wastes in the ponds ceased) that enabled transport/migration of contaminants into areas that now lie east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds. Additionally, the Y-12 Salvage Yard encompasses several former waste management units that are known sources of groundwater contamination (e.g., Salvage Yard Drum Deheader).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between November 1986 and October 1995, and the low-flow sampling method used to obtain four samples between May 2000 and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 1.4 ft below ground surface. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<4 ft) in seasonal groundwater surface elevations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are higher in well GW-275 than in well GW-274, which is completed at a shallower depth (35 ft bgs) in the Nolichucky Shale. Based on the distance (28.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005-0.031) during seasonally high and low flow conditions from the shallow bedrock to the water table interval.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-274 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields nitrate-contaminated and highly mineralized calcium-magnesium-bicarbonate groundwater generally characterized by:

- extremely high TDS (>40,000 mg/L);
- pH (field measurements) of 6.4 – 6.7;
- unusually high concentrations of calcium (>8,000 mg/L), magnesium (>1,000 mg/L), chloride (>40 mg/L), potassium (>25 mg/L), and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of several trace metals, notably barium (>100 mg/L) and strontium (>50 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for five groundwater samples collected from the well since January 1991.

5.1 NITRATE

Each groundwater sample had nitrate concentrations above 5,000 mg/L, with the highest levels reported for the samples collected in October 1995 (7,580 mg/L) and April 2003 (7,390 mg/L). The source of the nitrate is the former S-3 Ponds, the historical operation of which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east and west of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were entrained in the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume. Based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs (DOE 1998).

Under the conceptual model for contaminant transport from the former S-3 Ponds, sampling results for well GW-275 are representative of concentrations within long, strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, that promote much slower flow toward operating basement sumps located in Bldgs. 9204-4, 9201-5, 9201-4, and 9204-2, which are up to 4,000 ft east-southeast of the former S-3 Ponds (DOE 1998). As shown by the data summarized below, the nitrate concentrations in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-275 are significantly higher than the nitrate concentrations in the shallower groundwater flow/transport pathways intercepted by the monitored interval in well GW-274.

Well	Nitrate (mg/L)				
	October 1995	May 2000	October 2000	April 2003	October 2003
GW-274	4,270	5,410	3,890	3,010	2,950
GW-275	7,580	7,150	7,160	7,390	6,900

Little change in the relative flux of nitrate via these flowpaths is suggested by the close similarity between the nitrate concentrations evident in the groundwater samples collected from the well in October 1995 and April 2003, which reflect the indeterminate long-term concentration trend (Figure 1).

5.2 URANIUM

Four groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.00268 mg/L in May 2000) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for three of the five groundwater samples collected since January 1991 had low concentrations of at least one VOC. Tetrachloroethene was detected in samples collected in May 2000 (9 μg/L) and April 2003 (3 μg/L). Low (estimated) concentrations of chloroform (1μg/L) and methylene chloride (3 μg/L) were detected in the groundwater sample collected in October 1995.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the sample collected in October 2003 (154 pCi/L) exceeds the applicable MDA and corresponding CE, and is substantially above the MCL for gross alpha activity (15 pCi/L). In contrast, the gross alpha results for the other groundwater samples do not exceed the applicable MDA. The inconsistent detection of gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0), and the elevated result reported for the October 2003 sample is a suspected outlier.

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the sample collected in October 1995 (125 pCi/L) exceeds the applicable MDA and corresponding CE, and is above the SDWA screening level for gross beta activity (50 pCi/L). In contrast, gross beta results for the other groundwater samples do not exceed the applicable MDA. As for the gross alpha activity, this one elevated result may be an artifact of the very high TDS (>1,000 mg/L) in the samples, and is considered to be an outlier.

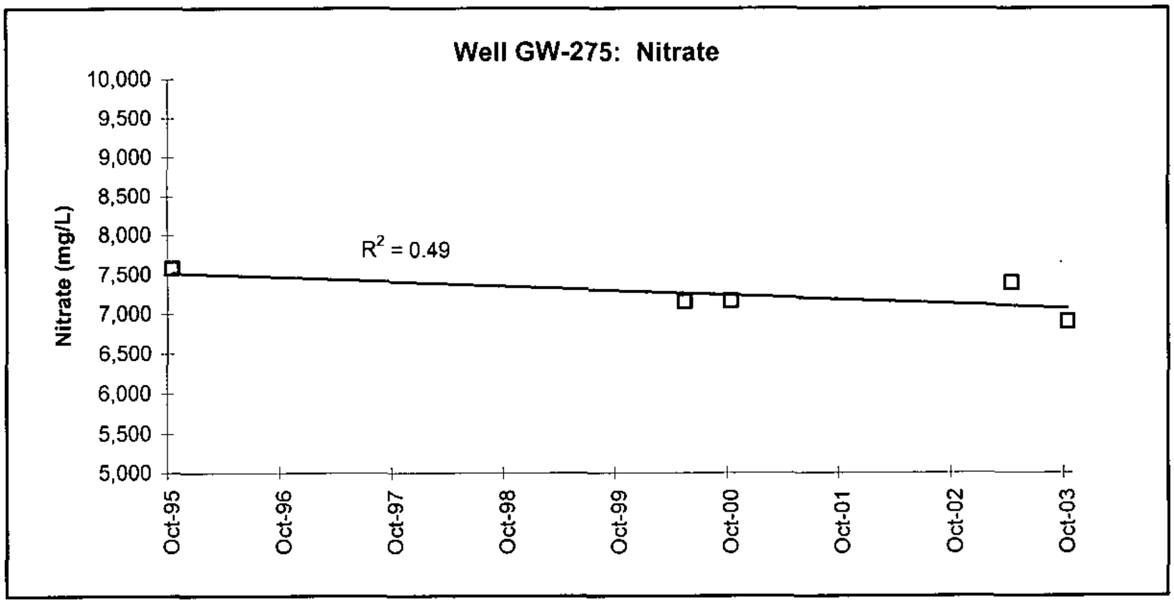
As noted in Section 5.1, nitrate concentrations in the groundwater samples from well GW-275 are substantially higher than evident in the groundwater samples from shallower well GW-274. However, the opposite appears true for gross beta activity (and Tc-99). As shown by the data summarized below, sampling results for well GW-274 show substantially higher gross beta activity than the sampling results for well GW-275, which seems peculiar in light of the very high nitrate concentrations in the groundwater from this well.

Well	Gross Beta Activity (pCi/L)				
	October 1995	May 2000	October 2000	April 2003	October 2003
GW-274	4,230	7,800	12,200	13,000	10,000
GW-275	125	<MDA	<MDA	<MDA	<MDA

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.



Well GW-275: Nitrate
Nitrate (mg/L)
10,000
9,500
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
R^2 = 0.49
Oct-95
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03

Figure 1

MAXIMUM CONCENTRATION: 2004

10 - 100	0.3 - 3.0	5 - 50	150 - 1,500	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-276

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,557.47
Y-12 GRID NORTH COORDINATE: 29,925.61
SURFACE ELEVATION: 998.70 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/15/86 PAIRED/CLUSTERED WITH: GW-277
TAG DEPTH (measured): 21.34 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,001.57 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.3	987.40
BOTTOM (filter pack or open hole):	18.5	980.20
MIDPOINT (filter pack or open hole):	14.9	983.80
PUMP INTAKE:	14.13	984.57
WATER LEVEL (average):	3.46	995.24

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	36		
CONVENTIONAL SAMPLING METHOD:	22 samples	10/29/86	08/13/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/22/98	07/08/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/06/04	.	07/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.55 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	22	220 mg/L	07/29/95	Decreasing
URANIUM (0.03 mg/L):	21	2 mg/L	07/29/95	Decreasing
SUMMED VOCs (5 µg/L):	22	53 µg/L	03/30/94	Decreasing
GROSS ALPHA (15 pCi/L):	20	852 pCi/L	07/29/95	Decreasing
GROSS BETA (50 pCi/L):	20	1,180 pCi/L	08/20/94	Decreasing

WELL GW-276

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during July 1986, completed with a screened monitored interval from 11.3 to 18.5 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-277 and is located in Bear Creek Valley (BCV) at the west end of Y-12, near the main headwaters channel of Bear Creek about 200 ft southeast of the former S-3 Ponds. This site consists of four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplaced a large heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains one of the primary sources of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-six groundwater samples have been collected from the well, with the conventional sampling method used to obtain 22 samples between October 1986 and August 1997 and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004. The sampling history encompasses a four-year gap (January 1990 – March 1994) as well as almost ten years of uninterrupted semiannual monitoring (March 1994 – January 2004).

High total dissolved solids (TDS) and acidic pH (<5.5) are distinguishing characteristics of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops beneath the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits moderate (<4 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-276 than in well GW-277, which is completed at a greater depth (77.4 ft bgs) in the Nolichucky Shale. Based on the distance (54.7 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005-0.027) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-276 indicate flow south and west toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields acidic, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 500 – 2,350 mg/L;
- pH of 2.6 – 5.8 (field measurements);
- concentrations of chloride (>300 mg/L), sodium (>120 mg/L), and sulfate (>50 mg/L) that are substantially higher than typically evident in samples from other wells completed at similarly shallow depths in the Nolichucky Shale;
- nitrate concentrations above 30 mg/L;
- total concentrations of several trace metals, including aluminum, barium, manganese, nickel, and uranium, that substantially exceed the respective range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The chloride and sodium-enriched geochemistry of the groundwater samples probably reflect contamination resulting from dissolution of bedrock minerals by the acidic seepage from the former S-3 Ponds. However, considering the vertically upward hydraulic gradients indicated by the presampling groundwater elevations in wells GW-276 and GW-277 (see Section 3.0), it is also possible for the geochemistry of the groundwater to reflect upwelling of chloride- and sodium-enriched groundwater from deeper in the Nolichucky Shale. Most of the water table and shallow bedrock wells (i.e., <100 ft bgs) completed in this formation elsewhere in BCV yield calcium-magnesium-bicarbonate groundwater, but a fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs (in BCV west of Y-12), with another change to sodium-chloride groundwater typically evident more than 400 ft bgs. The sodium- and chloride-enriched geochemistry of the groundwater is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture and increased fracture spacing (Solomon et al. 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, these contaminants are all present at elevated levels in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for each groundwater sample collected to date, with 25 samples having had concentrations above 100 mg/L, including eight samples with concentrations above 1,000 (Table 1). The source of the nitrate is the contaminant plume emplaced during historical operations of the former S-3 Ponds. Nitrate is the primary inorganic contaminant in the plume and, based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) transport/migration in the unconsolidated zone (water table interval) directly south toward the headwaters of Bear Creek; (2) westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft

(NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel flowpaths, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997).

Nitrate concentrations reported for all of the groundwater samples exceed the MCL (Table 1), with a historical maximum concentration of 1,580 mg/L in October 1986 and a historical minimum concentration of 32 mg/L in January 2004. These "bookend" results illustrate the clearly decreasing long-term concentration trend shown by a time-series plot of the nitrate concentrations (Figure 1). The decreasing nitrate concentrations correspond with the substantially reduced flux of nitrate (and other contaminants) in the shallow groundwater flow system following closure of the former S-3 Ponds in 1984 and the installation of the low-permeability cap in 1989 (DOE 1997). Also, the long-term decreasing trend is punctuated by temporal "peak" nitrate concentrations evident in February 1989 (1,200 mg/L), July 1995 (220 mg/L), July 1998 (138 mg/L), July 2000 (105 mg/L), and July 2002 (73.7 mg/L), most of which correspond with seasonally low groundwater flow conditions. This relationship suggests dilution of the "baseflow" nitrate concentrations during seasonal (and episodic) recharge of uncontaminated (or less nitrate-contaminated) groundwater. Under the conceptual model for contaminant transport from the former S-3 Ponds, recharge in the shallow flow system promotes relatively rapid groundwater transport toward discharge areas in the main channel of Bear Creek and its northern tributaries west of the site (DOE 1997).

5.2 URANIUM

All but one of the groundwater samples collected to date had uranium concentrations at least an order-of-magnitude above the MCL for uranium (0.03 mg/L), with concentrations above 5 mg/L reported for nine samples, including three samples with concentrations above 10 mg/L (Table 1). The acidic groundwater in this well and elsewhere immediately downgradient of the former S-3 Ponds contains elevated concentrations of several trace metals, some entrained in the wastes disposed at the site (e.g., uranium) and others dissolved from minerals in the bedrock (Nolichucky Shale) underlying the site (e.g., barium). The uranium in the groundwater probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Thus, the distribution of elevated uranium concentrations in the Nolichucky Shale near the former S-3 Ponds is largely confined to the low-pH groundwater within about 500 ft of the site (DOE 1997).

Excluding the non-detect uranium value reported for the groundwater sample collected in February 1999, which is an obvious outlier compared to the other uranium results and is a likely analytical artifact, the samples had a wide range of uranium concentrations, with the historical minimum value (0.613 mg/L in January 2004) being and order-of-magnitude lower than the historical maximum value (13.45 mg/L in October 1986). As with nitrate, these results illustrate the clearly decreasing long-term concentration trend shown by a time-series plot of the uranium concentrations (Figure 2). The decreasing uranium concentrations correspond with the substantially reduced flux of uranium (and other contaminants) in the shallow groundwater flow system following closure of the former S-3 Ponds in 1984 and the installation of the low-permeability cap in 1989 (DOE 1997). Unlike the nitrate concentrations in the samples, however, the uranium concentrations do not appear to exhibit any clear and consistent relationship with seasonal groundwater flow conditions, although temporal "peak" concentrations are indicated by the uranium results for the samples collected in August 1997 (1.3 mg/L) and July 2001 (1.5 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, two VOCs were detected in the groundwater samples collected to date: chloroform and PCE (Table 1). Both compounds are known components of the contaminant plume originating from the former S-3 Ponds, but are typically present at substantially lower concentrations compared to other components of the plume (e.g., nitrate). This is because chlorinated solvents were not extensively disposed at the site, with total volumes of organic wastes being substantially less than that of the inorganic wastes disposed at the site (DOE 1997).

The primary VOC in the groundwater samples is PCE, which has been detected in each sample collected from the well (Table 1), all of which had PCE concentrations above the MCL (5 µg/L). In contrast, chloroform has been detected (excluding false positive results) in only eleven samples and all of the results are estimated values below 5 µg/L. A time-series plot of the PCE results spans the four-year gap in the sampling history for the well and shows a clearly decreasing long-term trend (Figure 3). However, the rate of concentration decrease appears to have slowed, as indicated by substantially higher PCE concentration in February 1989 (250 µg/L) compared to February 1999 (11 µg/L), but little if any decrease since then, as indicated by the PCE concentration in July 2004 (10 µg/L). This suggests that the bulk of the dissolved VOCs have been flushed from the shallow flow system south of the former S-3 Ponds.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the groundwater samples collected before March 1994 do not meet data quality objectives (the MDA and corresponding CE were not for these results are not available), whereas the gross alpha activity reported for all but two of the samples collected since then not only exceed the applicable MDA and CE, but are more than 100 pCi/L (Table 2). Uranium isotopes (U-234 and U-238) from the contaminant plume emplaced during operation of the former S-3 Ponds are principal source of the gross alpha activity in the groundwater. Twenty of the samples collected since March 1994 were analyzed for U-234 and U-238, with both isotopes detected (i.e., >MDA and CE) in all but one of these samples (Table 2). Note that the historical maximum values for the samples analyzed for U-234 (271 pCi/L in January 1995) and U-238 (603 pCi/L in January 1995) do not correspond with the historical maximum value for gross alpha activity (852 pCi/L in July 1995). This is not surprising considering the inherent variability commonly associated with radiochemical analyses, particularly considering that the high TDS in the samples may cause analytical interferences for gross alpha activity.

Excluding the non-detect gross alpha activity (i.e., <MDA) reported for the groundwater samples collected in February 1996 and July 1998 (Table 2), which are outliers compared to the other results and are likely analytical artifacts, results for the other samples define a wide range of gross alpha activity, with the historical maximum value (852 pCi/L in July 1995) being several-times higher than the historical minimum value (117 pCi/L in January 2000). This may be at least partially attributable to analytical interferences associated with the TDS in the (unfiltered) samples. Also, wide temporal fluctuations tend to dominate the indeterminate long-term trend shown by a time-series plot of the gross alpha activity reported for each sample (Figure 4), which suggests minimal changes in the overall flux of uranium isotopes via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

As with gross alpha activity, the results for gross beta activity reported for groundwater samples collected before March 1994 do not meet applicable DQOs, with gross beta activity above the MDA and CE reported for all but two of the samples collected since then (Table 2). Moreover, all of these results substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). Uranium isotopes (and related daughter products) contribute to gross beta activity in the groundwater, but the primary source of the gross beta activity is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in Table 3, Tc-99 was detected (i.e., >MDA and CE) in all of the samples analyzed for this beta-emitting radionuclide, with the highest value reported for the sample collected in March 1994 (1,570 pCi/L) and the lowest value reported for the sample collected in July 2004 (326.4 pCi/L). Note that all the Tc-99 results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale west of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate, with transport in the water table interval south toward Bear Creek and more westward (strike-parallel) transport in the bedrock intervals toward discharge areas in NT-1 and NT-2 (DOE 1997).

Aside from the non-detect results (i.e., <MDA) reported for the groundwater samples collected in February 1996 and July 1998, which are both obvious outliers compared to the other results for gross beta activity (and are probably analytical artifacts), each sample collected to date had gross beta activity above 250 pCi/L (Table 2), with a historical maximum value of 1,180 pCi/L in August 1994 and a historical minimum value of 280 pCi/L in January 2004. These results "bookend" the decreasing long-term trend shown by a time-series plot of the gross beta activity reported for each sample except the two samples with results below the applicable MDA (Figure 5). Also, the decreasing long-term trend encompasses the five-year gap in the sampling history for this well (see Section 2.0) and is punctuated by a series of peaks evident in August 1994 (1,180 pCi/L), July 1995 (1,130 pCi/L), August 1997 (790 pCi/L), February 1999 (806 pCi/L), and July 2000 (567 pCi/L).

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-276: summary of results for nitrate, uranium, and PCE

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	PCE (μg/L)	Chloroform (μg/L)
10/29/86	1,580	13.45	8	.
03/05/87	1,479	12	210	.
06/01/87	1,499	8.67	160	.
08/20/87	1,242	11.2	140	.
10/28/87	1,242	7.97	93	.
03/24/88	1,217	9.18	230	.
06/18/88	493	3.22	21	.
09/01/88	1,030	7	220	.
11/02/88	931	5.99	190	.
02/25/89	1,200	6.1	250	.
05/18/89	636	3.11	220	.
09/06/89	528	4.8	180	.
12/05/89	546	2.86	180	.
01/23/90	454	3.11	180	.
03/30/94	147	1.16	52	1 J
08/20/94	152.9	1.55	43	1 J
01/24/95	151	1.6	37	1 J
07/29/95	220	2	32	1 J
02/29/96	129	1.9	18	1 J
07/08/96	129	1.2	22	1 J
01/28/97	110	0.78	24	.
08/13/97	125	1.3	23	1 J
01/22/98	129	0.63	12	FP
07/16/98	139	0.726	11	1 J
02/04/99	86.3	.	11	.
07/16/99	68	0.98562	14	.
01/04/00	96.1	0.947	9	1 J
07/12/00	105	0.96	14	2 J
01/04/01	69.2	0.822	9	.
07/10/01	67.2	1.5	9	.
01/07/02	51.3	0.723	8	.
07/08/02	73.7	0.79	10	2 J
01/07/03	38.8	0.624	9	.
07/09/03	35.8	0.676	10	.
01/06/04	32	0.613	10	.
07/08/04	30.6	0.86	10	.
MCL	**10**	**0.03**	**5**	**80***

Note: "." = Not detected; J = Estimated value below analytical reporting limit; FP = false positive result; * MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

Table 2. Well GW-276: summary of results for gross alpha activity, uranium isotopes, gross beta activity, and Tc-99

Sampling Method and Date	Concentration (pCi/L)				
	Gross Alpha Activity	U-234	U-238	Gross Beta Activity	Tc-99
10/29/86	DQO	.	.	DQO	.
03/05/87	DQO	.	.	DQO	.
06/01/87	DQO	.	.	DQO	.
08/20/87	DQO	.	.	DQO	.
10/28/87	DQO	.	.	DQO	.
03/24/88	DQO	.	.	DQO	.
06/18/88	DQO	.	.	DQO	.
09/01/88	DQO	.	.	DQO	.
11/02/88	DQO	.	.	DQO	.
02/25/89	DQO	.	.	DQO	.
05/18/89	DQO	.	.	DQO	.
09/06/89	DQO	.	.	DQO	.
12/05/89	DQO	.	.	DQO	.
01/23/90	DQO	.	.	DQO	.
03/30/94	398	179	387	1,110	1,570
08/20/94	454	225	519	1,180	1,120
01/24/95	469	271	603	978	1,350
07/29/95	852	260	552	1,130	1,280
02/29/96	<MDA	.	.	<MDA	.
07/08/96	368	<MDA	<MDA	575	1,020
01/28/97	360	190	410	680	920
08/13/97	340	19	46	790	760
01/22/98	140	100	220	590	970
07/16/98	<MDA	110	240	<MDA	840
02/04/99	354.5	113.8	253.4	806.17	683.07
07/16/99	514.95	178.5	425.9	473.92	591.49
01/04/00	117.75	153.2	366.5	175.34	734.64
07/12/00	293.08	139.2	314.3	567.31	360.63
01/04/01	500.51	152.3	323.6	482.99	651.27
07/10/01	443	143.3	342	454	532.43
01/07/02	238.65	80.45	182.3	357.54	501.55
07/08/02	210.7	73.7	193.8	391.23	501.01
01/07/03	293.07	96.29	210.3	366.31	381.29
07/09/03	516.16	123.5	243.5	364.25	349.46
01/06/04	343	111.8	234.8	280	339.49
07/08/04	291.88	111.6	215	324.68	326.4
MCL	**15**	**NA**		**50***	**3,790***

Note: "." = Not analyzed; DQO = Result does not meet data quality objectives; NA = Not applicable;
* SWDA screening level for a 4 millirem per year dose equivalent

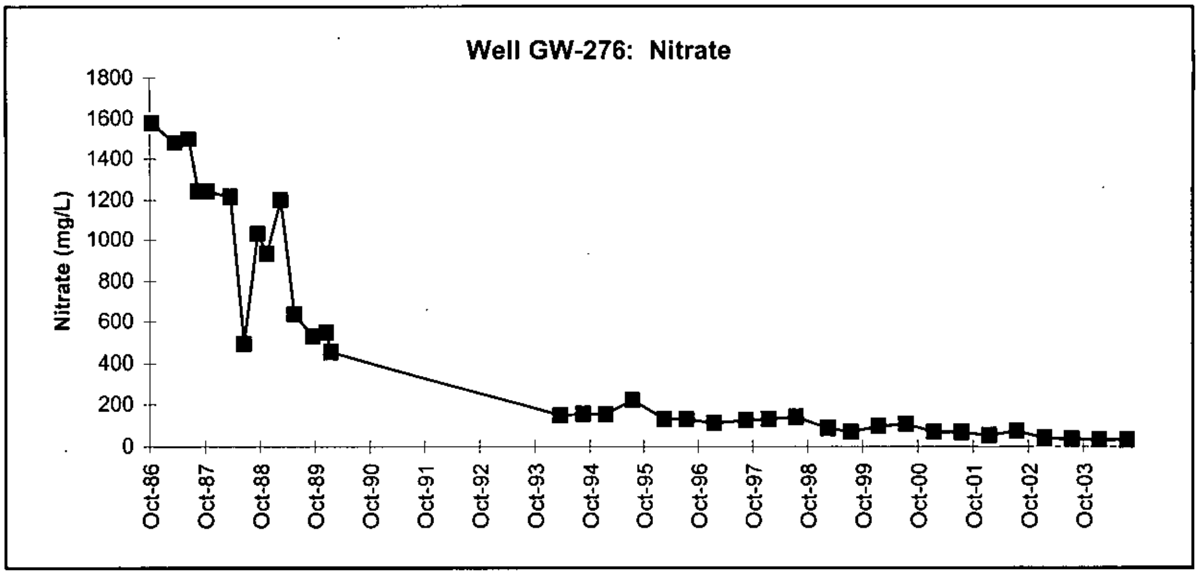


Figure 1

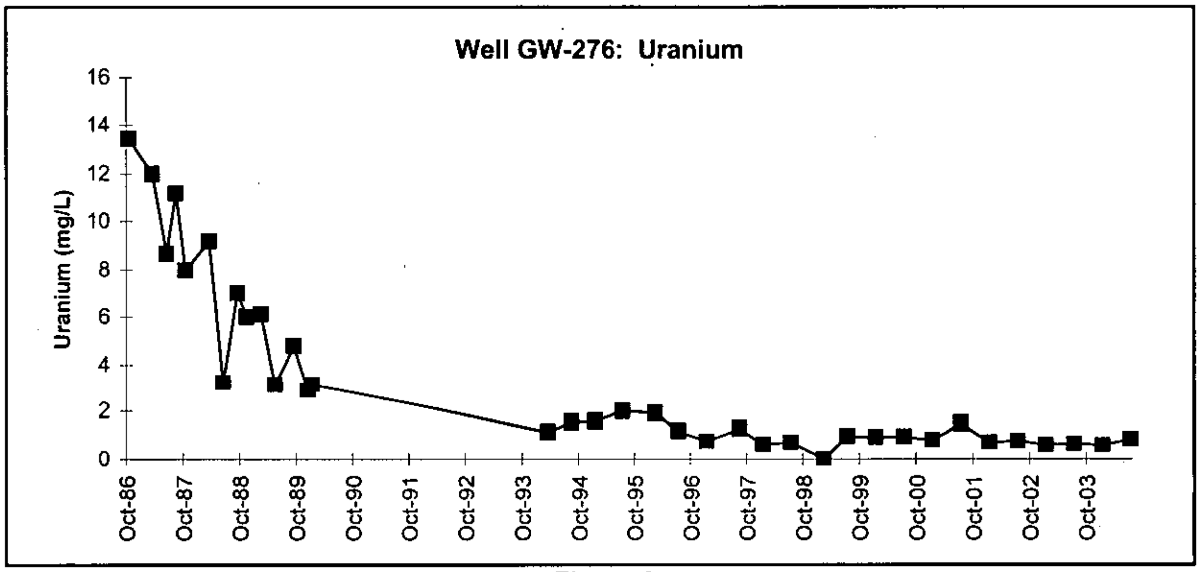


Figure 2

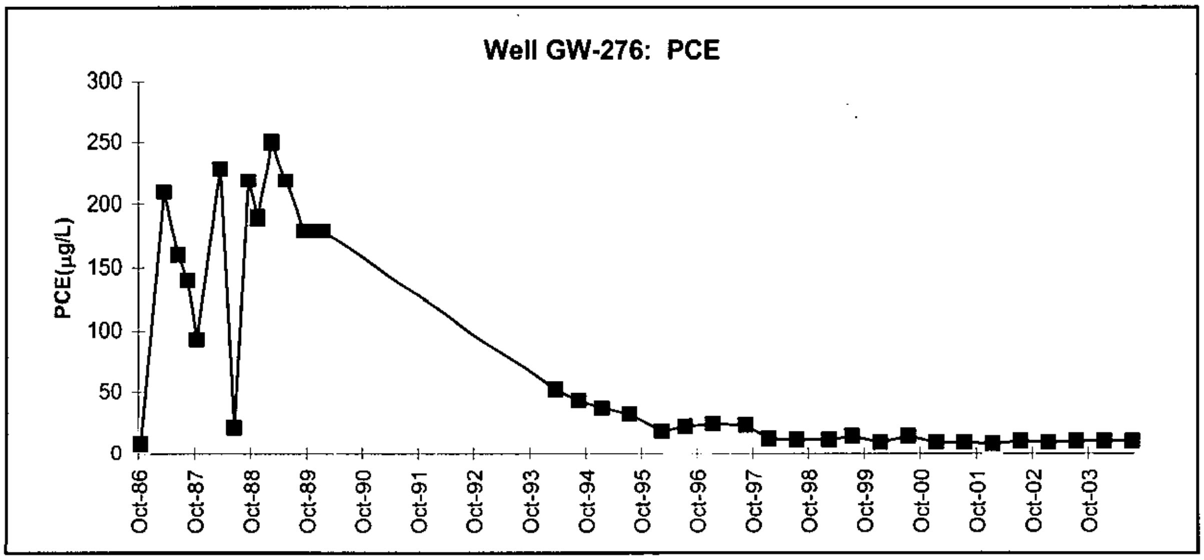


Figure 3

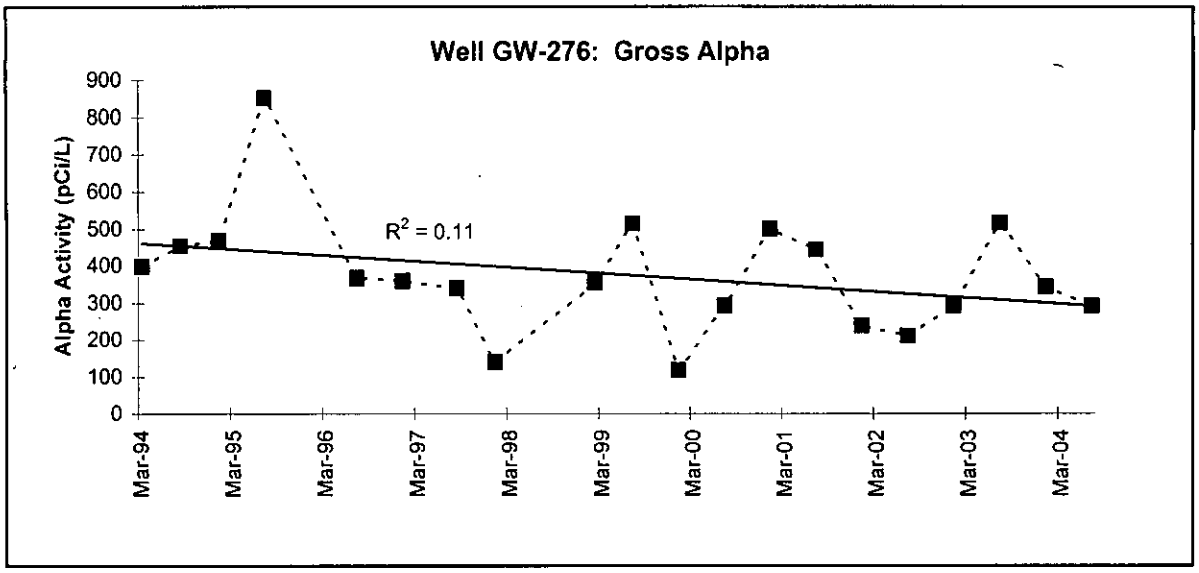


Figure 4

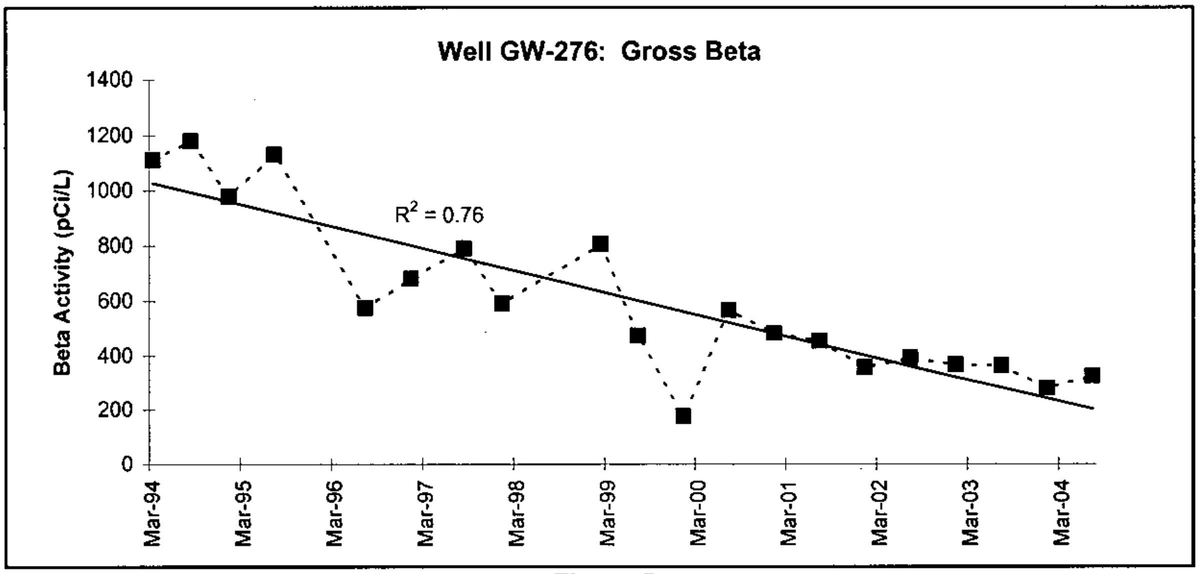


Figure 5

MAXIMUM CONCENTRATION: 2005

100 - 1,000	<0.015	5 - 50	ND	500 - 5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-277

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,564.63
Y-12 GRID NORTH COORDINATE: 29,937.47
SURFACE ELEVATION: 999.05 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/15/86 PAIRED/CLUSTERED WITH: GW-276
TAG DEPTH (measured): 80.63 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,001.76 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	62.2	936.85
BOTTOM (filter pack or open hole):	77.4	921.65
MIDPOINT (filter pack or open hole):	69.8	929.25
PUMP INTAKE:	72.8	926.26
WATER LEVEL (average):	3.96	995.09

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	10/29/86	01/23/90
LOW-FLOW SAMPLING METHOD:	2 samples	03/29/05	08/24/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/29/05	.	08/24/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.62 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	406 mg/L	08/24/05	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	2	32 µg/L	03/29/05	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	2	1200 pCi/L	03/29/05	Indeterminate

WELL GW-277

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during July 1986, completed with a screened monitored interval from 62.2 to 77.4 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-276 and is located in Bear Creek Valley (BCV) west of Y-12, approximately 200 ft east of the southeast corner of the former S-3 Ponds (hereafter referenced as the S-3 Site). Located near the western end of Y-12, directly north of the headwaters of Bear Creek, the S-3 Site consist of four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between October 1996 and January 1990 and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes quarterly, semiannual, and annual sampling frequencies and, as indicated by the sampling dates noted above, a 15-year period (January 1990 – March 2005); when no groundwater samples were collected from the well.

High total dissolved solids (TDS) is a distinguishing characteristics of the groundwater samples from this well (see Section 4.0), and is a direct consequence of contamination resulting from historical operation of the S-3 Site. Note that the high levels of TDS may cause analytical interferences for some laboratory analytes, including trace metals, gross alpha activity, and gross beta activity.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º - 55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Moreover, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the formation from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of approximately 4 ft bgs and exhibits minor (<1 ft) seasonal fluctuations. As indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements from nearby monitoring wells, directions of groundwater flow near the well are to the west, parallel with the trend (strike) of bedding in Nolichucky Shale, and to the south-southwest, across geologic-strike toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic flow via strike-parallel flowpaths (i.e., bedding-plane fractures) that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Also, possible dissolution of carbonate strata by the acidic seepage from the S-3 Site may locally enhance strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Additionally, directions of groundwater flow (and contaminant transport) now evident are undoubtedly different from the flow patterns that occurred during historical operations of the S-3 Site, which created a local "mound" in the water table that enabled groundwater flow (and contaminant transport) to the east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the (unfiltered) groundwater samples collected to date show that the well yields acidic, highly contaminated groundwater downgradient of the S-3 Site that is generally characterized by:

- TDS of 2,830 –11,796 mg/L;
- pH (field measurements) of 5.82 – 6.36;
- high concentrations of calcium (>500 mg/L), chloride (>70 mg/L), magnesium (>65 mg/L), nitrate (>300 mg/L), and sodium (>60 mg/L);
- low molar proportions of sulfate and potassium (<10% of total anions/cations);
- slightly elevated concentrations of several trace metals, notably barium (>0.7 mg/L), and strontium (>1 mg/L), that exceed the corresponding background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995)

Note that some of the inorganic compounds and trace metals in the groundwater at this well, such as nitrate, were entrained in the acidic wastes disposed at the S-3 Site, whereas other inorganics, such as calcium and barium, were dissolved from bedrock minerals by the highly acidic seepage from the site. Also, the high levels of TDS may cause analytical interferences for some laboratory analytes, including gross alpha activity and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants except gross alpha activity are present in the groundwater at this well. Note, however, that the bulk of the historical the analytical results for VOCs, gross alpha activity, and gross beta activity do not meet all applicable DQOs. The QA/QC sample data needed to identify false positive VOC results are not available for groundwater samples collected before January 1991. Similarly, gross alpha activity and gross beta activity reported for the groundwater samples collected before January 1990 are considered unusable because the sample-specific MDA and CE are not available for these analytes.

5.1 NITRATE

Nitrate concentrations above 1,000 mg/L were reported for all but two of the groundwater samples collected to date (Table 1), with the lowest concentrations reported for the samples collected most recently (March and August 2005). All of the results are at least an order-of-magnitude above the drinking water MCL for nitrate (10 mg/L). The S-3 Site is the source of the nitrate, which is a principal component of the contaminant plume emplaced during historical operations of the site. Nitrate is chemically stable and mobile in groundwater and is believed to effectively trace the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997).

Historical data show that the groundwater concentrations of nitrate in the groundwater from this well fluctuate seasonally, with the highest concentrations typically reported for the groundwater samples collected during seasonally low flow conditions (summer and fall). This apparent relationship with seasonal flow conditions also is mirrored by the most recent sampling results, with the nitrate concentration in the sample collected during August 2005 (406 mg/L) being approximately 30% higher than the concentration in the sample collected during March 2005 (317 mg/L). This relationship suggests that the nitrate concentrations in groundwater samples collected during seasonally (and episodically) high flow conditions (winter and spring) reflect greater relative inflow of uncontaminated (or less contaminated) recharge via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of the nitrate concentrations reported for the groundwater samples collected to date shows a widely variable trend between the initial sampling date in October 1986 (1,761 mg/L) and the historical maximum concentration in September 1988 (2,720 mg/L), followed by an equally variable but generally decreasing trend through January 1990 (1,690 mg/L). The most recent sampling results, including the historical minimum concentration evident in March 2005 (317 mg/L), demonstrate that the decreasing trend continued through the long gap in the sampling history for the well (Figure 1). The sharp concentration decrease evident after September 1988 is possibly attributable to a corresponding reduction in the relative flux of nitrate in the shallow groundwater flow system as a result of the closure and of the S-3 Site and installation of the low-permeability cap. Also, the most recent sampling results for nitrate indicate that the rate of concentration decrease has slowed considerably. For example, nitrate concentrations decreased at a generalized rate of approximately 2 mg/L per day from September 1988 to January 1990, but only 0.25 mg/L per day from January 1990 to March 2005. This suggests that the most highly contaminated groundwater has been flushed from the most permeable flowpaths at shallow depths in the Nolichucky Shale downgradient of the S-3 Site. Interestingly, although the nitrate concentrations decreased substantially in response to the closure/capping of the site, the acidity of the groundwater has remained relatively unchanged, as illustrated by the field pH measurements obtained during the collection of groundwater samples in August 1987 (6.5), January 1990 (6.1), and August 2005 (6.36).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations above the corresponding reporting limit (Table 1), with the historical maximum value (0.092 mg/L in October 1986) being the only result that exceeds the drinking water MCL for uranium (0.03 mg/L). As noted previously, uranium was entrained in the wastewaters disposed at the S-3 Site, and the uranium in the acidic seepage probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium are generally restricted to the acidic groundwater in the Nolichucky Shale within approximately 500 ft of the S-3 Site (DOE 1987).

Excluding the historical maximum value noted above, which was reported for the initial groundwater sample collected from the well and appears to be an outlier compared to all subsequent sampling results, a time-series plot of the uranium results shows a generally decreasing long-term concentration trend that spans the long gap in the sampling history for the well (Figure 2). This decreasing long-term trend reflects a corresponding reduction in the relative flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well. As with nitrate in the groundwater, the reduced flux of uranium occurred in direct response to the closure/capping of the S-3 Site. Additionally, it appears that the lower levels of uranium in the groundwater samples collected most recently is not attributable to a concurrent increase in the groundwater pH, which does not appear to have changed appreciably over the long term.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs was detected in each of the groundwater samples collected to date: acetone, chloroform, MC, PCE, toluene, and 111TCA (Table 2). Chlorinated solvents and organic chemicals were not substantial components of the waste stream for the S-3 Site (DOE 1997). Consequently, VOCs are fairly minor constituents within the contaminant plume emplaced during historical operation of the site, and are typically present at substantially lower concentrations compared to other plume constituents (e.g., nitrate).

Based on the frequency of detection and relative concentrations, the primary VOCs in the groundwater samples collected to date are PCE, chloroform, and MC (Table 2). The highest concentrations were reported for PCE, with the sampling result from March 2005 (30 µg/L) exceeding the historical maximum value (17 µg/L in December 1989) and showing that the PCE levels remain significantly above the drinking water MCL (5 µg/L). In contrast, only trace levels (4 µg/L or less) of chloroform were detected the samples and all of these results are substantially below the MCL for total trihalomethanes (80 µg/L). Similarly low concentrations of methylene chloride were detected in all but three of the samples collected between October 1986 (4 µg/L) and January 1990 (4 µg/L), although this compound was not detected in the samples collected most recently (March and August 2005). Of the other compounds detected in the samples, only acetone was detected at a concentration above 10 µg/L, the results for toluene are estimated values below 5 µg/L, and the results for 111TCA are estimated values below 1 µg/L (Table 2).

A time-series plot of the PCE concentrations detected in the groundwater samples collected to date is dominated by the long gap in the sampling history for the well, and shows a variable but generally increasing long-term concentration trend (Figure 3). This trend shows a modest increase in summed PCE concentrations following installation of the low-permeability cap over the S-3 Site, indicating an increase in the relative flux of PCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

As noted in Section 5.0, only the gross alpha activity reported for the groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples (see Section 4.0). Nevertheless, none of these samples had gross alpha activity above the applicable MDA and/or corresponding CE (Table 1). Low levels of gross alpha activity (i.e., <15 pCi/L drinking water MCL) are supported by analytical results for the primary alpha-emitting radionuclides entrained in the wastes disposed at the S-3 Site, U-234 and U-238, which were detected (i.e., >MDA and CE) at low levels in the groundwater samples collected most recently (Table 1).

5.5 GROSS BETA ACTIVITY

As noted in Section 5.0, only the gross alpha activity reported for the groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of analytical interferences associated with the high TDS of the samples (see Section 4.0). Although considered qualitative, the gross beta activity detected in the samples collected in January 1990 (2,900 pCi/L), March 2005 (1,200 pCi/L), and August 2005 (1,100 pCi/L) substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

Uranium decay products (e.g., Th-234) and other beta-emitting radionuclides known to be included in the waste stream for the S-3 Site (e.g., Np-237) probably contribute to the high level of gross beta activity in the groundwater from this well. However, Tc-99 is the principal source of beta activity and is the "signature" component of the contaminant plume emplaced during historical operation of the S-3 Site, which is the only site at Y-12 known to have received significant volumes of waste that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the groundwater downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater.

The Tc-99 activity reported for the groundwater samples collected in March 2005 (2,000 pCi/L) and August 2005 (1,700 pCi/L), which are the only samples collected to date that were analyzed for Tc-99, substantially exceed the SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. There are insufficient data to adequately characterize the long-term trend for Tc-99 activity. However, considering that the mobility of Tc-99 is similar to that of nitrate and the substantially reduced nitrate concentrations in the well reflect a corresponding reduction in the overall flux of nitrate after the S-3 Site was closed and capped, the levels of Tc-99 now evident in the groundwater from this well likewise probably reflect a corresponding decrease in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant*, *Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-277: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	**Total Uranium**	**Gross Alpha**	**Gross Beta**	**Tc-99**	**U-234**	**U-238**
10/29/86	1,761	0.092	DQO	DQO	.	.	.
03/05/87	1,976	0.023	DQO	DQO	.	.	.
06/01/87	2,122	0.02	DQO	DQO	.	.	.
08/20/87	1,693	0.024	DQO	DQO	.	.	.
10/28/87	2,046	0.017	DQO	DQO	.	.	.
03/24/88	1,464	0.007	DQO	DQO	.	.	.
06/15/88	2,090	0.015	DQO	DQO	.	.	.
09/01/88	2,720	0.014	DQO	DQO	.	.	.
11/02/88	2,130	0.011	DQO	DQO	.	.	.
02/25/89	1,800	0.011	DQO	DQO	.	.	.
05/18/89	2,370	0.013	DQO	DQO	.	.	.
09/07/89	2,310	0.013	DQO	DQO	.	.	.
12/06/89	1,800	0.011	DQO	DQO	.	.	.
01/23/90	1,690	0.008	< CE	2,900	.	.	.
03/29/05	317	0.0043	<MDA	1,200	2,000	0.42	1
08/24/05	406	0.00612	<MDA	1,100	1,700	1	1.8
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: Note: "." = Not analyzed; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent
DQO = does not meet data quality objectives;

Table 2. Well GW-277: summary of VOC results

Sampling Date	Primary VOCs (µg/L)		
	PCE	**Chloroform**	**MC**
10/29/86	4 J	3 J	4 J
03/05/87	3 J	4 J	4 J
06/01/87	.	4 J	4 J
08/20/87	.	4 J	2 J
10/28/87	.	1 J	2 J
03/24/88	4 J	4 J	.
06/15/88	2 J	2 J	6
09/01/88	3 J	2 J	3 J
11/02/88	6	2 J	.
02/25/89	11	2 J	4 J
05/18/89	10	3 J	3 J
09/07/89	9	2 J	4 J
12/06/89	17	3 J	.
01/23/90	14	2 J	4 J
03/29/05	30	2 J	.
08/24/05	18	3 J	.
MCL	**5**	**80***	**5**
Sampling Date	**Other VOCs (µg/L)**		
10/29/86	Acetone (41), Toluene (4 J)		
08/20/87	Toluene (2 J)		
03/24/88	111TCA (0.4 J)		
06/15/88	Toluene (0.6 J)		
11/02/88	Toluene (0.4 J)		
02/25/89	111TCA (0.8 J)		
05/15/89	Acetone (4 J)		
01/23/90	111TCA (0.8 J)		

Note: "." = Not detected; J = Estimated value below analytical reporting limit;
* = MCL is for total trihalomethanes

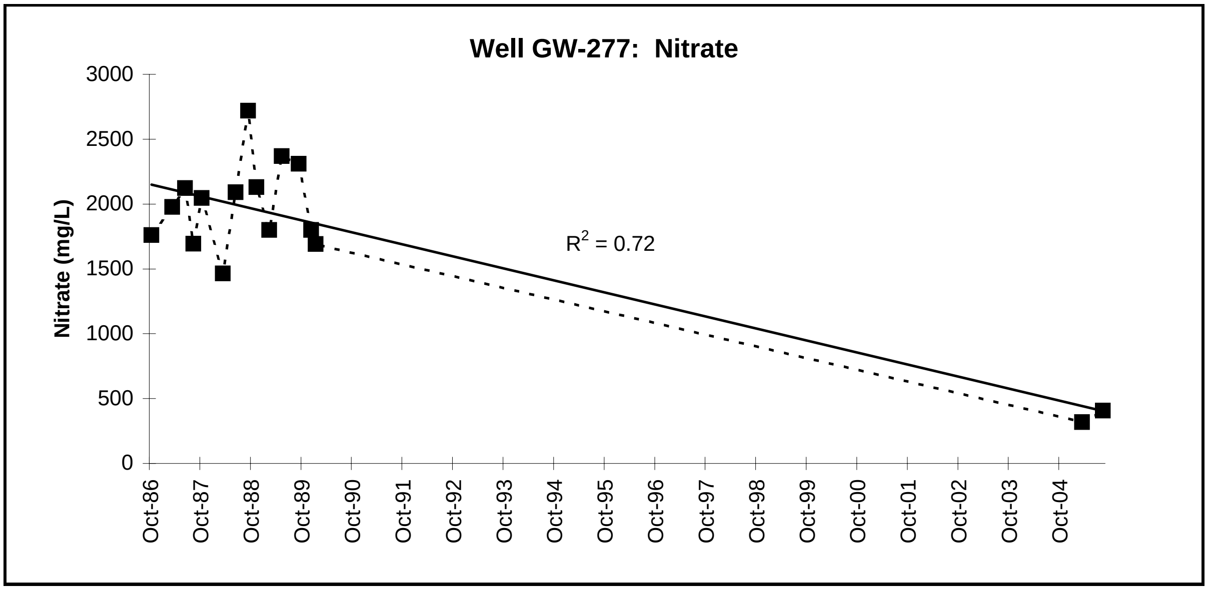


Figure 1

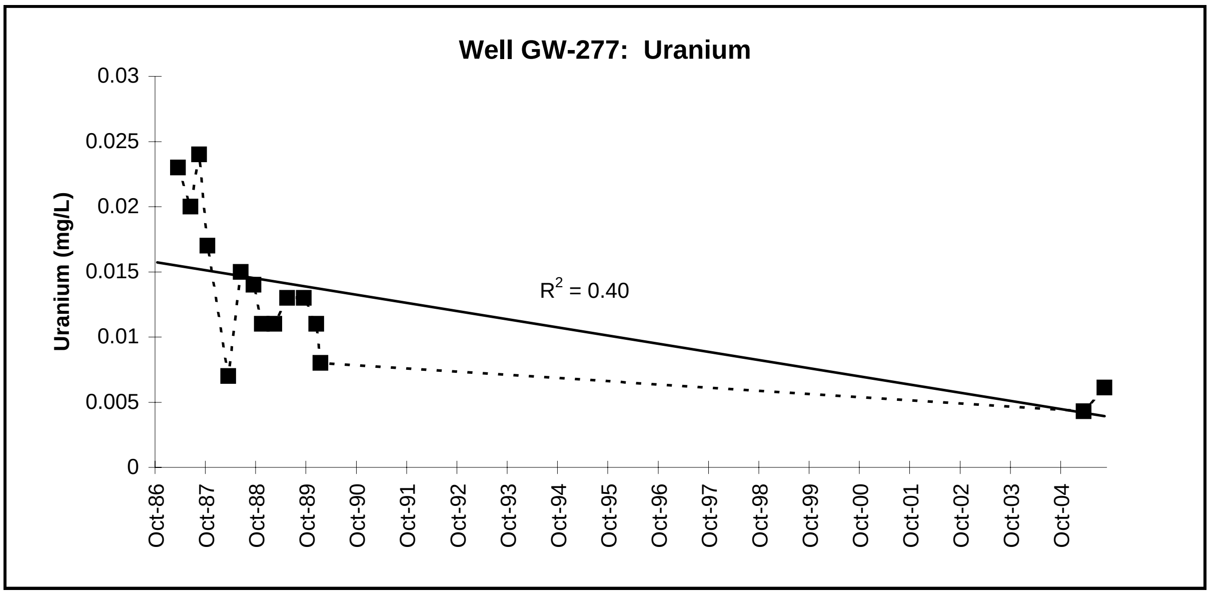


Figure 2

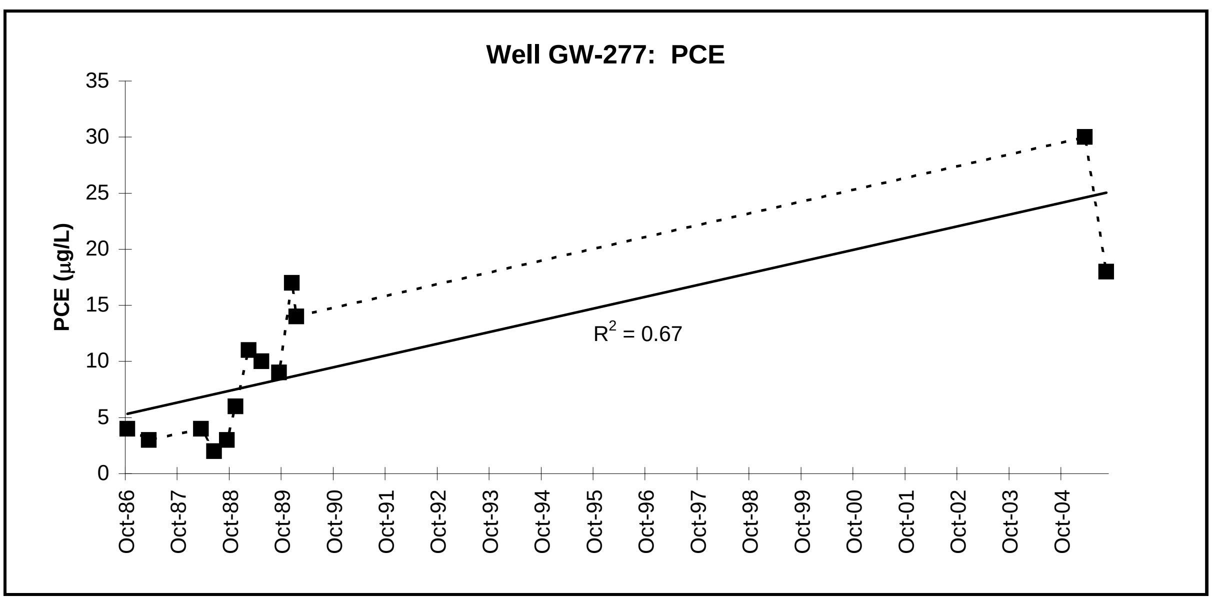


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-281

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: East End Fuel Facility
Y-12 GRID EAST COORDINATE: 61,907.13
Y-12 GRID NORTH COORDINATE: 29,771.37
SURFACE ELEVATION: 946.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/20/86 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 14.85 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 946.10 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Peristaltic pump Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.0	942.53
BOTTOM (filter pack or open hole):	15.0	931.53
MIDPOINT (filter pack or open hole):	9.5	937.03
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	6.97	939.56

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	22		
CONVENTIONAL SAMPLING METHOD:	22 samples	05/04/89	05/10/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/10/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.88 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-281

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1986, completed with a screened monitored interval from 4 to 15 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley at the Bldg. 9754-2 Fuel Facility, which is near the east end of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-two groundwater samples have been collected from the well to date using the conventional sampling method with a peristaltic pump and bailer.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). Note that the large monitored (screened) interval in the well is intended to straddle the water table during seasonally high and low flow conditions and facilitate detection of light non-aqueous phase liquids (LNAPL). The average static groundwater level in the well is 7 ft bgs. Presampling depth-to-water measurements for the well indicate minor (<5 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 214 mg/L – 386 mg/L;
- pH of 6.1 – 7.2 (field measurements);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for the groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twelve of the groundwater samples were analyzed for nitrate, and concentrations above the applicable analytical reporting limit were reported for the three samples, with the highest value (3.2 mg/L in April 1992) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twelve groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.005 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.17 pCi/L in January 1992) being less than the MCL for gross alpha activity (15 pCi/L)

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (16 pCi/L in January 1992) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-286

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,287.07
Y-12 GRID NORTH COORDINATE: 29,993.36
SURFACE ELEVATION: 924.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/20/86 PAIRED/CLUSTERED WITH: GW-287
TAG DEPTH (measured): 34.78 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 927.05 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.5	905.02
BOTTOM (filter pack or open hole):	32.3	892.22
MIDPOINT (filter pack or open hole):	25.9	898.62
PUMP INTAKE:	28.1	896.38
WATER LEVEL (average):	7.42	917.10

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	25 samples	03/27/87	10/07/93
LOW-FLOW SAMPLING METHOD:	2 samples	06/13/05	10/04/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/13/05	.	10/04/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.12 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	0	< μg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-286

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1986, completed with a screened monitored interval from 19.5 to 32.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-287 and is located on the southern flank of Pine Ridge west of Y-12, about 600 ft west of the central section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 25 samples between March 1987 and October 1993, and the low-flow sampling method used to obtain samples in June and October 2005. This sampling history includes an extended period (12 years) when no groundwater samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Maryville Limestone). The bulk of the groundwater flow in the Maryville Limestone occurs in the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Maryville Limestone (and Nolichucky Shale) and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 7 ft bgs, with seasonal fluctuations of about 1 ft. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-286 are typically lower than evident in well GW-287, which is completed at a shallower depth (12.5 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (16.9 ft), the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.024–0.061) from the water table interval (GW-287) to the shallow bedrock interval (GW-286).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-286 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-286 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-8.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 128 – 248 mg/L;
- pH (field measurements) of 7.5 – 8.5;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, none of the principal contaminants are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the analytical reporting limit.

5.2 URANIUM

Six groundwater samples had uranium concentrations that exceeded the analytical reporting limit, with the maximum value (0.006 mg/L in August 1988) being below the drinking water MCL for uranium (0.03 mg/L). Uranium concentrations have been at or below the reporting limit since August 1989.

5.3 VOLATILE ORGANIC COMPOUNDS

Several common laboratory reagents (acetone, chloroform, toluene, xylene, and MC) were detected in most of the samples collected from the well before March 1989. Excluding false positive results, only a trace (3 µg/L) of TCE was detected in one (April 1993) of the 12 groundwater samples collected from the well since September 1991.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.59 pCi/L in October 1993) being substantially below the MCL for gross alpha activity (15 pCi/L). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

One groundwater sample collected from the well since February 1990 had gross beta activity above the applicable MDA and corresponding CE limits, with that result (7.39 pCi/L in October 1993) being substantially less than the SDWA screening level (50 pCi/L) for a

4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	<5	ND	ND

GW-287

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,288.43
Y-12 GRID NORTH COORDINATE: 29,988.80
SURFACE ELEVATION: 924.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/20/86 PAIRED/CLUSTERED WITH: GW-286
TAG DEPTH (measured): 15.19 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 927.04 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.6	919.00
BOTTOM (filter pack or open hole):	12.5	912.10
MIDPOINT (filter pack or open hole):	9.1	915.55
PUMP INTAKE:	10.6	914.04
WATER LEVEL (average):	7.04	917.73

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	45		
CONVENTIONAL SAMPLING METHOD:	37 samples	03/27/87	09/03/97
LOW-FLOW SAMPLING METHOD:	8 samples	03/02/98	10/04/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/13/05	.	10/04/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.02 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-287

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1986, completed with a screened monitored interval from 5.6 to 12.5 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-286 and is located on the southern flank of Pine Ridge west of Y-12, about 600 ft west of the central section of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 37 samples between March 1987 and September 1997, and the low-flow sampling method used to obtain eight samples between March 1998 and October 2005.

Unusually low levels of TDS (<150 mg/L) are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0). The low TDS of the samples suggests relatively low residence time for the groundwater in the well, which indicates that the monitored interval for the well intercepts highly permeable groundwater flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The bulk of the groundwater flow in the Maryville Limestone occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Maryville Limestone (and Nolichucky Shale) and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits seasonal fluctuations of about 2 ft. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-287 are typically higher than evident in well GW-286, which is completed at a deeper depth (32.3 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (16.9 ft), the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.024 – 0.061) from the water table interval (GW-287) to the shallow bedrock interval (GW-286).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-288 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-288 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-8.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 39 – 288 mg/L, excluding a suspected outlier (404 mg/L) in March 1995;
- pH (field measurements) of 5.22 – 7.8;
- low molar proportions of chloride, sulfate, potassium, and sodium (<15% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations that exceeded the analytical reporting limit, with the highest value (0.42 mg/L in March 1995) being substantially less than the MCL for nitrate (10 mg/L).

5.2 URANIUM

Thirteen groundwater samples had uranium concentrations that exceeded the analytical reporting limit, with the highest value (0.004 mg/L in March 1995) being substantially less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false-positive results, 12 of the 30 groundwater samples collected from the well since September 1991 had very low concentrations of PCE, with the highest value (5 µg/L in February 1997 and March 1998) equal to the drinking water MCL for PCE (5 µg/L). The sporadic detection of PCE in groundwater at the well probably reflects limited westward (along geologic strike) transport from the Walk-In Pits in the BCBG. A time-series plot of the PCE results (Figure 1) shows a slightly increasing long-term trend, however the significance of this trend is questionable because the values are very low and PCE is not detected in most (18) of the samples from the well during this time period.

5.4 GROSS ALPHA ACTIVITY

Six of the 31 groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.12 pCi/L in June 1995) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five of the 31 groundwater samples collected from the well since February 1990 had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.9 pCi/L in February 1997) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

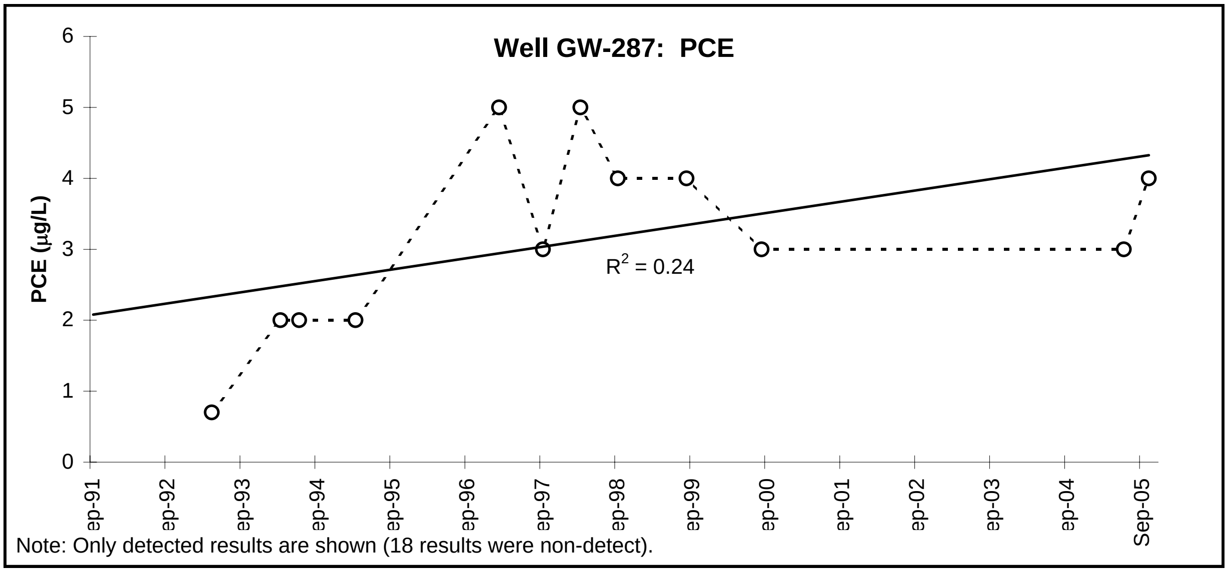

Well GW-287: PCE
PCE (µg/L)
6
5
4
3
2
1
0
R^2 = 0.24
ep-91
ep-92
ep-93
ep-94
ep-95
ep-96
ep-97
ep-98
ep-99
ep-00
ep-01
ep-02
ep-03
ep-04
Sep-05
Note: Only detected results are shown (18 results were non-detect).

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	50 - 500	ND	ND

GW-288

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,874.40
Y-12 GRID NORTH COORDINATE: 29,975.41
SURFACE ELEVATION: 946.07 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/13/86 PAIRED/CLUSTERED WITH: GW-289
TAG DEPTH (measured): 62.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 948.36 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	46.0	900.07
BOTTOM (filter pack or open hole):	60.0	886.07
MIDPOINT (filter pack or open hole):	53.0	893.07
PUMP INTAKE:	55.7	890.36
WATER LEVEL (average):	15.94	930.13

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	11 samples	02/11/88	08/09/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/13/02	10/06/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	.	06/15/05	.	10/06/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.72 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	5	690 µg/L	08/09/95	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-288

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1986, completed with a screened monitored interval from 46 to 60 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-289 and is located in Bear Creek Valley (BCV), immediately west of the central part of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between February 1988 and August 1995, and the low-flow sampling method used to obtain four samples between March 2002 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Maryville Limestone). The bulk of the groundwater flow in the Maryville Limestone occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Maryville Limestone (and Nolichucky Shale) and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 16 ft bgs and exhibits seasonal fluctuations of about 3 ft. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-288 are typically lower than evident in well GW-289, which is completed at a shallower depth (40.8 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (18.4 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.001 –0.03) from the shallow bedrock interval (GW-288) to the water table interval (GW-289).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-288 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-288 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-8.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 183 – 199 mg/L, excluding a suspected outlier (96 mg/L) in February 1990;
- pH of 6.8 – 7.53 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations);
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Five groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest value (0.25 mg/L in August 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations that exceeded the analytical reporting limit, the highest value (0.002 mg/L in April 1988) being substantially less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results and detection of common laboratory reagents (e.g., acetone) in samples collected from the well before February 1990, one or more of the following VOCs were detected in the groundwater samples: PCE, TCE, 12DCE, 11DCE, and VC (Table 1). The Walk-In Pits (WIP) are the likely the source of the dissolved VOCs in the shallow groundwater at this well. Groundwater near the WIP contains a distinct plume of dissolved VOCs dominated by PCE, with concentrations in some areas exceeding 2000 µg/L, which is about 1% of the maximum PCE solubility and possibly indicates DNAPLs in the subsurface (DOE 1997).

The primary contaminant in the groundwater samples is PCE, which has been detected in all but one of the samples and has a historical maximum concentration of 1,600 µg/L (May 1988). The non-detected result (August 1989) is a suspected outlier (Table 1). Secondary VOCs are TCE, VC, and c12DCE which have historical maximum concentrations below 20 µg/L. Recent sampling results show that concentrations of PCE, TCE, and VC continue to exceed respective drinking water MCLs (Table 1).

As shown by the data summarized below, the PCE concentrations are lower in the groundwater flow/transport pathways intercepted by the monitored interval in well GW-288 than the PCE concentrations in the shallower groundwater flow/transport pathways intercepted by the monitored interval in well GW-289.

Well	PCE Concentration (µg/L)							
	Conventional Sampling				Low-Flow Sampling			
	May 1988	Oct. 1988	Feb. 1990	Aug. 1995	Mar. 2002	Aug. 2002	June 2005	Oct. 2005
GW-288	1,600	1,400	1,200	690	180	250	65	110
GW-289	800	880	590	930	670	690	590	940

These results may reflect the influence of the upward vertical hydraulic gradient from the shallow bedrock interval (GW-288) to the water table interval (GW-289) in the vicinity of these wells (see Section 3.0). The PCE concentrations in the shallower groundwater flow system are at least partially maintained by PCE-contaminated groundwater upwelling from deeper in the Maryville Limestone.

The preceding data summary also suggests a decreasing trend in PCE concentrations at well GW-288, which is clearly illustrated by a time-series plot (Figure 1). These sampling results suggest a reduction in the relative flux of PCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Moreover, the persistent low concentrations of TCE and other PCE degradation products in the samples (Table 1) suggest that there is minimal biotic or abiotic degradation of the PCE in the groundwater at this well. Conversely, data for other wells that monitor VOC-contaminated groundwater with similar geochemical characteristics elsewhere at the BCBG indicate active biotic degradation of PCE and related degradation products. It is unclear from the available data why active biotic degradation of PCE apparently does not occur in the groundwater at this well.

5.4 GROSS ALPHA ACTIVITY

None of the six groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE. Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

None of the six groundwater samples collected from the well since February 1990 had gross beta activity above the MDA and corresponding CE limits. Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

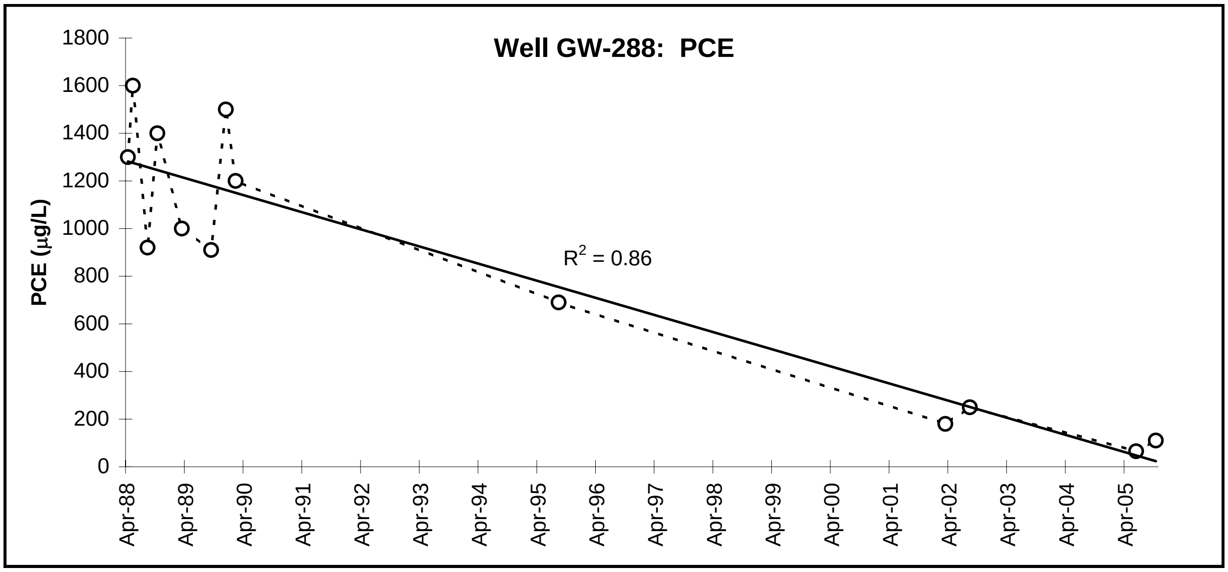
U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant*, *Oak Ridge*, *Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-288: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	**TCE**	**12DCE**	**c12DCE**	**VC**
04/11/88	1,300	11	4 J	NR	.
05/14/88	1,600	11	.	NR	.
08/02/88	920	12	.	NR	.
10/11/88	1,400	12	.	NR	.
03/07/89	1,000	11	3 J	NR	.
08/05/89	[.]	[1 J]	.	NR	.
09/28/89	910	10	.	NR	.
12/20/89	1,500	15	.	NR	.
02/20/90	1,200	12	.	NR	.
08/09/95	690	.	.	NR	.
03/13/02	180	11	3 J	3 J	3
08/07/02	250	14	3 J	3 J	4
06/15/05	65	10	3 J	3 J	5
10/06/05	110	11	3 J	3 J	5
MCL	**5**	**5**	**NA**	**70**	**2**

Sampling Date	Compound/Concentration (µg/L)
04/11/88	MC (2 J)
05/14/88	Acetone (4 J), Ethylbenzene (2 J), MC (4 J), Xylenes (1 J)
08/02/88	Chloroform (0.5 J), 4M2P (9)
10/11/88	.
03/07/89	MC (2 J)
08/05/89	Acetone (14), Chloroform (1 J)
09/28/89	.
12/20/89	11DCA (5)
02/20/90	.
08/09/95	.
03/13/02	.
08/07/02	.
06/15/05	11DCE (1 J)
10/06/05	.

Note: "." = Not detected; [ ] = suspected outlier; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported



Well GW-288: PCE
PCE (μg/L)
1800
1600
1400
1200
1000
800
600
400
200
0
R2 = 0.86
Apr-88
Apr-89
Apr-90
Apr-91
Apr-92
Apr-93
Apr-94
Apr-95
Apr-96
Apr-97
Apr-98
Apr-99
Apr-00
Apr-01
Apr-02
Apr-03
Apr-04
Apr-05

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	500 - 5,000	ND	ND

GW-289

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,874.66
Y-12 GRID NORTH COORDINATE: 29,981.56
SURFACE ELEVATION: 946.32 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/20/86 PAIRED/CLUSTERED WITH: GW-288
TAG DEPTH (measured): 43.14 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 948.73 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	28.9	917.42
BOTTOM (filter pack or open hole):	40.8	905.52
MIDPOINT (filter pack or open hole):	34.9	911.47
PUMP INTAKE:	35.6	910.73
WATER LEVEL (average):	16.79	929.79

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	11 samples	02/18/88	08/08/95
LOW-FLOW SAMPLING METHOD:	6 samples	06/24/98	10/06/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/15/05	.	10/06/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.3 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	7	960 µg/L	10/06/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-289

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1986, completed with a screened monitored interval from 28.9 to 40.8 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-288 and is located in Bear Creek Valley (BCV), along the western edge of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between February 1988 and August 1995, and the low-flow sampling method used to obtain six samples between June 1998 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The bulk of the groundwater flow in the Maryville Limestone occurs within this interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Maryville Limestone (and Nolichucky Shale) and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits seasonal fluctuations of about 3 ft. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-289 are typically lower than evident in well GW-288, which is completed at a greater depth (60 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (18.4 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.001 –0.03) from the shallow bedrock interval (GW-288) to the water table interval (GW-289).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-289 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-289 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-8.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 148 – 205 mg/L, excluding a suspected outlier (96 mg/L) in February 1990;
- pH of 6.2 – 6.81 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations);
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eleven groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest value (0.8 mg/L in March 1989) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations that exceeded the analytical reporting limit, with the highest value (0.005 mg/L in October 1988) being substantially less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results and detection of common laboratory reagents (e.g., acetone and MC) in samples collected from the well before February 1990, one or more of the following VOCs were detected in the groundwater samples: PCE, TCE, 12DCE, 11DCE, and VC (Table 1). The Walk-In Pits (WIP) are the likely the source of the dissolved VOCs in the shallow groundwater at this well. Groundwater near the WIP contains a distinct plume of dissolved VOCs dominated by PCE, with concentrations in some areas exceeding 2000 µg/L, which is about 1% of the maximum PCE solubility and possibly indicates DNAPLs in the subsurface (DOE 1997).

The primary contaminant in the groundwater near the well is PCE, which has been detected in all of the samples and has a historical maximum concentration of 1,300 µg/L (April 1988). Secondary VOCs are TCE, c12DCE, and VC which have historical maximum concentrations below 20 µg/L. Recent sampling results show that concentrations of PCE and TCE continue to exceed respective drinking water MCLs (Table 1).

As shown by the data summarized below, the PCE concentrations are higher in the groundwater flow/transport pathways intercepted by the monitored interval in well GW-289 than the PCE concentrations in the deeper groundwater flow/transport pathways intercepted by the monitored interval in well GW-288.

Well	PCE Concentration (µg/L)							
	Conventional Sampling				Low-Flow Sampling			
	May 1988	Oct. 1988	Feb. 1990	Aug. 1995	Mar. 2002	Aug. 2002	June 2005	Oct. 2005
GW-288	1,600	1,400	1,200	690	180	250	65	110
GW-289	800	880	590	930	670	690	590	940

These results may reflect the influence of the upward vertical hydraulic gradient from the shallow bedrock interval (GW-288) to the water table interval (GW-289) in the vicinity of these wells (see Section 3.0). The PCE concentrations in the shallower groundwater flow system are at least partially maintained by PCE-contaminated groundwater upwelling from deeper in the Maryville Limestone.

The preceding data summary also suggests a widely fluctuating, indeterminate trend in PCE concentrations at well GW-289, which is illustrated by a time-series plot (Figure 1). These sampling results suggest little if any long-term change in the relative flux of PCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Moreover, the persistent low concentrations of TCE and other PCE degradation products in the samples suggest that there is minimal biotic or abiotic degradation of the PCE in the groundwater at this well. Some of the geochemical characteristics of the groundwater at this well (e.g., oxidation-reduction potential is greater than 150 millivolts) are not conducive to anaerobic biotic degradation of PCE.

5.4 GROSS ALPHA ACTIVITY

Two of the eight groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (1.54 pCi/L in June 1998) being substantially below the MCL for gross alpha activity (15 pCi/L). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

5.5 GROSS BETA ACTIVITY

Three of the eight groundwater samples collected from the well since February 1990 had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.6 pCi/L in June 1998) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Results obtained before January 1990 do not meet applicable data quality objectives because the sample specific MDA and/or CE are not available for these samples.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-289: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	**TCE**	**12DCE**	**c12DCE**	**VC**
04/11/88	1,300	6	.	NE	.
05/14/88	800	7	.	NR	.
08/02/88	650	8	10	NR	.
10/11/88	880	6	.	NR	.
03/17/89	1,000	.	.	NR	.
08/05/89	690	7	.	NR	.
09/28/89	570	5	.	NR	.
12/20/89	870	.	.	NR	.
02/14/90	590	.	.	NR	.
08/08/95	930	.	.	NR	.
06/24/98	390	7	.	NR	.
07/20/98	360	8	1 J	NR	.
03/13/02	670	13	2 J	2 J	2
08/08/02	690	14	2 J	2 J	2
06/15/05	590	17	3 J	3 J	.
10/06/05	940	17	2 J	2 J	1 J
MCL	**5**	**5**	**NA**	**70**	**2**

Sampling Date	Compound/Concentration (µg/L)
04/11/88	Acetone (12), Ethylbenzene (2 J), MC (5), Xylenes (1 J)
05/14/88	.
08/02/88	.
10/11/88	.
03/17/89	.
08/05/89	.
09/28/89	Acetone (41)
12/20/89	.
02/14/90	.
08/08/95	.
06/24/98	.
07/20/98	.
03/13/02	.
08/08/02	.
06/15/05	11DCE (1 J)
10/06/05	.

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable
NR = Not reported

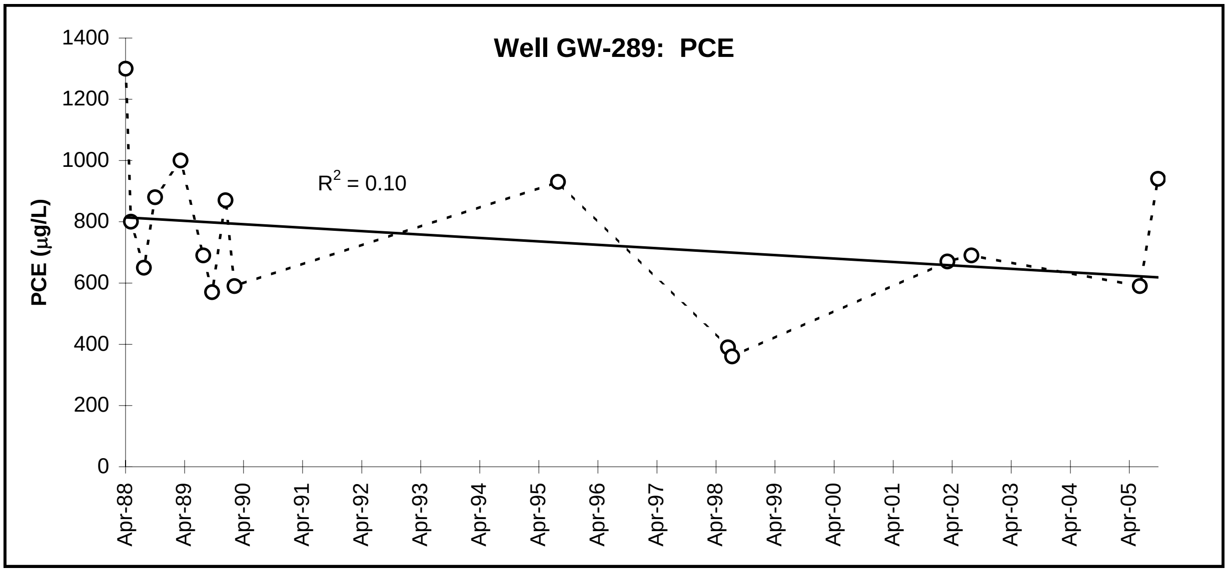

Well GW-289: PCE
PCE (μg/L)
1400
1200
1000
800
600
400
200
0
R^2 = 0.10
Apr-88
Apr-89
Apr-90
Apr-91
Apr-92
Apr-93
Apr-94
Apr-95
Apr-96
Apr-97
Apr-98
Apr-99
Apr-00
Apr-01
Apr-02
Apr-03
Apr-04
Apr-05

Figure 1

MAXIMUM CONCENTRATION: 2005

<5	<0.015	50 - 500	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-291

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,582.81
Y-12 GRID NORTH COORDINATE: 30,450.41
SURFACE ELEVATION: 944.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/14/86 PAIRED/CLUSTERED WITH: GW-290
TAG DEPTH (measured): 19.92 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 948.66 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	6.7	938.42
BOTTOM (filter pack or open hole):	14.2	930.92
MIDPOINT (filter pack or open hole):	10.5	934.67
PUMP INTAKE:	14.3	930.86
WATER LEVEL (average):	9.10	936.32

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	11 samples	02/16/88	08/03/95
LOW-FLOW SAMPLING METHOD:	6 samples	06/19/98	10/10/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/16/05	.	10/10/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.56 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	9	790 μg/L	06/19/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-291

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1986, completed with a screened monitored interval from 6.7 to 14.2 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-290 and is located in Bear Creek Valley (BCV) on the southern flank of Pine Ridge, south of Burial Ground C-West in the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between February 1988 and August 1995, and the low-flow sampling method used to obtain six samples between June 1998 and October 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The bulk of the groundwater flow in the Maryville Limestone occurs within this interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Maryville Limestone and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow toward the Maynardville Limestone, a highly permeable (karst) formation that statigraphically overlies the Maryville Limestone (and Nolichucky Shale) and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits seasonal fluctuations of about 3 ft. Moreover, measurements recorded during a contemporaneous sampling event (i.e., within 24 hours) showed that the presampling groundwater elevation in well GW-291 was lower than that evident in well GW-290, which is completed at a greater depth (32.5 ft bgs) in the Maryville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (15.18), the contemporaneous groundwater elevations indicate an upward vertical hydraulic gradient (0.213) from the shallow bedrock interval (GW-290) to the water table interval (GW-291).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-291 indicate flow to the south and southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Maryville Limestone is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-291 may be primarily westward (parallel with geologic strike) toward discharge areas in NT-8 (the well is located just south of NT-8-E).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 176 – 267 mg/L;
- pH of 6.4 – 7.1 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/ cations);
- elevated boron concentrations (>2 mg/L), probably from borax waste water (see Section 1.0); and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Fourteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest value (0.6 mg/L in February 1988) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations that exceeded the analytical reporting limit, with the highest concentration (0.002 mg/L in August 1989) being substantially less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results and detection of common laboratory reagents (e.g., acetone) in samples collected from the well before February 1990, one or more of the following VOCs were detected in the groundwater samples: PCE, TCE, 12DCE, 111TCA, trichlorofluoromethane (TCFM), 11DCA, and 12DCA (Table 1). The Walk-In Pits (WIP) are the likely the source of the dissolved VOCs in the shallow groundwater at this well. Groundwater near the WIP contains a distinct plume of dissolved VOCs dominated by PCE, with concentrations in some areas exceeding 2000 µg/L, which is about 1% of the maximum PCE solubility and possibly indicates DNAPLs in the subsurface (DOE 1997).

The primary contaminants in the groundwater samples are PCE and TCE, which have been detected in all of the samples, have historical maximum concentrations that exceed 100 µg/L, and continue to exceed the applicable drinking water MCL (Table 1). The secondary contaminants in the samples are c12DCE and TCFM, which have been detected in all samples for which the compounds have been reported and have historical maximum concentrations less than 10 µg/L. The low concentration of c12DCE and lack of other degradation products in the samples (11DCE or VC) suggest that there is minimal biotic or abiotic degradation of the PCE and TCE in the groundwater at this well.

A time-series plot of the PCE concentrations shows a widely fluctuating, indeterminate long-term trend (Figure 1). The indeterminate trend, also evident in concentration trends of the individual VOCs (Table 1), suggests little long-term change in the relative flux of dissolved VOCs along the shallow groundwater flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Two of the 10 groundwater samples collected from the well since February 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the highest values (2.25 pCi/L in March 1991) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three of the 10 groundwater samples collected from the well since February 1990 had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.06 pCi/L in March 1991) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

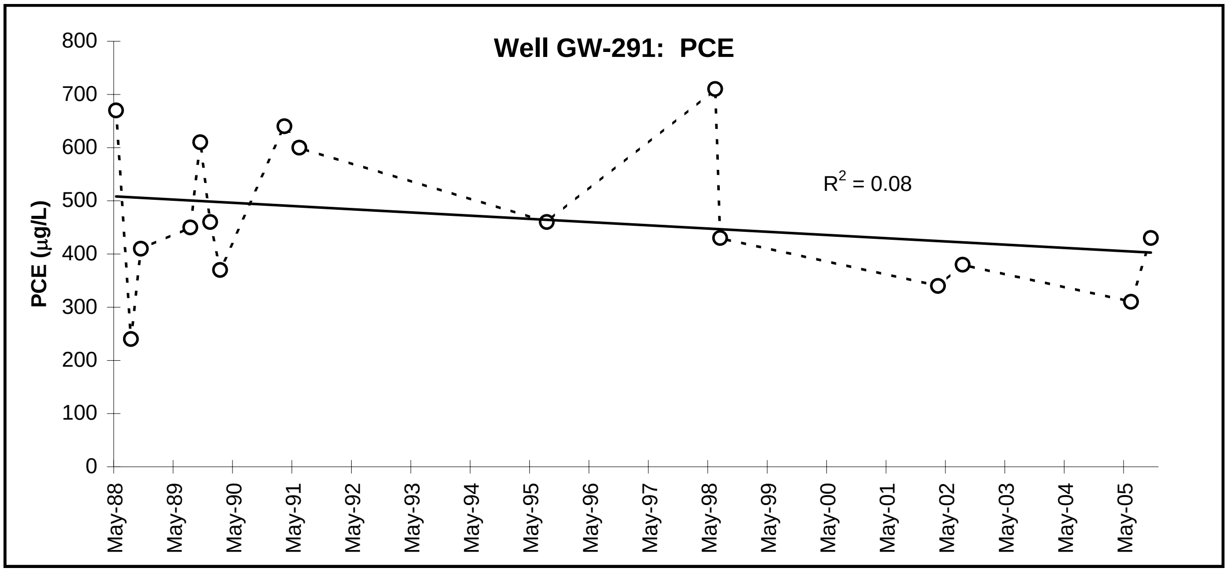
U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-291: summary of VOC results

Sampling Date	Concentration (µg/L)					
	PCE	**TCE**	**12DCE**	**C12DCE**	**111TCA**	**TCFM**
05/14/88	670	60	.	NR	4 J	NR
08/03/88	240	43	7	NR	2 J	NR
10/11/88	410	64	10	NR	2 J	NR
08/06/89	450	67	8	NR	.	NR
10/04/89	610	77	.	NR	.	NR
12/27/89	460	63	.	NR	3 J	NR
02/21/90	370	45	.	NR	.	NR
03/24/91	640	71	.	NR	.	NR
06/21/91	600	110	11	NR	3 J	NR
08/03/95	460	.	.	NR	.	NR
06/19/98	710	73	6	NR	1 J	NR
07/28/98	430	51	4 J	NR	.	NR
03/14/02	340	42	3 J	3 J	.	5 J
08/07/02	380	37	3 J	3 J	.	5 J
06/16/05	310	38	3 J	3 J	.	4 J
10/10/05	430	47	3 J	3 J	.	5
MCL	**5**	**5**	**NA**	**70**	**200**	**NA**

Sampling Date	Compound/Concentration (µg/L)
05/14/88	Chloroform (0.9 J), Ethylbenzene (2 J), MC (4 J), Xylenes (1 J), 11DCA (0.7 J), and 4-Methyl-2-Pentanone (1 J)
08/03/88	Chloroform (0.8 J), Toluene (0.8 J)
10/11/88	.
08/06/89	Acetone (110)
10/04/89	Acetone (33)
12/27/89	.
02/21/90	.
03/24/91	.
06/21/91	.
08/03/95	12DCA (38)
06/19/98	.
07/28/98	.
03/14/02	.
08/07/02	11DCA (2 J)
06/16/05	.
10/10/05	.

Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported



Well GW-291: PCE
PCE (µg/L)
800
700
600
500
400
300
200
100
0
R^2 = 0.08
May-88
May-89
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	<7.5	ND

GW-300

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Borrow Area Waste Pile
Y-12 GRID EAST COORDINATE: 62,041.13
Y-12 GRID NORTH COORDINATE: 27,487.18
SURFACE ELEVATION: 1,070.69 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/17/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 149.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,073.12 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	132.0	938.69
BOTTOM (filter pack or open hole):	147.0	923.69
MIDPOINT (filter pack or open hole):	139.5	931.19
PUMP INTAKE:	141.57	929.12
WATER LEVEL (average):	107.58	963.11

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	29 samples	02/01/88	04/30/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/19/04	10/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/19/04	.	10/12/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-300

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 132 to 147 ft bgs, and constructed nominal 4.5-inch diameter stainless steel (Type 304) and well screen (0.01 slot wire-wound). The well is located on the southern flank of Chestnut Ridge southeast of Y-12, just southwest of the Chestnut Ridge Borrow Area Waste Pile (CRBAWP). Before the CRBAWP was established (in 1984), the area served as as a borrow area (known as the East Borrow Area) for soil to be used in construction of multilayer caps. The CRBAWP contained low level mercury-contaminated soils from the Oak Ridge Civic Center/Sewer Line Beltway Project. These materials were excavated from the CRBAWP and transported to Industrial Landfill V during 2000 for final disposal.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 29 samples between February 1988 and April 1996, and the low-flow sampling method used to obtain samples in April and October 2004.

Unusually low levels of TDS (<150 mg/L) are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0). The low TDS of the samples suggests relatively low residence time for the groundwater in the well, which indicates that the monitored interval for the well intercepts highly permeable groundwater flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group, which forms the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 108 ft bgs and exhibits moderate (about 18 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-300 indicate flow to the south-southwest toward a drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicates that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 106 – 184 mg/L;
- pH of 7.1 – 7.8 (field measurements), excluding a suspected outlier (4.3 in September 1992);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Additionally, mercury is a contaminant of concern at the CRBAWP (see Section 1.0). As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, none of the principal contaminants are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

Six groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.5 mg/L in April 1995) being an order-of-magnitude below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit, and the highest result (0.001 mg/L in July 1994) is an order-of-magnitude lower than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples collected to date:

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (12.2 pCi/L in April 1996) being slightly below the MCL for gross alpha activity (15 pCi/L). However, this result appears to be an outlier because the other values area all less than 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Three groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (24 pCi/L in February 1992) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.6 Mercury

None of the groundwater samples collected to date had mercury concentrations above the reporting limit.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	ND	<7.5	<25

GW-301

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Borrow Area Waste Pile (former)
Y-12 GRID EAST COORDINATE: 61,963.77
Y-12 GRID NORTH COORDINATE: 27,661.71
SURFACE ELEVATION: 1,083.94 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/02/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 165.23 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,086.55 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	148.5	935.44
BOTTOM (filter pack or open hole):	163.5	920.44
MIDPOINT (filter pack or open hole):	156.0	927.94
PUMP INTAKE:	157.39	926.55
WATER LEVEL (average):	129.54	954.40

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	32 samples	02/03/88	07/24/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/06/98	07/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/12/04	.	07/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.03 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	13 µg/L	10/27/91	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-301

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 148.5 to 163.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 grid system), about 200 ft northeast (hydraulically downgradient) of the Chestnut Ridge Borrow Area Waste Pile (CRBAWP). The CRBWAP was used from the mid-1980s as a storage site for soils contaminated with mercury and other metals; all soil was removed from the site in 2000.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 32 samples between February 1988 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group (Copper Ridge Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 130 ft bgs and exhibit substantial (17 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 90 – 230 mg/L;
- pH (field measurements) of 6.5 – 8.7;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 34 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twenty-three groundwater samples (collected between February 1991 and January 1999) had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.64 mg/L in April 1995) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, and each result (0.001 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in four groundwater samples: acetone in October 1991(13 µg/L) and July 1998 (1 µg/L), chloroform in July 1997 (1 µg/L), chloromethane in January 2000 (2 µg/L), and bromomethane January 2000 (2 µg/L). These results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.62 pCi/L in January 2003) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.43 pCi/L in May 1992) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

<5	ND	.	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-302

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE: 54,353.40
Y-12 GRID NORTH COORDINATE: 28,693.55
SURFACE ELEVATION: 1,139.59 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/10/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 138.23 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,141.84 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	121.5	1018.09
BOTTOM (filter pack or open hole):	134.8	1004.79
MIDPOINT (filter pack or open hole):	128.2	1011.44
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	99.11	1040.48
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	26 samples	05/16/90	04/15/97
LOW-FLOW SAMPLING METHOD:	12 samples	11/11/97	08/12/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	02/03/03	.	08/12/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 20.6 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-302

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1989, completed with a screened monitored interval from 121.5 to 134.8 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 administrative grid), about 200 ft northeast (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge and radiologically-contaminated soils and demolition debris. A multilayer low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 26 samples between May 1990 and April 1997, and the low-flow sampling method used to obtain 12 samples between November 1997 and August 2003.

Elevated concentrations of chromium and nickel attributable to chemical and/or microbiologically-induced corrosion of the stainless steel well casing and/or screen (see Section 5.6) are a distinguishing characteristic of the groundwater samples from this well. It may be necessary to extensively purge (or redevelop) the well before sampling to obtain representative monitoring results for these metals.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group. The average static groundwater level in the well is 99 ft below ground surface. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6.7 – 7.7;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except chromium and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Groundwater samples from this well typically contain chloride concentrations above 20 mg/L and sodium levels above 10 mg/L, which exceed the respective UTLs for groundwater in the Knox Group. Elevated concentrations of these ions may result from the recharge of surface water containing dissolved salt used to de-ice the South Patrol Road. Similarly elevated levels of chloride and sodium also are evident in other wells at the UNCS (1090 and GW-339) that are accessed via this paved road, whereas much lower chloride and sodium concentrations (less than respective UTLs) are evident in the wells at the site that are accessed via a gravel road (GW-203, GW-205, and GW-221). Alternatively, elevated chloride and sodium concentrations in the groundwater at these wells may reflect dissolution of locally disseminated evaporite minerals. In either case, the elevated chloride levels in the groundwater at the well may play a role in maintaining the elevated chromium and nickel concentrations in the samples from the well (see Section 5.6) because chloride may combine with available metal cations to form soluble complexes that do not readily partition to mineral surfaces in the monitored-interval filter pack materials and surrounding bedrock (McLean and Bledsoe 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Also, as noted previously, chromium and nickel are contaminants in the groundwater samples from this well. The following discussion of contaminant concentrations in the well is based on the analytical results reported for groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-two groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (3.3 mg/L) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.002 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Fourteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (10.77 pCi/L) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (19.6 pCi/L) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

5.6 OTHER

Almost all of the groundwater samples collected from the well since January 1991 contained total chromium and/or nickel concentrations above the respective analytical reporting limit. As shown below in Table 1, most of the chromium and nickel concentrations exceed respective background levels (UTLs) in the Knox Aquifer and 22 of the samples had chromium and/or nickel concentrations above respective MCLs of 0.1 mg/L.

Table. Chromium and nickel results for well GW-302

Sampling Method and Date	Total Concentration (mg/L)	
	Chromium UTL = 0.029 MCL = 0.10	Nickel UTL = 0.02 MCL = 0.10
Conventional Sampling		
01/14/91	<0.01	<0.01
04/13/91	0.011	0.028
07/30/91	0.049	0.044
10/06/91	**0.16**	0.032
02/02/92	0.094	<0.01
05/04/92	**0.15**	**0.12**
07/31/92	**0.46**	**1.5**
10/18/92	**0.19**	0.035
01/20/93	0.058	0.049
05/13/93	**0.17**	**0.12**
07/27/93	**0.16**	0.056
10/09/93	**0.2**	0.039
01/11/94	**0.13**	0.034
04/12/94	0.057	0.039
07/28/94	0.047	<0.01
10/15/94	0.098	**0.12**
04/19/95	**0.17**	**0.34**
10/08/95	**0.36**	**0.23**
04/23/96	**0.24**	**0.54**
10/30/96	**0.36**	**0.58**
04/15/97	**0.19**	**0.42**
Low- Flow Sampling		
02/05/99	**0.233**	**0.366**
08/11/99	**0.209**	0.0718
02/23/00	<0.01	0.0209
08/14/00	**0.154**	0.034
01/31/01	**0.454**	**1.22**
07/26/01	**0.119**	0.0342
01/31/02	**0.32**	0.0769
07/31/02	0.0548	0.0425
02/03/03	**0.104**	**0.141**
08/12/03	0.0432	0.0469
Note: Bold typeface denotes results that exceed the MCL.		

The following considerations suggest that elevated concentrations of nickel and chromium in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel (Type 304) riser casing and well screen: (1) mobile species of these metals are not typically present in groundwater with the neutral pH evident in the well; (2) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); (3) groundwater in the well exhibits geochemical conditions that may be corrosive to Type 304 stainless steel (e.g., dissolved oxygen >2 mg/L; Driscoll 1986); and (4) as noted in Section 4.0, elevated chloride levels in the groundwater may greatly limit the partitioning of nickel and chromium ions in the well.

In addition to the considerations listed above, results of microbiological sampling of selected Knox Group wells in February 2000 support the possibility of microbiologically induced corrosion (MIC) of the stainless steel riser casing and screen as a potential source of the elevated nickel and chromium concentrations in the groundwater from the well. The microbiological sampling targeted four wells with stainless steel riser casing and screen, including an upgradient/background well (GW-521) and three wells where corrosion is suspected (GW-302, GW-305, and GW-339), and one well with PVC riser casing and screen (GW-203). Qualitative bacterial counts, estimated from the appearance of each groundwater sample after an eight- to nine-day growth period, provided data regarding the relative degree of microbial activity in the groundwater at each well (AJA 2001). As shown below in Table 2, the microbiological sampling results indicate: (1) microbial activity in the groundwater samples from each well where corrosion is suspected; (2) negligible microbial activity in the groundwater sample from the upgradient background well; and (3) high bacterial counts for the sample from well GW-203, which has PVC well casing and screen and does not yield groundwater samples with elevated chromium or nickel concentrations.

Table 2. February 2000 Microbiological Sampling Results

Well	Riser/Screen Material	Indication of Corrosion?	Maximum Bacterial Count (colony forming units per milliliter)		
			Iron-Related	Slime-Forming	Sulfate-Reducing
GW-203	PVC	No	5,000	50,000	<100
GW-302	Stainless steel	Yes	<100,000	<50,000	<100
GW-305	Stainless Steel	Yes	5,000	500,000	100
GW-339	Stainless steel	Yes	5,000	50,000	<100
GW-521	Stainless steel	No	<100	<100	<100
Note: Modified from (AJA 2001).					

Iron-related bacteria and slime-forming bacteria have been documented to cause MIC of stainless steel (Sarouhan et al. 1998).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Y-12 Groundwater Protection Program Calendar Year 2000 Groundwater Data Evaluation Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/SUB/01-006512/3, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Driscoll, F.G. 1986. *Groundwater and Wells.* Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*, EPA/540/S-92/018, U.S. Environmental Protection Agency, Office of Research and Development.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision.* IRC No. 910704.0092, Office of Environmental Protection, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	5 - 50	<7.5	<25

GW-305

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill IV
Y-12 GRID EAST COORDINATE: 52,961.67
Y-12 GRID NORTH COORDINATE: 28,547.52
SURFACE ELEVATION: 1,181.07 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/25/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 181.06 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,183.72 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	165.3	1015.77
BOTTOM (filter pack or open hole):	179.6	1001.47
MIDPOINT (filter pack or open hole):	172.5	1008.62
PUMP INTAKE:	173.45	1007.62
WATER LEVEL (average):	119.56	1061.51

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	63		
CONVENTIONAL SAMPLING METHOD:	36 samples	02/18/88	07/22/97
LOW-FLOW SAMPLING METHOD:	27 samples	01/12/98	10/26/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/14/04	05/03/04	07/14/04	10/26/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 18.4 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	43.7 µg/L	10/26/04	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-305

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1987, completed with a screened monitored interval from 165.3 to 179.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the crest of Chestnut Ridge southwest of the west end of Y-12, about 100 ft directly east (hydraulically downgradient) of Industrial Landfill IV. In operation since 1989, this landfill receives about 12,000 ft^3 per year of nonhazardous and nonradioactive industrial wastes, including cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 36 samples between February 1988 and July 1997, and the low-flow sampling method used to obtain 27 samples between January 1998 and October 2004.

Groundwater samples from this well are distinguished by elevated total (and dissolved) concentrations of nickel that are probably attributable to chemical and/or microbiologically-induced corrosion of the stainless steel riser casing and/or well screen (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from bedrock in the lower Knox Group (Copper Ridge Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

The average result of several falling head permeability tests performed in well GW-305 (Jones 2004) shows that the average hydraulic conductivity of the bedrock near the well is about 8.7×10^{-6} cm/s (0.025 ft/day). This indicates that the monitored interval for the well intercepts low-permeability groundwater flow/transport pathways.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 120 ft bgs and exhibits substantial (>15 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-305 indicate radial flow directions, with components of flow to the north into BCV, to the east along the axis of the ridge (parallel with geologic strike), and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS 88 – 240 mg/L;
- pH of 7.1 – 8.6 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals (except nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirty-five groundwater samples had nitrate above the applicable analytical reporting limit; all the results are less than 1 mg/L and are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Uranium concentrations reported for the groundwater samples collected in July 2004 (0.004 mg/L) and November 1999 (0.00122 mg/L) exceed the applicable analytical reporting limit; both results are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs have been detected in Forty-one of the groundwater samples collected since January 1992 (Table 1): 11DCA, 11DCE, and 111TCA. The source of these VOCs has not been confirmed but is probably Industrial Landfill IV, which is the only potential contaminant source area that is hydraulically upgradient of the well. However, chlorinated hydrocarbons or other wastes containing VOCs are not noted in the waste disposal records for the landfill. Additionally, assuming rapid migration to the saturated zone and unimpeded advective transport in the groundwater, the average hydraulic conductivity value (0.025 ft/d) indicated by falling head permeability tests in well GW-305 (Jones 2004) do not support transport of dissolved VOCs to the well within the time period (825 days) between the initial disposal of waste at Industrial Landfill IV (October 1, 1989) and the first-time detection of 111TCA in the well (January 4, 1992). Thus, the repeated detection of 111TCA and other VOCs in the groundwater samples from the well, despite the apparently low permeability of the flowpaths intercepted by the monitored interval in the well, suggest that: (1) the VOCs are from an unknown source area located very close to the well; (3) the VOCs are from undocumented or misidentified wastes disposed in Industrial Landfill IV, and have migrated via a combination of mechanisms (e.g., vapor phase transport) that may greatly increase the rate of transport relative to the groundwater flow rate inferred from the falling head permeability tests; or (3) the VOCs are from undocumented or misidentified wastes disposed in Industrial Landfill IV that were present in the groundwater at the well before January 1992, but were not detected in the groundwater samples collected from the well, perhaps because purging the well for conventional sampling diluted the samples.

The VOC data summarized in Table 1 and time-series plots (Figure 1) show: (1) the initial detection of 111TCA in January 1992 (0.6 μg/L) and subsequent concentration increase through July 2000 (26 μg/L), followed by a more indeterminate trend through October 2004 (18 μg/L); (2) the initial detection of 11DCA in July 1996 (1 μg/L) and subsequent concentration increase July 2003 (17 μg/L), followed by a more indeterminate trend through October 2004 (17 μg/L); and (3) the initial detection of 11DCE in January 1997 (1 μg/L), a subsequent increase through July 2003 (6.4 μg/L), followed by a slightly decreasing trend through October 2004 (4.6 μg/L). The sequential detection of these VOCs potentially reflects the arrival of the parent compound (111TCA) followed by the arrival of related degradation products (11DCA and 11DCE).

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (12.4 pCi/L in July 1994) being slightly below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (12.2 pCi/L in July 1994) being substantially less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

5.6 OTHER

As noted in Section 2.0, the groundwater samples from this well typically contain elevated nickel concentrations; 34 of the samples had nickel concentrations above the UTL, with 24 results exceeding the MCL, including nickel results reported for all but two of the samples collected since July 1999 (Table 2). Corrosion of the stainless steel well casing and screen in the well is the suspected source of the nickel (and chromium) in the samples because: (1) mobile species of nickel are not typically present in groundwater with the neutral pH evident in the well; (2) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); and (3) microbiological sampling results support the possibility of microbiologically induced corrosion (MIC). The microbiological sampling targeted four wells with stainless steel riser casing and screen, including an uncontaminated (upgradient/background) well (GW-521), three wells where corrosion of the riser casing/well screen is suspected (GW-302, GW-305, and GW-339), and one well with PVC riser casing and screen (GW-203) that does not yield samples with elevated chromium and/or nickel concentrations. Qualitative bacterial counts estimated from the appearance of each groundwater sample after an eight- to nine-day growth period, summarized in Table 3, indicate: (1) microbial activity, particularly iron-related and slime-forming bacteria, in the groundwater samples from each well where corrosion is suspected; (2) negligible microbial activity in the groundwater sample from the uncontaminated well; and (3) high bacterial counts for the sample from the well with PVC riser casing and screen (AJA 2001). Iron-related bacteria and slime-forming bacteria have been documented to cause MIC of stainless steel (Sarouhan et. al. 1998).

Two unidentified cylindrical objects were observed at the bottom of the well during a borehole camera survey performed in November 1999 (LMES 1999). The composition of the objects could not be determined from the camera survey, but if either object is metallic, then galvanic corrosion of the object(s) and the well end-cap also may be a source of the nickel in the groundwater samples from the well.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Y-12 Groundwater Protection Program Calendar Year 2000 Groundwater Data Evaluation Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/SUB/01-006512/3, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 1998. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at the Y-12 Plant, 1994-1997.* Letter to AJA Technical Services, Inc. February 12, 1998.

Lockheed Martin Energy Systems, Inc. (LMES) 1999. *Technical Explanation for the Detected Increase in Nickel in Groundwater Monitoring Well GW-305 at the Industrial Landfill IV, IDL-47-103-0075, Department of Energy Y-12 Plant, Anderson County, TN*, Y/TS-1774, Lockheed Martine Energy Systems, Inc., Oak Ridge, TN.

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*, EPA/540/S-92/018, U.S. Environmental Protection Agency, Office of Research and Development.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision*. IRC No. 910704.0092, Office of Environmental Protection, Oak Ridge, TN.

Table 1. Well GW-305: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	111TCA	11DCA	11DCE	Chloromethane
01/06/91	.	.	.	.
04/03/91	.	.	.	.
07/15/91	.	.	.	.
10/01/91	.	.	.	.
01/04/92	0.6 J	.	.	.
04/06/92	1 J	.	.	.
08/11/92	2 J	.	.	.
10/12/92	2 J	.	.	.
01/05/93	2 J	.	.	.
04/01/93	3 J	.	.	.
07/17/93	3 J	.	.	.
10/04/93	4 J	.	.	.
07/07/94	4 J	.	.	.
01/10/95	FP	.	.	.
01/10/94	5	.	.	.
04/06/94	5	.	.	.
10/05/94	6	.	.	.
07/12/95	6	.	.	.
01/17/96	9	.	.	.
07/08/96	9	1 J	.	.
01/08/97	12	2 J	1 J	.
07/22/97	15	3 J	2 J	.
01/12/98	17	4 J	2 J	.
07/13/98	3 J	2 J	.	.
01/14/99	18	5	3 J	.
07/20/99	19	7	4 J	.
02/07/00	18	9	4.2	.
05/23/00	24	11	4.3	.
07/27/00	26	11	3.3	.
11/06/00	14	9	3.9	.
01/17/01	20	12	4.1	.
05/03/01	18	11	4.2	.
07/16/01	19	11	3.2	1.2 J
11/07/01	18	10	3.7	.
01/28/02	22	15	.	.
05/02/02	17	12	4.1	.
07/15/02	18	13	3.7	.
11/21/02	18	13	4.3	.
01/15/03	20	16	4.3	.
05/01/03	17	14	4.6	.
07/21/03	20	17	6.4	.
11/17/03	17	15	6	.

Table 1. (continued)

Date Sampled	VOC Concentration (µg/L)			
	111TCA	11DCA	11DCE	Chloromethane
01/14/04	16	16	4.8	.
05/03/04	21	17	4.4	.
07/14/04	15	14	4.2	1.1 J
10/26/04	18	17	4.6	4.1
MCL	**200**	**NA**	**7**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit;
NA = Not applicable;

Table 2. Well GW-305: summary of chromium and nickel results

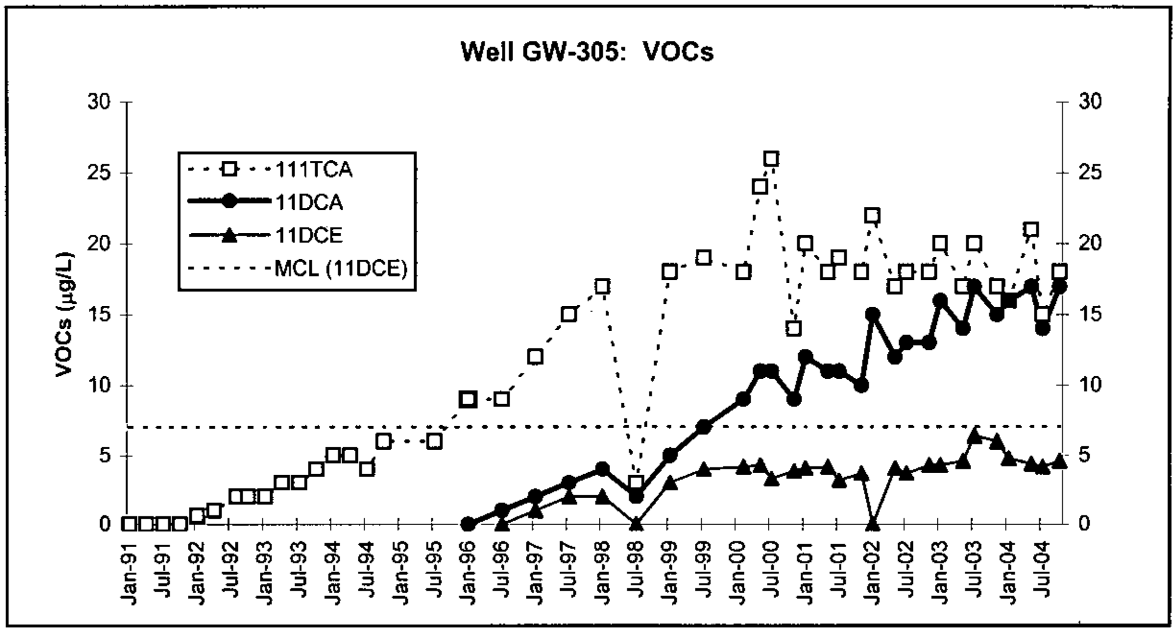
Sampling Method and Date	Total Concentration (mg/L)	
	Chromium UTL = 0.029 MCL = 0.10	Nickel UTL = 0.02 MCL = 0.10
01/06/91	<0.01	<0.01
04/03/91	<0.01	<0.01
07/15/91	<0.01	**0.18**
10/01/91	0.018	**0.29**
01/04/92	0.17	**0.6**
04/06/92	<0.01	0.059
07/28/92	<0.01	0.026
10/12/92	<0.01	0.019
01/05/93	<0.01	0.033
04/01/93	<0.01	<0.01
07/17/93	<0.01	<0.01
10/04/93	<0.01	<0.01
01/10/94	<0.01	<0.01
04/06/94	<0.01	<0.01
07/07/94	<0.01	<0.01
10/05/94	<0.01	0.011
01/10/95	<0.01	<0.01
07/12/95	<0.01	0.06
01/17/96	<0.01	<0.01
07/08/96	<0.01	0.011
01/08/97	0.013	0.029
07/22/97	<0.01	0.014
01/12/98	<0.01	0.039
07/13/98	<0.02	0.0502
01/14/99	<0.02	0.0713
07/20/99	<0.02	**0.143**
11/03/99	<0.02	**0.229**
11/04/99	0.0216	**0.689**
02/07/00	<0.005	0.0555
05/23/00	<0.005	0.05
07/27/00	<0.005	**0.13**
11/06/00	<0.005	**0.23**
01/17/01	<0.005	**0.46**
05/03/01	<0.005	**0.12**
07/16/01	<0.005	**0.12**
11/07/01	<0.005	**0.49**
01/22/02	<0.005	**0.25**
05/02/02	<0.005	**0.76**
07/15/02	<0.005	**0.31**
11/21/02	<0.005	**0.39**
01/15/03	<0.005	**0.23**
05/01/03	<0.005	**0.23**
07/21/03	<0.005	**0.47**
11/17/03	<0.005	**0.22**

Table 2. (continued)

Sampling Method and Date	Total Concentration (mg/L)	
	Chromium UTL = 0.029 MCL = 0.10	Nickel UTL = 0.02 MCL = 0.10
01/14/04	<0.005	**0.62**
05/03/04	<0.005	**0.53**
07/14/04	<0.005	**0.9**
10/26/04	<0.005	**0.45**
Note: Bold typeface denotes results that exceed the MCL.		

Table 3. Well GW-305: February 2000 microbiological sampling results

Well	Riser/Screen Material	Indication of *Corrosion?*	Maximum Bacterial Count (colony forming units per milliliter)		
			Iron-Related	Slime-Forming	Sulfate-Reducing
GW-203	PVC	No	5,000	50,000	<100
GW-302	Stainless steel	Yes	<100,000	<50,000	<100
GW-305	Stainless Steel	Yes	5,000	500,000	100
GW-339	Stainless steel	Yes	5,000	50,000	<100
GW-521	Stainless steel	No	<100	<100	<100
Note: Modified from (AJA 2001).					



Well GW-305: VOCs
111TCA
11DCA
11DCE
MCL (11DCE)
VOCs (µg/L)
30
25
20
15
10
5
0
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	ND	<25

GW-307

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Rust Spoil Area
Y-12 GRID EAST COORDINATE: 49,655.17
Y-12 GRID NORTH COORDINATE: 29,345.98
SURFACE ELEVATION: 991.01 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/15/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 43.60 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 993.14 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	28.7	962.31
BOTTOM (filter pack or open hole):	41.6	949.41
MIDPOINT (filter pack or open hole):	35.2	955.86
PUMP INTAKE:	36.4	954.64
WATER LEVEL (average):	26.49	964.52

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	11 samples	02/06/88	04/26/91
LOW-FLOW SAMPLING METHOD:	2 samples	03/28/05	08/15/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	03/28/05	.	08/15/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.84 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	2	12 mg/L	01/14/91	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	4	79 µg/L	04/26/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-307

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 28.7 to 41.6 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, directly south of the main channel of Bear Creek and approximately 100 ft north of the western end of the Rust Spoil Area, which was used from 1975 to 1983 for disposal of construction debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between February 1988 and April 1991, and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes a quarterly sampling frequency followed by a 14-year period (April 1991 – March 2005) when no samples were collected from the well, and semiannual sampling in 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of approximately 26 ft bgs and exhibits seasonal fluctuations of approximately 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the Rust Spoil Area indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 536 – 728 mg/L;
- pH of 6.33 – 6.7 (field measurements);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations);
- elevated sulfate concentrations (>80 mg/L); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, such as dissolution of locally disseminated sulfide minerals, or if the elevated concentrations are the result of contamination from one or more sources located hydraulically upgradient of the well, including the Rust Spoil Area.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), including eleven samples with concentrations that exceed the drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval for the well intercepts groundwater flow/transport pathways for nitrate (and other contaminants) released from the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located approximately 2,600 ft east-northeast (hydraulically upgradient) of the well, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984, which emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants in the groundwater. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale, which underlies the former S 3-Ponds, and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Because nitrate is chemically stable and highly mobile in groundwater, the elevated concentrations of nitrate (>10 mg/L) effectively trace the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of elevated nitrate concentrations in the Maynardville Limestone west of Y-12 reflects: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for approximately 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic communication with surface water in Bear Creek.

As shown by the groundwater sampling results summarized in Table 1, nitrate concentrations above the 10 mg/L drinking water MCL were reported for each sample collected between February 1988 and April 1991, with the historical maximum concentration of 40 mg/L in August 1988. In contrast, nitrate concentrations near 2.5 mg/L were detected in the samples collected most recently (March and August 2005). These results define a clearly decreasing long-term concentration trend, as illustrated by a time-series plot of the nitrate data (Figure 1), which undoubtedly corresponds with the substantially reduced flux of nitrate in the Maynardville Limestone that occurred in response to the closure/capping of the former S-3 Ponds. Note that the most recent nitrate results suggest that the rate of concentration decrease has slowed considerably. For example, the nitrate concentration evident in April 1991 (11 mg/L) reflects an approximately 75% decrease from the historical maximum evident only 19 months earlier (August 1988), but a further 75% decrease subsequently is evident 14 years later in March (2.24 mg/L) and August 2005 (2.67 mg/L). This suggests that the nitrate concentrations in the groundwater at this well may have reached asymptotic levels, which indicates that the most highly contaminated groundwater has been flushed from the shallow karst network in the Maynardville Limestone underlying the upper reaches of Bear Creek (DOE 1997). Thus, the nitrate concentrations may have reached asymptotic levels that reflect the relative rate of influx from less permeable intervals (matrix diffusion) and natural attenuation processes.

5.2 URANIUM

Ten groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit (Table 1), with the highest concentration (0.007 mg/L in May 1988) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected since November 1989 (previous samples were not analyzed for VOCs): acetone, CTET, chloroform, PCE, TCE, 12DCE (isomers), 11DCA, 111TCA, and 4-methyl-2-pentaone (Table 2). The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient (east) of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

Based on frequency of detection and concentration magnitude, the primary VOC in the groundwater samples is TCE, which is the only VOC detected in all of the samples collected to date, with concentrations above 50 µg/L detected in most of the samples collected before the extended (14-year) gap in the sampling history. Also, the most recent sampling results (March and August 2005) show that the TCE concentrations remain above the drinking water MCL (Table 2). At least one of the other VOCs was detected in each sample collected to date, with 12DCE detected at the highest concentration (23 µg/L in May 1990) and all the other compounds except chloroform detected at concentrations below 5 µg/L. Also, the most recent sampling results (March and August 2005) show that the concentrations of CTET, PCE, and c12DCE are less than corresponding MCLs (Table 2). The Rust Spoil Area (or nearby undocumented source within the Bear Creek floodplain) is the suspected source of the TCE in the groundwater at this well (DOE 1997). Considering the elevated nitrate concentrations and presence of Tc-99 in the groundwater at this well, the contaminant plume emplaced during historical operation of the S-3 Ponds also is a potential source of VOCs in the well, as is Spoil Area I, which was used from 1980 to 1988 for the disposal of construction spoil and related debris generated at Y-12 and is the suspected source of the VOCs (primarily PCE, TCE, and 12DCE) in monitoring wells at the site (DOE 1997).

As shown on Figure 2, a time-series plot of TCE concentrations detected in the groundwater samples collected since November 1989 shows a variable but clearly decreasing long-term concentration trend spanning the prolonged gap in the sampling history for the well. This trend suggests a corresponding decrease in the relative flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Interestingly, the concentrations of other VOCs detected in the samples do not show a similar long-term decrease, as illustrated by the equal PCE concentrations (2 µg/L) reported for the samples collected in January 1990 and March 2005. Assuming a heterogeneous mixture of dissolved VOCs in the groundwater from the shallow karst network in the Maynardville Limestone, it is unclear why the VOC concentrations exhibit such divergent trends. Perhaps the TCE is not well mixed with other VOCs in the groundwater system, but instead occurs within separate, discreet transport pathways intercepted by the monitored interval in the well. Separate transport from different source areas also may occur, with more temporally variable flux from the source of TCE but more consistent flux of PCE from a separate upgradient source area (e.g., Spoil Area I).

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the highest values (8.02 pCi/L in August and October 1990) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE (Table 1), including two values (51.3 pCi/L in January 1990 and 51.1 pCi/L in August 1990) that slightly exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which was detected (i.e., >MDA and CE) in the groundwater samples collected in March (16 pCi/L) and August 2005 (19 pCi/L), although both results are substantially below SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Nevertheless, Tc-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate, which reflects their common source and their similar transport characteristics in the groundwater.

A time-series plot of gross beta activity reported for the groundwater samples collected since January 1990 shows a decreasing long-term concentration trend (Figure 3). This decreasing trend for gross beta activity is probably attributable to the closure/capping of the former S-3 Ponds, which substantially reduced relative flux of Tc-99 in the Maynardville Limestone downstream of the site. Additionally, as with the nitrate concentrations in the well, gross beta activity appears to be decreasing at a slower rate than indicated by historical data. For instance, gross beta activity evident in April 1991 (27 pCi/L) reflects an approximately 50% decrease from the level evident in August 1990 (51 pCi/L), with a further 75% decrease indicated by the nitrate concentrations nearly 15 years (171 months) later in August 2005 (14 pCi/L). These findings suggest that gross beta activity may have reached essentially asymptotic levels.

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

Table 1. Well GW-307: summary results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)		
	Nitrate	Total Uranium	Gross Alpha Activity	Gross Beta Activity	Tc-99
02/06/88	38.1	<0.001	DQO	DQO	.
05/11/88	33	0.007	DQO	DQO	.
08/01/88	40	0.002	DQO	DQO	.
10/14/88	30	<0.001	DQO	DQO	.
11/27/89	20	0.003	DQO	DQO	.
01/12/90	21	<0.001	2.09	51.3	.
05/19/90	17	0.001	3.2	47.26	.
08/01/90	17	0.001	8.02	51.1	.
10/17/90	16	0.002	8.02	46.51	.
01/14/91	12	0.001	<CE	31.65	.
04/26/91	11	0.001	3.6	27.17	.
03/28/05	2.24	0.0015	<MDA	<MDA	16
08/15/05	2.67	0.00178	<MDA	14	19
MCL	**10**	**0.03**	**15**	**50***	**900***

Note: "." = Not analyzed; DQO = results do not meet data quality objectives; * = MCL is the SDWA screening level for a 4 mrem/yr dose equivalent

Table 2. Well GW-307: summary of VOC results

Sampling Date	Concentration (µg/L)		
	PCE	TCE	12DCE
11/27/89	4 J	72	18
01/12/90	2 J	57	22
05/19/90	2 J	67	23
08/01/90	2 J	55	21
10/17/90	1 J	43	15
01/14/91	1 J	37	.
04/26/91	.	54	16
03/28/05	2 J	21	6
08/15/05	.	21	5
MCL	**5**	**5**	**NA**
Sampling Date	**Concentration (µg/L)**		
	c12DCE	**111TCA**	**11DCA**
11/27/89	NR	3 J	4 J
01/12/90	NR	3 J	4 J
05/19/90	NR	3 J	4 J
08/01/90	NR	2 J	.
10/17/90	NR	2 J	3 J
01/14/91	NR	2 J	4 J
04/26/91	NR	2 J	3 J
03/28/05	6	.	2 J
08/15/05	5	.	2 J
MCL	**70**	**200**	**NA**

Table 2. Well GW-307: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L)		
	CTET	**Chloroform**	**Other**
11/27/89	3 J	6	Acetone (15), 4-Methyl-2-Pentanone (2 J)
01/12/90	4 J	6	Acetone (4 J)
05/19/90	4 J	6	.
08/01/90	2 J	5	.
10/17/90	.	6	.
01/14/91	.	.	.
04/26/91	4 J	.	.
03/28/05	.	.	.
08/15/05	.	.	.
MCL	**5**	**80***	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable;
* = MCL is for total trihalomethanes

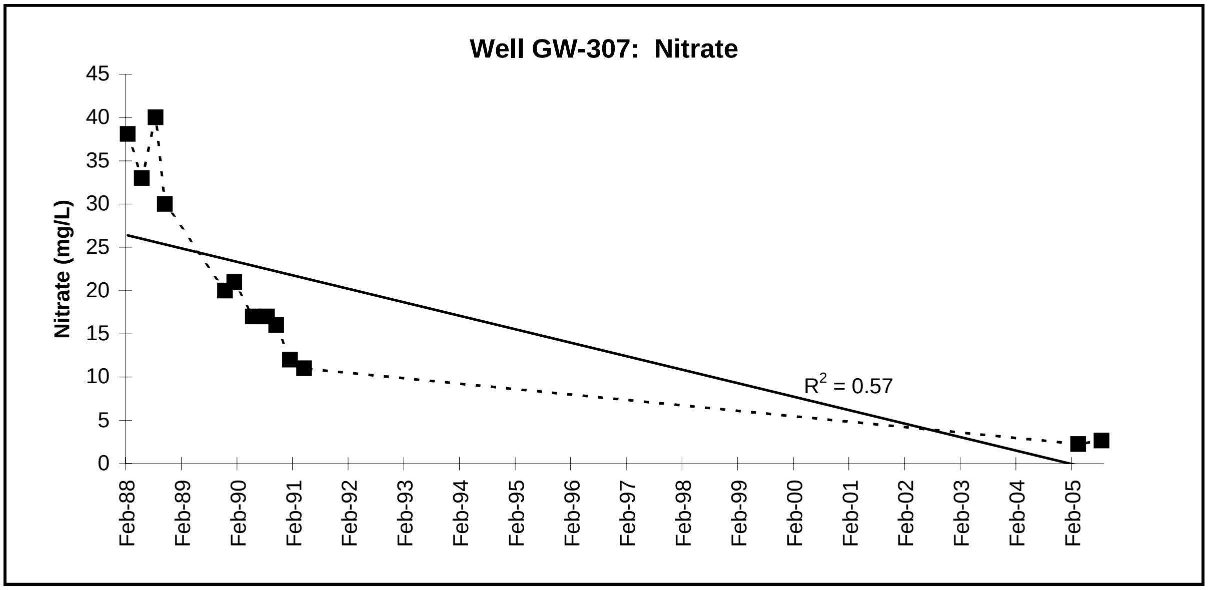


Figure 1

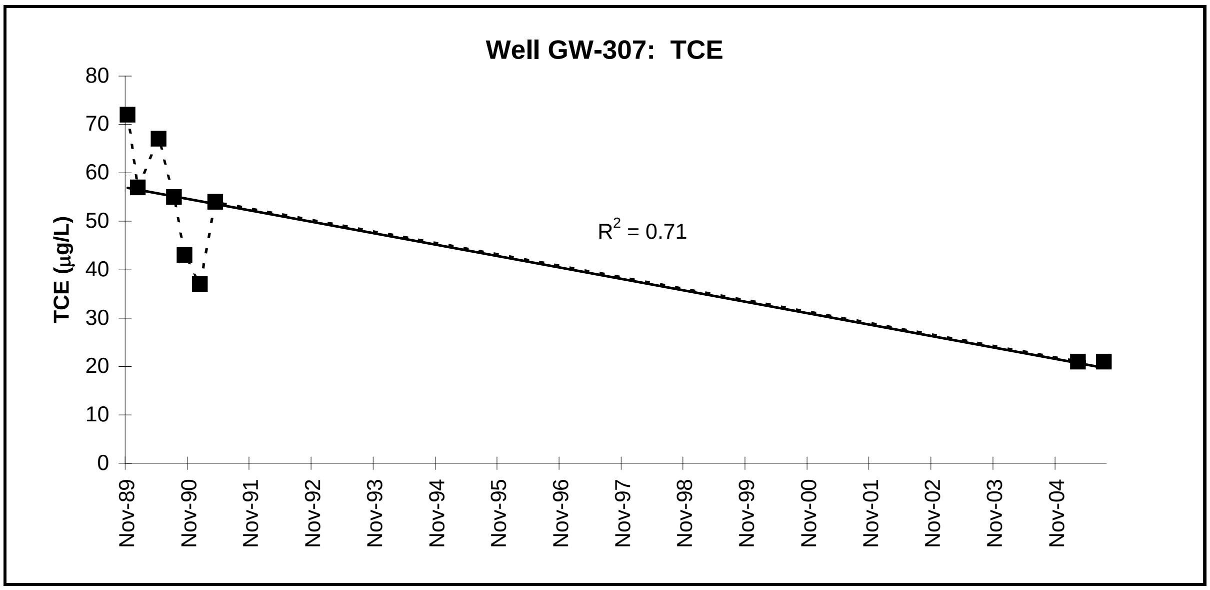


Figure 2

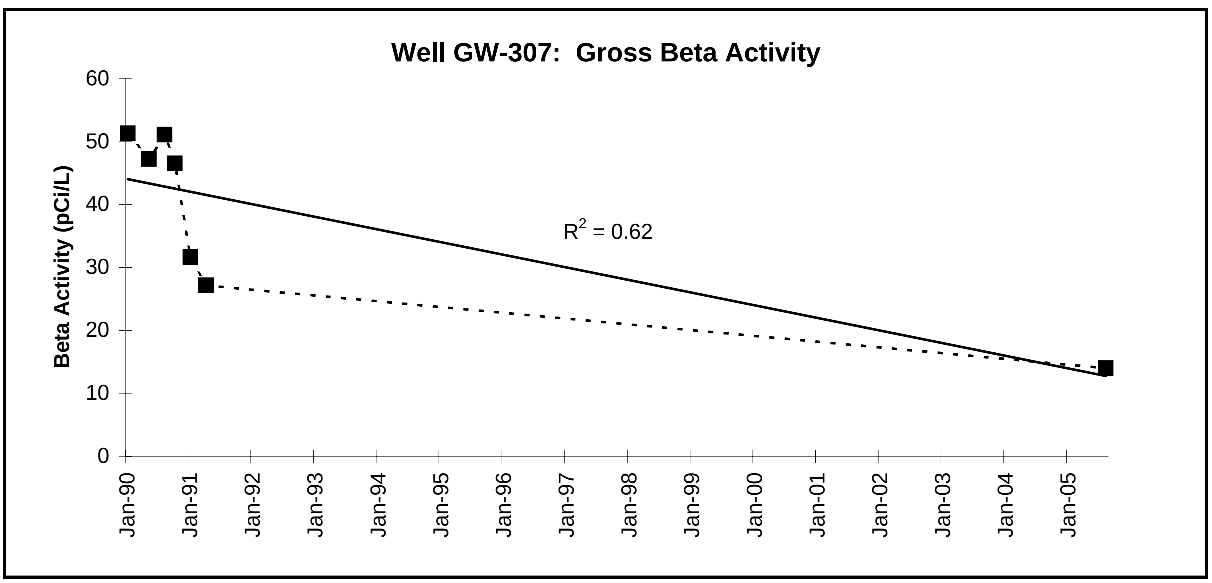


Figure 3

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
5 - 10	<0.015	5 - 50	<7.5	<25

GW-310

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Rust Spoil Area
Y-12 GRID EAST COORDINATE:	50,497.34
Y-12 GRID NORTH COORDINATE:	29,437.19
SURFACE ELEVATION:	992.40 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	X
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	07/23/87
PAIRED/CLUSTERED WITH:	
TAG DEPTH (measured):	30.47 ft below top of casing (TOC)
MEASURING POINT ELEVATION:	995.35 ft above msl
MEASURING POINT:	TOWW
WELL BORE DIAMETER:	10 inches
WELL CASING MATERIAL:	SS304
WELL CASING DIAMETER:	4.5 inches (outside diameter)
WELL SCREEN TYPE:	SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT:	Well Wizard
Sampling Port No.:	.
Port Depth :	. (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.5	972.90
BOTTOM (filter pack or open hole):	27.1	965.30
MIDPOINT (filter pack or open hole):	23.3	969.10
PUMP INTAKE:	25.0	967.35
WATER LEVEL (average):	18.18	974.22

GEOLOGIC FORMATION:	Maynardville Limestone
HYDROGEOLOGIC ZONE:	Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	13 samples	02/05/88	04/30/91
LOW-FLOW SAMPLING METHOD:	2 samples	03/28/05	08/17/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	03/28/05	.	08/17/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	.	
WATER LEVEL FLUCTUATION:	3.31 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	14 mg/L	01/15/91	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	4	85 µg/L	04/30/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-310

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 19.5 to 27.1 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley west of Y-12, directly south of the main channel of Bear Creek and approximately 50 ft east of the northeast corner of the Rust Spoil Area, which was used from 1975 to 1983 for disposal of construction debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between February 1988 and April 1991, and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes a quarterly sampling frequency followed by a 14-year period (April 1991 – March 2005) when no samples were collected from the well, with semiannual sampling in 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of approximately 18 ft bgs, and exhibits seasonal fluctuations of approximately 3 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the Rust Spoil Area indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 432 – 700 mg/L;
- pH of 6.1 – 6.59 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<15% of total anions/cations); and

- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), including eleven samples with concentrations that exceed the drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval for the well intercepts groundwater flow/transport pathways for nitrate (and other contaminants) released from the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located approximately 1,700 ft east-northeast (hydraulically upgradient) of the well, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984, which emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants in the groundwater. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale, which underlies the former S-3 Ponds, and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Because nitrate is chemically stable and highly mobile in groundwater, the elevated concentrations of nitrate (>10 mg/L) effectively trace the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of elevated nitrate concentrations in the Maynardville Limestone west of Y-12 reflects: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for approximately 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic communication with surface water in Bear Creek.

As shown by the groundwater sampling results summarized in Table 1, nitrate concentrations reported for all but one of the samples collected between February 1988 (29.1 mg/L) and January 1991 (14 mg/L) exceed the 10 mg/L drinking water MCL, with the historical maximum concentration of 61 mg/L in August 1988. In contrast, nitrate concentrations near 5 mg/L were detected in the samples collected in April 1991 and in March and August 2005. These results define a clearly decreasing long-term concentration trend, as illustrated by a time-series plot of the nitrate data (Figure 1), but suggest that the rate of concentration decrease has slowed. For example, the nitrate concentration evident in April 1991 (5 mg/L) reflects an approximately 90% decrease from the historical maximum concentrations evident only 19 months earlier (August 1988), but indicates little significant change compared to the nitrate concentration evident 15 years later in March (3 mg/L). The overall decrease in nitrate concentrations primarily reflects the substantially reduced flux of nitrate in the Maynardville Limestone following the closure/capping of the former S-3 Ponds, and the slowing rate of decrease in nitrate concentrations indicates that the most highly contaminated groundwater has been flushed from the shallow karst network in the Maynardville Limestone. Thus, the nitrate concentrations may have reached asymptotic levels that reflect the relative rate of influx from less permeable intervals (matrix diffusion) and natural attenuation processes.

5.2 URANIUM

Eleven groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.007 mg/L in May 1988) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected since May 1989 (previous samples were not analyzed for VOCs): chloroform, PCE, TCE, 12DCE, and 4-methyl-2-pentaone (4M2P) (Table 2). The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

Based on frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples are TCE and 12DCE, one or both of which were detected in each of the samples collected to date, with a historical maximum concentration above 100 µg/L for each compound (Table 2). Additionally, the most recent (March and August 2005) show that TCE concentrations remain at or slightly above the 5 µg/L drinking water MCL. Of the other VOCs detected in the samples, most of the results are less than 5 µg/L, and only PCE was detected in any of the samples collected after January 1990 (Table 2). Also, as noted above, the dominance of TCE in the samples is believed to indicate groundwater transport/migration from the Rust Spoil Area (or nearby source within the Bear Creek floodplain). Considering the elevated nitrate concentrations in the groundwater samples, the contaminant plume emplaced during historical operation of the S-3 Ponds also is a potential source of VOCs in the well, as is Spoil Area I, which was used from 1980 to 1988 for the disposal of construction spoil and related debris generated at Y-12 and is the suspected source of the VOCs (primarily PCE, TCE, and 12DCE) in monitoring wells at the site (DOE 1997).

A time-series plot of TCE concentrations detected in the groundwater samples collected since May 1989 shows a variable but clearly decreasing long-term concentration trend (Figure 2). The trend spans the prolonged gap in the sampling history for the well, but nonetheless suggests a corresponding decrease in the relative flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Interestingly, the concentrations of 12DCE likewise show a decreasing concentration trend, but the PCE levels do not, as illustrated by the equal PCE concentrations (2 µg/L) evident in May 1989, August 1990, and March 2005. Assuming a heterogeneous mixture of dissolved VOCs in the groundwater from the shallow karst network in the Maynardville Limestone, it is unclear why the VOC concentrations exhibit such divergent trends. Perhaps the TCE is not well mixed with the other VOCs in the groundwater system, but instead occurs within separate, discreet transport pathways intercepted by the monitored interval in the well. Separate transport from different sources of VOCs also may occur, with more temporally variable flux from the source of TCE but more consistent flux of PCE from a separate upgradient source area (e.g., Spoil Area I).

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the highest values (6.76 pCi/L in October 1990) being below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE (Table 1), including results for samples collected in August (71 pCi/L) and October 1990 (125 pCi/L) that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The other results for gross beta activity are all less than 40 pCi/L with the most recent results (March and August 2005) being below 20 pCi/L. The source of the gross beta activity in the groundwater at this well is probably Tc-99, a beta-emitting radionuclide that is considered a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate, which reflects their common source and their similar transport characteristics in the groundwater.

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

Table 1. Well GW-310: summary results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)	
	Nitrate	Uranium	Gross Alpha	Gross Beta
02/05/88	29.1	.	DQO	DQO
05/11/88	34	0.007	DQO	DQO
08/01/88	61	0.002	DQO	DQO
10/14/88	17	.	DQO	DQO
05/09/89	12	.	DQO	DQO
08/21/89	18	0.001	DQO	DQO
11/22/89	17	0.002	DQO	DQO
01/12/90	11	.	< CE	22.8
05/19/90	9	0.001	2.9	28.63
08/02/90	24	0.001	3.19	71.47
10/18/90	48	0.001	6.76	124.79
01/15/91	14	0.001	< CE	38.85
04/30/91	5	0.001	1.96	23.14
03/28/05	3.21	0.00352	2.4	12
08/17/05	7.27	0.00399	<MDA	18
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; DQO = results do not meet data quality objectives; * = MCL is the SDWA screening level for a 4 mrem/yr dose equivalent

Table 2. Well GW-310: summary of VOC results

Sampling Date	Concentration (µg/L)			
	PCE	TCE	12DCE	Other
05/09/89	2 J	120	200	Chloroform (6)
08/21/89	2 J	72	82	Chloroform (2 J)
11/22/89	3 J	44	35	Chloroform (1 J); 4M2P (2 J)
01/12/90	1 J	30	27	Chloroform (1 J)
05/19/90	.	42	28	.
08/02/90	2 J	20	13	.
10/18/90	4 J	17	9	.
01/15/91	3 J	52	20	.
04/30/91	3 J	48	34	.
03/28/05	2 J	7	.	.
08/17/05	2 J	5	.	.
MCL	**5**	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

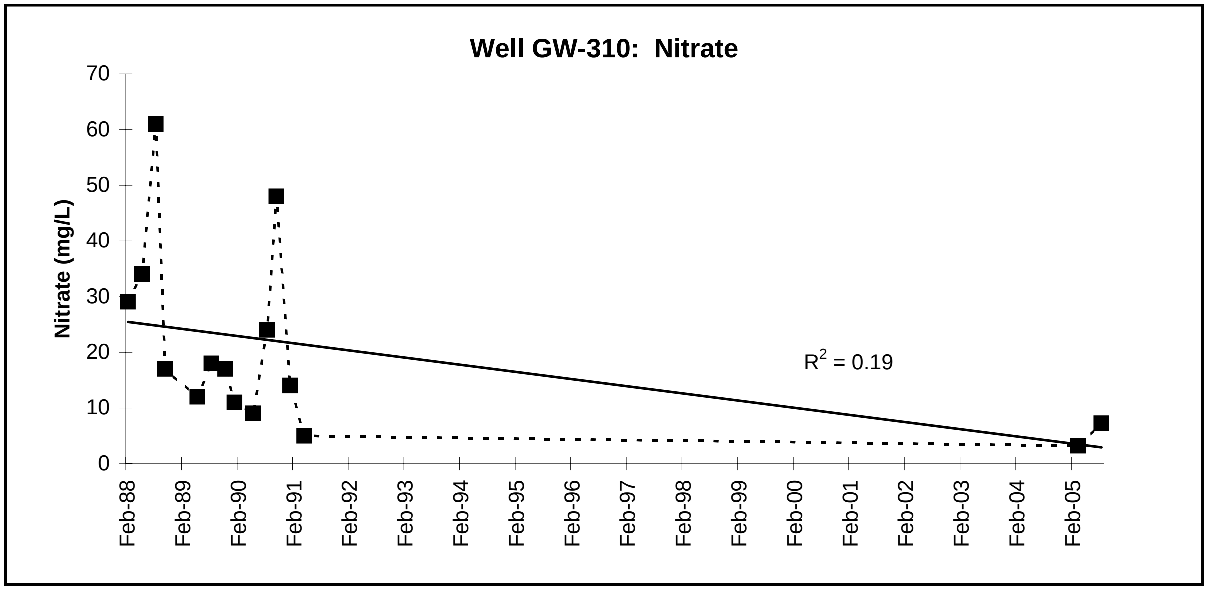


Figure 1

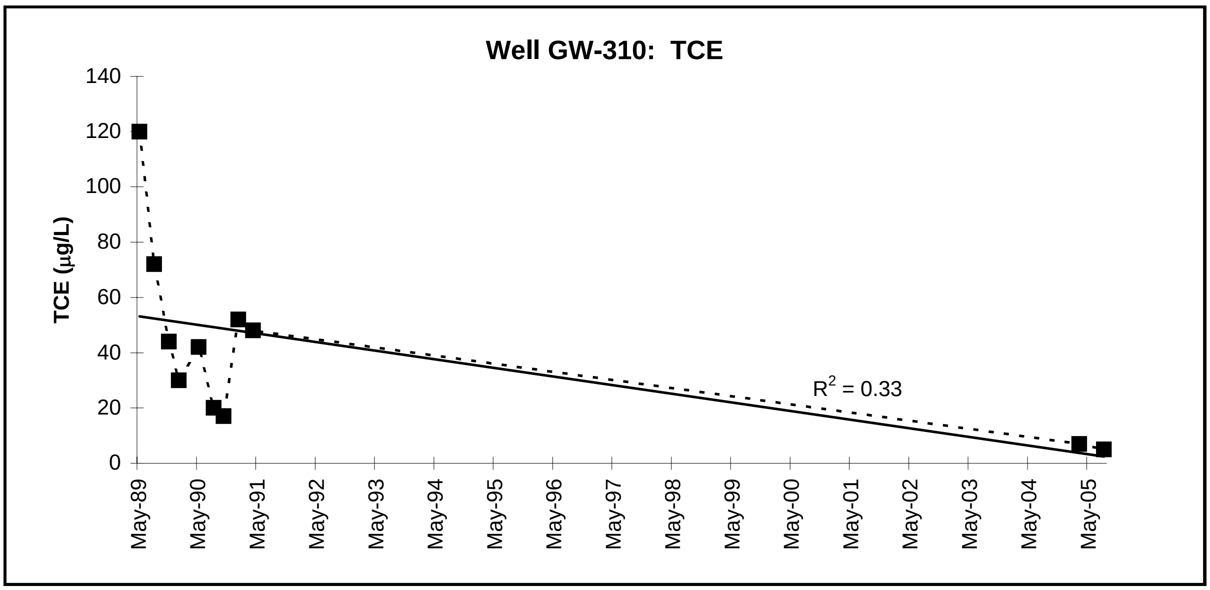


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	ND	ND

GW-311

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Rust Spoil Area
Y-12 GRID EAST COORDINATE: 50,125.50
Y-12 GRID NORTH COORDINATE: 29,266.88
SURFACE ELEVATION: 996.43 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/15/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 43.64 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 999.52 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	25.6	970.83
BOTTOM (filter pack or open hole):	40.3	956.13
MIDPOINT (filter pack or open hole):	33.0	963.48
PUMP INTAKE:	31.91	964.52
WATER LEVEL (average):	32.68	963.75

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	41		
CONVENTIONAL SAMPLING METHOD:	27 samples	02/05/88	09/19/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/05/98	08/02/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/18/04	.	08/02/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 20.77 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	21	33 µg/L	01/13/91	Decreasing
GROSS ALPHA (15 pCi/L):	1	18 pCi/L	02/28/00	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-311

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1987, completed with a screened monitored interval from 25.6 to 40.3 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley west of Y-12, adjacent to Old Bear Creek Road on the south side of the Rust Spoil Area, which was used from 1975 to 1983 for disposal of construction debris.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between February 1988 and September 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 33 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 192 – 320 mg/L;
- pH of 6.4 – 7.7 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 31 groundwater samples collected from the well since January 1991.

5.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.78 mg/L in March 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Fifteen groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.003 mg/L in February 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

TCE was detected in all 31 groundwater samples collected from the well since January 1991; CTET and/or chloroform were detected in 14 of the 19 samples collected between January 1991 and August 1998. The source of the VOCs in the well is believed to be the Rust Spoil Area. This site (or a nearby source in the Bear Creek floodplain) contributes primarily TCE to the discontinuous plume of dissolved VOCs in the Maynardville Limestone, which receives influx from multiple sources in the Bear Creek Regime via direct recharge, hydrologic communication with Bear Creek, and inflow of contaminated groundwater from the Nolichucky Shale (DOE 1997). Available data show that the concentration of TCE in the well decreased steadily from 30 μg/L in January 1991 to less than 10 μg/L after August 1998 and has remained at or below the MCL (5 μg/L) since September 2000 (Figure 1). Also, neither CTET nor chloroform was detected in the samples collected since March 1999.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (18 pCi/L in February 2000) being slightly above the MCL for gross alpha activity (15 pCi/L). None of the other gross alpha results exceed 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10.1 pCi/L in February 1993) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

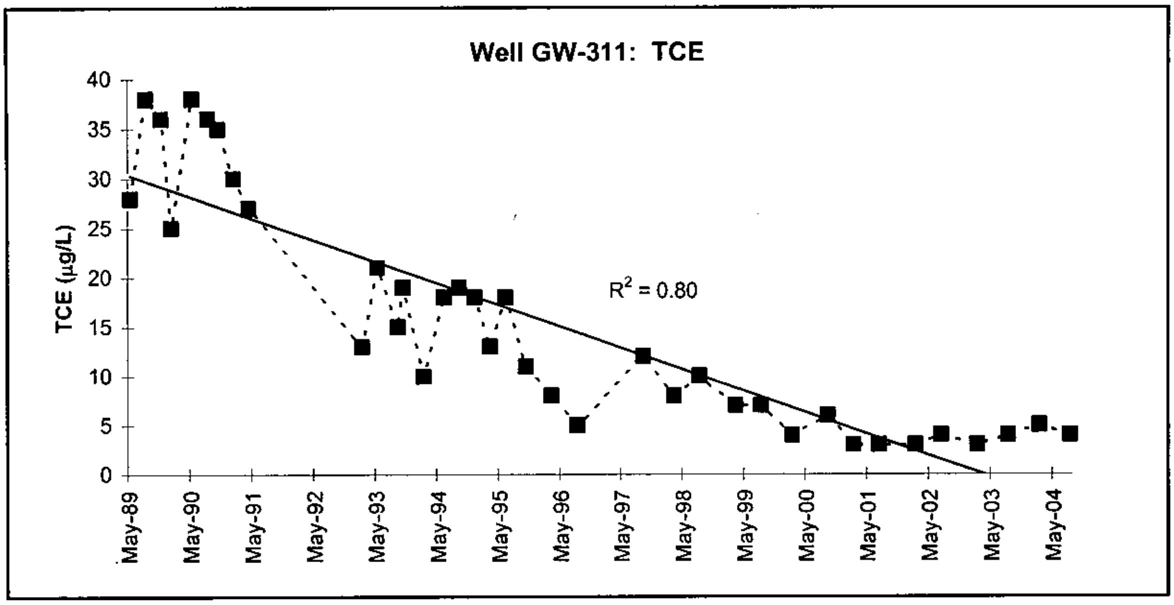

Well GW-311: TCE
TCE (µg/L)
40
35
30
25
20
15
10
5
0
R^2 = 0.80
May-89
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	ND	<25

GW-312

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Rust Spoil Area
Y-12 GRID EAST COORDINATE: 49,777.77
Y-12 GRID NORTH COORDINATE: 29,215.52
SURFACE ELEVATION: 994.13 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/22/87   PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 42.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 996.70 ft above msl   MEASURING POINT: TOWW
WELL BORE DIAMETER: 12 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard   Sampling Port No.: .   Port Depth : . (ft bgs)

MONITORED INTERVAL   TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	29.6	964.53
BOTTOM (filter pack or open hole):	41.0	953.13
MIDPOINT (filter pack or open hole):	35.3	958.83
PUMP INTAKE:	32.4	961.70
WATER LEVEL (average):	33.04	961.30

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	23 samples	02/09/88	08/06/95
LOW-FLOW SAMPLING METHOD:	2 samples	03/28/05	08/17/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	03/28/05	.	08/17/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .   TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: .   LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: .   OTHER: .
WATER LEVEL FLUCTUATION: 11.62 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	15	85 µg/L	01/14/91	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-312

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1987, completed with a screened monitored interval from 29.6 to 41 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley west of Y-12, adjacent to Old Bear Creek Road on the south side of the Rust Spoil Area, which was used from 1975 to 1983 for disposal of construction debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 23 samples between February 1988 and August 1995, and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes a quarterly sampling frequency followed by a 10-year period (August 1995 – March 2005) when no samples were collected from the well, with semiannual sampling in 2005.

Unusually low levels of TDS (<150 mg/L in recent samples) and high levels of pH are distinguishing characteristics of the groundwater samples from this well (see Section 4.0). The low TDS of the samples suggests relatively low residence time for the groundwater in the well, which indicates that the monitored interval for the well intercepts highly permeable groundwater flowpaths. Historic data (conventional sampling) showed that the groundwater had very high pH (>12), but recent (low-flow sampling) results show moderately lower pH values (9.5 – 10).

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of approximately 33 ft bgs, and exhibits seasonal fluctuations up to 13 ft. Note that the water level typically occurs within the screened interval of the well. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the Rust Spoil Area indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields slightly alkaline sodium-bicarbonate groundwater generally characterized by:

- TDS of 80 – 740 mg/L, recent results (low-flow sampling) are 80 – 123 mg/L;
- pH of 9.63 – 12.6 (field measurements), excluding an outlier (7) in June 1995;

- low molar proportions of chloride, potassium, and sulfate (<15% of total anions/cations);
- high molar proportion of sodium (>45% of total anions/cations);
- low concentrations of calcium (<20 mg/L) and magnesium (<5 mg/L); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated pH and unusually high sodium concentrations in the groundwater at this well may reflect the influence from grout used to construct the well or from concrete debris disposed at the Rust Spoil Area.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All but one of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2 mg/L in April 1991) being substantially below the MCL for nitrate (10 mg/L). The lack of elevated nitrate concentrations in the samples indicates that the monitored interval for the well does not intercept groundwater flow/transport pathways that are extensively interconnected with the contaminant plume emplaced during historical operation of the former S-3 Ponds (nitrate is a highly mobile component of the plume), which is a primary source of groundwater contamination in the Maynardville Limestone west of Y-12 and is located approximately 2,600 ft east-northeast (hydraulically upgradient) of the well.

5.2 URANIUM

Four groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.002 mg/L in May 1989) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: acetone, CTET, chloroform, toluene, TCE, 11DCE, 12DCE, and 4-methyl-2-pentanone (4M2P) (Table 1). The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient (east) of the well, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

Based on frequency of detection and concentration magnitude (Table 1), the primary VOC in the groundwater samples is TCE, which was detected in each sample collected to date and has the highest historical maximum concentration (80 µg/L in January 1991 and February 1994). Moreover, the results for TCE, including the historical minimum value (10 µg/L in September 1993) and the most recent (March and August 2005) sampling results, are all above the drinking water MCL (5 µg/L). In contrast, aside from the acetone concentrations detected in the samples collected in May 1989 (12 µg/L) and January 1990 (13 µg/L), concentrations of all the other VOCs detected in the samples are 5 µg/L or less, and the bulk of these results are estimated concentrations of 1 µg/L or less (Table 1). The Rust Spoil Area or nearby undocumented source within the Bear Creek floodplain is the suspected source of the TCE in the groundwater at this well (DOE 1997). Although hydraulically upgradient of the well, the contaminant plume emplaced during historical operation of the S-3 Ponds seems an unlikely source of TCE or other VOCs in the well, considering the lack of elevated nitrate levels noted in Section 5.1. The only other confirmed source of VOCs upgradient of the well is Spoil Area I, which was used from 1980 to 1988 for the disposal of construction spoil and related debris generated at Y-12 and is the suspected source of the VOCs (primarily PCE, TCE, and 12DCE) in monitoring wells at the site (DOE 1997).

A time-series plot of the TCE concentrations detected in the groundwater samples collected to date shows an indeterminate long-term trend dominated by wide fluctuations (Figure 1). Also, the variability generally correlates with seasonal flow conditions. For example, the lowest levels of TCE (e.g., 10 µg/L in September 1993) were detected in samples collected during summer or fall, whereas the highest TCE concentrations (e.g., 80 µg/L in January 1991 and February 1994) are evident for samples collected during winter or spring. This relationship suggests seasonally variable flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well, with the greater recharge during seasonally (and episodically) high flow inducing greater transport of TCE. Interestingly, the results for chloroform, which was detected at 2 µg/L or less in most of the samples collected to date (Table 1), do not exhibit wide temporal variability, as illustrated by the chloroform results reported for samples collected in December 1994 (2 µg/L), March 1995 (2 µg/L), and June 1995 (2 µg/L). Assuming a heterogeneous mixture of dissolved VOCs in the karst network at shallow depths in the Maynardville Limestone, it is unclear why the TCE and chloroform concentrations exhibit such divergent temporal trends. Perhaps the TCE and chloroform (and other VOCs) are not well mixed in the groundwater system, but instead occur within separate, discreet transport pathways that are intercepted by the monitored interval in the well. Separate transport from different source areas also may occur, with more temporally variable flux from the source of TCE but more consistent flux of chloroform from a separate upgradient source area (Spoil Area I).

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.81 pCi/L in December 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE, with the highest value (23.86 pCi/L in January 1990) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

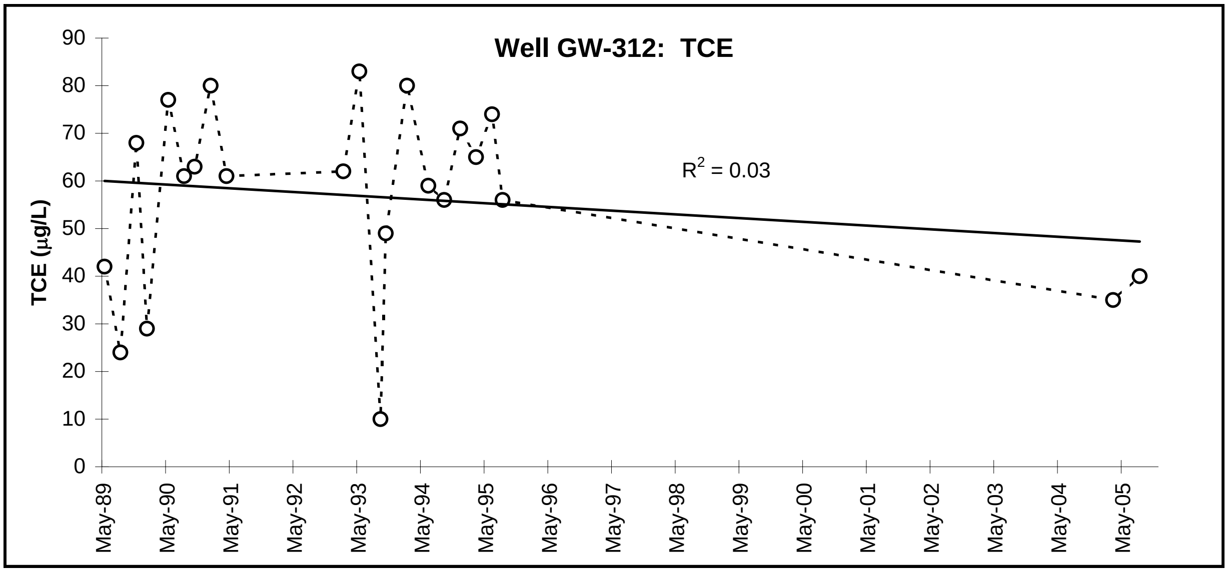
Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

Table 1. Well GW-312: summary of VOC results

Sampling Date	Concentration (µg/L)		
	TCE	**Chloroform**	**Other**
05/05/89	42	0.5 J	Toluene (1 J), Acetone (12)
08/21/89	24	.	.
11/20/89	68	0.8 J	CTET (0.9 J), Acetone (5 J)
01/15/90	29	0.5 J	Acetone (13)
05/18/90	77	0.8 J	CTET (1 J)
08/01/90	61	.	.
10/17/90	63	0.6 J	12DCE (1 J)
01/14/91	80	.	4M2P (5)
04/26/91	61	.	.
02/08/93	62	1 J	.
05/11/93	83	1 J	.
09/12/93	10	.	.
10/21/93	49	.	.
02/09/94	80	1 J	.
06/23/94	59	1 J	.
09/06/94	56	1 J	.
12/14/94	71	2 J	12DCE (1 J)
03/25/95	65	2 J	12DCE (1 J), 11DCE (1 J)
06/06/95	74	2 J	.
08/06/95	56	.	.
03/28/05	35	1 J	.
08/17/05	40	1 J	.
MCL	**5**	**80***	**NA**

Note: "." = Not detected; J = Estimated value; NA = Not applicable; * = MCL is for total trihalomethanes



Well GW-312: TCE
TCE (µg/L)
90
80
70
60
50
40
30
20
10
0
R^2 = 0.03
May-89
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05

Figure 1

MAXIMUM CONCENTRATION: 2005

<5	<0.015	5 - 50	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-313

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spoil Area I
Y-12 GRID EAST COORDINATE: 52,015.69
Y-12 GRID NORTH COORDINATE: 29,350.83
SURFACE ELEVATION: 1,056.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/11/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 121.40 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,059.74 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	98.2	958.40
BOTTOM (filter pack or open hole):	113.0	943.60
MIDPOINT (filter pack or open hole):	105.6	951.00
PUMP INTAKE:	113.4	943.24
WATER LEVEL (average):	68.99	987.61

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	03/08/88	08/15/92
LOW-FLOW SAMPLING METHOD:	2 samples	03/23/05	08/16/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	03/23/05	.	08/16/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.12 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	8	146 µg/L	01/09/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-313

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1987, completed with a screened monitored interval from 98.2 to 113 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). Located at Spoil Area I, which is at the base of the northern flank of Chestnut Ridge southwest of Y-12, the well is approximately 600 ft south of the headwaters channel of Bear Creek. Spoil Area I was used from 1980 to 1988 for disposal of construction spoil and related debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between March 1988 and August 1992, and the low-flow sampling method used to obtain samples in March and August 2005. The sampling history includes a quarterly sampling frequency followed by a 13-year period (August 1992 – March 2005) when no samples were collected from the well, with semiannual sampling in 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100-300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network), with hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of approximately 69 ft bgs and exhibits seasonal fluctuations up to 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths indicate northwesterly flow near the well, toward the headwaters channel of the Bear Creek. Note, however, local flow may be more directly west because groundwater flow in the Maynardville Limestone is strongly anisotropic, with preferred flow parallel with geologic strike.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 306 – 400 mg/L;
- pH (field measurements) of 6.5 – 7.1;
- very low molar proportions of chloride, potassium, sodium, and sulfate (<5% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (9.82 mg/L in August 1992) being slightly below the drinking water MCL for nitrate (10 mg/L). However, this value is a suspected outlier because all other nitrate results are less than 4 mg/L. Nitrate concentrations reported for the most recent samples (March and August 2005) were less than 2 mg/L.

5.2 URANIUM

Three groundwater sample collected to date had uranium concentrations above the applicable analytical reporting limit, with the highest value (0.004 mg/L in May and August 1988) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in at least one of the groundwater samples collected to date (Table 1): PCE, TCE, 12DCE, acetone, MC, and chloroform. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from Spoil Area I, which is believed to contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE.

Based on frequency of detection and concentration magnitude, the primary VOC in the groundwater samples is PCE (Table 1), which was detected in every sample collected to date and, excluding a suspected outlier result for 12DCE (120 in January 1991), has the highest historical maximum concentration (18 µg/L in January 1991 and August 1992). Also, the recent sampling results (March and August 2005) show that PCE concentrations remain slightly above the drinking water MCL (5 µg/L). Secondary compounds in the samples are TCE and 12DCE (c12DCE): one or both of which were detected in all but one of the samples collected to date, with the most recent sampling results showing only trace levels of each VOC (i.e., estimated concentrations below 5 µg/L). Spoil Area I is the suspected source of the VOCs in the groundwater at this well.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date (excluding the suspected outlier described above) shows slightly decreasing long-term concentration trend dominated by wide fluctuations and the prolonged (13-year) gap in the sampling history (Figure 1). Also, the variability in the summed VOC concentrations generally correlates with seasonal flow conditions. For example, the lowest levels of summed VOCs (e.g., 6 µg/L in April 1991) were detected in samples collected during winter or spring, whereas the highest summed VOC concentrations (e.g., 42 µg/L in August 1992) are evident for samples collected during summer or fall. This relationship suggests reduction in the concentrations of VOCs in the groundwater as a result of "dilution" from seasonal (or episodic) inflow of uncontaminated (or less VOC-contaminated) recharge via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Additionally, the overall decrease in VOC concentrations suggests a corresponding reduction in the relative flux of dissolved VOCs through the Maynardville Limestone in the upper reaches of Bear Creek.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross alpha activity above the applicable MDA and corresponding CE, and this result (1.68 pCi/L in July 1991) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples collected since January 1990 (the sample-specific MDA and/or CE are not available for previous samples) had gross beta activity above the applicable MDA and corresponding CE, with the highest value (19.3 pCi/L in May 1992) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee*, Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-313: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	TCE	12DCE	c12DCE	Other
03/15/90	0.8 J	.	.	NR	Acetone (12), MC (0.9 J)
05/14/90	4 J	2 J	4 J	NR	.
07/30/90	13	6	9	NR	.
10/12/90	17	9	15	NR	.
01/09/91	18	8	[120]	NR	.
04/09/91	5	1 J	.	NR	.
07/18/91	9	4 J	5	NR	.
10/05/91	13	7	10	NR	.
02/22/92	6	4 J	4 J	NR	.
05/07/92	5	3 J	3 J	NR	.
08/15/92	18	10	12	NR	Chloroform (2 J)
03/23/05	4 J	1 J	.	NR	.
08/16/05	7	3 J	1 J	1 J	.
MCL	**5**	**5**	**NA**	**70**	**NA**

Note: "." = Not detected; J = Estimated value; [ ] = Suspected outlier; NR = Not reported;
NA = Not applicable

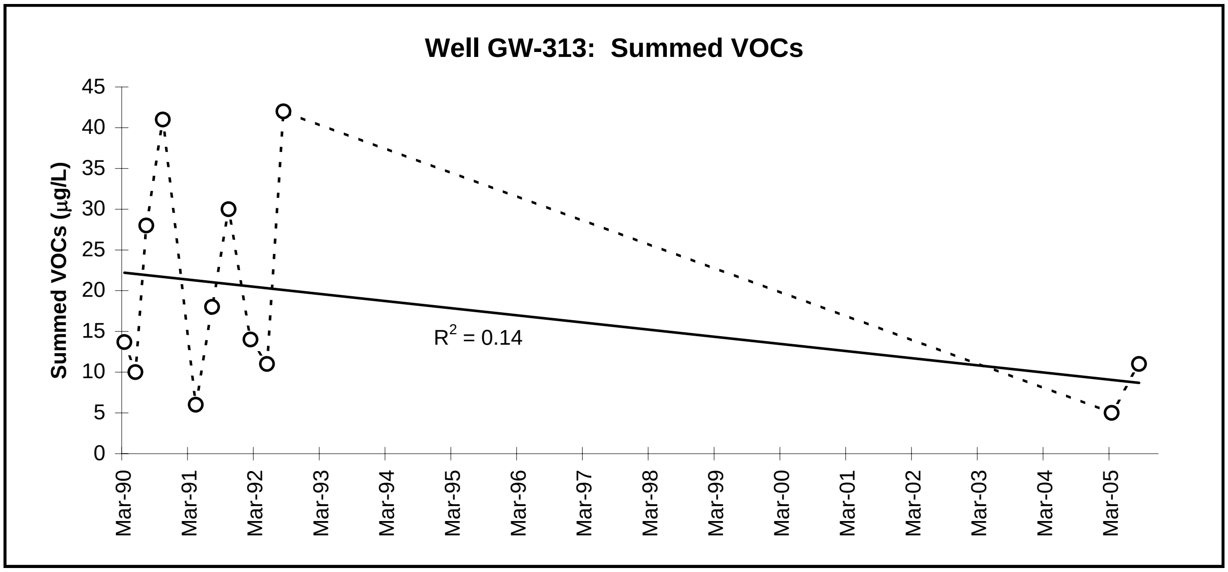

Well GW-313: Summed VOCs
Summed VOCs (µg/L)
45
40
35
30
25
20
15
10
5
0
R^2 = 0.14
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Mar-05

Figure 1

MAXIMUM CONCENTRATION: 2004

5 - 10	<0.015	5 - 50	ND	25 - 50
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-315

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spoil Area I
Y-12 GRID EAST COORDINATE: 52,268.13
Y-12 GRID NORTH COORDINATE: 29,454.61
SURFACE ELEVATION: 1,044.84 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/25/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 105.98 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,047.45 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	90.0	954.84
BOTTOM (filter pack or open hole):	104.0	940.84
MIDPOINT (filter pack or open hole):	97.0	947.84
PUMP INTAKE:	97.39	947.45
WATER LEVEL (average):	54.36	990.48

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	32 samples	03/07/88	09/16/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/02/98	08/02/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/18/04	.	08/02/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 18.56 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	15	34.05 mg/L	08/15/92	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	38	85 µg/L	01/08/91	Decreasing
GROSS ALPHA (15 pCi/L):	1	17.4 pCi/L	08/15/92	Outlier
GROSS BETA (50 pCi/L):	7	159 pCi/L	10/05/91	Decreasing

WELL GW-315

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1987, completed with a screened monitored interval from 90 to 104 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). Located at Spoil Area I, which is at the base of the northern (scarp) flank of Chestnut Ridge southwest of Y-12, the well is about 500 ft south of the headwaters channel of Bear Creek. Spoil Area I was used from 1980 to 1988 for disposal of construction spoil and related debris generated at Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 32 samples between March 1988 and September 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 54 ft bgs and exhibits seasonal fluctuations up to 19 ft. Wide fluctuations in groundwater elevations are characteristic of many wells on Chestnut Ridge. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of the well indicate northwesterly flow toward the headwaters channel of the Bear Creek.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the samples collected from the well indicate that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 425 – 650 mg/L;
- pH (field measurements) of 6.2 – 7.8;
- elevated sulfate concentrations (>e.g., 77.9 mg/L in February 2004) that are substantially higher than evident in groundwater at other wells completed at similar depths (and hydrogeologic zones) in the Maynardville Limestone, and are the likely source of the unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for the sample collected in December 1995 (RPD = -22.8%);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the unusually high sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, such as dissolution of locally disseminated sulfide minerals, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected since January 1991, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Each groundwater sample had nitrate above the analytical reporting limit (Table 1), including results for 16 samples that exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 700 ft directly north of Spoil Area I, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) than the deeper bedrock and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, nitrate concentrations reported for 16 groundwater samples exceed the MCL (Table 1), including the historical maximum value (34 mg/L in October 1991 and August 1992) and a result (16.8 mg/L in December 1995) considered qualitative because of the ion charge-balance error determined for the sample (see Section 4.0). Also, the nitrate data reflect apparently seasonal concentration fluctuations; the highest nitrate values (22.4 mg/L in July 1991, 34 mg/L in October 1991, 34.05 mg/L in August 1992) were reported for samples obtained during seasonally low groundwater flow conditions and the lowest nitrate values (2.24 mg/L in March 1997, 3 mg/L in January 1991, 3.3 mg/L in February 1994, and 3.4 mg/L in December 1995) were reported for samples obtained during seasonally high groundwater flow conditions. This relationship suggests seasonal (and episodic) "dilution" from uncontaminated (and/or less nitrate-contaminated) recharge via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of nitrate concentrations in the groundwater samples (excluding the qualitative result noted above) shows a generally decreasing long-term trend dominated by wide temporal (seasonal) concentration fluctuations (Figure 1). Also, the nitrate results obtained with the conventional sampling method seemingly exhibit greater temporal variability than the low-flow sampling results. This may be an artifact of the semiannual sampling frequency used for low-flow sampling (the bulk of the conventional sampling events were performed quarterly), but also may be related to inherent differences in the manner in which each sampling method induces inflow of groundwater into the well. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval.

5.2 URANIUM

All but four of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00289 mg/L in September 2000) being an order-of-magnitude below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): acetone, bromodichloromethane, chloroform, freon-113, PCE, TCE, and 12DCE (isomers). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone, as defined by individual or summed VOC concentrations above 5 μg/L, appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV. As with nitrate in the Maynardville Limestone, the VOC plume seems to be contiguous in the fracture-dominated flowpaths at depth in the bedrock, but discontinuous in the shallow karst network. Also, the distribution of VOCs within the plume reflects the relative contributions from multiple source areas and commingling during downgradient transport; Spoil Area I and the former S-3 Ponds are the suspected sources of the dissolved VOCs in the groundwater at this well (DOE 1997).

The primary VOC in the groundwater samples is PCE (Table 2); this compound was detected in every sample, with the historical maximum concentration of 38 μg/L in January 1991. Also, the most recent sampling results show that the PCE concentrations remain slightly above the MCL (5 μg/L). Secondary compounds in the samples are TCE and 12DCE (c12DCE), one or both of which were detected in all of the samples collected to date (Table 2), with respective historical maximum concentrations of 15 μg/L and 32 μg/L in January 1991. The most recent sampling results show TCE concentrations slightly below the MCL (5 μg/L) and c12DCE concentrations substantially below the MCL (70 μg/L). Acetone, bromodichloromethane, chloroform, and freon-113 have been detected much more infrequently, with the bulk of the results being estimated values below 5 μg/L (Table 2).

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples shows a decreasing long-term concentration trend through August 2004 (Figure 2), which established a new historical low value for summed VOCs (11 μg/L) . As with the long-term trend for nitrate, the conventional sampling results show significant temporal (seasonal) changes in summed VOC concentrations, with a sequence of temporal peaks evident in July 1991 (43 μg/L), August 1992 (46 μg/L), August 1994 (51 μg/L), and June 1996 (56 μg/L) (i.e., seasonally low groundwater flow conditions). In contrast, the low-flow sampling results show lower and much less variable VOC concentrations, but it is not clear from the available data if this is an artifact of the change in groundwater sampling methods (see Section 5.1). In any case, the overall decrease in VOC concentrations suggests a corresponding reduction in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (17.4 pCi/L in August 1992) being slightly above the MCL for gross alpha activity (15 pCi/L). This result appears to be an outlier because all of the other gross alpha results are less than 10 pCi/L. Also, only four of the 27 samples collected since June 1993 had gross alpha activity above the MDA and CE and these results are all less than 3 pCi/L.

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), including seven samples with gross beta activity that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is believed to be Tc-99 based on the detection of this radionuclide (i.e., >MDA and CE) in the samples collected in February (101 pCi/L), June (194 pCi/L), August (114 pCi/L), and December 1994 (117 pCi/L). Note that these results are all less than the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. This radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

As shown on Table 1, all but one of the groundwater samples had gross beta activity above the MDA, with the highest values reported for samples collected in October 1991 (108 pCi/L) and October 1991 (159 pCi/L) and the lowest values reported for samples collected in January 1991 (8 pCi/L) and February 1994 (7 pCi/L). The gross beta results generally mirror the apparently seasonal fluctuations in nitrate concentrations (see Section 5.1), with the highest values evident during seasonally low groundwater flow and the lowest values evident during seasonally high groundwater flow.

A time-series plot of gross beta activity for groundwater samples shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 3). The overall decrease in gross beta activity is attributable to the reduced flux of Tc-99 from the former S-3 Ponds following closure of the site and installation of the low-permeability cap. Also, as with the long-term concentration trends for nitrate and summed VOCs, the gross beta results reported for samples obtained with the conventional sampling method exhibit substantially more temporal variability than the low-flow sampling results for gross beta activity (Figure 3).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-315: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
01/08/91	3	8.57
04/08/91	6	17.1
07/20/91	22.4	108.55
10/05/91	34	159
02/22/92	20	63.6
05/07/92	21.1	69.8
08/15/92	34.05	70.5
11/18/92	15	49.6
02/03/93	7.8	12.9
06/03/93	8.9	15.7
09/14/93	15	31.3
10/27/93	19.8	53.8
02/17/94	3.3	7.11
06/20/94	8.3	25.6
08/30/94	12	30.6
12/05/94	14	30
03/15/95	3.4	10.4
06/26/95	12	22.9
08/21/95	15	36.3
12/07/95	(16.8)	70
03/26/96	7.95	24.4
08/19/96	8.56	21.1
03/05/97	2.24	<MDA
09/16/97	11.4	25
03/02/98	9.33	30
08/27/98	7.84	21
03/16/99	8.04	30
08/30/99	9.785	31
02/28/00	9.06	31
09/05/00	8.73	34
01/29/01	10.7	35
07/31/01	11.1	47
02/13/02	7.84	27
07/30/02	7.77	38
02/05/03	7.12	25
08/06/03	6.04	30
02/18/04	6.24	13
08/02/04	6.51	30
MCL	**10**	**50***

Note: ( ) = Result considered qualitative because of ion charge-balance error; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-315: summary of VOC results

Date Sampled	Concentration (µg/L)			
	PCE	TCE	12DCE (Total)	c12DCE
01/08/91	38	15	32	NR
04/08/91	19	6	12	NR
07/20/91	20	9	14	NR
10/05/91	18	6	12	NR
02/22/92	17	10	.	NR
05/07/92	14	6	10	NR
08/15/92	20	11	14	NR
11/18/92	6	2 J	2 J	NR
02/03/93	8	4 J	5	NR
06/03/93	5	2 J	2 J	NR
09/14/93	10	5	7	NR
10/27/93	7	4	5	NR
02/17/94	11	6	9	NR
06/20/94	16	11	14	NR
08/30/94	23	11	14	NR
12/05/94	11	6	8	NR
03/15/95	15	8	9	NR
06/26/95	27	12	15	NR
08/21/95	26	11	15	NR
12/07/95	14	6	7	NR
03/26/96	9	.	3 J	NR
08/19/96	14	5	4 J	NR
03/05/97	14	6	4 J	4 J
09/16/97	19	7	5	5
03/02/98	12	6	5	5
08/27/98	11	5	3 J	3 J
03/16/99	14	6	3 J	3 J
08/30/99	13	6	3 J	3 J
02/28/00	13	6	3 J	3 J
09/05/00	10	5	3 J	3 J
01/29/01	11	5	2 J	2 J
07/31/01	10	5	2 J	2 J
02/13/02	9	5	2 J	2 J
07/30/02	11	4 J	2 J	2 J
02/05/03	10	5	2 J	2 J
08/06/03	13	5	2 J	2 J
02/18/04	8	4 J	1 J	1 J
08/02/04	8	3 J	.	.
MCL	**5**	**5**	**NA**	**70**

Table 2. (continued)

Date Sampled	Concentration (µg/L)		
	Chloroform	Bromodichloromethane	Other
01/08/91	.	.	.
04/08/91	.	.	.
07/20/91	.	.	.
10/05/91	.	.	.
02/22/92	.	.	.
05/07/92	.	.	.
08/15/92	0.7 J	.	.
11/18/92	11	4 J	.
02/03/93	7	2 J	.
06/03/93	9	2 J	.
09/14/93	8	2 J	.
10/27/93	6	1 J	.
02/17/94	6	1 J	.
06/20/94	2 J	.	.
08/30/94	3 J	.	.
12/05/94	2 J	.	.
03/15/95	1 J	.	.
06/26/95	2 J	.	.
08/21/95	2 J	.	.
12/07/95	2 J	.	.
03/26/96	1 J	.	.
08/19/96	1 J	.	.
03/05/97	.	.	.
09/16/97	FP	.	Acetone (47)
03/02/98	FP	.	.
08/27/98	.	.	.
03/16/99	.	.	.
08/30/99	.	.	.
02/28/00	.	.	.
09/05/00	.	.	.
01/29/01	.	.	.
07/31/01	.	.	.
02/13/02	.	.	.
07/30/02	.	.	.
02/05/03	.	.	.
08/06/03	.	.	.
02/18/04	.	.	Freon-113 (2 J)
08/02/04	.	.	
MCL	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; FP = False positive result; NA = Not applicable; NR = Not reported

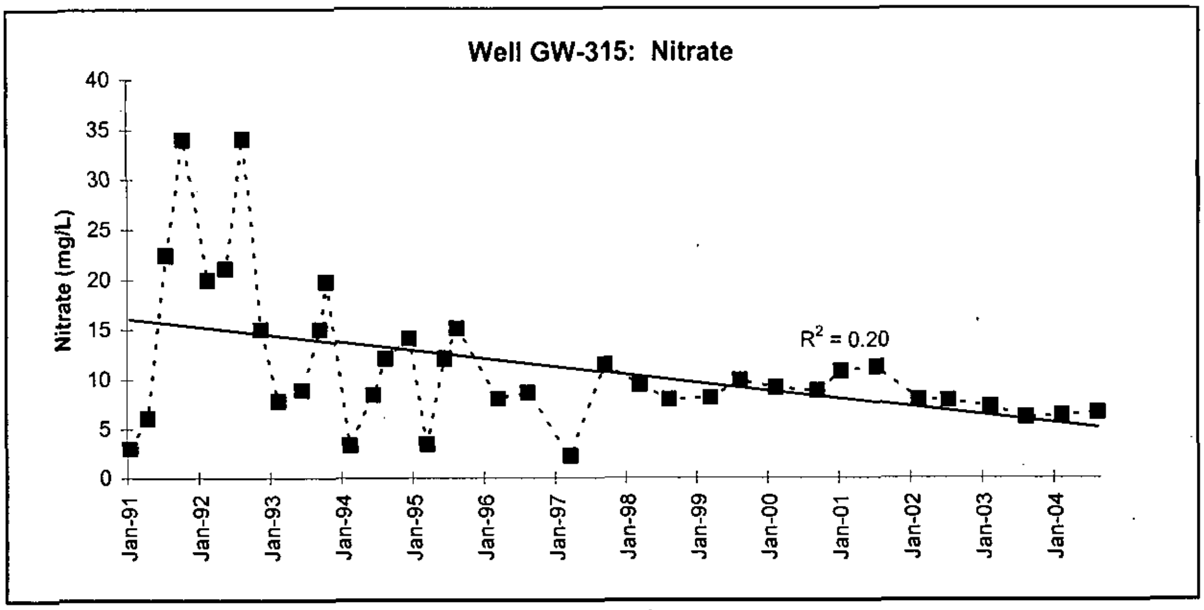


Figure 1

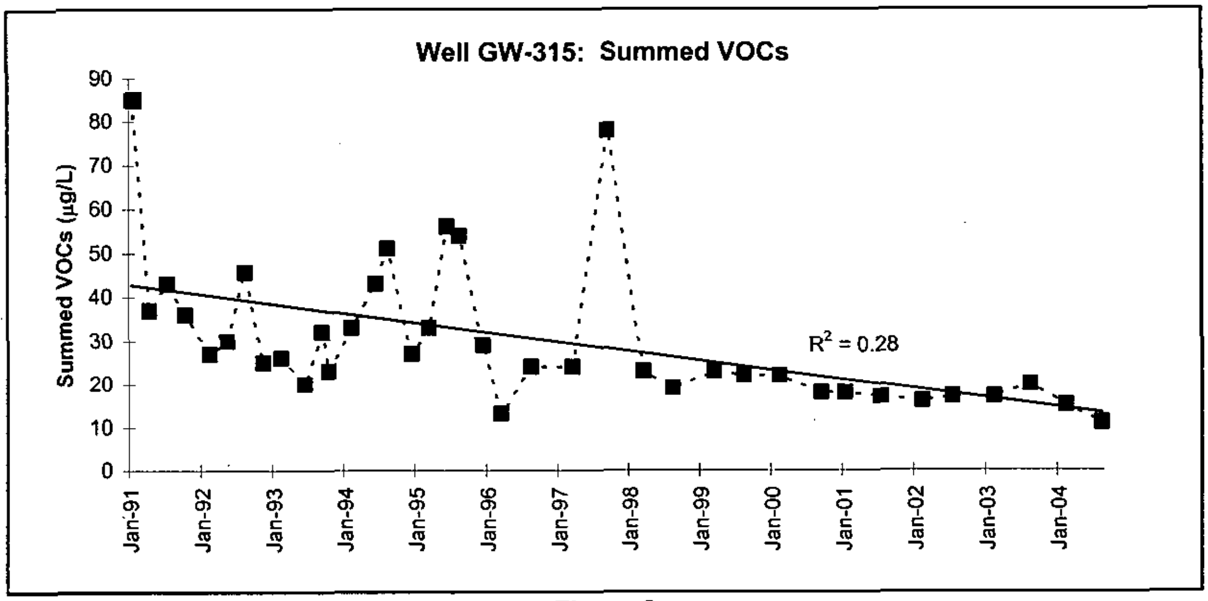


Figure 2

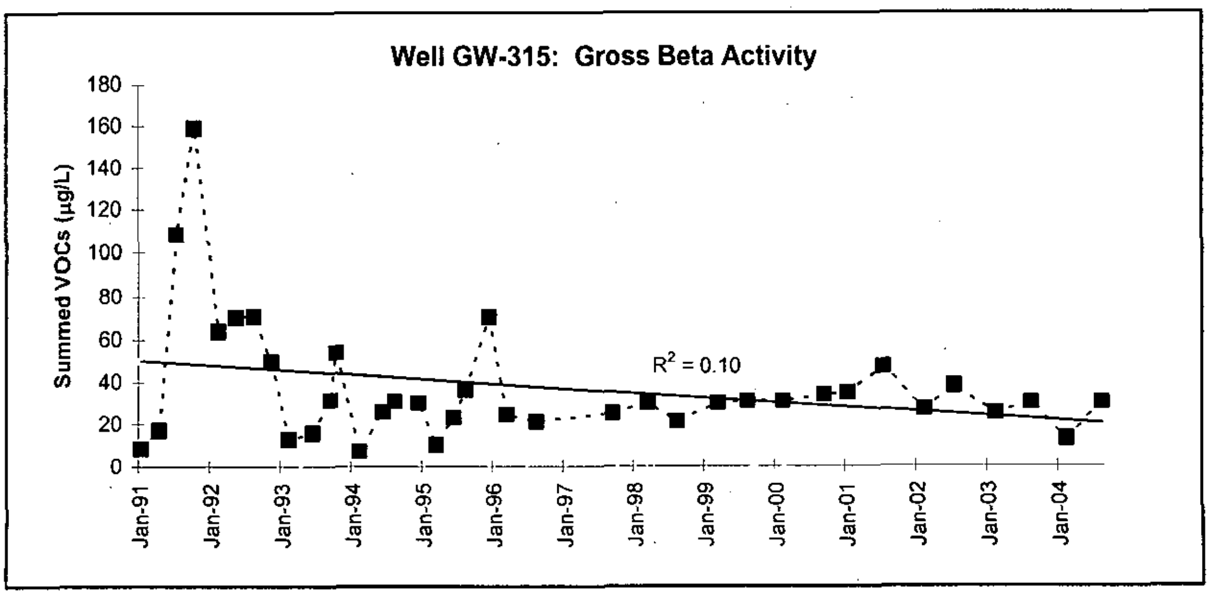


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	50 - 500	<7.5	ND

GW-322

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,912.05
Y-12 GRID NORTH COORDINATE: 28,240.69
SURFACE ELEVATION: 1,131.81 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/02/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 191.99 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,134.98 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	128.0	1003.81
BOTTOM (filter pack or open hole):	193.0	938.81
MIDPOINT (filter pack or open hole):	160.5	971.31
PUMP INTAKE:	182.33	949.48
WATER LEVEL (average):	150.50	981.31

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	22		
CONVENTIONAL SAMPLING METHOD:	19 samples	03/12/88	07/24/92
LOW-FLOW SAMPLING METHOD:	3 samples	01/12/98	10/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/13/04	.	10/11/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 27.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	10	680 µg/L	02/04/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-322

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1987, completed with an open-hole monitored interval from 128 to 193 ft bgs, and constructed with nominal 4.5-inch diameter steel riser casing. The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 100 ft south of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-two groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between March 1988 and July 1992, and the low-flow sampling method used to obtain samples in January 1998, May 2004, and October 2004.

Presampling depth-to-water measurements show that the static water level in the well exhibits substantial (>25 ft) temporal (seasonal) fluctuations (Figure 1). Similarly distinctive groundwater elevation fluctuations also are evident in other wells completed in the Knox Group on Chestnut Ridge, particularly wells located at or near the crest of the ridge, which is both a recharge area and a groundwater flow divide (Solomon et al. 1992).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 151 ft bgs and exhibits wide seasonal fluctuations (see Section 2.0). Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV; to the east along the axis of the ridge (toward well GW-322), parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 154 – 282 mg/L;
- pH of 7.2 – 8.0 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Four groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.5 mg/L in February 1991) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

One of the groundwater samples collected to date had a uranium concentration at the applicable analytical reporting limit and this result (0.001 mg/L in February 1991) is substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in at least one groundwater sample collected to date: 111TCA, 12DCA, 11DCA, PCE, 11DCE, TCE, ethylbenzene, TCFM, and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113 (F113). Of the VOCs, 111TCA, 11DCA, 11DCE, PCE, TCFM, and F113 are consistently detected and are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

Each groundwater sample collected to date contained 111TCA, 11DCA, and 11DCE, with PCE detected in all but three of the samples (Table 1). Relatively high concentrations of TCFM (34 - 54 μg/L) were detected in the three samples collected most recently, and F113 also was detected in the May and October 2004 samples (Table 1). The sample collected in January 1998 contained trace levels (<5 μg/L) of ethylbenzene and 12DCA, which are considered to be outliers. Historical data for 111TCA, 11DCA, and 11DCE show respective maximum values of 790 μg/L (August 1988), 160 μg/L (January 1998), and 170 μg/L (January 1998), with the most recent sampling results showing that the concentrations of 11DCE remain substantially above the drinking water MCL (7 μg/L). Conversely, much lower concentrations of PCE were detected in the samples, the historical maximum value being only 10 μg/L (January 1998), with the most recent sampling results showing concentrations slightly above the 5 μg/L MCL (Table 1). The dominance of 111TCA, 11DCA, and 11DCE in the groundwater at this well suggests that the monitored interval in the well intercepts some of the primary strike-parallel groundwater flow/contaminant transport pathways for VOCs that originate primarily from the western disposal trenches at the CRSP. Also, assuming that the eastern disposal trenches are the source of the PCE in the well, which is directly south of the eastern trench area, the relatively low levels of PCE in the groundwater at this well suggest there is only a minor cross-strike or down-dip component to the migration/transport of the VOCs from either disposal trench area.

As noted previously, some of the compounds in the CRSP VOC plume are present as a result of the degradation of related parent compounds. Abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), probably explains the frequent detection and relatively high concentrations of 11DCA and 11DCE in the groundwater at well GW-322. This is clearly illustrated by a time-series plot of the proportional distribution of 111TCA, 11DCA, and 11DCE concentrations detected in each groundwater sample collected to date (Figure 2), whereby a substantial decrease in the relative proportion of 111TCA is accompanied by a concurrent increase in combined proportion of 11DCA and 11DCE. In contrast, none of the groundwater samples collected to date contained PCE degradation products, particularly TCE and c12DCE, indicating that the monitored interval for the well does not intercept groundwater flow/transport pathways where biologically mediated degradation (reductive dechlorination) of PCE occurs.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample (excluding false positive results) shows a clearly decreasing long term trend that spans two large gaps in the sampling history for the well: July 1992 - January 1998 and January 1998 - May 2004 (Figure 3). Before the first sampling gap, the VOC data show a variable but decreasing trend following the historical maximum summed VOC concentration evident in August 1988 (1,025 μg/L), with a total reduction of about 48% through July 1992 (542 μg/L). The relatively rapid concentration decrease, which was probably a direct response to the substantially reduced flux of dissolved VOCs following the closure of the CRSP in 1988 and the installation of the low-permeability cap in 1989, suggests that the shallow source of VOCs has been isolated and the most highly contaminated groundwater has been flushed from the flow/transport pathways intercepted by the monitored interval (128-193 ft bgs) in the well. Although slightly higher summed VOC concentrations subsequently were evident in January 1998 (618 μg/L), the most recent data suggest a continued reduction of about 51% through October 2004 (303 μg/L). Note, however, that the overall downward trend in summed VOC concentrations encompasses: (1) a substantial decrease in the concentration of 111TCA, with the most recent sampling results establishing a historical minimum value (47 μg/L in May 2004) that is an order-of-magnitude lower than the historical maximum value (790 μg/L in August 1988); (2) a significant increase in the concentrations of 11DCA, with the concentration evident in October 2004 (110 μg/L) being about three times higher than the concentration evident in October 1988 (34 μg/L); (3) variable but relatively unchanged concentrations of 11DCE, as illustrated by the results reported for samples collected in August 1988 (93 μg/L), October 1990 (95 μg/L), and October 2004 (93 μg/L); and (4) no significant change in the relative concentrations of PCE, as illustrated by the equal PCE concentrations (6 μg/L) detected in the samples collected in June 1988, October 1991, and October 2004.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.61 pCi/L in October 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Ten groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.83 pCi/L in October 1991) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-322: summary of VOC results

Date Sampled	Concentration (μg/L)					
	111TCA	**11DCA**	**11DCE**	**PCE**	**TCFM**	**F113**
03/12/88	670	30	87	4 J	NR	NR
06/07/88	620	34	95	6	NR	NR
08/05/88	790	37	93	7	NR	NR
10/24/88	670	34	94	6	NR	NR
01/05/89	630	41	95	5	NR	NR
04/03/89	530	40	98	5	NR	NR
08/11/89	530	35	80	5	NR	NR
10/11/89	550	45	90	.	NR	NR
01/28/90	580	54	100	6	NR	NR
05/23/90	560	54	110	6	NR	NR
07/26/90	590	63	110	7	NR	NR
10/29/90	520	59	95	.	NR	NR
02/04/91	480	62	130	8	NR	NR
05/04/91	480	60	110	.	NR	NR
08/13/91	460	78	110	7	NR	NR
10/21/91	370	64	100	6	NR	NR
02/13/92	410	65	97	6	NR	NR
04/10/92	350	58	82	5	NR	NR
07/24/92	360	76	99	7	NR	NR
01/12/98	220	160	170	10	54	NR
05/13/04	47	96	77	6	34	5
10/11/04	51	110	93	6	38	5
MCL	**200**	**NA**	**7**	**5**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

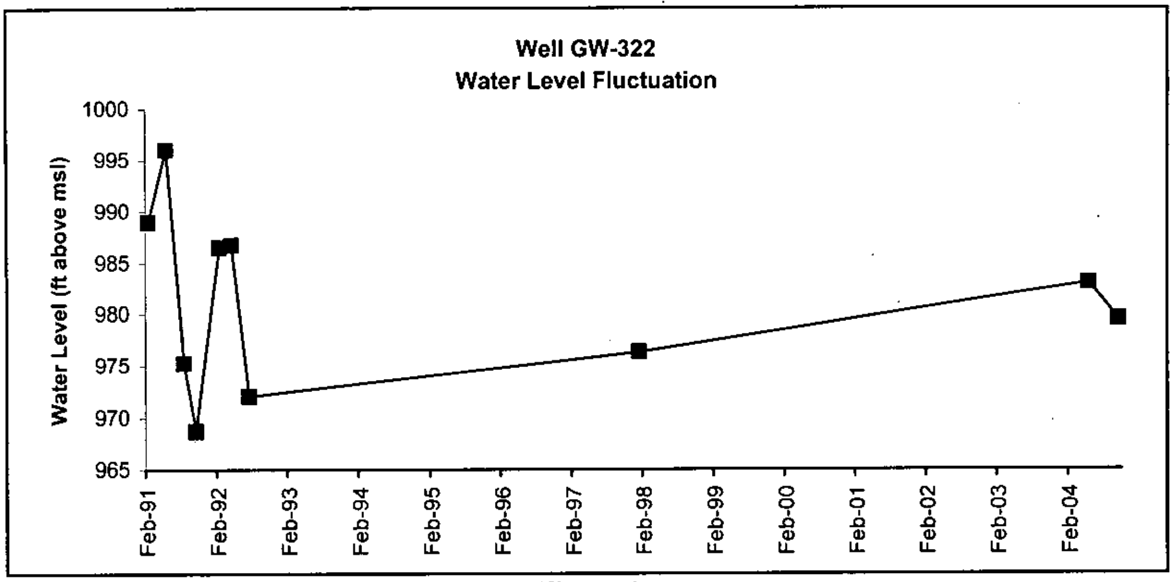


Figure 1

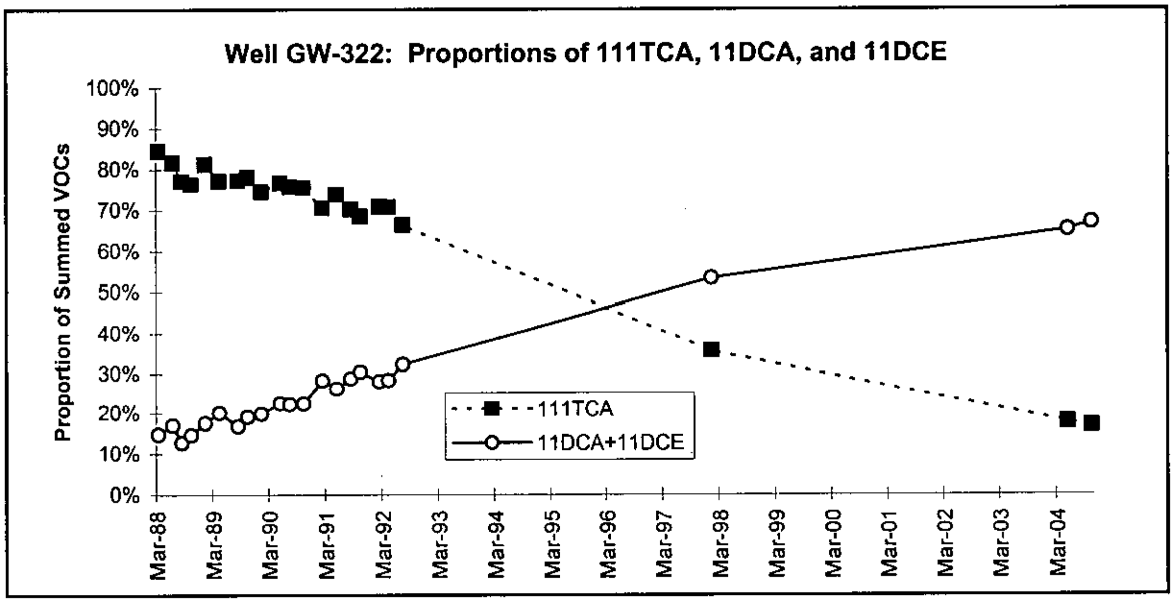


Figure 2

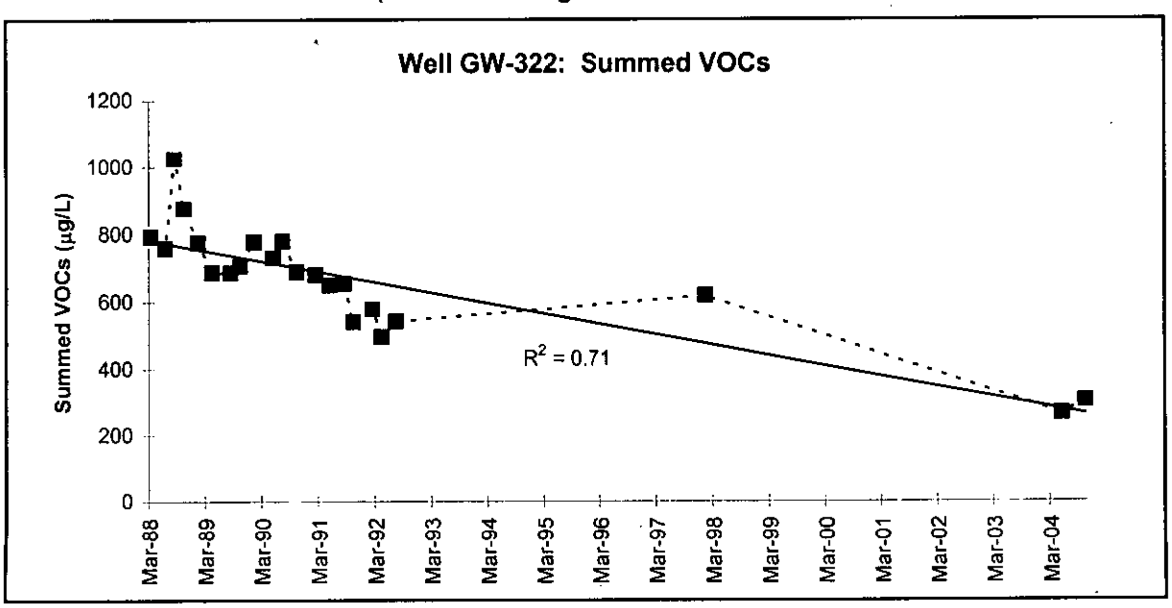


Figure 3

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	500 - 5,000	ND	ND

GW-336

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Waste Coolant Processing Area
Y-12 GRID EAST COORDINATE: 54,694.44
Y-12 GRID NORTH COORDINATE: 30,056.93
SURFACE ELEVATION: 981.56 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/06/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 23.93 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 985.92 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	13.2	968.36
BOTTOM (filter pack or open hole):	21.4	960.16
MIDPOINT (filter pack or open hole):	17.3	964.26
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	6.33	975.23

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	12		
CONVENTIONAL SAMPLING METHOD:	10 samples	05/25/89	03/13/97
LOW-FLOW SAMPLING METHOD:	2 samples	05/29/03	11/17/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/29/03	.	11/17/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.09 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	5	6,331 µg/L	04/14/91	Mixed
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-336

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during August 1987, completed with a screened monitored interval from 13.2 to 21.4 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) within the west-central section of Y-12, on the east side of the Waste Coolant Processing Area (WCPA), which includes: the Waste Coolant Storage Tanks (WCST), the Waste Coolant Biodegradation Facility (WCBF), and the Waste Coolant Processing Facility (WCPF). These facilities were used between 1977 and 1985 to handle and treat large volumes of waste machine coolants that contained very high levels (several thousand parts per million) total organic carbon, chlorinated hydrocarbons, and methyl ethyl ketone along with metals and depleted uranium (DOE 1998). In August 1988, the WCPA was clean-closed under RCRA, with closure-related wastes sent to the Interim Drum Yard at the west end of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twelve groundwater samples have been collected from the well, with the conventional sampling method used to obtain ten samples between May 1989 and March 1997 and the low-flow sampling method used to obtain samples in May and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-336 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the low-permeability formations of the Conasauga Group, including the Nolichucky Shale, exhibit strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 175 – 250 mg/L;
- pH of 5.7 – 6.4 (field measurements);

- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the analytical results for the five groundwater samples collected since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (3.6 mg/L in March 1997) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the sample collected in April 1991 (0.004 mg/L) exceeds the analytical reporting limit, and this result is substantially less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one or more of the following VOCs was detected in each groundwater sample (Table 1): methylene chloride (MC), PCE, TCE, trichlorofluoromethane (TCFM), VC, 11DCA, 11DCE, 12DCE (c12DCE and t12DCE), and 111TCA. These compounds are components of a plume of dissolved VOCs in the groundwater emplaced during historical operation of the WCPA. Also, soluble compounds leached from contaminated soils in the vadose zone and dissolution of constituents from potential DNAPL below the saturated zone represent ongoing secondary sources of VOCs in the groundwater at this site (DOE 1998). The current network of monitoring wells does not indicate any strongly preferential groundwater flow/transport patterns in the vicinity of the WCPA, with generally eastward (parallel with geologic strike) transport/migration of the mobile components of the VOC plume suggested by the presence of "signature" VOCs in storm drains to the east of the site and in basements sumps in Bldg. 9204-4 and Bldg. 9201-5 (DOE 1998).

The dominant VOCs in the groundwater samples are c12DCE, PCE and TCE, which have historical maximum concentrations above 500 μg/L (Table 1). Note that the historical minimum concentrations of PCE and TCE were reported for the sample collected in May 2003 (270 μg/L and 370 μg/L, respectively) and the historical maximum concentrations of PCE and TCE were reported for the sample collected in (November 2003 680 μg/L and 610 μg/L, respectively). Secondary VOCs in the samples are VC and 11DCE, each with historical maximum concentrations above 100 μg/L, and 11DCA and 111TCA, which have historical maximum concentrations below 100 μg/L. Other compounds have been detected infrequently, with MC and TCFM each detected in only one sample each, and at lower concentrations than evident for the primary and secondary VOCs (Table 1). Although the summed concentrations of dissolved VOCs detected in the groundwater samples are relatively high, the maximum concentrations of individual compounds (e.g., PCE) are not high enough (i.e., > 1% of pure-phase solubility) to suggest the presence of DNAPL in the subsurface near the well, which is located about 175 ft east of the WCPA. However, substantially higher concentrations of dissolved VOCs in the groundwater at a shallow well (GW-337) to the west suggest DNAPL in the subsurface near the WCST.

Some of the VOCs in the groundwater samples were probably major components of the waste coolants and oils handled and processed at the WCPA, whereas other compounds may be present as a consequence of the natural degradation of related parent compounds. For example, 11DCA may be present as a result of the abiotic degradation of 111TCA, which is the only major chlorinated hydrocarbon (solvent) that chemically degrades in groundwater (McCarty 1996). Likewise, c12DCE and VC may be present because of biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater. However, results for several indicator parameters, including the strongly positive REDOX values (Table 2), do not indicate the reducing (methanogenic) conditions necessary to transform parent compounds to DCE isomers (Chapelle 1996). Perhaps the monitored interval intercepts groundwater flow/transport pathways for dissolved VOCs transported from a source where conditions are better suited for biodegradation of chlorinated solvents (e.g., the biodegradation facility within the WCPA).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample spans two gaps in the sampling history (April 1991 – March 1997 and March 1997 – May 2003) and shows a clearly decreasing long-term trend (Figure 1). As shown by the data summarized in Table 1, the decreasing trend is primarily attributable to the substantial reduction (abut 50%) in the concentrations of 12DCE (Table 1). Although the samples collected since March 1997 were obtained with the low-flow sampling method, the lower VOC concentrations do not appear to be an artifact of change from the conventional sampling method. Also, the decreasing concentration trends are not evident for all of the VOCs in the samples (Table 1), as illustrated by the 11DCA concentrations evident in January 1991 (49 μg/L) and May 2003 (53 μg/L). Assuming a heterogeneous mixture of VOCs from common source(s), it is not clear why the concentrations of individual compounds exhibit divergent concentration trends or if the trends are significant with respect to the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in April 1991 and this result (3.77 pCi/L) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity).

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-336: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	**TCE**	**12DCE (Total)**	**c12DCE**	**t12DCE**
01/23/91	500	540	4,000	NR	NR
04/14/91	590	490	4,800	NR	NR
03/13/97	460	400	2,730	2,700	30
05/29/03	270	370	2,319	2,300	19
11/17/03	680	610	2,520	2,500	20
MCL	**5**	**5**	**NA**	**70**	**NA**
Date Sampled	**Concentration (µg/L)**				
	VC	**11DCE**	**11DCA**	**111TCA**	**OTHER**
01/23/91	160	240	49	91	MC (130)
04/14/91	130	210	43	68	.
03/13/97	64	140	77	58	.
05/29/03	32	99	53	29	TCFM (9)
11/17/03	42	100	58	29	.
MCL	**2**	**7**	**NA**	**200**	**.**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

Table 2. Well GW-336: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2003	November 2003
Nitrate < 1 mg/L	1.79	1.68
Iron (II) > 1 mg/L	0.0654*	<0.01*
Sulfate < 20 mg/L	8.78	9.16
Dissolved Oxygen < 0.5 ppm	1.55**	0.6**
REDOX < 50 mV	179**	198**
pH >5 and < 9 st. units	6.39**	6.27**

Note: *Results are for total iron; **Field measurement.

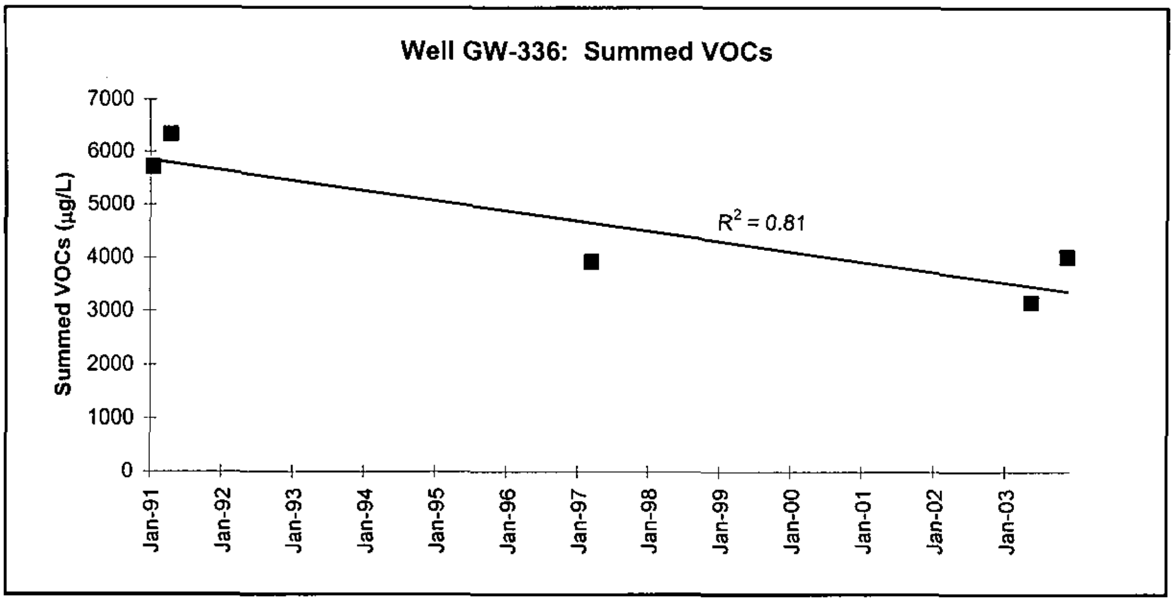

Well GW-336: Summed VOCs
Summed VOCs (µg/L)
7000
6000
5000
4000
3000
2000
1000
0
$R^2 = 0.81$
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03

Figure 1

MAXIMUM CONCENTRATION: 2003

ND	<0.015	>5,000	ND	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-337

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Waste Coolant Processing Area
Y-12 GRID EAST COORDINATE: 54,518.63
Y-12 GRID NORTH COORDINATE: 30,057.37
SURFACE ELEVATION: 984.12 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/12/87 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 25.33 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 987.48 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	15.0	969.12
BOTTOM (filter pack or open hole):	22.1	962.02
MIDPOINT (filter pack or open hole):	18.6	965.57
PUMP INTAKE:	16.81	967.31
WATER LEVEL (average):	7.52	976.60

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	32		
CONVENTIONAL SAMPLING METHOD:	25 samples	05/25/89	05/30/95
LOW-FLOW SAMPLING METHOD:	7 samples	07/01/98	11/17/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/29/03	.	11/17/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.03 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	25	16,940 µg/L	01/22/92	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-337

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during August 1987, completed with a screened monitored interval from 15 to 22.1 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) within the west-central section of Y-12 at the Waste Coolant Processing Area (WCPA), which includes: the Waste Coolant Storage Tanks (WCST), the Waste Coolant Biodegradation Facility (WCBF), and the Waste Coolant Processing Facility (WCPF). These facilities were used between 1977 and 1985 to handle and treat large volumes of waste machine coolants that contained very high levels (several thousand parts per million) total organic carbon, chlorinated hydrocarbons, and methyl ethyl ketone along with metals and depleted uranium (DOE 1998). In August 1988, the WCPA was clean-closed under RCRA, with closure-related wastes sent to the Interim Drum Yard at the west end of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-two groundwater samples have been collected from the well, with the conventional sampling method used to obtain 25 samples between May 1989 and March 1995 and the low-flow sampling method used to obtain seven samples between July 1998 and November 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7.5 ft bgs and exhibits minimal (<3 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-337 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the low-permeability formations of the Conasauga Group, including the Nolichucky Shale, exhibit strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 175 – 250 mg/L;
- pH of 6.2 – 7.1 (field measurements);

- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the analytical results for the 25 groundwater samples collected since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Only one groundwater sample had nitrate above the applicable analytical reporting limit, and this result (0.36 mg/L in December 1994) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-two groundwater samples had uranium concentrations at or above the analytical reporting limit, with the highest concentration (0.003 mg/L in August 1994) being an order-of-magnitude below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one or more of the following VOCs was detected in each groundwater sample (Table 1): acetone, benzene, ethylbenzene, methylene chloride, toluene, PCE, TCE, trichlorofluoromethane (TCFM), VC, xylenes, 11DCA, 11DCE, 12DCE (c12DCE and t12DCE), and 111TCA. These compounds are components of a plume of dissolved VOCs in the groundwater emplaced during historical operation of the WCPA. Also, soluble compounds leached from contaminated soils in the vadose zone and dissolution of constituents from potential DNAPL below the saturated zone represents ongoing secondary sources of VOCs in the groundwater at this site (DOE 1998). The current network of monitoring wells does not indicate any strongly preferential groundwater flow/transport patterns in the vicinity of the WCPA, with generally eastward (parallel with geologic strike) transport/migration of the mobile components of the VOC plume suggested by the presence of "signature" VOCs in storm drains to the east of the site and in basements sumps in Bldg. 9204-4 and Bldg. 9201-5 (DOE 1998).

The dominant VOCs in the groundwater samples are 12DCE (c12DCE), with historical maximum concentrations above 10,000 μg/L, along with PCE and TCE, which both have historical maximum concentrations above 1,000 μg/L (Table 1). Secondary VOCs in the samples include VC, 11DCE, 11DCA, and 111TCA, which have historical maximum concentrations of 450 μg/L, 380 μg/L, 220 μg/L, and 500 μg/L respectively. Other compounds have been detected infrequently, with highest concentrations (>500 μg/L) reported for acetone and methylene chloride detected in several samples. The very high concentrations of dissolved VOCs in the groundwater samples from this well, which exceed 1% of pure-phase solubility for several compounds (e.g., PCE), suggest the presence of DNAPL near the well, which is located at the southeast corner of the WCST.

Some of the VOCs in the groundwater samples were probably major components of the machine coolants handled and processed at the WCPA, whereas other compounds may be present as a consequence of the natural degradation of related parent compounds. For example, 11DCA may be present as a result of the abiotic degradation of 111TCA, which is the only major chlorinated hydrocarbon (solvent) that chemically degrades in groundwater (McCarty 1996). Likewise, c12DCE and VC may be present because of biologically mediated degradation (sequential dechlorination) of PCE and TCE by anaerobic methanotropic organisms in the groundwater. However, results for several indicator parameters, including the strongly positive REDOX values (Table 2), do not indicate the reducing (methanogenic) conditions necessary to transform parent compounds to DCE isomers (Chapelle 1996). Perhaps the monitored interval intercepts groundwater flow/transport pathways for dissolved VOCs transported from a source located where geochemical conditions are better suited for biodegradation of chlorinated solvents (e.g., the biodegradation facility within the WCPA).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample spans two gaps in the sampling history (May 1995 – July 1998 and October 2000 - May 2003) and shows a clearly decreasing long-term trend (Figure 1). As shown by the data summarized in Table 1, the decreasing trend is primarily attributable to the substantial reduction (abut 70%) in the concentrations of 12DCE (Table 1). Although the samples collected since March 1997 were obtained with the low-flow sampling method, the lower VOC concentrations do not appear to be an artifact of change from the conventional sampling method. Also, the decreasing concentration trends are not evident for all of the VOCs in the samples (Table 1), as illustrated by the PCE concentrations evident in January 1991 (790 μg/L) and November 2003 (770 μg/L). Assuming a heterogeneous mixture of VOCs from common source(s), it is not clear why the concentrations of individual compounds exhibit divergent concentration trends or if the trends are significant with respect to the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (13.5 pCi/L in January 1993) being slightly below the MCL for gross alpha activity (15 pCi/L). However, the historical maximum value for gross alpha activity appears to be an outlier compared to the other results, which are all less than 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Fourteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (19.3 pCi/L in January 1993) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity).

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: <u>Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water</u>. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-337: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	t12DCE
01/23/91	790	1,400	13,000	NR	NR
04/14/91	870	1,100	11,000	NR	NR
07/14/91	930	1,300	11,000	NR	NR
10/04/91	960	1,200	12,000	NR	NR
01/22/92	1,100	1,400	13,000	NR	NR
04/22/92	810	1,100	10,000	NR	NR
08/01/92	1,000	1,200	10,000	NR	NR
10/20/92	860	1,100	10,000	NR	NR
01/21/93	870	960	9,300	NR	NR
05/07/93	760	980	8,200	NR	NR
09/17/93	760	1,000	8,100	NR	NR
12/09/93	910	1,000	8,400	NR	NR
02/08/94	830	920	7,600	NR	NR
05/10/94	910	1,000	7,100	NR	NR
08/25/94	890	920	6,700	NR	NR
12/08/94	890	1,000	7,200	NR	NR
03/02/95	980	1100	7,900	NR	NR
05/30/95	790	870	5,700	NR	NR
07/01/98	720	760	5,100	NR	NR
08/20/98	460	590	4,100	NR	NR
09/02/99	940	1,000	5,700	5,600	57
05/23/00	590	720	3,700	3,700	40
10/19/00	860	940	5,000	4,900	59
05/29/03	640	800	4,400	4,400	38
11/17/03	770	750	3,500	3,500	46
MCL	**5**	**5**	**NA**	**70**	**NA**

Table 1. (continued)

Date Sampled	Concentration (µg/L)			
	VC	11DCE	11DCA	111TCA
01/23/91	450	300	210	500
04/14/91	.	.	190	430
07/14/91	310	280	190	430
10/04/91	.	240	.	340
01/22/92	350	380	220	490
04/22/92	190	.	160	360
08/01/92	250	360	200	480
10/20/92	260	250	180	300
01/21/93	340	230	190	360
05/07/93	280	210	170	360
09/17/93	230	210	160	360
12/09/93	170	230	170	330
02/08/94	280	200	160	270
05/10/94	.	.	.	280
08/25/94	.	170	150	290
12/08/94	.	180	170	310
03/02/95	130	210	200	410
05/30/95	.	170	150	290
07/01/98	.	170	150	220
08/20/98	92	130	140	200
09/02/99	66	130	130	180
05/23/00	46	110	96	140
10/19/00	63	160	140	190
05/29/03	35	110	88	120
11/17/03	46	120	98	100
MCL	**2**	**7**	**NA**	**200**

Table 1. (continued)

Date Sampled	Concentration (µg/L)		
	Acetone	**Methylene Chloride**	**OTHER**
01/23/91	.	220	.
04/14/91	.	.	.
07/14/91	.	1,600	.
10/04/91	.	.	Toluene (72)
01/22/92	.	FP	.
04/22/92	.	.	.
08/01/92	700	120	Ethylbenzene (140), Xylene (110)
10/20/92	410	.	.
01/21/93	.	.	.
05/07/93	.	60	.
09/17/93	.	.	.
12/09/93	240	110	.
02/08/94	.	.	.
05/10/94	.	.	.
08/25/94	.	.	.
12/08/94	.	.	.
03/02/95	500	98	.
05/30/95	.	.	.
07/01/98	.	.	.
08/20/98	.	.	.
09/02/99	19	.	.
05/23/00	20	.	TCFM (8)
10/19/00	.	.	TCFM (9)
05/29/03	.	.	TCFM (6)
11/17/03	.	.	.
MCL	**NA**	**NA**	.

Note: "." = Note detected; NA = Not applicable; NR = Not reported; FP = False positive

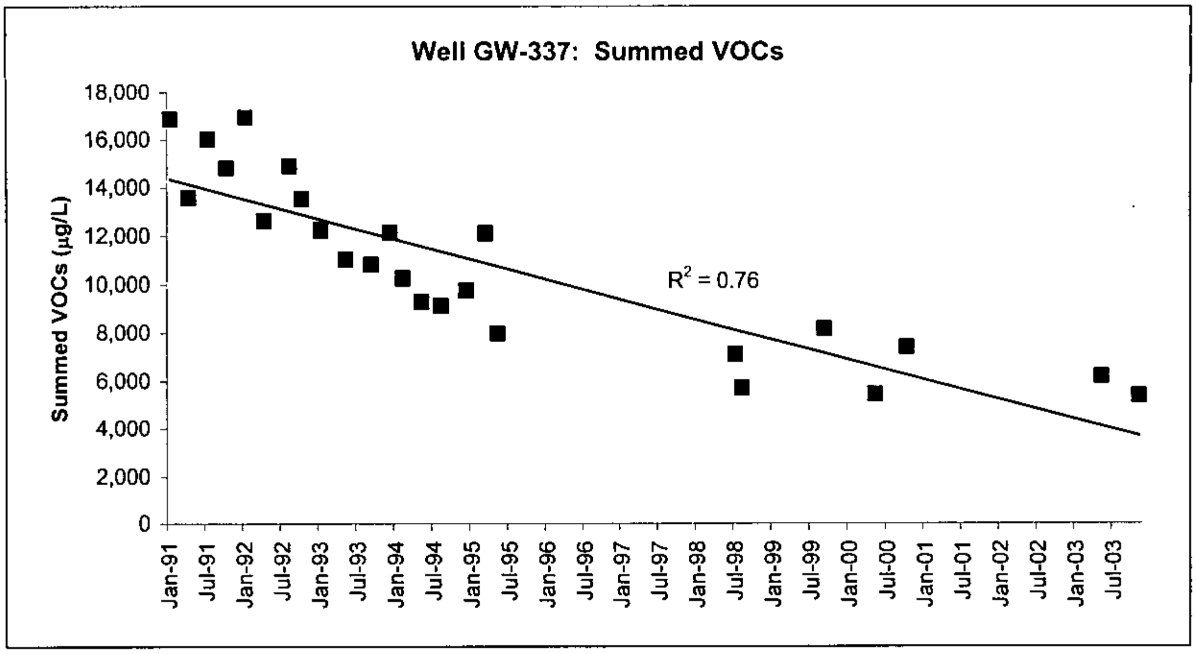

Well GW-337: Summed VOCs
Summed VOCs (µg/L)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
R^2 = 0.76
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03

Figure 1

MAXIMUM CONCENTRATION: 2003

<5	ND	.	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-339

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: United Nuclear Corporation Site
Y-12 GRID EAST COORDINATE: 54,146.52
Y-12 GRID NORTH COORDINATE: 28,658.72
SURFACE ELEVATION: 1,122.18 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/04/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 116.92 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,124.83 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	101.0	1021.18
BOTTOM (filter pack or open hole):	114.0	1008.18
MIDPOINT (filter pack or open hole):	107.5	1014.68
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	70.14	1052.04

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	26 samples	05/15/90	04/15/97
LOW-FLOW SAMPLING METHOD:	12 samples	11/11/97	08/11/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	02/03/03	.	08/11/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 26.45 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-339

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1989, completed with a screened monitored interval from 101 to 114 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge south of Y-12, about 100 ft north (hydraulically downgradient) of the United Nuclear Corporation Site (UNCS). The UNCS is a closed facility that was used for the disposal of cement-fixed sludge and radiologically-contaminated soils and demolition debris. A multilayer low-permeability cap was installed at the site in 1992 in accordance with the CERCLA ROD signed in 1991 (DOE 1991).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 26 samples between May 1990 and April 1997, and the low-flow sampling method used to obtain 12 samples between November 1997 and August 2003.

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium and nickel that are most likely attributable to chemical and/or microbiologically-induced corrosion of the stainless steel well casing and/or screen (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group. The average static groundwater level in the well is 70 ft below ground surface. Presampling depth-to-water measurements for the well indicate substantial (>25 ft) water-level fluctuations (Figure 1).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6. 9 – 8.4;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except chromium and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Chloride concentrations above 20 mg/L and sodium levels above 10 mg/L are characteristic of the groundwater samples from the well. Elevated concentrations of these ions may reflect recharge of surface water containing dissolved salt used to de-ice the South Patrol Road. Similarly elevated levels of chloride and sodium also are evident in other wells at the UNCS (1090 and GW-302) that are accessed via this paved road, whereas much lower chloride and sodium concentrations are evident in the wells at the site that are accessed via a gravel road (GW-203, GW-205, and GW-221). In either case, the elevated chloride levels may play a role in maintaining the elevated chromium and nickel concentrations in the samples from the well (see Section 5.6) because chloride may combine with available metal cations to form soluble complexes that may not readily partition to mineral surfaces in the subsurface (McLean and Bledsoe 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 35 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-two groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2.8 mg/L) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.002 mg/L and 0.001 mg/L) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Twenty-one groundwater samples were analyzed for VOCs and the analytical results for 19 samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Chestnut Ridge Regime. Low (estimated) concentrations of chloroform were detected in the samples collected in April 1991 (2 µg/L), July 1991 (0.9 µg/L), July 1993 (0.6 µg/L), and July 1994 (0.7µg/L).

5.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.91 pCi/L) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (38.79 pCi/L) being below the SDWA screening level for gross beta activity (50 pCi/L).

5.6 OTHER

Groundwater samples collected from the well since January 1991 contained total nickel concentrations above the respective analytical reporting limit. As shown in Table 1, almost all of these results exceed the background level (UTL) in the Knox Aquifer, with 13 of the results exceeding the MCL, including the nickel concentrations reported for each of the samples obtained with the low-flow sampling method. These results also show that total chromium concentrations in the well sporadically exceed the background UTL, but only one result exceeds the MCL. The following considerations suggest that elevated concentrations of nickel and chromium in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel (Type 304) riser casing and well screen: (1) mobile species of these metals are not typically present in groundwater with the neutral pH evident in the well; (2) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); (3) groundwater in the well exhibits geochemical conditions that may be corrosive to Type 304 stainless steel (e.g., dissolved oxygen >2 mg/L; Driscoll 1986); (4) as noted in Section 4.0, elevated chloride levels in the groundwater may greatly limit the partitioning of nickel and chromium ions in the well.

Table 1. Chromium and nickel results for well GW-339

Sampling Method and Date	Total Concentration (mg/L)	
	Nickel UTL = 0.020 MCL = 0.10	Chromium UTL = 0.029 MCL = 0.10
Conventional Sampling		
01/13/91	0.024	<0.01
04/13/91	0.028	<0.01
07/30/91	0.043	0.021
10/06/91	0.015	0.011
02/02/92	**0.14**	<0.01
05/04/92	0.028	0.03
07/31/92	0.058	0.025
10/18/92	0.032	0.014
01/19/93	0.017	<0.01
05/13/93	0.052	0.049
07/27/93	**0.15**	0.022
10/09/93	**0.13**	<0.01
01/11/94	0.06	0.022
04/08/94	0.053	0.025
07/27/94	0.064	0.093
10/15/94	0.075	0.047
04/19/95	0.059	<0.01
10/08/95	**0.43**	0.068
04/22/96	0.063	<0.01
10/29/96	0.087	**0.12**
04/15/97	0.055	0.033
Low-Flow Sampling		
02/04/99	**0.31**	0.0181
08/11/99	**0.322**	<0.005
02/23/00	**0.184**	0.0058
08/14/00	**0.246**	0.0097
01/30/01	**0.222**	0.0065
07/26/01	**0.221**	0.0106
01/29/02	**0.161**	<0.005
07/30/02	**0.2**	0.0117
02/03/03	**0.226**	0.0072
Note: Bold typeface denotes results that exceed the MCL.		

In addition to the considerations listed above, results of microbiological sampling of selected Knox Group wells in February 2000 support the possibility of microbiologically induced corrosion (MIC) of the stainless steel riser casing and screen as a potential source of the elevated nickel and chromium concentrations in the groundwater from the well. The microbiological sampling targeted four wells with stainless steel riser casing and screen, including an upgradient/background well (GW-521) and three wells where corrosion is suspected (GW-302, GW-305, and GW-339), and one well with PVC riser casing and screen (GW-203). Qualitative bacterial counts, estimated from the appearance of each groundwater sample after an eight- to nine-day growth period, provided data regarding the relative degree of mmicrobial activity in the groundwater at each well (AJA 2001). As shown in Table 2, the microbiological sampling results indicate: (1) microbial activity in the groundwater samples from each well where corrosion is suspected; (2) negligible microbial activity in the groundwater sample from the upgradient background well; and (3) high bacterial counts for the sample from well GW-203, which has PVC well casing and screen and does not yield groundwater samples with elevated chromium or nickel concentrations.

Table 2. February 2000 Microbiological Sampling Results

Well	Riser/Screen Material	Indication of Corrosion?	Maximum Bacterial Count (colony forming units per milliliter)		
			Iron-Related	Slime-Forming	Sulfate-Reducing
GW-203	PVC	No	5,000	50,000	<100
GW-302	Stainless steel	Yes	<100,000	<50,000	<100
GW-305	Stainless Steel	Yes	5,000	500,000	100
GW-339	Stainless steel	Yes	5,000	50,000	<100
GW-521	Stainless steel	No	<100	<100	<100
Note: Modified from (AJA 2001).					

Iron-related bacteria and slime-forming bacteria have been documented to cause MIC of stainless steel (Sarouhan et al. 1998).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Y-12 Groundwater Protection Program Calendar Year 2000 Groundwater Data Evaluation Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/SUB/01-006512/3, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*, EPA/540/S-92/018, U.S. Environmental Protection Agency, Office of Research and Development.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

U.S. Department of Energy (DOE) 1991. *United Nuclear Corporation Record of Decision.* IRC No. 910704.0092, Office of Environmental Protection, Oak Ridge, TN.

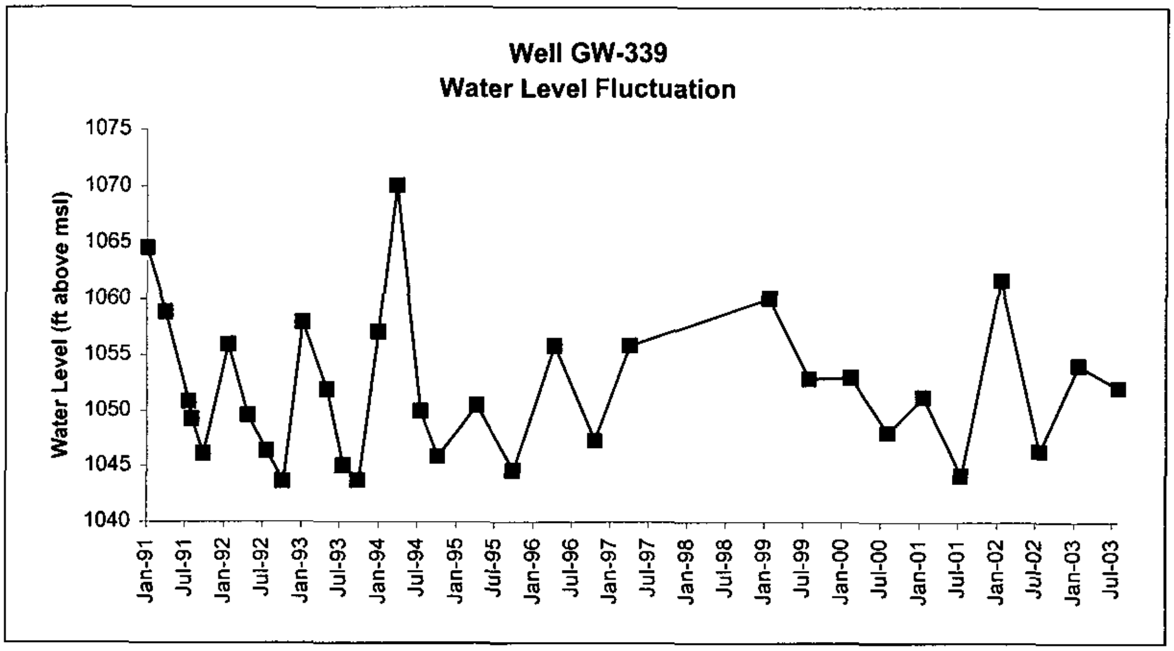

Well GW-339
Water Level Fluctuation
Water Level (ft above msl)
1075
1070
1065
1060
1055
1050
1045
1040
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03

Figure 1

MAXIMUM CONCENTRATION: 2005

100 - 1,000	<0.015	<5	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-346

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 50,703.01
Y-12 GRID NORTH COORDINATE: 30,029.99
SURFACE ELEVATION: 995.08 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/07/88 PAIRED/CLUSTERED WITH: GW-345 GW-526
TAG DEPTH (measured): 68.13 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 995.82 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	51.5	943.58
BOTTOM (filter pack or open hole):	64.9	930.18
MIDPOINT (filter pack or open hole):	58.2	936.88
PUMP INTAKE:	60.3	934.82
WATER LEVEL (average):	16.65	978.43

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	11		
CONVENTIONAL SAMPLING METHOD:	8 samples	09/28/88	08/31/95
LOW-FLOW SAMPLING METHOD:	3 samples	03/09/99	10/20/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	.	06/22/05	.	10/20/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.21 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	3	872 mg/L	10/20/05	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-346

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during June 1988, completed with a screened monitored interval from 51.5 to 64.9 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with wells GW-345 and GW-526 and is located in Bear Creek Valley (BCV) west of Y-12, about 1,300 ft west-southwest of the former S-3 Ponds (hereafter referenced as the S-3 Site). Located near the western end of Y-12, directly north of the headwaters of Bear Creek, the S-3 Site encompasses four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eleven groundwater samples have been collected from the well, with the conventional sampling method used to obtain eight samples between September 1988 and August 1995 and the low-flow sampling method used to obtain three samples between March 1999 and October 2005. The sampling history includes a quarterly sampling frequency, followed by 5-year (January 1990 – August 1995), 4-year (August 1995 – March 1999), and 6-year (March 1999 – June 2005) periods when no groundwater samples were collected from the well.

High total dissolved solids (TDS) is a distinguishing characteristics of the groundwater samples from this well (see Section 4.0), and is a direct consequence of contamination resulting from historical operation of the former S-3 Site.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º - 55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. The bulk of the groundwater flow in the Nolichucky Shale occurs in a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock). Also, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek; well GW-346 is located on the west side of the tributary (NT-1) closest to the headwaters. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of about 16.5 ft bgs and exhibits seasonal fluctuations up to 6 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-346 are typically lower than evident in wells GW-345 and GW-526, which are completed at shallower (GW-345 = 26 ft) and greater (GW-526 = 123 ft bgs) depths in the Nolichucky Shale. Based on the distance between the monitored interval midpoint in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.06 – 0.13) from the deeper bedrock (GW-526) to the shallow bedrock interval (GW-346) and downward vertical gradients (0.03 – 0.1) from the water table interval (GW-345) to the shallow bedrock interval during seasonally high and low flow conditions.

As indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, groundwater near the well flows primarily southwest toward the Maynardville Limestone and the main channel of Bear Creek. However, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 4,400 – 5,316 mg/L;
- pH of 7.05 – 7.2 (field measurements);
- high concentrations calcium (>650 mg/L), magnesium (>200 mg/L), sodium (>100 mg/L), and nitrate (>750 mg/L);
- low molar proportions of chloride, potassium, and sulfate (<5% of total anions/cations);
- high concentrations of barium (>2 mg/L) and strontium (>20 mg/L); and
- total concentrations of trace metals (except barium and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Note that some of the inorganic compounds and trace metals in the groundwater at this well, such as nitrate, were entrained in the acidic wastes disposed at the S-3 Site, whereas other inorganics, such as barium, were dissolved from bedrock minerals by the highly acidic seepage from the site. Also, the high levels of TDS may cause analytical interferences for some laboratory analytes, including gross alpha activity and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected to date, nitrate is the principal contaminant present in the groundwater at this well. Note, however, that the bulk of the historical the analytical results for VOCs, gross alpha activity, and gross beta activity do not meet all applicable DQOs. The QA/QC sample data needed to identify false positive VOC results are not available for groundwater samples collected before January 1991. Similarly, gross alpha activity and gross beta activity reported for the groundwater samples collected before January 1990 are considered unusable because the sample-specific MDA and CE are not available for these analytes.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical detection limit and all of these results are at least an order-of-magnitude higher than the drinking water MCL for nitrate (10 mg/L). Nitrate is the principal component of the contaminant plume emplaced during historical operations of the site, is chemically stable and mobile in groundwater, and is believed to effectively trace the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997). The extent of elevated nitrate concentrations (>10 mg/L) in the shallow groundwater west of the Nolichucky Shale indicate primarily westward transport/migration toward discharge areas in the northern tributaries of Bear Creek (NT-1 and NT-2), with the sampling results for this well demonstrating that the nitrate plume in the shallow groundwater flow system extends west of NT-1.

The highest nitrate concentrations were reported for the groundwater samples collected in September 1988 (1,100 mg/L), November 1988 (4,380 mg/L), and March 1999 (1,005 mg/L), but all of these results are considered qualitative. The ion charge balance error (i.e., the percent difference between respective summed milliequivalent concentrations of the major cations and anions) determined for these samples exceeds 20% (80.8% in September 1988, -60.3% in November 1988, and -42.1 % in March 1999). Unlike the nitrate concentrations evident in groundwater from wells completed at similarly shallow depths in the Nolichucky Shale, the nitrate results do not exhibit any clear relationship with seasonal groundwater flow conditions. This suggests that the monitored interval in the well does not intercept highly permeable groundwater flow/transport pathways. Note also that the most recent sampling results for the well (750-872 mg/L) are lower than the nitrate concentrations (1,290-1,400 mg/L) in groundwater samples collected during CY 2005 from well GW-526, a deeper well (123 ft bgs) clustered with well GW-346 (see Section 3.0).

Excluding the qualitative nitrate results noted above, a time series plot of the nitrate concentrations detected in the groundwater samples collected to date (Figure 1) shows an indeterminate long term trend, encompassing a decreasing trend between February (1,000 mg/L) and September 1989 (806 mg/L) and a fairly steady trend through October 2005 (872 mg/L). The most recent sampling results suggesting a slight concentration decrease, with a new minimum value (750 mg/L) reported for the sample collected in March 2005. The relatively high nitrate concentrations indicated by the most recent sampling results suggest that the closure/capping of the S-3 Site has not (yet) impacted the overall flux of nitrate via the groundwater flow/transport pathways at depth in the Nolichucky Shale along geologic strike to the west of the site.

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the highest value (0.011 mg/L in November 1988) being below the MCL for uranium (0.03 mg/L). However, this maximum value is an order of magnitude higher than all other results and is a suspected outlier. Considering the relatively high nitrate concentrations in the groundwater from this well, the low levels of uranium seems conspicuous, especially because, as noted previously, uranium was entrained in the wastewaters disposed at the S-3 Site. Uranium in the acidic seepage from the site probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium are generally restricted to the acidic groundwater in the Nolichucky Shale within approximately 500 ft of the site (DOE 1987).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in four of the groundwater sample collected to date, and all but one of these results are estimated concentrations (3 µg/L) for common laboratory reagents (e.g., acetone). Only a trace of benzene (1 µg/L in October 2005) has been detected in samples collected since January 1991, and the other results are most likely analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

As noted in Section 5.0, only the gross alpha activity reported for the five groundwater samples since January 1990 meet applicable DQOs, and these results are considered qualitative because of inherent analytical interferences associated with the very high TDS levels in the samples (Section 4.0). None of the groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE (Table 1). Low (background) levels of gross alpha activity in the groundwater from this well are supported by the similarly low levels of U-234 and U-238 reported for the samples collected in June (U-234 = 1.4 pCi/L and U-238 = 0.64 pCi/L) and October 2005 (U-234 = 2.1 pCi/L and U-238= 1 pCi/L). Uranium isotopes were entrained in the wastewater disposed at the S-3 Site and are the primary alpha particle-emitting radionuclides in the contaminant plume emplaced during historical operation of the site (DOE 1997). However, as with the total uranium concentrations in the groundwater from this well, the low levels of uranium isotopes reflect greater attenuation outside the acidic groundwater typically encountered at shallow depths in the Nolichucky Shale within approximately 500 ft of the site.

5.5 GROSS BETA ACTIVITY

As with gross alpha activity, five of the analytical results for gross beta activity reported for the groundwater samples collected to date meet DQOs and recent sampling results are considered qualitative because of analytical interferences associated with the high TDS of the groundwater samples. One groundwater sample collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE (Table 1), with that value (34.7 pCi/L in August 1995) is less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

The low levels of gross beta activity in the groundwater collected to date are supported by the analytical results for Tc-99 reported for the samples collected in June and October 2005 (19 pCi/L and 24 pCi/L, respectively). A beta particle-emitting radionuclide, Tc-99 is a “signature” component of the contaminant plume emplaced during historical operation of the S-3 Site, which is the only site at Y-12 known to have received significant volumes of waste that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the shallow groundwater flow system in the Nolichucky Shale downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater. Thus, it is not clear from the available data why Tc-99 is not present at similarly high concentrations in the groundwater from this well.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-346: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	Total Uranium	Gross Alpha	Gross Beta	Tc-99	U-234	U-238
09/28/88	[1,100]	0.001	DQO	DQO	.	.	.
11/05/88	[4,380]	{0.011}	DQO	DQO	.	.	.
02/22/89	1,000	0.002	DQO	DQO	.	.	.
05/16/89	933	0.003	DQO	DQO	.	.	.
09/14/89	806	0.001	DQO	DQO	.	.	.
11/28/89	859	0.009	DQO	DQO	.	.	.
01/22/90	811	0.003	< CE	< CE	.	.	.
08/31/95	830	0.0033	< CE	34.7	.	.	.
03/09/99	[1,005]	0.003	<MDA	<MDA	.	.	.
06/22/05	750	0.00176	<MDA	<MDA	19	1.4	0.64
10/20/05	872	0.00345	<MDA	<MDA	24	2.1	1
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**

Note: "." = Not analyzed; [ ] = qualitative because of ion charge balance error; { } = suspected outlier; DQO = results do not meet DQOs; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent

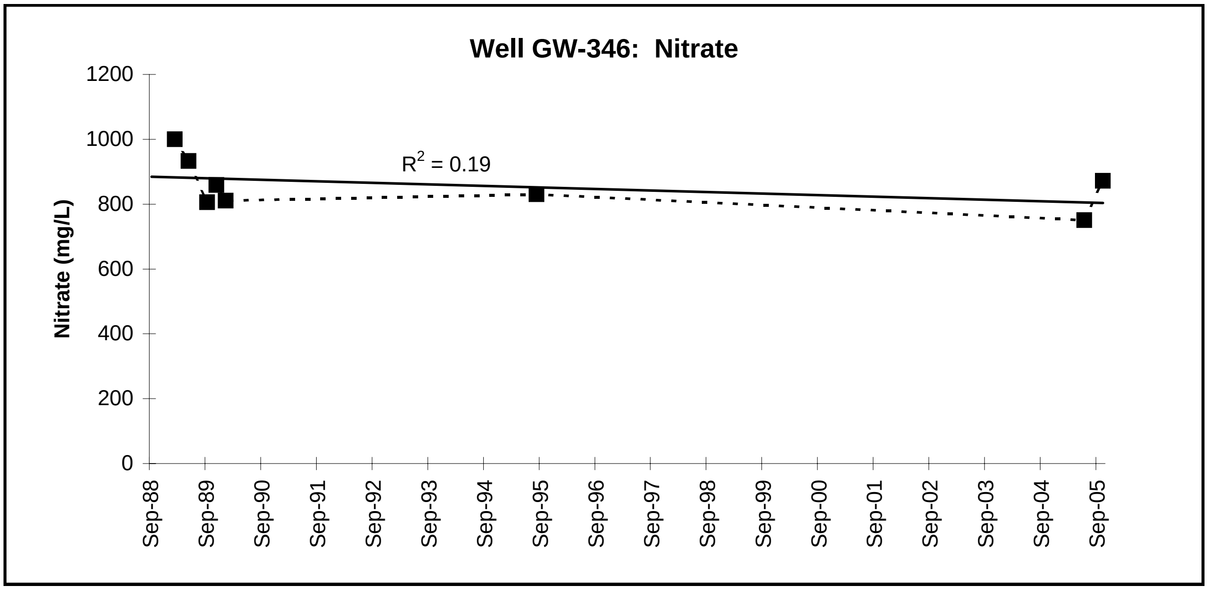

Well GW-346: Nitrate
Nitrate (mg/L)
1200
1000
800
600
400
200
0
R^2 = 0.19
Sep-88
Sep-89
Sep-90
Sep-91
Sep-92
Sep-93
Sep-94
Sep-95
Sep-96
Sep-97
Sep-98
Sep-99
Sep-00
Sep-01
Sep-02
Sep-03
Sep-04
Sep-05

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-363

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 46,871.80
Y-12 GRID NORTH COORDINATE: 29,961.35
SURFACE ELEVATION: 955.41 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/16/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 77.27 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 957.91 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	50.0	905.41
BOTTOM (filter pack or open hole):	75.0	880.41
MIDPOINT (filter pack or open hole):	62.5	892.91
PUMP INTAKE:	62.50	892.91
WATER LEVEL (average):	1.97	953.44

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	33			
CONVENTIONAL SAMPLING METHOD:	19	samples	09/21/88	08/14/97
LOW-FLOW SAMPLING METHOD:	14	samples	04/04/01	11/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/15/04	06/08/04	09/08/04	11/18/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	13 µg/L	02/12/96	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-363

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1988, completed with an open-hole monitored interval from 50 to 75 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley west of Y-12, near the northwest corner of the Oil Landfarm hazardous waste disposal unit. This site, which was used between 1972 and 1982 for the biological degradation of about one million gallons of waste oils and coolants generated at Y-12, is covered by a low-permeability multi-layer cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between September 1988 and August 1997, and the low-flow sampling method used to obtain 14 samples between April 2001 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 2 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 228 – 328 mg/L;
- pH (field measurements) of 7.7–9.9, excluding a suspected outlier (6.56 in December 2002);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 26 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Sixteen groundwater samples were analyzed for nitrate (between March 1994 and November 2001), and three of these samples had nitrate concentrations above the applicable analytical reporting limit. The highest nitrate concentration (0.39 mg/L in January 1995) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Seventeen groundwater samples were analyzed for uranium (between March 1994 and May 2003), and two of these samples had uranium concentrations above the applicable analytical reporting limit. The highest concentration (0.004 mg/L in May 1994) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples: acetone in February 1996 (13 µg/L) and November 2003 (0.4 µg/L); and toluene in November 2003 (0.1 µg/L) and June 2004 (0.2 µg/L). These VOCs are common laboratory reagents and the results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

None of the 17 groundwater samples analyzed for gross alpha activity (between March 1994 and May 2003) had results above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Two of the 17 groundwater samples analyzed for gross beta activity (between March 1994 and May 2003) had results above the applicable MDA and corresponding CE. The highest value (5.85 pCi/L in August 2001) is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

<5	<0.015	5 - 50	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-364

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 46,507.65
Y-12 GRID NORTH COORDINATE: 29,151.79
SURFACE ELEVATION: 933.39 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/04/88 PAIRED/CLUSTERED WITH: GW-365
TAG DEPTH (measured): 62.86 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 936.16 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	47.0	886.39
BOTTOM (filter pack or open hole):	60.3	873.09
MIDPOINT (filter pack or open hole):	53.7	879.74
PUMP INTAKE:	55.2	878.16
WATER LEVEL (average):	15.64	917.78

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	22 samples	09/22/88	12/18/93
LOW-FLOW SAMPLING METHOD:	4 samples	03/13/01	09/01/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/07/05	.	09/01/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.69 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS — **Results (since 1991) > Screening Level**

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	10.2 mg/L	09/19/93	Outlier
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	15	50 µg/L	09/08/92	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-364

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1988, completed with a screened monitored interval from 47 to 60 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is paired with well GW-365 and is located in Bear Creek Valley (BCV) south of the main channel of Bear Creek approximately 6,000 ft west of Y-12 and 500 ft west of the southwest corner of the Oil Landfarm waste management area (WMA). The Oil Landfarm WMA encompasses the following closed waste management facilities: the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 22 samples between September 1988 and December 1993, and the low-flow sampling method used to obtain four samples between March 2001 and September 2005. The sampling history includes a quarterly sampling frequency followed by 7-year (December 1993 – March 2001) and 4-year (August 2001 – March 2005) periods when no samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of approximately 16 ft bgs and exhibits maximum seasonal fluctuations up to approximately 18 ft. Also, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-364 are typically lower than those evident in well GW-365, which is completed at a greater depth (150 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint in each well (85 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.024–0.104) from the intermediate depth bedrock (GW-365) to the shallow bedrock interval (GW-364) during seasonally high and low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-364 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located downstream of a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 188 – 658 mg/L;
- pH of 6.9 – 8.2 (field measurements);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

As illustrated by the following summary of selected data from the most recent sampling events (March and September 2005), the geochemical characteristics of the groundwater in this well differ substantially from those of the deeper groundwater from well GW-365. The difference in groundwater geochemistry probably reflects the relative permeability of the flowpaths intercepted by the monitored interval in each well, whereby the lower TDS indicates shorter residence time for groundwater from well GW-364 as a consequence of the substantially higher permeability of the groundwater flowpaths at shallow depths in the Maynardville Limestone.

Well/Monitored Interval / Sampling Date	pH (st. units)	DO (ppm)	REDOX (mV)	TDS (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate (mg/L)
GW-364 (47-60 ft bgs)							
03/07/05	8.2	0.29	122	188	44.7	9.98	147
09/01/05	7.95	2.47	120	265	57.9	13.6	186
GW-365 (127-150 ft bgs)							
03/07/05	7.05	0.03	-140	604	146	39.3	443
09/01/05	7.16	1.95	-195	636	158	41.2	468

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All but one of the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum concentration (10.2 mg/L in September 1993) slightly exceeding the drinking water MCL for nitrate (10 mg/L). However, the historical maximum value is a suspected outlier compared to the other results for nitrate, none of which exceed 4 mg/L, with nitrate concentrations below 1 mg/L reported for all the samples collected since March 2001. Nevertheless, the elevated nitrate concentrations shown by the historical sampling results indicate that the monitored interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 5,500 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

5.2 URANIUM

All but four of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.009 mg/L in December 1992) being substantially below the MCL for uranium (0.03 mg/L). These results indicate that the monitored interval in the well does not intercept the primary groundwater transport pathways for uranium from the former BYBY. Hydraulically upgradient approximately 2,700 ft east-northeast of the well, the BYBY was identified during the CERCLA remedial investigation as the primary source of uranium in Maynardville Limestone hydraulically downgradient (west) of the Oil Landfarm WMA (DOE 1997). Uranium-bearing wastes in the subsurface at the BYBY were below the seasonally high water table and carbonate dissolved from the limestone bedrock combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility, considering the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area for uranium, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site (above the seasonally high water table); and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 1): CTET, chloroform, ethylbenzene, PCE, toluene, TCE, vinyl acetate, 2-hexanone, 11DCA, 11DCE, 12DCE, and 111TCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). There are several confirmed and suspected sources of VOCs In the upper part of BCV hydraulically upgradient (north and east) of the well, including Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, the Rust Spoil Area, and several potential sources within the Oil Landfarm WMA, including the Oil Landfarm, HCDA, and Sanitary Landfill I.

Based on frequency of detection and concentration magnitude, TCE and 12DCE (c12DCE) are the primary VOCs in the groundwater samples collected to date (Table 1). Both compounds were detected in all but three of the samples, with historical maximum concentrations of 26 µg/L and 12 µg/L respectively. Also, the most recent sampling results show that TCE concentrations remain near the drinking water MCL (5 µg/L), whereas c12DCE concentrations are substantially below the MCL (70 µg/L). Secondary compounds detected in the samples are 11DCA, 11DCE, and 111TCA, each of which were detected in all but five of the samples, although only 11DCE was detected in the samples collected most recently: this result (1 µg/L in September 2005) is less than the MCL for 11DCE (7 µg/L). Historical maximum concentrations of these compounds are all less than 10 µg/L, with concentrations of 5 µg/L or less detected in each sample collected since December 1992. The remaining VOCs were detected infrequently (three samples or less) with most of the results being estimated values below 5 µg/L (Table 1).

Several of the VOCs detected in the groundwater samples collected to date, particularly 11DCA, 11DCE, and c12DCE, are probably present in the groundwater as a result of biologically mediated degradation (sequential dechlorination) of related parent compounds (TCE and 111TCA). However, as illustrated by the data summarized in Table 2, results for several indicator parameters suggest that geochemical characteristics of the groundwater in the well may not be within the optimum ranges for biotic degradation of chlorinated hydrocarbons. Considering the upward vertical hydraulic gradients noted previously, the presence of the VOC-degradation products in the groundwater at his well may be at least partially attributable to upward migration from the deeper flow system, where geochemical conditions may promote more effective biotic degradation.

As illustrated by the selected sampling results summarized below, historical data show that TCE concentrations in the shallow groundwater from well GW-364 were substantially lower than evident in the deeper groundwater from well GW-365, although more recent sampling results show similar TCE concentrations for each well. Considering the upward vertical hydraulic gradients indicated by the presampling groundwater elevations, as noted in Section 4.0, the presence of TCE in the shallower groundwater at well GW-364 may be at least partially attributable to upward migration of TCE from the deeper flow system in the Maynardville Limestone. Additionally, the lower TCE concentrations in well GW-364 reflects the greater permeability of the shallow karst network in the Maynardville Limestone, which facilitates more rapid flushing of the VOC-contaminated groundwater during seasonal (and episodic) recharge/discharge cycles.

TCE (µg/L)			
GW-364 (47-60 ft bgs)		**GW-365 (127-150 ft bgs)**	
03/22/89	16	03/29/89	73
05/12/91	15	05/14/91	26
03/27/93	6	03/28/93	89
03/13/01	7	03/27/01	54
03/07/05	2 J	03/07/05	4 J

A time-series plot of TCE concentrations reported for the groundwater samples collected to date shows a clearly decreasing long-term trend dominated by concentration fluctuations and the prolonged gaps in the sampling history for the well (Figure 1). The decreasing concentration trend probably mirrors a corresponding reduction in the relative flux of TCE in the shallow karst network in the Maynardville Limestone. Reduced flux of TCE (and other VOCs) occurred in response to various remedial actions at the primary sources of VOCs in BCV west of Y-12, including the RCRA closure/capping of the former S-3 Ponds and Oil Landfarm and the CERCLA remedial action at the BYBY, which included excavation and removal of subsurface wastes at the HCDA that were suspected sources of VOCs in the groundwater. Note that several of the "peak" TCE concentrations, such as those evident in September 1991 (21 µg/L) and June 1993 (16 µg/L), were reported for samples collected during seasonally low flow conditions (summer and fall), whereas low TCE concentrations, such as those reported for the samples collected in March 1992 (9 µg/L) and March 1993 (6 µg/L), often correlate with seasonally high flow conditions (winter and spring). This relationship suggests seasonally variable flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples collected since February 1990 (previous results for gross alpha activity do not meet applicable data quality objectives) had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.15 pCi/L in October 1990) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

All but four of the groundwater samples collected since February 1990 (previous results for gross beta activity do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE, with the highest value (22.3 pCi/L in September 1993) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-364: summary of VOC results

Sampling Date	VOC (µg/L)					
	TCE	12DCE	c12DCE	11DCE	111TCA	11DCA
09/22/88	25	5	NR	8	7	6
12/08/88	26	7	NR	9	6	6
03/22/89	16	6	NR	6	4 J	6
07/23/89	19	7	NR	6	4 J	5
09/19/89	18	9	NR	7	4 J	6
12/13/89	19	10	NR	6	3 J	6
02/02/90	13	6	NR	3 J	2 J	4 J
05/25/90	14	10	NR	6	3 J	6
08/13/90	12	.	NR	4 J	2 J	4 J
10/30/90	15	.	NR	6	3 J	6
02/07/91	15	12	NR	5	2 J	5
05/12/91	15	10	NR	5	2 J	5
08/28/91	12	8	NR	3 J	2 J	3 J
10/28/91	13	12	NR	5	2 J	5
03/16/92	9	6	NR	4 J	2 J	3 J
06/05/92	16	12	NR	7	2 J	4 J
09/08/92	21	12	NR	9	3 J	5
12/15/92	13	8	NR	4 J	2 J	3 J
03/27/93	6	.	NR	.	.	2 J
06/27/93	16	6	NR	.	.	.
09/19/93	15	7	NR	5	2 J	3 J
12/18/93	8	4 J	NR	2 J	1 J	2 J
03/13/01	7	3 J	3 J	.	.	.
08/07/01	12	8	8	4 J	.	3 J
03/07/05	2 J	2 J	2 J	.	.	.
09/01/05	5	4 J	4 J	1 J	.	.
MCL	**5**	**NA**	**70**	**7**	**200**	**NA**

Sampling Date	OTHER VOCs (µg/L)
09/22/88	PCE (0.8 J), CTET (0.7 J)
03/22/89	Chloroform (0.4 J), Ethylbenzene (0.9 J), PCE (1 J), Toluene (0.3 J)
12/13/89	2-Hexanone (2 J)
08/07/90	Vinyl acetate (2 J)
12/18/93	PCE (0.3 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not Reported

Table 2. Well GW-364: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	September 2005
Nitrate	mg/L	<1	<0.028	0.0587
Iron (II)	mg/L	>1	<0.05*	<0.05*
Sulfate	mg/L	<20	11.8	15.6
Dissolved Oxygen	ppm	<0.5	0.29**	2.47**
REDOX	mV	<50	122**	120**
pH	st. units	>5 and < 9	8.2**	7.95**
Note: *Results are for total iron; **Field measurement.				

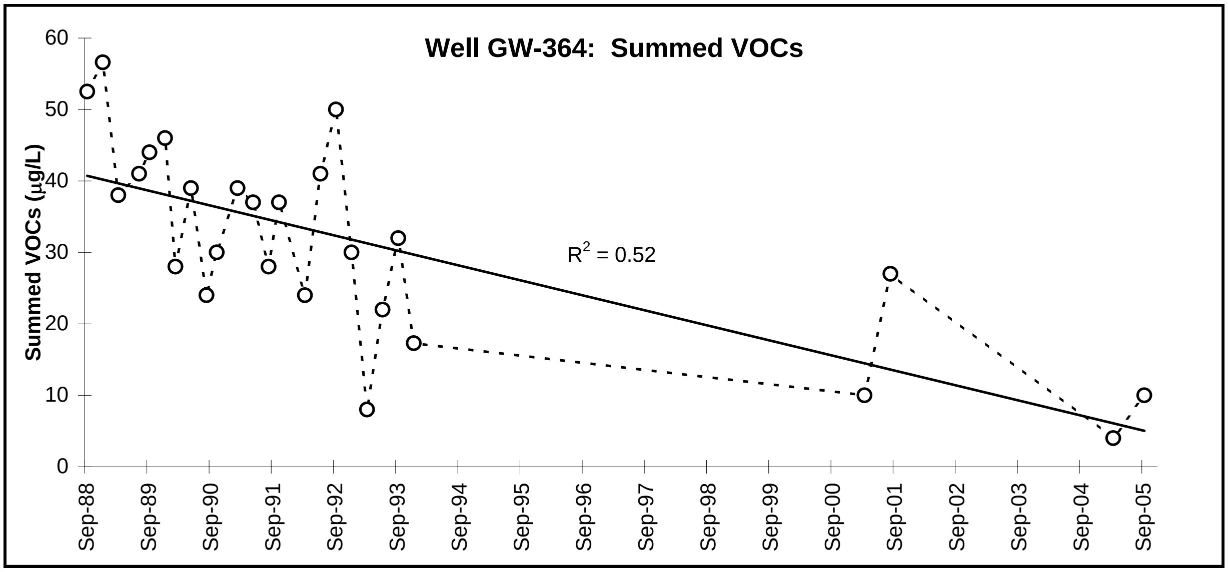

Well GW-364: Summed VOCs
Summed VOCs (μg/L)
60
50
40
30
20
10
0
R2 = 0.52
Sep-88
Sep-89
Sep-90
Sep-91
Sep-92
Sep-93
Sep-94
Sep-95
Sep-96
Sep-97
Sep-98
Sep-99
Sep-00
Sep-01
Sep-02
Sep-03
Sep-04
Sep-05

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	50 - 500	<7.5	ND

GW-365

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 46,490.30
Y-12 GRID NORTH COORDINATE: 29,149.64
SURFACE ELEVATION: 933.03 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/02/88 PAIRED/CLUSTERED WITH: GW-364
TAG DEPTH (measured): 152.49 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 935.58 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.75 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	126.7	806.33
BOTTOM (filter pack or open hole):	150.0	783.03
MIDPOINT (filter pack or open hole):	138.4	794.68
PUMP INTAKE:	145.4	787.58
WATER LEVEL (average):	9.05	923.98

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	22 samples	09/21/88	12/19/93
LOW-FLOW SAMPLING METHOD:	4 samples	03/27/01	09/01/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	03/07/05	.	09/01/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 12.7 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	16	152 µg/L	03/28/93	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-365

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1988, completed with an open-hole monitored interval from 126.7 to 150 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well is paired with well GW-364 and is located in Bear Creek Valley (BCV) south of the main channel of Bear Creek approximately 6,000 ft west of Y-12 and 500 ft west of the southwest corner of the Oil Landfarm waste management area (WMA). The Oil Landfarm WMA encompasses the following closed waste management facilities: the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 22 samples between September 1988 and December 1993, and the low-flow sampling method used to obtain four samples between March 2001 and September 2005. The sampling history includes a quarterly sampling frequency followed by 7-year (December 1993 – March 2001) and 4-year (August 2001 – March 2005) periods when no samples were collected from the well.

Groundwater samples obtained from this well using the low-flow sampling method are significantly more turbid (turbidity >200 NTU and TSS >20 mg/L) than the samples obtained using the conventional method (turbidity <20 NTU and TSS <8 mg/L). This is somewhat unusual because turbid samples are more frequently associated with the conventional sampling method, which involves purging a fixed volume of groundwater from the well at a pumping rate that may substantially lower the water level in the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100–200 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 9 ft bgs and exhibits maximum seasonal fluctuations up to approximately 13 ft. Also, depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show groundwater elevations in well GW-365 are higher than evident in well GW-364, which is completed at a shallower depth (60 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint in each well (about 85 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.024–0.104) from the intermediate depth bedrock (GW-365) to the shallow bedrock interval (GW-364) during seasonally high and low flow conditions.

Groundwater elevation isopleths based on contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-365 indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located downstream of a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface-water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 494 – 638 mg/L;
- pH of 6.8 – 7.3 (field measurements);
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations);
- elevated chloride concentrations (>80 mg/L);
- very high iron (>20 mg/L) and slightly elevated boron (>0.2 mg/L) concentrations; and
- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated iron concentrations are reported only for samples obtained using the low-flow sampling method, which are significantly more turbid than the samples obtained with the conventional method (see Section 2). Thus, these iron concentrations are likely artifacts of the preservation (acidification) of the turbid samples, with the suspended material in the samples possibly including fine particles of rust from the steel riser casing in the well.

As illustrated by the following summary of selected data from the most recent sampling events (March and September 2005), the geochemical characteristics of the groundwater in this well differ substantially from those of the shallower groundwater from well GW-364. The difference in groundwater geochemistry reflects the relative permeability of the flowpaths intercepted by the monitored interval in each well, whereby the higher TDS indicates longer residence time for groundwater from well GW-365 as a consequence of the substantially lower permeability of the groundwater flowpaths at depth in the Maynardville Limestone.

Well/Monitored Interval / Sampling Date	**pH (st. units)**	**DO (ppm)**	**REDOX (mV)**	**TDS (mg/L)**	**Calcium (mg/L)**	**Magnesium (mg/L)**	**Bicarbonate (mg/L)**
GW-364 (47-60 ft bgs)							
03/07/05	8.2	0.29	122	188	44.7	9.98	147
09/01/05	7.95	2.47	120	265	57.9	13.6	186
GW-365 (127-150 ft bgs)							
03/07/05	7.05	0.03	-140	604	146	39.3	443
09/01/05	7.16	1.95	-195	636	158	41.2	468

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest value (5.17 mg/L in September 1993) being below the drinking water MCL for nitrate (10 mg/L). Nevertheless, these nitrate concentrations substantially exceed background levels in uncontaminated groundwater (<0.028 mg/L) in BCV and indicate that the open-hole interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 5,500 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

5.2 URANIUM

Eighteen groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00108 mg/L in September 2005) being below the MCL for uranium (0.03 mg/L) and within the range of background levels in the Maynardville Limestone. These results suggest that the water-producing features intercepted by the open-hole interval in the well are not hydraulically connected with the primary groundwater transport pathways for uranium from the former BYBY. Hydraulically upgradient approximately 2,700 ft east-northeast of the well, the BYBY was identified during the CERCLA remedial investigation as the primary source of uranium in Maynardville Limestone hydraulically downgradient (west) of the Oil Landfarm WMA (DOE 1997). Uranium-bearing wastes in the subsurface at the BYBY were below the seasonally high water table and carbonate dissolved from the limestone bedrock combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility, considering the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 1): acetone, benzene, CTET, chloroethane, chloroform, ethylbenzene, methylene chloride, PCE, toluene, TCE, vinyl chloride (VC), 11DCA, 11DCE, 12DCE, and 111TCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). There are several confirmed and suspected sources of VOCs In the upper part of BCV hydraulically upgradient (north and east) of the well, including Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, the Rust Spoil Area, and several potential sources within the Oil Landfarm WMA, including the Oil Landfarm, HCDA, and Sanitary Landfill I.

Based on frequency of detection and concentration magnitude, TCE, 11DCE, and 12DCE are the primary VOCs in the groundwater samples collected to date (Table 1). All three compounds were detected in all but one of the samples, with historical maximum concentrations of 89 µg/L, 36 µg/L, and 69 µg/L respectively. Also, the most recent sampling results show that TCE and 11DCE concentrations remain near or slightly above their drinking water MCLs (5 µg/L and 7 µg/L), whereas the concentrations of c12DCE are substantially below the MCL (70 µg/L). Secondary compounds are PCE, 11DCA, and 111TCA, at least one of which was detected in each sample collected to date (Table 1). Results for these VOCs show only the historical maximum concentration of 111TCA (21 µg/L in September 1988) exceeds 10 µg/L, 11DCA was detected in samples collected most recently (March and September 2005), and all results for PCE and 111TCA are less than respective MCLs (5 µg/L and 200 µg/L). The remaining VOCs were detected infrequently, with results for each compound except acetone and t12DCE being estimated values below 5 µg/L (Table 1). Of these, VC was detected the most frequently (seven samples) and the most recent sampling results (5 µg/L in March and September 2005) show that VC concentrations remain above the MCL (2 µg/L).

Several of the VOCs detected in the groundwater samples collected to date, particularly 11DCA, 11DCE, c12DCE, and VC, are probably present in the groundwater as a result of biologically mediated degradation (sequential dechlorination) of related parent compounds (TCE and 111TCA). As illustrated by the data summarized in Table 2, results for several indicator parameters suggest that geochemical characteristics of the groundwater at this well are within the optimum ranges for biotic degradation of chlorinated hydrocarbons. Moreover, the historical data show an often inverse relationship between the concentrations of TCE and 12DCE (total). For example, while TCE concentrations decreased by 25% between September 1988 (84 µg/L) and January 1990 (63 µg/L), 12DCE concentrations increased more than 150% (from 19 µg/L to 50 µg/L) over the same period. Similarly, respective results for samples collected more recently in March 2001 and March 2005 show a substantial decrease in TCE concentrations (from 54 µg/L to 4 µg/L), but relatively unchanged concentrations of 12DCE (17 µg/L and 20 µg/L). This relationship suggests the accumulation of 12DCE through biotic degradation of TCE.

As illustrated by the selected sampling results summarized below, historical data show that TCE concentrations in the deeper groundwater from well GW-365 were substantially higher than evident in the shallower groundwater from well GW-364, although more recent sampling results show similar TCE concentrations for each well. Considering the upward vertical hydraulic gradients indicated by the presampling groundwater elevations, as noted in Section 4.0, the presence of TCE in the shallower groundwater at well GW-364 may be at least partially attributable to upward migration of TCE from the deeper flow system in the Maynardville Limestone. Additionally, the higher TCE concentrations in well GW-365 reflects the lesser permeability of the water-producing features with depth in the Maynardville Limestone, whereas the much higher permeability of the shallow karst network facilitates more rapid flushing of VOC contaminated groundwater during seasonal (and episodic) recharge/discharge cycles.

TCE (µg/L)			
GW-364 (47-60 ft bgs)		**GW-365 (127-150 ft bgs)**	
03/22/89	16	03/29/89	73
05/12/91	15	05/14/91	26
03/27/93	6	03/28/93	89
03/13/01	7	03/27/01	54
03/07/05	2 J	03/07/05	4 J

A time-series plot of TCE concentrations reported for the groundwater samples collected to date shows a generally decreasing long-term trend dominated by wide concentration fluctuations and the gaps in the sampling history for the well (Figure 1). The decreasing concentration trend probably reflects a combination of reduced flux of TCE (and other VOCs) and, as discussed previously, biotic degradation of the TCE. Reduced flux of TCE (and other VOCs) in the Maynardville Limestone occurred in response to various remedial actions at the primary sources of VOCs in BCV west of Y-12, including the RCRA closure/capping of the former S-3 Ponds and Oil Landfarm and the CERCLA remedial action at the BYBY, which included excavation and removal of subsurface wastes at the HCDA that were suspected sources of VOCs in the groundwater.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples collected since February 1990 (previous results for gross alpha activity do not meet applicable data quality objectives) had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.29 pCi/L in March 1993) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples collected since February 1990 (previous results for gross beta activity do not meet applicable data quality objectives) had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10.2 pCi/L in March 1992) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Note that gross beta activity has been below the applicable MDA and corresponding CE in all of the groundwater samples collected since March 1993.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: <u>Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water</u>. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-365: summary of VOC results

Sampling Date	Concentration (µg/L)					
	PCE	**TCE**	**12DCE**	**11DCE**	**111TCA**	**11DCA**
09/21/88	2 J	84	19	27	21	7
11/29/88	3 J	84	25	26	17	7
03/29/89	3 J	73	31	25	14	8
07/26/89	2 J	62	31	19	12	6
09/18/89	3 J	63	28	20	11	6
12/13/89	3 J	64	40	19	11	6
01/31/90	4 J	63	50	22	11	7
05/29/90	.	15	15	7	3 J	3 J
08/17/90	.	59	69	21	11	7
11/01/90	0.9 J	22	26	8	4 J	4 J
02/09/91	.	16	52	12	6	5
05/14/91	1 J	26	42	11	5	4 J
08/28/91	2 J	44	50	16	7	5
10/29/91	1 J	27	51	13	4 J	5
03/17/92	2 J	64	34	23	13	6
06/06/92	2 J	87	.	36	10	7
09/09/92	1 J	21	57	22	6	6
12/17/92	.	16	36	14	2 J	3 J
03/28/93	2 J	89	23	21	11	5
06/27/93	.	77	19	20	5	.
09/19/93	1 J	46	14	14	2 J	4 J
12/19/93	1 J	39	12	13	2 J	4 J
03/27/01	.	54	17	18	3 J	5
08/07/01	.	45	19	16	2 J	6
03/07/05	.	4 J	20	7	.	6
09/01/05	.	10	24	10	.	7
MCL	**5**	**5**	**NA**	**7**	**200**	**NA**

Sampling Date	OTHER (µg/L)
09/21/88	CTET (2 J)
11/29/88	Benzene (0.3 J), Chloroform (0.5 J), Ethylbenzene (0.8 J), Toluene (0.4 J)
07/26/89	CTET (1 J)
09/18/89	Acetone (12), Chloroethane (2 J), VC (2 J)
12/13/89	CTET (2 J)
01/31/90	Acetone (13)
11/01/90	Acetone (7), Benzene (1 J), MC (2 J)
08/28/91	VC (3)
10/29/91	VC (2)
09/09/92	Chloroethane (2 J), VC (2)
03/28/93	Chloroform (1 J)
03/27/01	c12DCE (17)
08/07/01	c12DCE (19), VC (2)
03/07/05	c12DCE (20), VC (5)
09/01/05	c12DCE (24), VC (5)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

Table 2. Well GW-365: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		March 2005	September 2005
Nitrate	< 1 mg/L	<0.028	<0.028
Iron (II)	> 1 mg/L	27.4*	25.1*
Sulfate	< 20 mg/L	20.8	16.5
Dissolved Oxygen	< 0.5 ppm	0.03**	1.95 **
REDOX	< 50 mV	-140**	-195**
pH	>5 and < 9 st. units	7.05**	7.16**

Note: *Results are for total iron; **Field measurement.

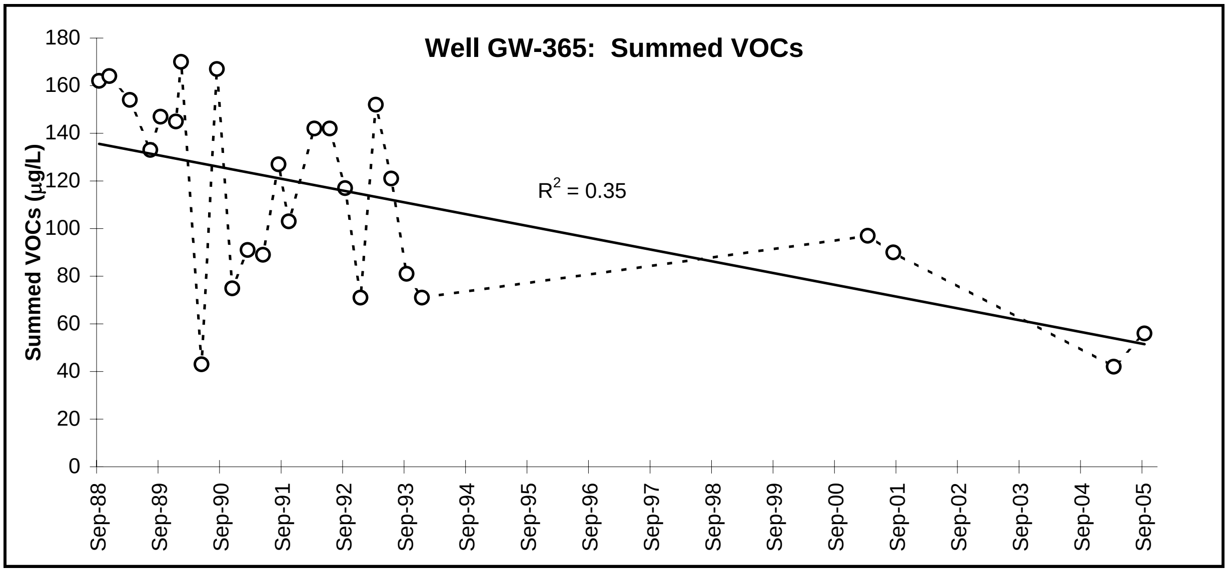

Well GW-365: Summed VOCs
Summed VOCs (µg/L)
R^2 = 0.35
180
160
140
120
100
80
60
40
20
0
Sep-88
Sep-89
Sep-90
Sep-91
Sep-92
Sep-93
Sep-94
Sep-95
Sep-96
Sep-97
Sep-98
Sep-99
Sep-00
Sep-01
Sep-02
Sep-03
Sep-04
Sep-05

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
5 - 10	<0.015	50 - 500	7.5 - 15	<25

GW-368

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,617.59
Y-12 GRID NORTH COORDINATE: 28,912.85
SURFACE ELEVATION: 998.63 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/13/88 PAIRED/CLUSTERED WITH: GW-369 GW-601
TAG DEPTH (measured): 247.46 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,000.53 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	225.0	773.63
BOTTOM (filter pack or open hole):	245.0	753.63
MIDPOINT (filter pack or open hole):	235.0	763.63
PUMP INTAKE:	235.6	763.03
WATER LEVEL (average):	66.82	931.81

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	9		
CONVENTIONAL SAMPLING METHOD:	7 samples	09/24/88	01/31/90
LOW-FLOW SAMPLING METHOD:	2 samples	03/21/05	09/12/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	03/21/05	.	09/12/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.42 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	2	62 μg/L	03/21/05	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-368

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1988, completed with an open-hole monitored interval from 225 to 245 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well forms a cluster with wells GW-369 and GW-601 and is located in Bear Creek Valley (BCV) approximately 5,000 ft west of Y-12. The well cluster is on the steep northern (scarp) flank of Chestnut Ridge, approximately 300 ft directly south of the main channel of Bear Creek and 500 ft south of the Oil Landfarm waste management area (WMA). The Oil Landfarm WMA encompasses the following closed hazardous and nonhazardous waste management facilities: the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain seven samples between September 1988 and January 1990, and the low-flow sampling method used to obtain samples in March and September 2005. The sampling history includes a quarterly sampling frequency, followed by a 15-year period (January 1990 – March 2005) when no samples were collected from the well, with semiannual sampling in 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100-300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 67 ft bgs, with presampling measurements indicating maximum seasonal water-level fluctuations of approximately 6 ft. Groundwater elevation isopleths based on contemporaneous depth-to-water measurements for wells located in the vicinity of well GW-368 indicate westerly local flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located directly south of a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

Presampling depth-to-water measurements recorded during one contemporaneous sampling event (i.e., within 24 hours) show a lower presampling groundwater elevation in well GW-368 (929.1 ft above msl) compared to well GW-601 (931.27 ft above msl), which is completed deeper (356 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint in each well (102 ft), the respective groundwater elevations indicate a slightly upward vertical hydraulic gradient (0.021) from the deep bedrock (GW-601) to the intermediate depth bedrock interval (GW-368). Note that the contemporaneous presampling groundwater elevations were recorded during seasonally low flow (September 2005) and, consequently, may not be representative of the vertical hydraulic gradients evident during seasonally high flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields chloride- and sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 330 – 409 mg/L;
- pH of 7.32 – 7.58 (field measurements);
- low molar proportions of potassium and sodium (<10% of total anions/cations);
- elevated concentrations of chloride (>30 mg/L) and sulfate (>50 mg/L); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated sulfate and chloride concentrations typical of the groundwater samples reflect natural geochemical characteristics at depth in the Maynardville Limestone, or if the elevated concentrations are the result of contamination from one or more sources hydraulically upgradient of the well. Similarly, it is unclear if the unusually high total iron (3.61 mg/L) reported for the sample collected in September 2005 is a potential artifact related to corrosion of the steel riser casing in the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit (Table 1), although none of these results exceed the drinking water MCL for nitrate (10 mg/L). Nevertheless, the nitrate concentrations exceed background levels in uncontaminated (<0.028 mg/L) groundwater in BCV, particularly considering the depth of the well, and indicates that the open-hole interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 4,500 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

Nitrate concentrations above background levels in the groundwater flow/transport pathways intercepted by the open-hole interval in this well are attributable to westward (downgradient) transport of nitrate via strike-parallel flowpaths at depth in the Maynardville Limestone (>200 ft bgs). As illustrated by the most recent sampling results summarized below, the nitrate concentrations do not exhibit wide seasonal fluctuations, suggesting that the well does not have a direct hydraulic connection with the shallow karst network, where nitrate concentrations exhibit substantial fluctuations in response to seasonal (and episodic) flow conditions. Without evidence for a more direct hydraulic connection with the shallow karst network, the presence of nitrate in the groundwater from this well does not seem attributable to extensive down-dip inflow (recharge) of nitrate-contaminated surface water via the losing reach of Bear Creek noted in Section 3.0.

Nitrate (mg/L)			
GW-368 (225-245 ft bgs)		**GW-601 (318-356 ft bgs)**	
01/31/90	6	03/05/90	16
03/21/05	8.48	03/15/05	19.6
09/12/05	8.94	09/12/05	18.4

Both historical and more recent sampling results, as illustrated by the data summarized above, indicate that nitrate concentrations in the groundwater in well GW-368 are lower than evident deeper in the Maynardville Limestone in the groundwater from well GW-601. In light of the upward vertical gradient noted in Section 4.0, the presence of nitrate in the groundwater from well GW-368 may be at least partially attributable to upward migration from the deeper flow system. Moreover, considering the depth of open-hole interval in each well relative to the hydrostratigraphic zones in the Maynardville Limestone (see Section 3.0), the lower levels of nitrate in well GW-368 potentially indicate lesser relative flux of nitrate (and other similarly mobile contaminants) via less permeable strike-parallel flowpaths within hydrostratigraphic zones toward the middle of the formation.

Nitrate concentrations detected in the groundwater samples collected to date suggest a fairly indeterminate long-term concentration trend, as illustrated by the nitrate results reported for samples collected in September 1988 (5.9 mg/L), September 1989 (10 mg/L, the historical maximum value), and September 2005 (8.94 mg/L). This indeterminate trend suggests that there has been minimal change in the overall flux of nitrate via the groundwater flow/transport pathways intercepted by the open-hole interval in the well. In the shallow karst network in the Maynardville Limestone, however, clearly decreasing nitrate concentrations indicated by data for wells located both upgradient (east) and downgradient (west) of well GW-368 reflect the substantially reduced flux of nitrate that occurred after closure of former S-3 Ponds and installation of a low-permeability cap at the site.

5.2 URANIUM

Five groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0018 mg/L in September 2005) being substantially below the MCL for uranium (0.03 mg/L) and within the range of background levels in the Maynardville Limestone. These results suggest that the open-hole interval in the well intercepts water-producing features that are not extensively connected with the primary groundwater transport pathways for uranium from the former BYBY, which is hydraulically upgradient approximately 1,650 ft east-northeast of the well. Uranium-bearing wastes at the BYBY were identified during the CERCLA RI as a principal source of uranium in the Maynardville Limestone downgradient of the Oil Landfarm WMA (DOE 1997). Subsequent

CERCLA remedial action at the BYBY, completed in May 2002, included the excavation and removal of wastes from above and below the saturated zone. Additionally, the low (background) levels of uranium in the well do not indicate extensive down-dip inflow (recharge) of uranium-contaminated surface water via the losing reach of Bear Creek noted in Section 3.0.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, CTET, chloroform, ethylbenzene, PCE, toluene, TCE, 11DCE, and 111TCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997).

Based on frequency of detection and concentration magnitude, TCE is the primary VOC detected in the groundwater samples collected to date (Table 2). This compound was detected in all the samples, with TCE concentrations above 100 µg/L, including the historical maximum concentration (130 µg/L in September 1988), reported for all but three of the samples. All the TCE results, including results for the samples collected most recently (March and September 2005), substantially exceed the drinking water MCL (5 µg/L). Other VOCs were detected infrequently, with estimated concentrations below 5 µg/L reported for all these compounds except acetone and CTET (Table 2). Indeed, the general lack of other VOCs in the groundwater samples, particularly c12DCE, suggests minimal biotic degradation of the TCE (and other VOCs) in the groundwater. This interpretation is supported by results for several indicator parameters, which suggest that selected geochemical characteristics are not within the ranges considered optimum for biologically mediated degradation of chlorinated hydrocarbons in the groundwater (Table 3).

The predominance of TCE in the groundwater samples from this well suggests that the primary source of the VOCs is the Rust Spoil Area (or nearby site within the Bear Creek floodplain). The Rust Spoil Area is a closed construction and demolition waste disposal site underlain by the Maynardville Limestone approximately 2,200 ft directly east (parallel with geologic strike) of the wells and is the suspected source of a TCE-dominated plume of dissolved VOCs in the shallow groundwater at the site (DOE 1997). Also, the former S-3 Ponds are a potential source area of VOCs because the presence of nitrate in the well (Section 5.1) demonstrates a connection with the contaminant plume originating from that site. Additional influx of VOCs into the Maynardville Limestone occurs from several potential sources within the Oil Landfarm WMA that are hydraulically upgradient of the well to the north (the Oil Landfarm and Sanitary Landfill I) and east-northeast (the HCDA). However, the previously discussed results for nitrate and uranium suggests strike-parallel contaminant transport from an upgradient source to the east of the well, rather than down-dip inflow (recharge) of contaminants from potential source areas to the north-northeast of the well.

As illustrated by the selected sampling results summarized below, historical data show similar levels of TCE in the groundwater from wells GW-368 and GW-601, which suggests similar relative flux of TCE via the groundwater flow/transport pathways intercepted by the open-hole interval in each well. Additionally, the most recent sampling results for both wells indicate that the TCE concentrations in deeper groundwater remain significantly higher than evident in wells completed at shallower depths in the Maynardville Limestone, including wells located at the Rust Spoil Area (e.g., GW-312). This may reflect the greater permeability of the shallow karst network, which facilitates more rapid flushing of the most contaminated groundwater by seasonal (and episodic) recharge/discharge cycles (DOE 1997).

TCE (µg/L)			
GW-368 (225-245 ft bgs)		**GW-601 (318-356 ft bgs)**	
01/31/90	120	03/05/90	110
03/21/05	62	03/15/05	85
09/12/05	50	09/12/05	72

A time-series plot of TCE concentrations reported for the groundwater samples collected to date (Figure 1) shows an indeterminate or slightly decreasing trend between September 1988 (130 µg/L) and January 1990 (120 µg/L), followed by the prolonged gap (15-year) in the sampling history and substantially lower TCE levels in March (62 µg/L) and September 2005 (50 µg/L). The lower TCE concentrations indicated by the most recent sampling results are probably attributable to a combination of natural attenuation (dilution and dispersion) in the groundwater and the reduced flux of TCE (and other VOCs) via the groundwater flow/transport pathways intercepted by the open-hole interval in the well.

5.4 GROSS ALPHA ACTIVITY

Two of the three groundwater samples collected since January 1990 had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (9.2 pCi/L in September 2005) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

All three of the groundwater samples collected since January 1990 had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.7 pCi/L in March 2005) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-368: summary of nitrate results

Sampling Date	Nitrate (mg/L)
09/24/88	5.9
11/23/88	4.2
03/23/89	5.8
07/22/89	3
09/21/89	10
12/15/89	5
01/31/90	6
03/21/05	8.48
09/12/05	8.94
MCL	**10**

Table 2. Well GW-368: summary of VOC results

Sampling Date	VOC (µg/L)					
	PCE	**TCE**	**11DCE**	**111TCA**	**CTET**	**Chloroform**
09/24/88	0.6 J	130	0.7 J	1 J	7	2 J
11/23/88	0.6 J	120	0.8 J	0.7 J	4 J	1 J
03/23/89	.	110	.	.	4 J	.
07/22/89	.	92	.	.	1 J	0.9 J
09/21/89	.	120	.	0.7 J	5	1 J
12/15/89	.	120	.	.	.	.
01/31/90	.	120	.	.	3 J	.
03/21/05	.	62	.	.	.	.
09/12/05	.	50	.	.	.	.
MCL	**5**	**5**	**7**	**200**	**5**	**80***
Sampling Date	**Other VOCs (µg/L)**					
11/23/88	Ethylbenzene (0.8 J), Toluene (0.3 J)					
07/22/89	Acetone (11)					
09/21/89	Acetone (5 J)					
Note: "." = Not detected; J = Estimated value; * = MCL is for total trihalomethanes						

Table 3. Well GW-368: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	September 2005
Nitrate	mg/L	<1	8.48	8.94
Iron (II)	mg/L	>1	0.719*	3.61*
Sulfate	mg/L	<20	56.9	54.3
Dissolved Oxygen	ppm	<0.5	2.79**	3.35**
REDOX	mV	<50	49**	160**
pH	st. units	>5 and < 9	7.32**	7.58**
Note: *Results are for total iron; **Field measurement.				

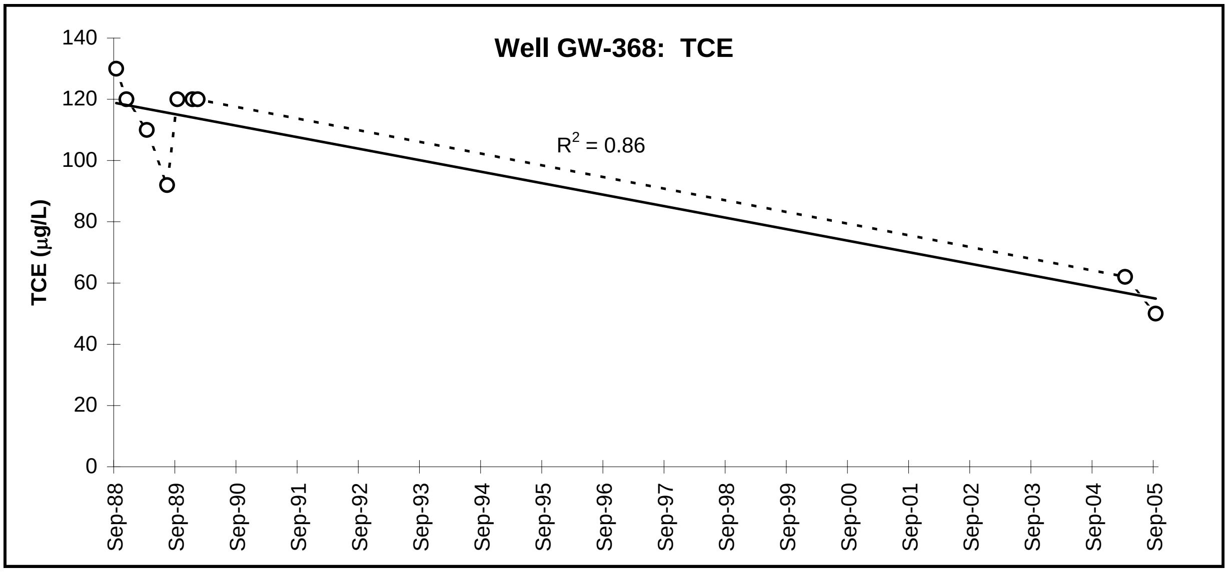

Well GW-368: TCE
TCE (µg/L)
140
120
100
80
60
40
20
0
R^2 = 0.86
Sep-88
Sep-89
Sep-90
Sep-91
Sep-92
Sep-93
Sep-94
Sep-95
Sep-96
Sep-97
Sep-98
Sep-99
Sep-00
Sep-01
Sep-02
Sep-03
Sep-04
Sep-05

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	<5	<7.5	<25

GW-380

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 62,938.21
Y-12 GRID NORTH COORDINATE: 28,714.28
SURFACE ELEVATION: 913.66 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/19/88 PAIRED/CLUSTERED WITH: GW-381 GW-382
TAG DEPTH (measured): 15.80 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 913.55 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	2.8	910.86
BOTTOM (filter pack or open hole):	15.5	898.16
MIDPOINT (filter pack or open hole):	9.2	904.51
PUMP INTAKE:	12.61	901.05
WATER LEVEL (average):	10.32	903.34

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	47		
CONVENTIONAL SAMPLING METHOD:	34 samples	12/22/88	05/21/97
LOW-FLOW SAMPLING METHOD:	13 samples	12/02/97	08/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/18/04	04/29/04	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 5.52 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	4	26 μg/L	04/25/91	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-380

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1988, completed with a screened monitored interval from 2.8 to 15.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-381 and GW-382 in Bear Creek Valley near the east end of Y-12, about 500 ft directly west (hydraulically upgradient) of New Hope Pond (NHP). NHP is a closed surface water impoundment formerly used to regulate flow in Upper East Fork Poplar Creek, and is covered with a low-permeability multilayer cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 34 samples between December 1988 and May 1997, and the low-flow sampling method used to obtain 13 samples between December 1997 and August 2004.

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium and nickel that are most likely attributable to chemical and/or microbiologically-induced corrosion of the stainless steel well casing and/or screen (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 10 ft below ground surface. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<6 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 215 – 682 mg/L;
- pH (field measurements) of 5.6 – 7.4;
- low molar proportions of nitrate, potassium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except chromium and nickel) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Groundwater samples from this well often contain chloride and sodium concentrations above 50 mg/L, which substantially exceeds the respective UTLs for groundwater in the Maryville Limestone. The source of the chloride and sodium is not known but there are multiple industrial sources of these ions within Y-12 upgradient (west) of the well, including chloride from the biotic degradation of dissolved VOCs in the groundwater. Whatever the source, the elevated chloride levels in the groundwater at the well may play a role in maintaining the elevated chromium and nickel concentrations in the samples from the well (see Section 5.6) because chloride may combine with available metal cations to form soluble complexes that do not readily adsorb to mineral surfaces in the monitored-interval filter pack materials and surrounding bedrock (McLean and Bledsoe 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for 37 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (4.43 mg/L in June 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-eight groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0045 mg/L in May 1995) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for 25 groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime. As shown in Table 1, low (estimated) concentrations of PCE, TCE, CT chloroform, and ethylbenzene were detected in a total of 12 samples; the maximum concentration of each compound does not exceed the applicable MCL. These compounds are confirmed components of dissolved VOC plumes in the groundwater hydraulically upgradient (west) of the well.

Table 1. Summary of VOC results for well GW-380

Sampling Date	Concentration (µg/L)				
	PCE	TCE	CT	Chloroform	Ethylbenzene
08/23/91	0.6 J	.	.	1 J	.
08/01/92	2 J	1 J	2 J	2 J	1 J
09/21/94	2 J	.	.	1 J	.
05/23/95	3 J	.	.	1 J	.
11/30/95	1 J	.	.	1 J	.
11/19/96	1 J	.	.	2 J	.
12/02/97	2 J	.	.	2 J	.
06/04/99	.	.	.	2 J	.
08/05/02	.	.	.	5 J	.
02/13/03	.	.	3 J	1 J	.
08/12/03	.	.	.	4 J	.
8/11/04	.	.	.	3 J	.

Note: "." = Not detected; J = Estimated concentration; FP = false positive result

The data summarized above also indicate a fairly indeterminate long-term concentration trend for the VOCs in the well, which suggest minimal change in the relative flux of dissolved VOCs transported via the groundwater flowpaths intercepted by the monitored interval in this well.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.97 pCi/L in February 1994) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty-one groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (12.6 pCi/L in November 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

5.6 OTHER

As shown in Table 2, all of the groundwater samples collected from the well since January 1991 had concentrations of chromium and/or nickel above the respective analytical reporting limit, with chromium and/or nickel above respective MCLs reported for all but one of the samples.

Table 2. Chromium and nickel results for well GW-380

Sampling Method and Date	Total Concentration (mg/L)	
	Chromium UTL = 0.029 MCL = 0.10	Nickel UTL = 0.06 MCL = 0.10
Conventional Sampling		
01/29/91	0.065	**0.36**
04/25/91	**0.14**	**0.23**
08/23/91	**1.1**	**0.72**
10/22/91	**0.4**	**0.22**
01/25/92	**0.41**	**0.26**
04/20/92	**0.27**	**0.31**
08/01/92	**1.5**	**0.39**
10/17/92	0.067	**0.2**
01/25/93	**0.99**	**0.16**
04/21/93	**0.27**	**0.12**
08/05/93	**4**	**3.9**
10/29/93	**0.82**	**0.39**
02/04/94	**0.66**	**0.31**
05/11/94	**3.1**	**0.31**
09/21/94	**9.7**	**5.1**
11/15/94	**1.7**	**1**
02/27/95	**0.16**	**0.16**
05/23/95	**0.26**	**0.12**
08/24/95	**0.42**	**0.56**
11/30/95	**4.6**	**0.61**
03/19/96	**0.21**	**0.18**
06/12/96	**0.83**	**0.3**
08/22/96	**0.46**	**0.48**
11/19/96	**0.24**	**0.8**
05/21/97	**0.26**	**0.25**
12/02/97	0.048	**0.13**
Low-Flow Sampling		
06/02/98	0.0572	**0.194**
12/10/98	**0.228**	**0.434**
06/04/99	0.0337	**0.268**
11/10/99	0.0426	**0.211**
02/04/02	**0.405**	**0.153**
08/05/02	**0.186**	**0.338**
02/13/03	0.0498	0.0865
08/12/03	**0.277**	**0.299**
2/18/04	0.0229	0.0937
4/29/04	0.0446	**0.217**
8/11/04	**0.983**	**2.32**

Note: Bold typeface denotes results that exceed the MCL.

The following considerations suggest that the elevated concentrations of chromium and nickel in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel riser casing and well screen: (1) chromium and nickel concentrations in groundwater samples from the deeper wells (GW-381 and GW-382) clustered with well GW-380, which both have open-hole monitored intervals, rarely exceed respective analytical reporting limits, although the groundwater in the deeper wells contains the same VOCs detected in well GW-380 (see Section 5.3.); (2) mobile species of each metal are not typically present in groundwater with the neutral pH conditions evident in the well; (3) there are not any confirmed or suspected sources of either metal near the well; (4) neither metal is a primary component of the commingled groundwater contaminant plume in the Maynardville Limestone hydraulically upgradient (east) of the well; (5) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); (6) groundwater in the well exhibits geochemical conditions known to be corrosive to Type 304 stainless steel (e.g., dissolved oxygen > 2 mg/L; Driscoll 1986); and (7) as noted in Section 4.0, elevated chloride levels in the groundwater may greatly limit the partitioning of nickel and chromium ions in the well.

In addition to the considerations listed above, microbiologically induced corrosion (MIC) of the stainless steel riser casing and screen may be a potential source of the elevated nickel and chromium concentrations in the groundwater samples from this well. Results of microbiologic sampling performed in May 2000 and April 2004, summarized in Table 3, show minimal microbial activity in the deeper groundwater at well GW-381, but substantial microbial activity in the shallower groundwater at well GW-380, including the presence of iron-related bacteria and slime-forming bacteria, which have been demonstrated to cause MIC of stainless steel (Sarouhan et al. 1998).

Table 3. Microbiological sampling results for wells GW-380 and GW-381

Well	Riser/Screen Material	Sampling Date	Maximum Bacterial Count (colony forming units per milliliter)			
			Heterotrophic Aerobic	Iron-Related	Slime-Forming	Sulfate-Reducing
GW-380	Stainless steel	May 2000 April 2004	. 500,000	>5,000 >100	>10,000 1,000	100 <100
GW-381	Steel/Open-hole	May 2000	.	<100	<1,000	<100
Note: Modified from (AJA 2001).						

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Y-12 Groundwater Protection Program Calendar Year 2000 Groundwater Data Evaluation Report for the Upper East Fork Poplar Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee*, Y/SUB/01-006512/4, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*, EPA/540/S-92/018, U.S. Environmental Protection Agency, Office of Research and Development.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

MAXIMUM CONCENTRATION: 2004

ND	ND	500 - 5,000	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-381

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 62,947.70
Y-12 GRID NORTH COORDINATE: 28,715.04
SURFACE ELEVATION: 913.44 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/25/88 PAIRED/CLUSTERED WITH: GW-380 GW-382
TAG DEPTH (measured): 61.01 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 913.36 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	49.3	864.14
BOTTOM (filter pack or open hole):	60.4	853.04
MIDPOINT (filter pack or open hole):	54.9	858.59
PUMP INTAKE:	55.48	857.96
WATER LEVEL (average):	10.86	902.58

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	27 samples	12/17/88	05/27/95
LOW-FLOW SAMPLING METHOD:	11 samples	05/17/00	11/02/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/19/04	.	11/02/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.5 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	28	8,530 µg/L	03/06/95	Decreasing, Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-381

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1988, completed with an open-hole interval from 49.3 to 60.4 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. This well forms a cluster with wells GW-380 and GW-382 and is located in Bear Creek Valley near the east end of Y-12, adjacent to the Upper East Fork Poplar Creek (UEFPC) distribution channel about 200 ft immediately west-southwest (hydraulically upgradient) of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through the concrete-lined distribution channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between December 1988 and May 1995, and the low-flow sampling method used to obtain 11 samples between May 2000 and November 2004. Note that a five-year gap (June 1995 – April 2000) in the sampling history for the well spans the change in groundwater sampling methods.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits minor (<2 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically about 0.5 ft higher in well GW-381 than well GW-382, which is completed deeper (175 ft bgs) in the Maynardville Limestone. Based on the distance (94 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations suggest slightly downward vertical hydraulic gradients (0.003 to 0.011) during seasonally high and low flow conditions. However, upward vertical gradients (0.008 to 0.038) are indicated by the unusually high presampling groundwater elevations in well GW-382 during February 1991, October 1992, and September 1994.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-381 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 1,300 ft east-southeast (hydraulically downgradient) of well GW-381 and is treated on-site to remove VOCs, particulates, iron, and manganese. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 330 – 714 mg/L;
- pH (field measurements) of 6.7 – 7.9;
- very high concentrations of chloride (>70 mg/L) and iron (>10 mg/L) compared to other wells that yield groundwater from shallow depths in the Maynardville Limestone;
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations);
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. Additionally, elevated chloride concentrations in the groundwater samples may be a consequence of the biologically mediated degradation (dechlorination) of dissolved chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). Moreover, as illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical characteristics of the groundwater, particularly the REDOX conditions, are conducive to biotic degradation of VOCs (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since February 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nine groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.62 mg/L in March 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Seven groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L) being an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in at least one of the groundwater samples: acetone, CTET, chloroform, chloromethane, MC, toluene, PCE, TCE, c12DCE, and VC (Table 2). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 1,500 ft east (parallel with geologic strike) of well GW-381; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The principal VOCs in the groundwater samples are CTET and chloroform; each compound was detected in all but one of the samples (Table 2). Historical maximum concentrations exceed 1,000 µg/L for both compounds, including CTET concentrations above 5,000 µg/L reported for most of the samples obtained between February 1991 and May 2000. Results have been substantially lower since May 2000, excluding the chloroform result in June 2003 (1,500 µg/L) (Table 2). All results for CTET still exceed the drinking water MCL (Table 2). Secondary VOCs in the samples are MC, PCE, TCE, c12DCE, and VC. Of these, only MC was detected in any of the samples collected before May 2000 (i.e., obtained with the conventional sampling method and diluted before analysis). Since May 2000, PCE and c12DCE have been detected in all but two of the samples, and TCE and VC were first detected (1 µg/L) in one sample during CY 2004. Concentrations of PCE and c12DCE are all less than 10 µg/L, with the most recent results showing PCE levels slightly above and below the MCL.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows two trends on either side of the five-year gap in the sampling history for this well (Figure 1). Monitoring (conventional sampling) results obtained through May 1995 show an indeterminate or slightly decreasing summed VOC concentrations, with minor temporal fluctuations that often reflect an inverse relationship with seasonal groundwater flow conditions (i.e., concentrations are typically highest in samples obtained during seasonally low flow). However, wide temporal concentration changes are not evident for all of the VOCs in the groundwater samples (Table 2). Also, although the summed VOC concentrations are substantially lower, the monitoring (low-flow sampling) results obtained since April 2000 exhibit wide temporal fluctuations that reflect a more direct correlation with seasonal flow conditions (i.e., concentrations are typically highest in samples obtained during seasonally high flow). Additionally, based on the monitoring data obtained to date, the VOCs concentrations in the groundwater at this well do not appear to exhibit any clear response to the full-time operation of groundwater extraction well GW-845.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.7 pCi/L in June 2003) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.89 pCi/L in October 1991) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: <u>Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water</u>. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

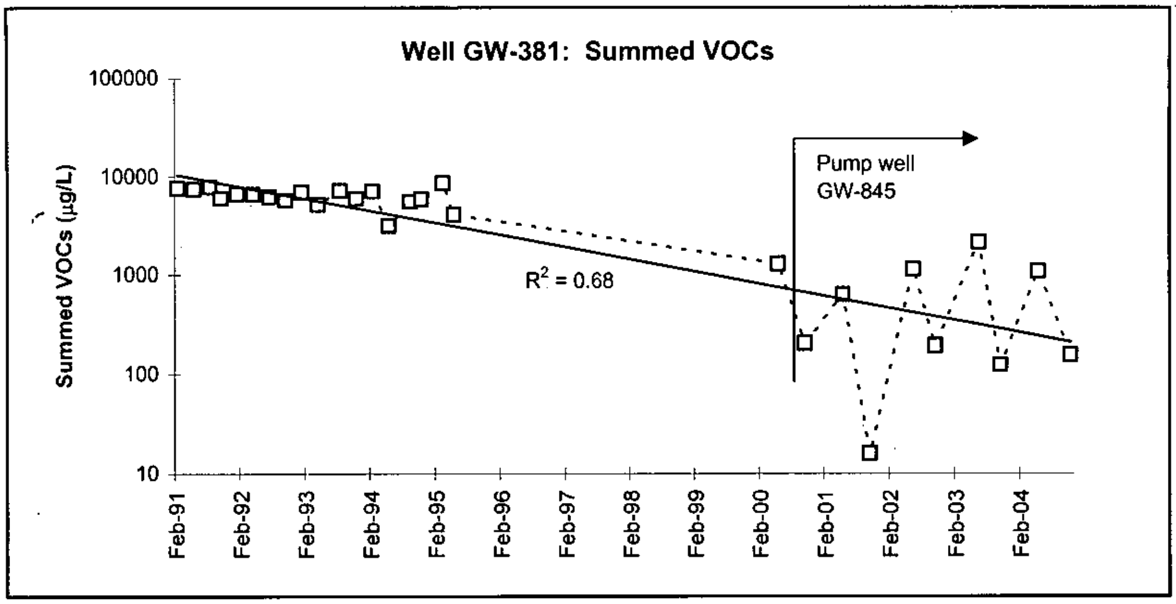
Table 1. Well GW-381: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2004	November 2004
Nitrate < 1 mg/L	<0.02	<0.02
Iron (II) > 1 mg/L	6.7*	13*
Sulfate < 20 mg/L	0.26	0.37
Dissolved Oxygen < 0.5 ppm	1.73**	0.85**
REDOX < 50 mV	-187**	-149**
pH >5 and < 9 st. units	7.41**	7.25**
Note: *Result is for total iron; **Field measurement.		

Table 2. Well GW-381: summary of VOC results

Date Sampled	VOC Concentration (µg/L)						
	CTET	**Chloroform**	**MC**	**PCE**	**TCE**	**c12DCE**	**VC**
02/04/91	6,800	830	.	.	.	.	.
05/08/91	6,700	680	.	.	.	.	.
08/28/91	7,100	790	.	.	.	.	.
10/27/91	5,300	580	42	.	.	.	.
01/28/92	6,100	550	.	.	.	.	.
04/25/92	5,900	700	.	.	.	.	.
07/30/92	5,700	520	.	.	.	.	.
10/16/92	5,000	710	.	.	.	.	.
01/27/93	6,400	520	.	.	.	.	.
04/26/93	4,800	380	.	.	.	.	.
08/08/93	6,600	570	.	.	.	.	.
11/08/93	5,500	440	.	.	.	.	.
02/09/94	6,400	720	.	.	.	.	.
05/17/94	2,500	640	.	.	.	.	.
09/27/94	4,900	660	.	.	.	.	.
11/21/94	5,400	470	.	.	.	.	.
03/06/95	8,000	530	.	.	.	.	.
05/27/95	1,900	2,200	.	.	.	.	.
05/17/00	1,000	280	.	5	.	4 J	.
10/16/00	130	63	.	7	.	4 J	.
05/01/01	320	300	2 J	4 J	.	3 J	.
10/24/01	14	.	.	2 J	.	.	.
06/12/02	380	620	120	5	.	6	.
10/22/02	160	19	11	.	.	2 J	.
06/17/03	590	1,500	26	7	.	6	.
10/16/03	41	65	7	4 J	.	6	.
05/19/04	260	780	29	6	1 J	3 J	.
11/02/04	52	87	4 J	4 J	.	8	1 J
MCL	**5**	**80***	**5**	**5**	**5**	**70**	**2**

Notes: "." = Not detected; J = Estimated value below the analytical reporting limit; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane



Well GW-381: Summed VOCs
100000
10000
1000
100
10
Summed VOCs (µg/L)
Pump well
GW-845
R² = 0.68
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	500 - 5,000	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-382

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 62,956.12
Y-12 GRID NORTH COORDINATE: 28,715.79
SURFACE ELEVATION: 913.16 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/11/88 PAIRED/CLUSTERED WITH: GW-380 GW-381
TAG DEPTH (measured): 173.20 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 913.17 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	125.0	788.16
BOTTOM (filter pack or open hole):	173.0	740.16
MIDPOINT (filter pack or open hole):	149.0	764.16
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	10.96	902.20

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	27 samples	12/10/88	05/26/95
LOW-FLOW SAMPLING METHOD:	11 samples	09/02/99	08/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/11/04	.	08/11/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 5.2 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	7,560 µg/L	11/04/93	Decreasing, Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-382

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1988, completed with an open-hole interval from 125 to 173 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. This well forms a cluster with wells GW-380 and GW-381 and is located in Bear Creek Valley near the east end of Y-12, adjacent to the Upper East Fork Poplar Creek (UEFPC) distribution channel about 200 ft immediately west-southwest (hydraulically upgradient) of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC bypasses Lake Reality and is directed through the concrete-lined distribution channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between December 1988 and May 1995, and the low-flow sampling method used to obtain 11 samples between September 1999 and August 2004. Note that a four-year gap (June 1995 – August 1999) in the sampling history for the well spans the change in groundwater sampling methods.

An evaluation of the monitoring data available through September 2000 indicated that the well may exhibit sensitivity to the groundwater sampling method: samples obtained with the conventional sampling method had substantially higher VOC concentrations than samples obtained with the low-flow sampling method (AJA 2001). It is possible, however, that the disparity in the VOC concentrations is attributable to a decreasing long-term concentration trend (see Section 5.3). Nevertheless, results of "paired" groundwater sampling, with the low-flow sampling method used to collect a sample one day and the conventional sampling method used to collect a sample the next day, are needed to determine if the VOC concentrations are biased by the sampling method.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits moderate (<6 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically about 0.5 ft lower in well GW-382 than well GW-381, which is completed at a shallower depth (60 ft bgs) in the Maynardville Limestone. Based on the distance (94 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations suggest slightly downward vertical hydraulic gradients (0.003 to 0.011) during seasonally high and low flow conditions. However, upward vertical gradients (0.008 to 0.038) are indicated by the unusually high presampling groundwater elevations in well GW-382 during February 1991, October 1992, and September 1994.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-382 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. However, a gravel and perforated-pipe underdrain constructed beneath portions of the UEFPC distribution channel (see Section 1.0) substantially influences local groundwater flow directions. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 1,300 ft east-southeast (hydraulically downgradient) of well GW-382 and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 248 –502 mg/L;
- pH (field measurements) of 6.9 – 7.9;
- unusually high concentrations of chloride (>50 mg/L) and iron (>5 mg/L) compared to other wells that yield groundwater from the Maynardville Limestone;
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations);
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). However, as illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical characteristics of the groundwater in the well, particularly the REDOX conditions, are not especially conducive to biotic degradation of VOCs (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since February 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All but two of the groundwater samples had nitrate at or above the applicable analytical reporting limit, with the highest concentration (4.5 mg/L in May 1995) being less than the drinking water MCL for nitrate (10 mg/L). The specific source of nitrate in groundwater at this well has not been identified, but a potential source is the S-2 Site, which is an unlined waste site excavated into the lower slope of Chestnut Ridge about 9,000 ft west (hydraulically upgradient) of the well that received an unknown volume of corrosive and toxic aqueous wastes.

5.2 URANIUM

Six groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.0129 mg/L in July 2001) being substantially below the drinking water MCL for uranium (0.03 mg/L). However, this result is a suspected outlier because most results (21 samples) were below the detection limit and the next highest results are an-order-of magnitude lower (0.001 mg/L, which equals the detection limit, in four samples) than this result.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in at least one of the groundwater samples (Table 2): acetone, CTET, chloroform, chloromethane, MC, toluene, PCE, TCE, 11DCE, 12DCE (c12DCE), carbon disulfide, and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater plume capture system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 1,500 ft east (parallel with geologic strike) of well GW-382; treating the groundwater on-site to remove VOCS, particulates, iron, and manganese; and discharging the effluent into UEFPC.

The primary VOCs in the groundwater samples are CTET, chloroform, and PCE, each of which was detected in each groundwater sample (Table 2). Secondary compounds are TCE, detected in about half of the samples, and c12DCE, which was detected in nine of the 11 samples collected since September 1999. Other VOCs were detected in no more than seven samples, with acetone, carbon disulfide, chloromethane, 11DCE, and 111TCA each detected in only one sample. The highest concentrations were reported for CTET (7,000 µg/L in November 1993), chloroform (1,300 µg/L in October 1992), acetone (490 µg/L in February 1994), and PCE (330 µg/L in February 1994); all the other VOCs have historical maximum concentrations below 100 µg/L. The most recent monitoring results show that the concentrations of CTET, chloroform, and PCE remain above respective drinking water MCLs (Table 2).

Summed concentrations of VOCs detected in the groundwater samples obtained with the conventional sampling method (February 1991 – May 1995) show a widely fluctuating, indeterminate long-term concentration trend (Figure 1). The wide concentration variations indicated by the conventional sampling data do not consistently correlate with seasonal groundwater flow conditions, as illustrated by the temporal low summed concentrations of VOCs detected in the groundwater samples obtained in February 1991 (3,380 µg/L) and October 1992 (2,157 µg/L).

Summed concentrations of VOCs detected in the groundwater samples obtained with the low-flow sampling method (September 1999 – August 2003) show much lower concentrations that exhibit substantially less temporal variability and a clearly decreasing trend through August 2002, followed by higher concentrations through August 2003 (Figure 1). As noted in Section 4, the lower VOC concentrations indicated by the low-flow sampling results may be an artifact of the sampling method. Nevertheless, the lower VOC concentrations generally coincide with the full-time operation the groundwater plume capture system.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.72 pCi/L in September 2000) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.6 pCi/L in September 2000) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-382: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	February 2004	August 2004
Nitrate < 1 mg/L	0.44	0.19
Iron (II) > 1 mg/L	0.01*	0.06*
Sulfate < 20 mg/L	5.3	4.9
Dissolved Oxygen < 0.5 ppm	10.28*	0.89*
REDOX < 50 mV	84*	182*
pH >5 and < 9 st. units	7.19*	6.98*
Note: *Field measurement.		

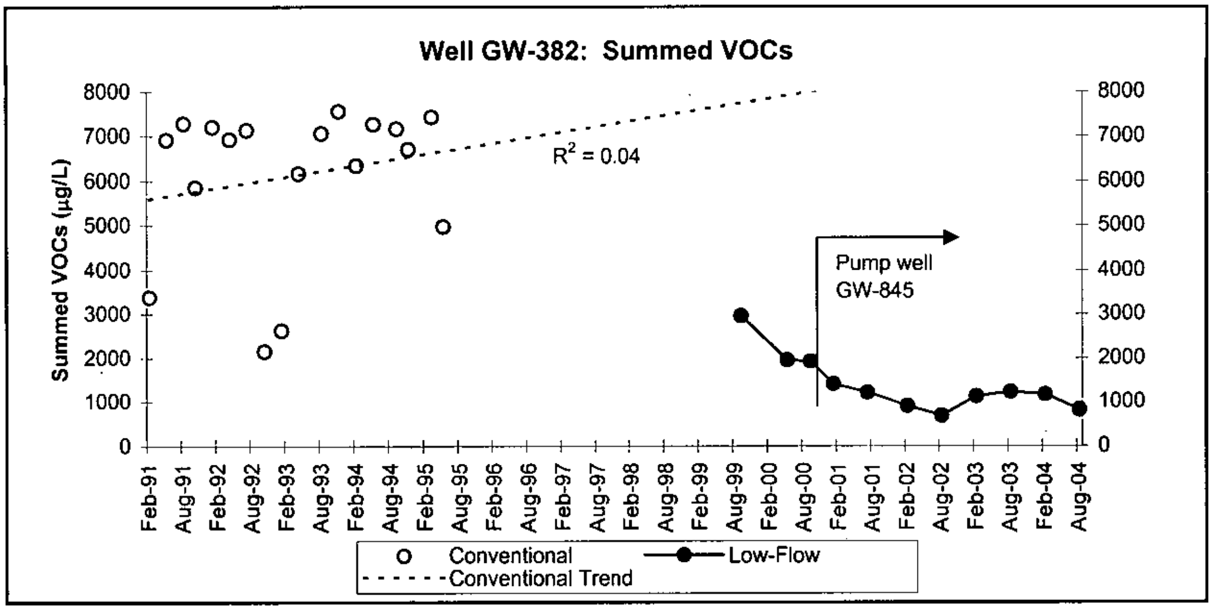
Table 2. Well GW-382: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	CTET	Chloroform	MC	Other
Conventional Sampling				
02/04/91	3,100	140	.	Toluene (23)
05/07/91	6,500	180	.	Toluene (69)
08/27/91	6,800	200	.	.
10/27/91	5,300	260	.	.
01/28/92	6,700	290	.	.
04/25/92	6,500	250	.	Chloromethane (19)
07/30/92	6,600	210	65	.
10/15/92	620	1,300	14	.
01/28/93	1,500	950	24	.
04/26/93	5,500	380	.	.
08/08/93	6,500	330	.	.
11/04/93	7,000	220	80	.
02/08/94	5,800	210	.	Acetone (490)
05/16/94	6,800	240	.	.
09/26/94	6,100	220	.	.
11/18/94	6,200	210	.	.
03/02/95	6,900	220	.	.
05/26/95	4,500	270	.	.
Low Flow Sampling				
09/02/99	1,900	920	.	11DCE (1 J); 111TCA (2 J)
05/18/00	1,400	540	.	.
09/11/00	1,300	610	.	.
01/22/01	1,000	390	.	.
07/31/01	580	610	.	.
02/04/02	510	380	.	.
08/06/02	230	400	43	.
02/13/03	760	310	.	.
08/14/03	1,000	190	.	.
02/11/04	930	200	.	.
08/11/04	620	170	.	Carbon disulfide (3 J)
MCL	**5**	**80***	**NA**	

Table 2. (continued)

Date Sampled	VOC Concentration (μg/L)		
	PCE	TCE	c12DCE
Conventional Sampling			
02/04/91	140	.	.
05/07/91	210	28	.
08/27/91	260	.	.
10/27/91	220	.	.
01/28/92	210	.	.
04/25/92	170	.	.
07/30/92	260	.	.
10/15/92	180	24	.
01/28/93	130	20	.
04/26/93	250	34	.
08/08/93	230	.	.
11/04/93	260	.	.
02/08/94	330	.	.
05/16/94	230	.	.
09/26/94	310	43	.
11/18/94	250	44	.
03/02/95	310	.	.
05/26/95	200	.	.
Low Flow Sampling			
09/02/99	110	17	6
05/18/00	17	.	.
09/11/00	13	2 J	3 J
01/22/01	12	2 J	3 J
07/31/01	12	2 J	3 J
02/04/02	8	2 J	2 J
08/06/02	9	.	.
02/13/03	37	9	7
08/14/03	24	4 J	6
02/11/04	26	4 J	8
08/11/04	11	2 J	7
MCL	**5**	**5**	**70**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane



Well GW-382: Summed VOCs
Summed VOCs (µg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
R² = 0.04
Pump well
GW-845
Feb-91
Aug-91
Feb-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
Conventional
Low-Flow
Conventional Trend

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	500 - 5,000	7.5 - 15	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-383

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 63,522.39
Y-12 GRID NORTH COORDINATE: 29,201.44
SURFACE ELEVATION: 906.00 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/04/88 PAIRED/CLUSTERED WITH: GW-384 GW-385
TAG DEPTH (measured): 26.54 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 908.77 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	16.6	889.40
BOTTOM (filter pack or open hole):	23.6	882.40
MIDPOINT (filter pack or open hole):	20.1	885.90
PUMP INTAKE:	20.53	885.47
WATER LEVEL (average):	6.62	899.38

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	51		
CONVENTIONAL SAMPLING METHOD:	35 samples	08/23/88	05/22/97
LOW-FLOW SAMPLING METHOD:	16 samples	12/04/97	11/03/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/20/04	.	11/03/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.55 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	41	959 µg/L	08/17/00	Mixed
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-383

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1988, completed with a screened monitored interval from 16.6 to 23.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-384 and GW-385 and is located in Bear Creek Valley near the east end of Y-12, adjacent to Second Street immediately west (hydraulically upgradient) of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through the concrete-lined distribution channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 35 samples between August 1988 and May 1997, and the low-flow sampling method used to obtain 16 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group) and is believed to intercept groundwater flow/transport pathways associated with the buried former channel of UEFPC on the west side of NHP (DOE 2002). The bulk of the groundwater flow in the Nolichucky Shale occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibits minor (<5 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-381 indicate east and southeasterly flow toward the UEFPC. Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which generally coincides with the eastward flow directions indicated by the groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 400 mg/L;
- pH (field measurements) of 5.8 – 7.6;
- high concentrations of chloride (>50 mg/L) and iron (>1 mg/L) compared to other wells that yield groundwater from the water-table interval in the Nolichucky Shale;
- low molar proportions of potassium, sulfate, and sodium (<10% of total anions/cations);
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as application of salt to roadways during winter months or leaking industrial process lines, sanitary sewers, or storm drains. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). As illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical characteristics of the groundwater in the well, particularly the REDOX conditions, are conducive to biotic degradation of VOCs (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Four groundwater samples had nitrate above the applicable analytical reporting limit, with the highest concentration (3.9 mg/L in August 2000) being less than the drinking water MCL for nitrate (10 mg/L). However, the historical maximum result appears to be an outlier because the other three nitrate concentrations are less than 1 mg/l.

5.2 URANIUM

Uranium concentrations at or above the applicable analytical reporting limit were reported only for the groundwater samples collected in May 1994 (0.001 mg/L) and June 1999 (0.000666 mg/L) and both of these values are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each groundwater sample contained one or more of the following VOCs: acetone, CTET, chloroform, PCE, TCE, VC, 11DCE, c12DCE, t12DCE, and 111TCA. The source of these compounds is believed to be DNAPL that is suspected to be present in the subsurface near Bldg. 9720-6, which is about 500 ft west-southwest of the well (DOE 1998). The former UEFPC channel, intercepted by well GW-382 (see Section 3.0), is believed to be an active pathway for northward transport of VOCs from Bldg. 9720-6 (DOE 2002). Also, the groundwater geochemistry in the well (see section 4.0) appears to be conducive to the biotic degradation of chlorinated hydrocarbons. Thus, some of the compounds (e.g., CTET and PCE) are probably the principal components of the suspected DNAPL at Bldg. 9720-6, whereas other compounds (e.g., c12DCE and VC) are present as a consequence of the biotic degradation of related parent compounds during residence/transit in the groundwater system. Indeed, the low dissolved oxygen and negative REDOX that are characteristic of the groundwater samples potentially indicate the reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC (Chapelle 1996).

The primary VOCs in the groundwater samples are PCE, TCE, and 12DCE, each of which was detected in each sample (Table 2). In contrast, CTET, chloroform, 11DCE, and VC were detected in 24-44% of the samples and 111TCA was detected in only one sample. Respective historical maximum concentrations exceed 100 μg/L for PCE, TCE and 12DCE, whereas the bulk of the results for CTET, chloroform, 11DCE, and VC are estimated values below 5 μg/L. Also, the most recent monitoring data also show that PCE and TCE concentrations remain substantially above respective drinking water MCLs (5 μg/L). Based on the analytical results reported for the samples collected since May 1997, c12DCE is the primary 12DCE isomer in the groundwater samples, with the most recent monitoring data showing c12DCE concentrations substantially above the MCL (80 μg/L). Although detected infrequently (in 13 of 41 samples) and at substantially lower concentrations, all the VC results equal or exceed the MCL (2 μg/L), including the concentration detected in the most recent sample.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample, show a widely fluctuating but generally increasing long-term concentration trend (Figure 1). However, increasing trends are not evident for all of the VOCs. For instance, between January 1991 and November 2004, the concentrations of PCE, TCE, and 12DCE have increased significantly, whereas there are minimal differences in the initial and most recent concentrations of VC and 11DCE (Table 2). Also, the widely fluctuating summed VOC concentrations reflect sharp temporal changes in the concentrations of PCE, TCE, and 12DCE, with the highest concentrations of each compound typically evident in the groundwater samples collected during seasonally low flow conditions (summer and fall). Additionally, the concentrations of CTET and chloroform have decreased from the peak levels evident during the early 1990s (Figure 2), and have not been detected in samples collected since May 1997 (Table 2).

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.8 pCi/L in May 2004) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.4 pCi/L in November 1999) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Battelle Press, Columbus, OH.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*. Prepared for the U.S. Department of Energy (DOE/OR/01-1941&D2/R1).

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-383: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2004	November 2004
Nitrate < 1 mg/L	<0.02	<0.02
Iron (II) > 1 mg/L	1.52	1.27
Sulfate < 20 mg/L	17.4	17.6
Dissolved Oxygen < 0.5 ppm	1.09**	0.1**
REDOX < 50 mV	-13**	-92**
pH >5 and < 9 st. units	7.12**	7.11**
Note: *Results are for total iron; **Field measurement.		

Table 2. Well GW-383: summary of VOC results

Date Sampled	VOC Concentration (μg/L)				
	PCE	TCE	12DCE		
			Total	c12DCE	t12DCE
01/29/91	390	150	41	NR	NR
04/25/91	320	120	65	NR	NR
08/27/91	370	130	80	NR	NR
10/26/91	180	73	97	NR	NR
01/26/92	350	130	110	NR	NR
04/23/92	370	130	73	NR	NR
07/29/92	390	120	71	NR	NR
10/23/92	350	130	87	NR	NR
01/26/93	300	120	72	NR	NR
04/22/93	400	130	71	NR	NR
08/07/93	120	48	73	NR	NR
11/03/93	190	77	84	NR	NR
02/05/94	410	160	100	NR	NR
05/13/94	200	72	62	NR	NR
09/22/94	380	150	89	NR	NR
11/17/94	180	76	100	NR	NR
02/28/95	490	180	100	NR	NR
05/25/95	330	120	93	NR	NR
08/29/95	410	160	110	NR	NR
12/05/95	380	150	120	NR	NR
03/21/96	470	170	120	NR	NR
06/17/96	350	150	99	NR	NR
08/26/96	330	120	85	NR	NR
11/20/96	500	200	120	NR	NR
05/22/97	350	180	132	130	2 J
12/04/97	310	100	101	100	1 J
06/01/98	400	150	111	110	1 J
12/08/98	440	170	122	120	2 J
06/03/99	360	150	150	150	.
11/11/99	550	160	140	140	.
05/15/00	470	150	110	110	.
08/17/00	610	200	141	140	1 J
10/16/00	520	200	150	150	.
04/30/01	390	190	130	130	.
10/24/01	640	180	132	130	2 J
04/25/02	400	170	130	130	.
10/22/02	380	200	140	140	.
06/17/03	450	150	120	120	.
10/16/03	510	170	141	140	1 J
05/20/04	380	160	141	140	1 J
11/03/04	440	180	192	190	2 J
MCL	**5**	**5**	**NA**	**80**	**NA**

Table 2. (continued)

Date Sampled	VOC Concentration (µg/L)			
	11DCE	VC	CTET	Chloroform
01/29/91	.	.	19	11
04/25/91	.	.	14	10
08/27/91	.	.	8	7
10/26/91	1 J	.	.	FP
01/26/92	2 J	.	9	FP
04/23/92	.	.	6	4 J
07/29/92	.	.	.	.
10/23/92	.	.	2 J	2 J
01/26/93	.	.	3 J	.
04/22/93	.	.	4 J	3 J
08/07/93	.	.	.	.
11/03/93	.	.	.	.
02/05/94	2 J	.	4 J	2 J
05/13/94	.	.	.	.
09/22/94	.	.	2 J	2 J
11/17/94	1 J	2 J	.	.
02/28/95	.	.	2 J	1 J
05/25/95	.	.	.	.
08/29/95	.	.	.	.
12/05/95	.	.	.	.
03/21/96	.	.	.	.
06/17/96	.	.	.	.
08/26/96	.	.	.	.
11/20/96	2 J	2 J	2 J	1 J
05/22/97	3 J	4 J	2 J	FP
12/04/97	3 J	.	.	.
06/01/98	3 J	2 J	.	.
12/08/98	3 J	2 J	.	.
06/03/99	3 J	2 J	.	.
11/11/99	.	.	.	.
05/15/00	.	.	.	.
08/17/00	3 J	.	.	.
10/16/00	.	2 J	.	.
04/30/01	.	.	.	.
10/24/01	3 J	2 J	.	.
04/25/02	3 J	.	.	.
10/22/02	3 J	2 J	.	.
06/17/03	2 J	2 J	.	.
10/16/03	2 J	2 J	.	.
05/20/04	2 J	2 J	.	.
11/03/04	4 J	3	.	.
MCL	**7**	**2**	**5**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

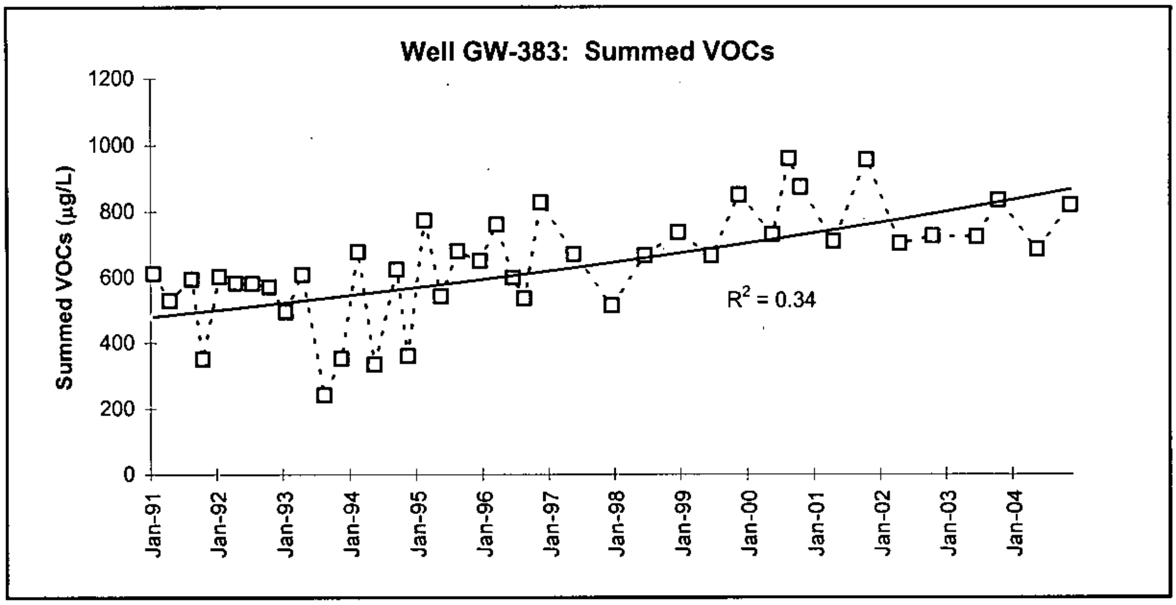


Figure 1

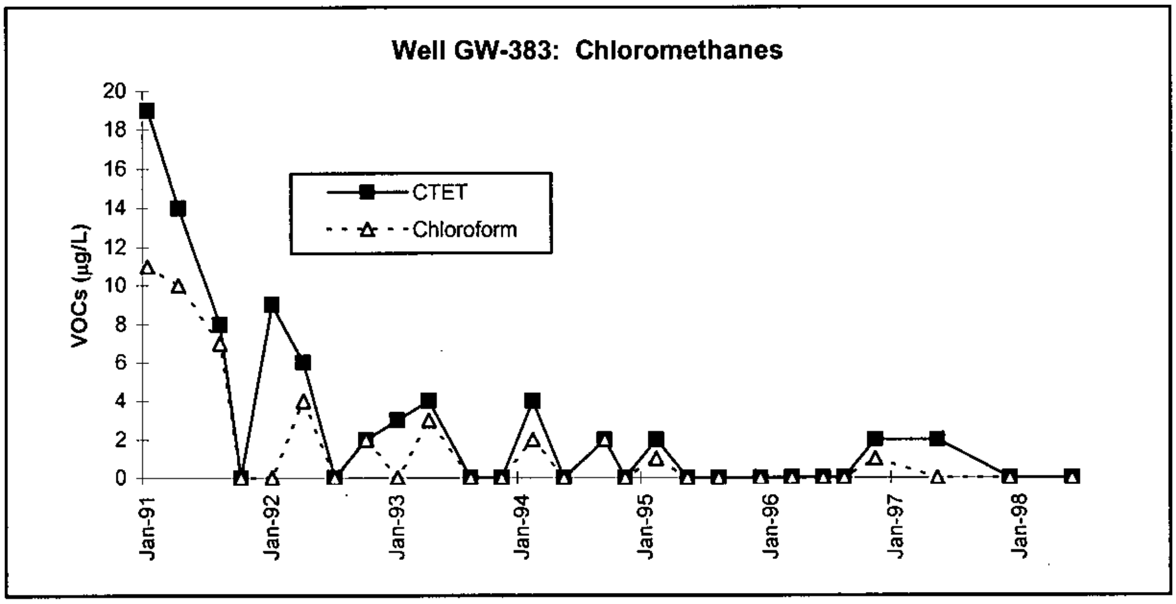


Figure 2

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	0.015 - 0.03	ND	15 - 150	<25

GW-505

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Rust Garage Area
Y-12 GRID EAST COORDINATE: 53,037.45
Y-12 GRID NORTH COORDINATE: 30,400.04
SURFACE ELEVATION: 1,011.60 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/06/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 16.80 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,015.19 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 7 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	1.5	1010.10
BOTTOM (filter pack or open hole):	13.5	998.10
MIDPOINT (filter pack or open hole):	7.5	1004.10
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	1.17	1010.43

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	21		
CONVENTIONAL SAMPLING METHOD:	19 samples	12/29/88	02/24/96
LOW-FLOW SAMPLING METHOD:	2 samples	05/12/03	10/06/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/12/03	.	10/06/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.79 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	6 μg/L	09/20/91	Decreasing
GROSS ALPHA (15 pCi/L):	9	28 pCi/L	10/06/03	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-505

1.0 *INSTALLATION, CONSTRUCTION, AND LOCATION*

This well was installed during April 1988, completed with a screened monitored interval from 1.5 to 13.5 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) near the west end of Y-12, at the Rust Garage (RG) about 400 ft east-southeast of the former S-3 Ponds. The RG once housed several petroleum fuel underground storage tanks (USTs) and associated service lines and dispenser, a fuel unloading station, and drum storage area for used oil (DOE 1998). Note that the large monitored (screened) interval in the well is intended to straddle the water table during seasonally high and low flow conditions and facilitate detection of light non-aqueous phase liquids (LNAPL).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-one groundwater samples have been collected from the well, with the conventional sampling method used to obtain 19 samples between December 1988 and February 1996, and the low-flow sampling method used to obtain samples in May and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 1 ft bgs and exhibits minimal (<3 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-505 indicate east-southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 94 - 226 mg/L;
- pH of 5.2 – 6.76 (field measurements);
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of*

Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the analytical results for the 15 groundwater samples collected since March 1991, groundwater contamination at this well is dominated by elevated levels of gross alpha radioactivity.

5.1 NITRATE

Fifteen groundwater samples had nitrate concentrations at or above the analytical reporting limit, with the highest value (2.9 mg/L) being substantially below the MCL for nitrate (10 mg/L). Low nitrate concentrations in the samples at this well is surprising considering the substantially higher concentrations (>100 mg/L) in the groundwater samples from wells completed at similar depths in the Nolichucky Shale along geologic strike to the west (GW-105) and east (GW-270) of the well. The source of the nitrate is the former S-3 Ponds, which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium) were dissolved from bedrock minerals by the acidic seepage from the ponds. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume and, based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs (DOE 1998).

The low nitrate concentrations in the groundwater samples from the well may be attributable to localized hydrologic and/or geochemical attenuation processes. For instance, a section of storm drain that traverses north-south across the RG about 100 ft west of the well may intercept nitrate-contaminated groundwater moving eastward via the shallow flowpaths in the water table interval. Also, groundwater elsewhere at the RG contains a residual plume of dissolved petroleum hydrocarbons that originated from former petroleum fuel underground storage tanks at the site, and the lack of both nitrate and dissolved hydrocarbons in the groundwater at well GW-505 potentially results from their co-metabolic biodegradation in the subsurface.

5.2 URANIUM

As shown on Table 1, each groundwater sample had a total uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.028 mg/L in March 1994) being slightly below the MCL (0.03 mg/L). Although below the MCL, the uranium concentrations are almost an order-of-magnitude above the applicable UTL (0.005 mg/L). The contaminant plume emplaced in the Nolichucky Shale during historical operation of the former S-3 Ponds is the most likely source of the uranium. Considering the acidic pH of the samples from the well (see Section 4.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993).

It seems somewhat unusual that uranium concentrations in the shallow groundwater at this well are higher than evident in well GW-105, which is located about 200 ft directly west (hydraulically upgradient and closer to the former S-3 Ponds) of the well is completed at similar depth in the Nolichucky Shale. Also, as noted in Section 5.1, the available monitoring data show that nitrate concentrations in the shallow groundwater at this well are at least an order-of-magnitude lower than nitrate levels evident in the groundwater at well GW-105. Assuming both wells yield groundwater containing a heterogeneous mixture of uranium and nitrate from a common source (the former S-3 Ponds), the inverse relationships between the uranium and nitrate concentrations in these wells suggest that localized geochemical conditions have lowered the nitrate levels in the groundwater at well GW-505 because localized hydrologic conditions would be expected to influence both nitrate and uranium concentrations in the groundwater.

5.3 VOLATILE ORGANIC COMPOUNDS

Low levels of PCE, TCE, 11DCE, and 12DCE were detected in six of the ten groundwater samples collected between March 1991 and June 1993; all of these results are estimated values below 5 μg/L. Each of these VOCs are components of the contaminant plume originating from the former S-3 Ponds. Acetone, chloroform, and methylene chloride have been detected in several samples but all of these results are false positives. The most recent sampling results (May and October 2003) do not indicate the presence of dissolved VOCs in the groundwater at this well.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, with values above the MCL for gross alpha activity (15 pCi/L) reported for all but six of the samples (Table 1). The most recent sampling results suggest that uranium isotopes (U-234 and U-238) in the groundwater are the likely source of the alpha activity. Also, a time-series plot of the results for gross alpha activity, which spans a nine-year gap in the sampling history for the well (March 1994 – May 2003), suggests a slightly upward long-term trend (Figure 1). However, this upward trend is of questionable significance and may be an artifact of the change from conventional sampling method to the low-flow sampling method.

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the highest value (23 pCi/L in October 2003) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity). Radiochemical analyses of the samples collected in May and October 2003 show that uranium isotopes (and related daughters) are the source of the gross beta activity in the groundwater; Tc-99, a beta-emitting radionuclide and a principal component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, was not detected (i.e., <MDA) in the samples collected in May and October 2003.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-505: summary of results for uranium and uranium isotopes, gross alpha activity, and gross beta activity

Date Sampled	Total Uranium (mg/L)	Uranium Isotopes (pCi/L)		Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
		U-234	U-238		
03/12/91	0.016	NA	NA	13.62	8.82
06/21/91	0.015	NA	NA	12.05	6.07
09/20/91	0.012	NA	NA	21.2	16.9
12/15/91	0.007	NA	NA	3.87	<CE
03/05/92	0.013	NA	NA	17.5	12.7
04/30/92	0.008	NA	NA	12.6	10
08/12/92	0.011	NA	NA	6.35	8.45
11/03/92	0.014	NA	NA	19.9	15
03/01/93	0.012	NA	NA	16.4	12.3
06/18/93	0.009	NA	NA	16.2	<CE
09/15/93	0.007	NA	NA	10.8	4.71
11/16/93	0.014	NA	NA	18.9	16.9
03/01/94	0.028	NA	NA	15.3	10
05/12/03	0.0232	16	7.8	24	<MDA
10/06/03	0.0135	9.6	5.1	28	23
MCL	**0.03 mg/L**	**Not Applicable**		**15 pCi/L**	**50 pCi/L***

Note: NA = Not applicable; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

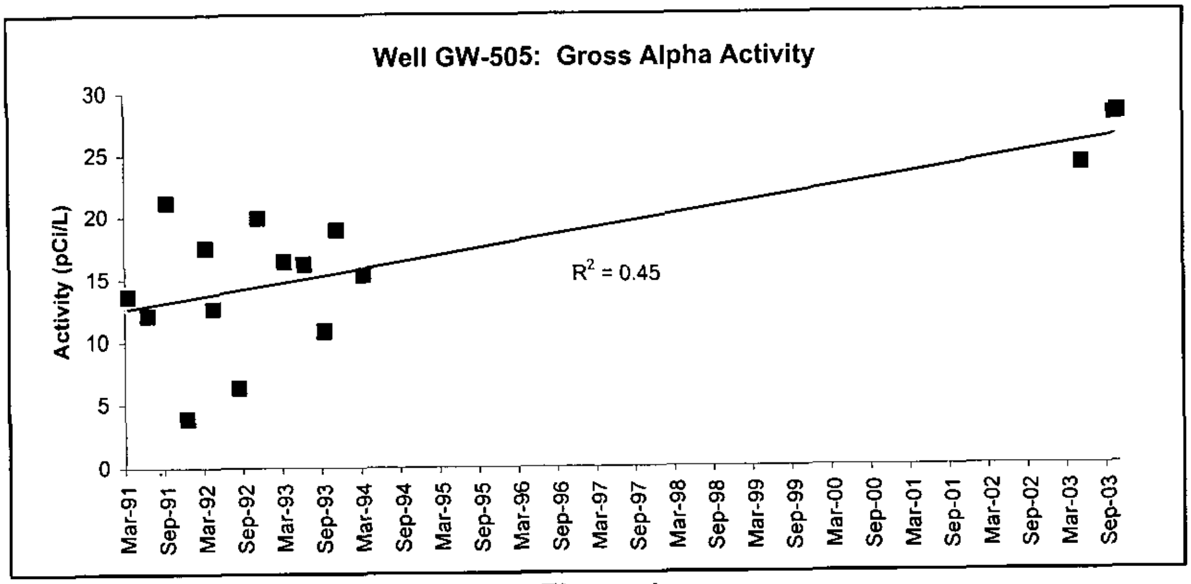

Well GW-505: Gross Alpha Activity
Activity (pCi/L)
30
25
20
15
10
5
0
R^2 = 0.45
Mar-91
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-513

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Filled Coal Ash Pond
Y-12 GRID EAST COORDINATE: 57,331.91
Y-12 GRID NORTH COORDINATE: 27,606.52
SURFACE ELEVATION: 998.99 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/30/88 PAIRED/CLUSTERED WITH: GW-512, GW-514
TAG DEPTH (measured): 127.53 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,001.41 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	111.0	887.99
BOTTOM (filter pack or open hole):	125.3	873.69
MIDPOINT (filter pack or open hole):	118.2	880.84
PUMP INTAKE:	120.1	878.91
WATER LEVEL (average):	20.32	978.67

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	28 samples	12/03/88	04/29/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/20/04	10/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/20/04	.	10/13/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 25.75 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-513

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1988, completed with a screened monitored interval from 111 to 125 ft bgs, and constructed nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the southern flank of Chestnut Ridge approximately one-half mile south of Y-12, about 300 ft north of the northern (upstream) side of the Filled Coal Ash Pond (FCAP). The FCAP occupies the former basin behind an earthen dam, constructed in 1955 across a northern tributary of McCoy Branch, which had filled with fly-ash slurry pumped from the Y-12 Steam Plant. The final approved ROD for FCAP (DOE 1996) required dam stabilization and wetlands construction as CERCLA corrective actions at the site, which were completed in 1997 (DOE 1997).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 28 samples between December 1988 and April 1996, and the low-flow sampling method used to obtain samples in April and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group, which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 20 ft bgs and exhibits substantial (>25 ft) seasonal fluctuations (Figure 1). Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-513 indicate flow directly south toward the FCAP.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 130 – 210 mg/L;
- pH of 7.2 – 7.96 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);

- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample)concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, none of the principal contaminants are present at elevated concentrations in the groundwater at this well.

5.1 NITRATE

Four groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit and these results are all less than 1 mg/L and are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit, and both results (0.001 mg/L in November 1992 and April 1994) are an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

One of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, and this value (3.5 pCi/L in October 1994) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, and the highest result (4.89 pCi/L in December 1993) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

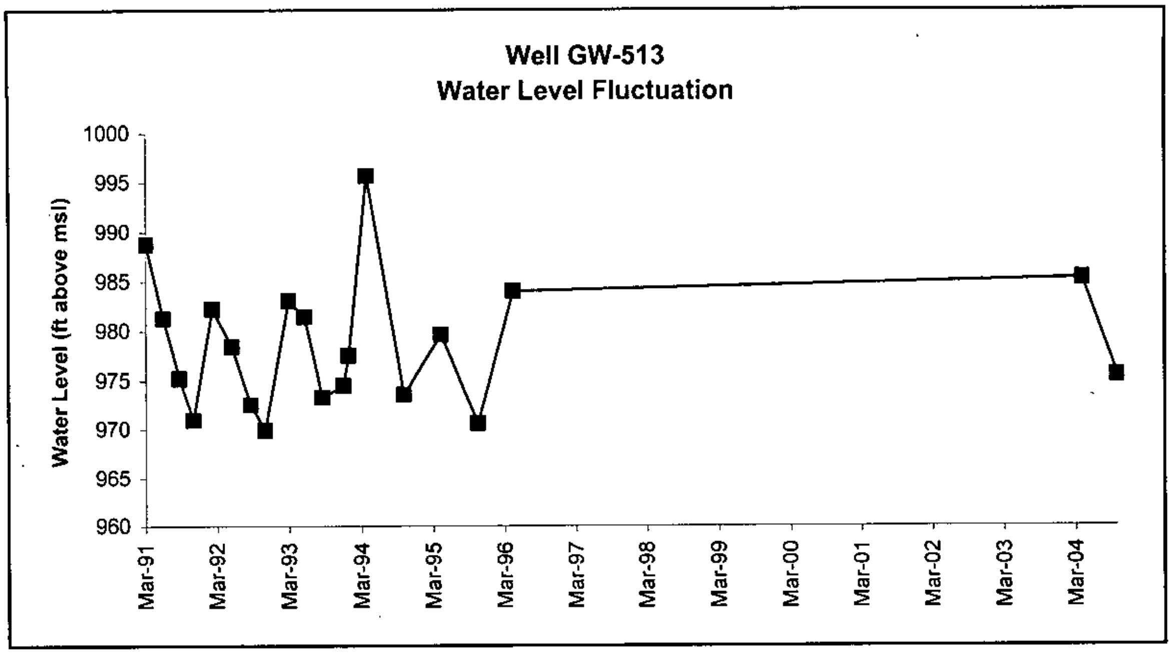
6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/02-1410&D3, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/01-1596&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.



Well GW-513
Water Level Fluctuation
Water Level (ft above msl)
1000
995
990
985
980
975
970
965
960
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-521

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill IV
Y-12 GRID EAST COORDINATE: 52,039.50
Y-12 GRID NORTH COORDINATE: 28,541.02
SURFACE ELEVATION: 1,179.46 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/14/88   PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 136.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,182.88 ft above msl   MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard   Sampling Port No.: .   Port Depth : . (ft bgs)

MONITORED INTERVAL   TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	123.2	1056.26
BOTTOM (filter pack or open hole):	136.0	1043.46
MIDPOINT (filter pack or open hole):	129.6	1049.86
PUMP INTAKE:	128.98	1050.48
WATER LEVEL (average):	80.46	1099.00

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	31 samples	09/08/89	07/21/97
LOW-FLOW SAMPLING METHOD:	15 samples	01/07/98	07/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/14/04	.	07/14/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .   TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: .   LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: .   OTHER: .
WATER LEVEL FLUCTUATION: 11.95 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS   Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	18 µg/L	07/17/91	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-521

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1988, completed with a screened monitored interval from 123.2 to 136 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the crest of Chestnut Ridge southwest of the west end of Y-12, less than 100 ft directly west (hydraulically upgradient) of the Industrial Landfill IV. In operation since 1989, this landfill receives about 12,000 ft^2 per year of nonhazardous and nonradioactive industrial wastes, including cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 31 samples between September 1989 and July 1997, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 80 ft bgs and exhibit substantial (>10 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge. The average result of several falling head permeability tests performed in well GW-521 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 4.5×10^{-4} cm/s (1.28 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 102 – 230 mg/L;
- pH (field measurements) of 6.0 – 8.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 39 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Twenty-five groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.68 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in July 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, acetone is the only VOC that has been detected in samples from the well. These results (18 μg/L in July 1991, 3 μg/L in January 2000, and 3.3 μg/L in January 2003) are considered sampling or analytical artifacts because acetone in commonly detected in blank samples.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.37 pCi/L in October 1994) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (3.86 pCi/L August 1992) being substantially below the SDWA for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-522

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill IV
Y-12 GRID EAST COORDINATE: 52,612.31
Y-12 GRID NORTH COORDINATE: 28,377.44
SURFACE ELEVATION: 1,172.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/20/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 197.10 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,175.48 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	183.0	989.04
BOTTOM (filter pack or open hole):	195.3	976.74
MIDPOINT (filter pack or open hole):	189.2	982.89
PUMP INTAKE:	187.56	984.48
WATER LEVEL (average):	95.11	1076.93
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	45		
CONVENTIONAL SAMPLING METHOD:	30 samples	08/30/89	07/21/97
LOW-FLOW SAMPLING METHOD:	15 samples	01/08/98	07/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/14/04	.	07/14/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 28.02 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	15 µg/L	07/17/91	Outliers
GROSS ALPHA (15 pCi/L):	1	35.6 pCi/L	04/14/92	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-522

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1988, completed with a screened monitored interval from 183 to 195.3 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the crest of Chestnut Ridge southwest of the west end of Y-12, less than 100 ft directly south (hydraulically downgradient) of the Industrial Landfill IV. In operation since 1989, this landfill receives about 12,000 ft^2 per year of nonhazardous and nonradioactive industrial wastes, including cardboard, plastics, rubber, scrap metal, wood, paper, and special wastes generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 30 samples between August 1989 and July 1997, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group. The average static groundwater level in the well is 95 ft bgs. Presampling depth-to-water measurements for the well indicate wide (>25 ft) water-level fluctuations, with generally decreasing groundwater elevations evident between January 1994 and January 2001, followed by generally increasing groundwater elevations through July 2003 (Figure 1). The average result of several falling head permeability tests performed in well GW-522 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.9×10^{-4} cm/s (0.54 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 88 – 266 mg/L;
- pH (field measurements) of 5.9 – 8.5;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 37 groundwater samples collected from the well since January 1991.

5.1 NITRATE

Thirty-six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.83 mg/L in July 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

The total uranium concentration reported for the groundwater sample collected from the well in July 1994 (0.003 mg/L) exceeds the analytical reporting limit but is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low levels in three groundwater samples. Trace levels of PCE (0.43 μg/L) and 1,1,2,2-tetrachloroethane (0.57 μg/L) were detected in the sample collected in July 2002, and acetone (a common laboratory reagent) was detected in two samples (15 μg/L in July 1991 and 13 μg/L in February 2000). These results may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (35.6 pCi/L in April 1992) exceeding the MCL for gross alpha activity (15 pCi/L). However, this gross alpha result is considered an outlier (none of the other results exceed 5 pCi/L) and is probably an analytical artifact.

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.39 pCi/L in January 1993) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

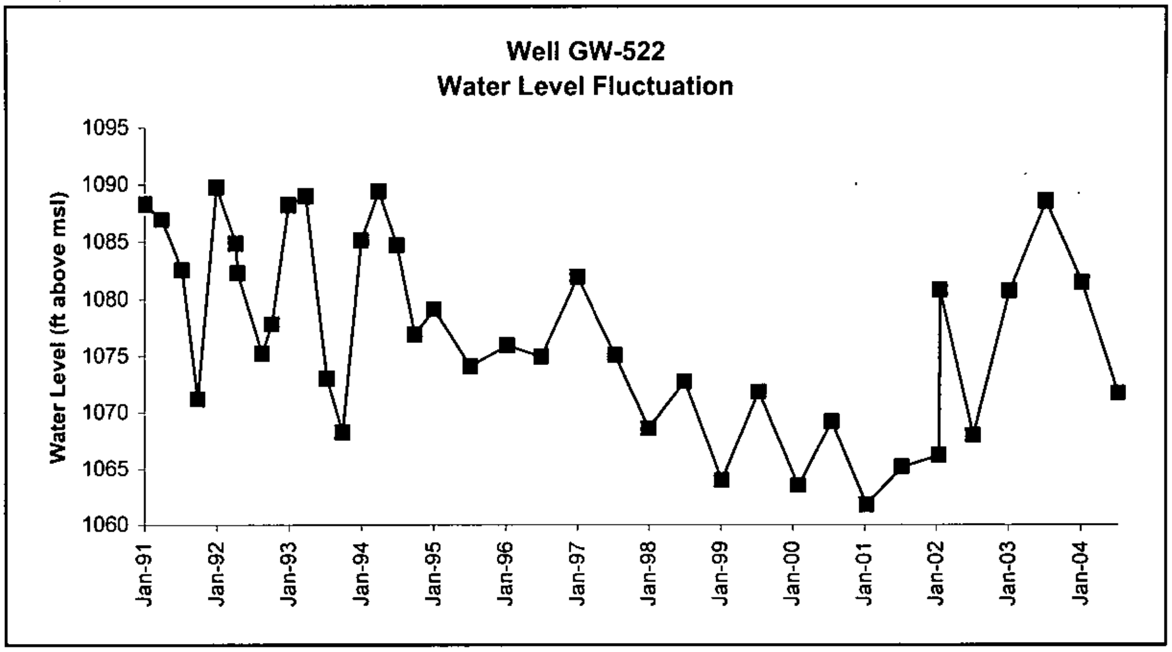

Well GW-522
Water Level Fluctuation
Water Level (ft above msl)
1095
1090
1085
1080
1075
1070
1065
1060
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
>1,000	ND	ND	15 - 150	ND

GW-526

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 50,708.14
Y-12 GRID NORTH COORDINATE: 30,032.85
SURFACE ELEVATION: 995.34 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/13/88 PAIRED/CLUSTERED WITH: GW-345 GW-346
TAG DEPTH (measured): 123.80 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 998.25 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 6.62 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	101.0	894.34
BOTTOM (filter pack or open hole):	123.0	872.34
MIDPOINT (filter pack or open hole):	112.0	883.34
PUMP INTAKE:	112.09	883.25
WATER LEVEL (average):	10.15	985.19

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	37		
CONVENTIONAL SAMPLING METHOD:	24 samples	09/28/88	09/05/97
LOW-FLOW SAMPLING METHOD:	13 samples	02/11/98	08/16/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/17/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.99 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	23	2,550 mg/L	04/16/97	Increasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	7 µg/L	08/02/91	Outliers
GROSS ALPHA (15 pCi/L):	9	282.55 pCi/L	09/05/97	Indeterminate
GROSS BETA (50 pCi/L):	6	718.01 pCi/L	08/06/01	Indeterminate

WELL GW-526

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during June 1988, completed with an open-hole monitored interval from 101 to 123 ft bgs, and constructed with nominal 6.5-inch diameter steel (SF25) riser casing. The well is clustered with wells GW-345 and GW-346 and is located in Bear Creek Valley (BCV) west of Y-12, about 1,300 ft west-southwest of the former S-3 Ponds. The well is adjacent to a northern tributary (NT) of Bear Creek (NT-1), several of which traverse northeast-southwest across the southern flank of Pine Ridge west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-seven groundwater samples have been collected from the well, with the conventional sampling method used to obtain 24 samples between September 1988 and September 1997 and the low-flow sampling method used to obtain 13 samples between February 1998 and August 2004.

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits seasonal fluctuations up to 5 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-526 are typically several feet higher than evident in wells GW-345 and GW-346, which are completed at shallower depths (26 ft and 65 ft bgs, respectively) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.06 – 0.13) from the deeper bedrock (GW-526) to the shallow bedrock interval (GW-346) and downward vertical gradients (0.03 – 0.1) from the water table interval (GW-345) to the shallow bedrock interval during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-526 indicate southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated sodium-bicarbonate groundwater generally characterized by:

- TDS of 1,100 – 13,100 mg/L;
- pH of 6.9 – 10 (field measurements);
- very high concentrations of barium (>10 mg/L), strontium (>20 mg/L), nitrate (>1,000 mg/L), and sodium (>1,000 mg/L), the latter of which dominate the ion chemistry of the samples and are the likely sources of the unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for samples collected in January 1991 (RPD = -25.8%), April 1991 (RPD = 50.1%), and October 1993 (RPD = -85.3%);
- comparatively low concentrations and molar proportions of calcium, magnesium, chloride, potassium, and sulfate; and
- total concentrations of trace metals (except barium and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Aside from the very high levels of nitrate, these geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability formations of the Conasauga Group (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow bedrock wells (i.e., <100 ft bgs) completed in these formations yield calcium-magnesium-bicarbonate groundwater, but a fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs (in BCV west of Y-12). The sodium-enriched geochemistry of the groundwater is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the monitoring data reported for 29 groundwater samples collected since January 1990, nitrate and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for each groundwater sample, with concentrations above 500 mg/L for all but one of the samples, including 19 samples with concentrations above 1,000 mg/L (Table 1). The source of the nitrate is the contaminant plume emplaced during historical operations of the former S-3 Ponds, which are located near the headwaters of Bear Creek at the west end of Y-12, and are four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The former S-3 Ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplaced an extensive plume of groundwater contamination containing a heterogeneous mixture of inorganic, organic, and radiological contaminants. Some of the inorganic contaminants (e.g., nitrate and uranium) were entrained in the nitric acidic wastes and others (e.g., barium and strontium) were dissolved from bedrock minerals. Nitrate is the primary inorganic contaminant in the plume and, based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) relatively rapid, westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel flowpaths, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997).

Very high nitrate concentrations (and TDS) are characteristic of the groundwater samples from this well, more than half of which had concentrations above 1,000 mg/L, but the historical maximum nitrate value (2,550 mg/L in September 1997) appears to be an outlier (all of the other results are less than 1,500 mg/L) and may be a sampling or analytical artifact. The same can be said of the historical minimum nitrate value (258 mg/L in April 1991), which is less than half the next lowest concentration (657 mg/L in October 1991) and is considered qualitative because of the ion-charge balance error (see Section 4.0). Additionally, the nitrate concentrations do not exhibit a wide range of temporal fluctuations or show a consistent relationship with groundwater flow conditions. These results are representative of concentrations in the deeper bedrock groundwater flow/transport pathways in the Nolichucky Shale near NT-1 and reflect the upwelling of nitrate-contaminated groundwater from deeper in the bedrock (DOE 1997).

A time-series plot of the nitrate concentrations detected in the groundwater samples (Figure 1), excluding the suspected outlier (September 1997) and qualitative results (January 1991, April 1991, and October 1993), shows a generally increasing trend that spans a 4-year gap in the sampling history for the well (September 1993 – September 1997). However, the rate of concentration increase appears to have slowed. For example, nitrate concentrations increased by approximately 53% between January 1990 (732 mg/L) and November 1992 (1,120 mg/L), but only about 14% between September 1997 (1,190 mg/L) and August 2003 (1,360 mg/L). Also, nitrate results obtained after August 2003 suggest a decreasing concentration trend, with the result reported for the sample collected in August 2004 (1,150 mg/L) being the lowest concentration evident since March 1999 (1,190 mg/L). Increasing concentrations of nitrate in the groundwater at this well are interpreted to reflect the westward (strike-parallel) migration of the center of mass of the contaminant plume at depth in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997).

5.2 URANIUM

Eleven groundwater samples had total uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00201 mg/L in February 2001) being an order-of-magnitude below the MCL for uranium (0.03 mg/L). Uranium is one of the primary components of the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. The low concentrations of uranium in the groundwater at this well, in contrast to the very high nitrate levels, illustrate the significantly greater attenuation of uranium relative to nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Several VOCs were detected in a total of four groundwater samples, and all of these results are false positives except for one-time detections of TCE (6 µg/L) and 12DCE (1 µg/L) in the August 1991 sample, and chloroform (2 µg/L) in the October 1993 sample.

5.4 GROSS ALPHA ACTIVITY

Thirteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with results for nine samples exceeding the MCL for gross alpha activity (15 pCi/L). However, the gross alpha activity does not consistently exceed the MDA or CE, and results that do range from less than 3 pCi/L to almost 300 pCi/L. The inconsistent detection and widely variable results for gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0). Also, 19 of the samples (including all eight samples collected between February 2000 and August 2004) were analyzed for U-234 and U-238, which are alpha-emitting radionuclides most likely to be present in the groundwater. Eleven of the samples had U-234 and/or U-238 activities above the MDA and corresponding CE, and all of these results are less than 2 pCi/L. The general lack of uranium isotopes in the samples also suggests that the gross alpha results may be inaccurate because of analytical interferences related to the TDS in the samples.

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for eight of the samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). However, as with gross alpha activity, the results for gross beta activity do not consistently exceed the MDA or CE and exhibit widely variable values ranging from less than 5 pCi/L to more than 500 pCi/L. The source of the gross beta activity in the groundwater at this well has not been confirmed. Although the contaminant plume from the former S-3 Ponds contains Tc-99, this beta-emitting radionuclide may not be the source of the gross beta activity in the groundwater at this well; five samples were analyzed for Tc-99, which was detected (i.e., >MDA and CE) in only two samples (4,320 pCi/L in May 1992 and 3,040 pCi/L in August 1992). The inconsistent detection and widely variable results for gross beta activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

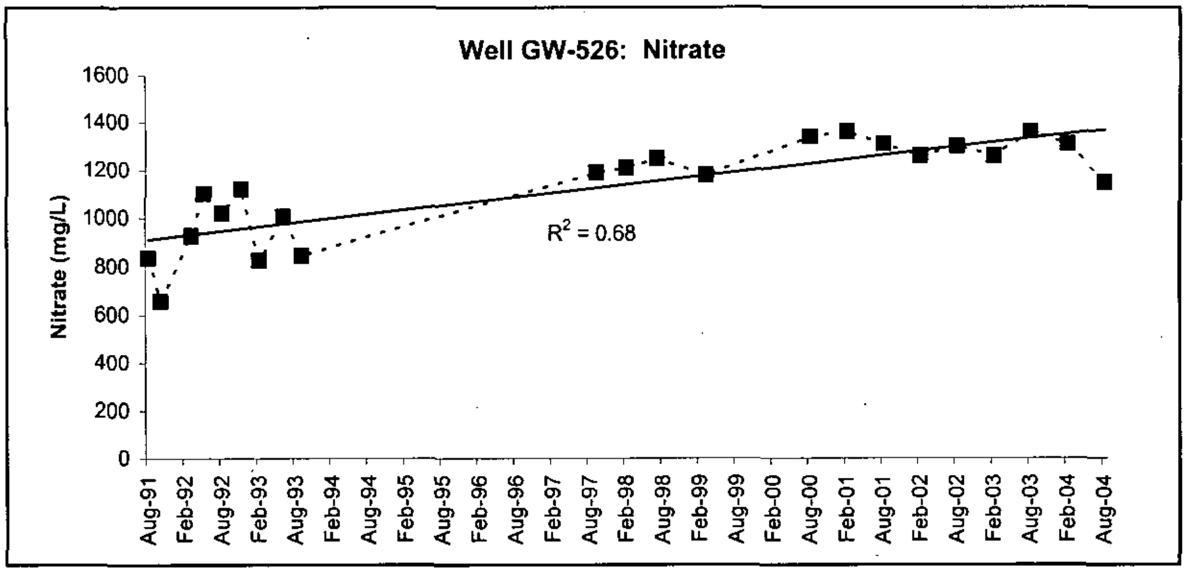
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-526: summary of results for nitrate, gross alpha activity, and gross beta activity

Sampling Date	Concentration		
	Nitrate (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/19/90	732	< CE	< CE
05/17/90	824	< CE	55.89
07/31/90	793	11.2	< CE
10/15/90	1,030	< CE	< CE
01/16/91	(1,390)	< CE	< CE
04/13/91	(258)	< CE	< CE
08/02/91	837	< CE	< CE
10/06/91	657	7.47	< CE
03/14/92	928	2.46	4.07
05/12/92	1,102	29	< CE
08/17/92	1,021	275	443
11/18/92	1,120	6.16	8.79
02/03/93	826	2.04	3.53
06/03/93	1,006	121	287
09/14/93	846	< CE	< CE
10/26/93	(1,171)	< CE	44.7
09/05/97	[2,550]	282.55	374.36
02/11/98	1,190	<MDA	62.19
07/14/98	1,210	19.52	<MDA
03/11/99	1,250	< CE	<MDA
02/22/00	1,180	31.04	<MDA
08/16/00	1,340	<MDA	<MDA
02/01/01	1,360	27.55	<MDA
08/06/01	1,310	155.82	718.01
02/26/02	1,260	<MDA	<MDA
08/08/02	1,300	<MDA	<MDA
02/10/03	1,260	<MDA	53.42
08/18/03	1,360	<MDA	25.46
02/17/04	1,130	54.11	<MDA
08/16/04	1,150	<MDA	<MDA
MCL	**10**	**15**	**50***

Note: ( ) = Result considered qualitative because of ion-charge balance error; [ ] = Suspected outlier; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)



Well GW-526: Nitrate
Nitrate (mg/L)
1600
1400
1200
1000
800
600
400
200
0
$R^2 = 0.68$
Aug-91
Feb-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04

Figure 1

MAXIMUM CONCENTRATION: 2004

100 - 1,000	<0.015	<5	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-537

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 49,538.95
Y-12 GRID NORTH COORDINATE: 30,057.01
SURFACE ELEVATION: 974.49 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/14/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 27.35 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 976.65 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.75 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.8	969.39
BOTTOM (filter pack or open hole):	23.3	950.89
MIDPOINT (filter pack or open hole):	14.1	960.14
PUMP INTAKE:	22.84	951.65
WATER LEVEL (average):	4.77	969.72

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	30 samples	12/06/89	09/17/97
LOW-FLOW SAMPLING METHOD:	16 samples	02/12/98	08/03/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	.	08/03/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.83 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	37	1,127 mg/L	02/11/94	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	8	91.5 pCi/L	10/31/92	Indeterminate
GROSS BETA (50 pCi/L):	37	760 pCi/L	04/23/97	Increasing

WELL GW-537

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during September 1988, completed with a screened monitored interval from 4.8 to 23.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12, near a northern tributary (NT) of Bear Creek (NT-2) about 2,500 ft west of the former S-3 Ponds.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well, with the conventional sampling method used to obtain 30 samples between December 1989 and September 1997 and the low-flow sampling method used to obtain 16 samples between February 1998 and August 2004.

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well and are a direct consequence of contamination from the former S-3 Ponds (see Section 5.0.).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops beneath the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 5 ft bgs and exhibits seasonal fluctuations up to about 4 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-537 indicate southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields highly mineralized, sodium- and chloride-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 3,600 – 7,468 mg/L;
- pH of 6.4 – 7.2 (field measurements);
- total (unfiltered sample) concentrations of barium (>2 mg/L), chloride (>30 mg/L), sodium (>40 mg/L), and strontium (>2 mg/L) that are substantially higher than typically evident in samples from other wells completed at similarly shallow depths in the Nolichucky Shale;

- very high nitrate concentrations (>500 mg/L) that dominate the ion chemistry of the samples and are probably the source of, or are in some way related to, the unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion charge-balance error exceeds 20%) determined for the samples collected in August 1992 (RPD = -26.1%) and September 1994 (RPD = 68.2%);
- low concentrations and molar proportions of potassium and sulfate; and
- total concentrations of trace metals (except barium and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The sodium- and chloride-enriched geochemistry of the groundwater at this well is believed to reflect the upwelling of (contaminated) sodium-bicarbonate groundwater from deeper in the bedrock (DOE 1997). In the low-permeability formations of the Conasauga Group (e.g., Nolichucky Shale) in BCV west of Y-12, a transition from calcium-magnesium-bicarbonate groundwater to sodium-bicarbonate groundwater typically occurs at a depth of about 100 ft bgs. This change in groundwater geochemistry is interpreted to be a function of lower flux and longer residence time as a result of reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the monitoring data reported for 41 groundwater samples collected since January 1990, nitrate and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for each groundwater sample, all but one of which had concentrations above 500 mg/L (Table 1). The source of the nitrate is the contaminant plume emplaced during historical operations of the former S-3 Ponds, which are located near the headwaters of Bear Creek at the west end of Y-12, and are four unlined surface impoundments that were filled and covered with a multilayer low-permeability cap (and an asphalt-paved parking lot) during RCRA closure of the site in 1988. The former S-3 Ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, which emplaced an extensive plume of groundwater contamination containing a heterogeneous mixture of inorganic, organic, and radiological contaminants. Some of the inorganic contaminants (e.g., nitrate and uranium) were entrained in the nitric acidic wastes and others (e.g., barium and strontium) were dissolved from bedrock minerals. Nitrate is the primary inorganic contaminant in the plume and, based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) relatively rapid, westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel flowpaths, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997).

Very high nitrate concentrations (and TDS) are characteristic of the groundwater samples from this well: all of the samples have nitrate above 500 mg/L. Also, the nitrate concentrations do not exhibit a wide range of temporal fluctuations or show a consistent relationship with groundwater flow conditions. Note that both the historical maximum nitrate value (1,285 mg/L in August 1992) and the historical minimum nitrate value (81 mg/L in September 1994) are considered qualitative because of the respective ion charge-balance errors determined for these samples (see Section 4.0). The next highest and lowest nitrate concentrations are 1,127 mg/L in February 1994 and 525 mg/L in September 1993. These results are representative of nitrate concentrations in the shallow flow system near NT-1, which are maintained by the upwelling of nitrate-contaminated groundwater from deeper in the bedrock (DOE 1997).

A time-series plot of the nitrate concentrations detected in the groundwater samples (Figure 1), excluding the qualitative results (August 1992 and September 1994), shows a generally indeterminate long-term concentration trend punctuated by temporal concentration "peaks" in February 1994 (1,127 mg/L), June 1995 (980 mg/L), and August 1999 (897 mg/L). The long-term trend suggests generally stable flux of nitrate via the groundwater flowpaths intercepted by the monitoring interval in the well. Additionally, temporal changes in nitrate concentrations do not appear to be strongly influenced by seasonal groundwater flow conditions, as illustrated by the peak concentrations evident for samples collected during seasonally high (winter and spring) and low (summer and fall) flow, and may be of limited significance with regard to the overall flux of nitrate.

5.2 URANIUM

Forty groundwater samples had total uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00902 mg/L in February 2001) being almost an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L). Uranium is one of the primary components of the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. The low concentrations of uranium in the groundwater at this well, in contrast to the very high nitrate levels, illustrate the significantly greater attenuation of uranium relative to nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Several VOCs were detected in a total of 24 groundwater samples, with all false positive results for each compound except chloroform. As shown in Table 1, very low (estimated) concentrations of chloroform (2 μg/L or less) were detected in 21 samples (excluding false positive results), most recently in the sample collected in August 2004 (2 μg/L). A minor component of the contaminant plume originating from the former S-3 Ponds, chloroform is chemically stable, does not readily partition to soils, and is persistent and mobile in groundwater. Thus, the repeated detection of chloroform in the groundwater samples suggests chloroform is probably present in the groundwater upwelling from the deeper bedrock into the shallow flow system near NT-1 (EPA 2001).

5.4 GROSS ALPHA ACTIVITY

Thirteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1). Results for eight samples exceed the MCL for gross alpha activity (15 pCi/L), with a substantial difference between the historical maximum value (91.5 pCi/L in October 1992) and historical minimum value (4.3 pCi/L in March 1999). Also, only two of the 17 samples collected since March 1996 had gross alpha activity above the MDA and CE. The infrequent detection of gross alpha activity and wide range of results above the MDA may be related to analytical interferences related to the high TDS of the samples. Moreover, relatively low (background) levels of gross alpha activity is supported by results for 11 samples analyzed for U-234 and U-238, which are alpha-emitting radionuclides most likely to be present in the groundwater. Nine of the samples had U-234 and/or U-238 activities above the MDA and corresponding CE, and all but one of these results are less than 3 pCi/L, with the U-234 activity reported for the sample collected in June 1995 (371 pCi/L) being an outlier and potential analytical artifact. The general lack of uranium isotopes in the samples also suggests that the gross alpha results may be inaccurate because of analytical interferences related to the TDS in the samples.

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for all but one of these samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). Most of the samples had gross beta activity above 100 pCi/L, with the two lowest values (56.9 pCi/L in February 1992) and (29.3 pCi/L in August 1992) being suspected outliers. The source of the gross beta activity in the groundwater at this well is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in Table 1, Tc-99 was detected (i.e., >MDA and CE) in 14 of the 16 samples analyzed for this beta-emitting radionuclide, with the highest value reported for the samples collected in February 1994 (1,460 pCi/L) and the most recent results showing concentrations remain near 1,000 pCi/L August 2001 (940 pCi/L). Note that all the Tc-99 results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale west of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate, with primarily westward strike-parallel transport in the water table and bedrock intervals toward discharge areas in NT-1 and NT-2 (DOE 1997).

Aside from the suspected outlier results noted above, each groundwater sample had gross beta activity above 100 pCi/L, with a historical maximum value of 760 pCi/L in April 1997 and a historical minimum value of 112 pCi/L in October 1992. As with nitrate concentrations in the samples, gross beta activity also does not exhibit a consistent relationship with groundwater flow conditions, with temporal "peak" concentrations reported for samples obtained during both seasonally high and low flow conditions, and reflects the transport of Tc-99 in groundwater upwelling from deeper bedrock flowpaths in the Nolichucky Shale near NT-2 (DOE 1997). It is also possible that the results for gross beta activity, as with gross alpha activity, reflect analytical interferences related to the high TDS of the samples.

A time-series plot of the gross beta activity reported for the groundwater samples shows a generally increasing long term trend, with the most recent sampling results, including the historical maximum value, being at least 100% higher than reported for samples obtained in the early 1990s (Figure 1). The increasing long-term trend for gross beta activity potentially corresponds with an overall increase in the relative flux of Tc-99 upwelling from the deeper bedrock flowpaths near NT-2. Also, the gross beta results show significant temporal variability, with a sequence of peak values evident in September 1990 (681 pCi/L), February 1994 (713 pCi/L), June 1995 (619 pCi/L), and April 1997 (760 pCi/L). However, the range of temporal variability in gross beta activity seems to have decreased following the change from conventional sampling to low-flow sampling, which suggests that the sampling method may be at least partially responsible for the apparent temporal changes in gross beta activity.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-537: summary of results for nitrate, chloroform, and gross beta activity

Sampling Date	Concentration				
	Nitrate (mg/L)	Chloroform (µg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)	Tc-99 (pCi/L)
01/27/90	650			145.9	NA
06/27/90	738			288.66	NA
09/22/90	899			681	NA
12/10/90	988			299.25	NA
03/26/91	744	FP	<CE	157.86	NA
06/25/91	626	.	<CE	234.67	NA
08/14/91	647	.	14.5	404.43	NA
10/23/91	717.54	.	9.81	134	NA
02/27/92	703	.	6.26	[56.9]	NA
06/03/92	654	.	<CE	343	NA
08/30/92	(1,285)	0.9 J	17.2	[29.3]	NA
10/31/92	767	.	91.5	112	NA
02/11/93	782	0.8 J	39.8	287	<CE
05/12/93	692	0.8 J	<CE	373	<CE
09/14/93	525	0.9 J	<CE	426	1,190
10/22/93	791.6	.	19.7	432	1,040
02/11/94	1,127	.	<CE	713	1,460
06/24/94	830	0.9 J	<CE	397	1,040
09/07/94	(81)	1 J	32.6	392	1,020
12/15/94	734	.	<CE	350	1,070
03/26/95	760	1 J	4.7	365	1,030
06/08/95	980	1 J	28.4	619	837
08/03/95	900	.	<CE	575	1,160
10/25/95	771	1 J	31.7	556	1,010
03/25/96	780	1 J	<MDA	168	1,200
08/20/96	730	1 J	<MDA	401	1,060
03/04/97	782	2 J	<MDA	420	NA
04/23/97	700	.	<MDA	760	NA
09/17/97	696	2 J	<MDA	550	NA
03/03/98	674	FP	18	440	NA
08/31/98	617	2 J	<MDA	380	NA
03/18/99	579	.	4.3	<MDA	NA
08/31/99	897.2	2 J	<MDA	420	NA
03/01/00	680	.	<MDA	600	NA
09/11/00	734	.	<MDA	620	NA
02/06/01	662	2 J	<MDA	600	750
08/02/01	620	.	<MDA	670	940
02/18/02	669	2J	<MDA	540	NA
07/31/02	610	2 J	<MDA	640	NA
MCL	**10**	**80***	**15**	**50****	**3,790****

Table 1. Well GW-537: summary of results for nitrate, chloroform, and gross beta activity (continued)

Sampling Date	Concentration				
	Nitrate (mg/L)	Chloroform (μg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)	Tc-99 (pCi/L)
02/13/03	633	2 J	<MDA	640	NA
08/11/03	659	.	<MDA	650	NA
02/23/04	566	2 J	<MDA	390	NA
08/03/04	539	2 J	<MDA	400	NA
MCL	**10**	**80***	**15**	**50****	**3,790****

Note: "." = Not detected; FP = False positive; ( ) = Result considered qualitative because of ion-charge balance error; * MCL is for total trihalomethanes; **SDWA screening level for a 4 millirem per year dose equivalent

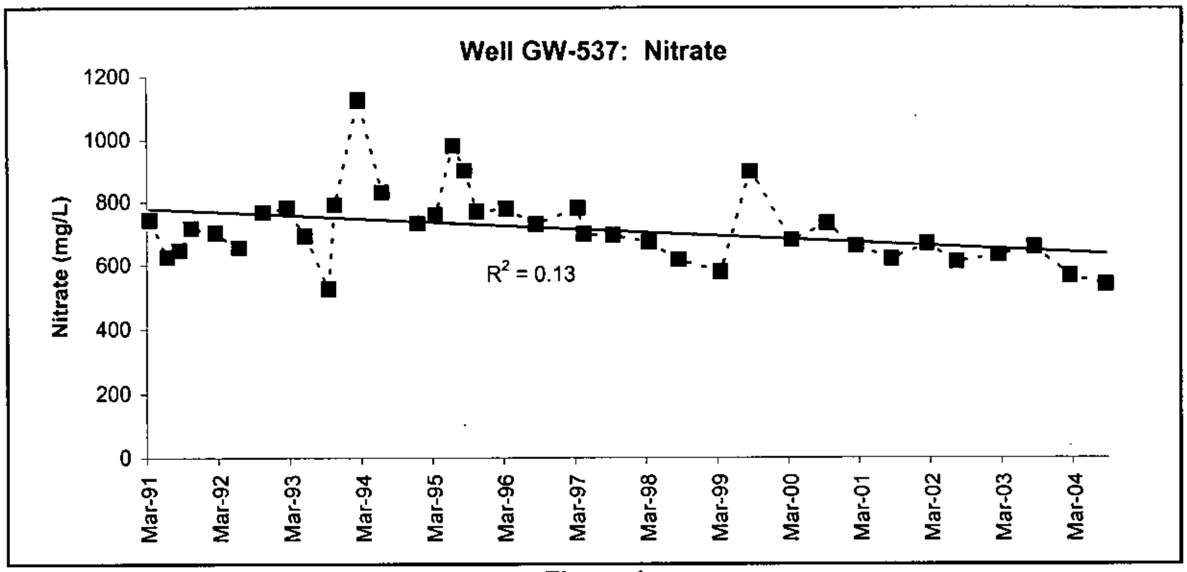


Figure 1

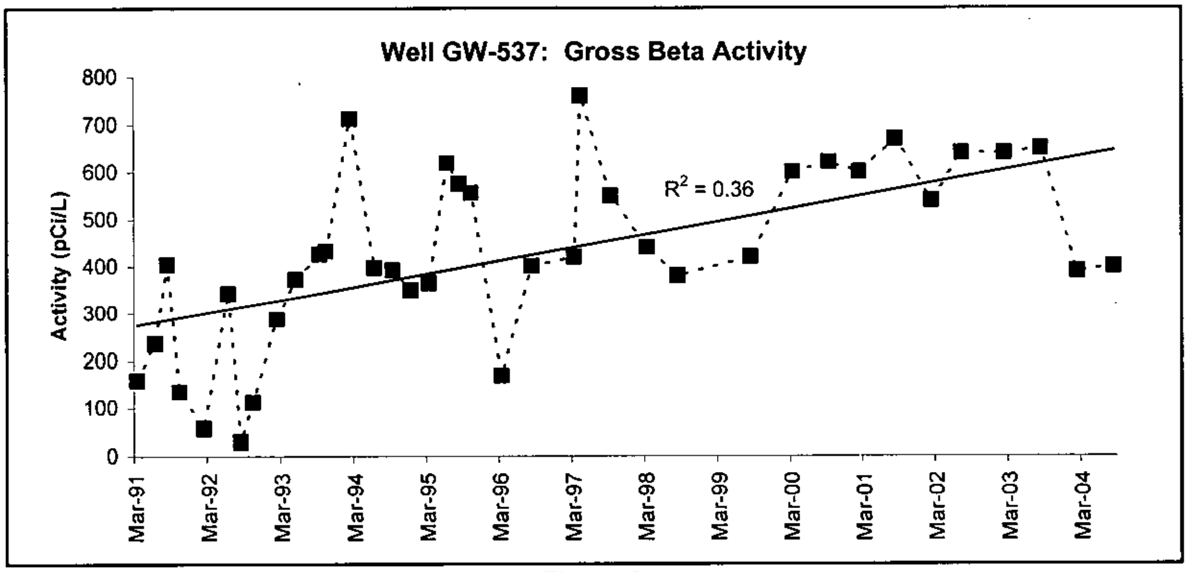


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-540

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill II
Y-12 GRID EAST COORDINATE: 52,371.31
Y-12 GRID NORTH COORDINATE: 27,489.06
SURFACE ELEVATION: 1,069.38 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/02/89 PAIRED/CLUSTERED WITH: GW-546
TAG DEPTH (measured): 173.83 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,072.31 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.25 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	158.5	910.88
BOTTOM (filter pack or open hole):	171.5	897.88
MIDPOINT (filter pack or open hole):	165.0	904.38
PUMP INTAKE:	166.07	903.31
WATER LEVEL (average):	76.15	993.23

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	18 samples	03/16/91	04/09/96
LOW-FLOW SAMPLING METHOD:	16 samples	03/11/98	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/22/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 40.35 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	48 µg/L	02/02/00	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-540

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1989, completed with a screened monitored interval from 158.5 to 171.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 250 ft east (hydraulically downgradient) of Construction/Demolition Landfill VI. This closed landfill operated from 1994 to 2003 and received nonhazardous and nonradioactive solid wastes, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between March 1991 and April 1996, and the low-flow sampling method used to obtain 16 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is 76 ft bgs. Presampling depth-to-water measurements for the well indicate unusually wide (>40 ft) water-level fluctuations, especially the fluctuations evident before March 1999 (Figure 1). The result of a falling head permeability test performed in well GW-540 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 8.3×10^{-5} cm/s (0.24 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 136 – 270 mg/L;
- pH (field measurements) of 7.2 – 8.4;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Sixteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.6 mg/L in February 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in September 1991 and March 1993) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in five groundwater samples: methylene chloride was detected in August 1993 (1 μg/L); 2-butanone was detected in April 1996 (7 μg/L) and March 1998 (2 μg/L); and acetone was detected in October 1998 (1μg/L) and February 2000 (48 μg/L). These results are probably analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.8 pCi/L in April 1999) being substantially below the MCL for gross alpha activity (15 pCi/L).

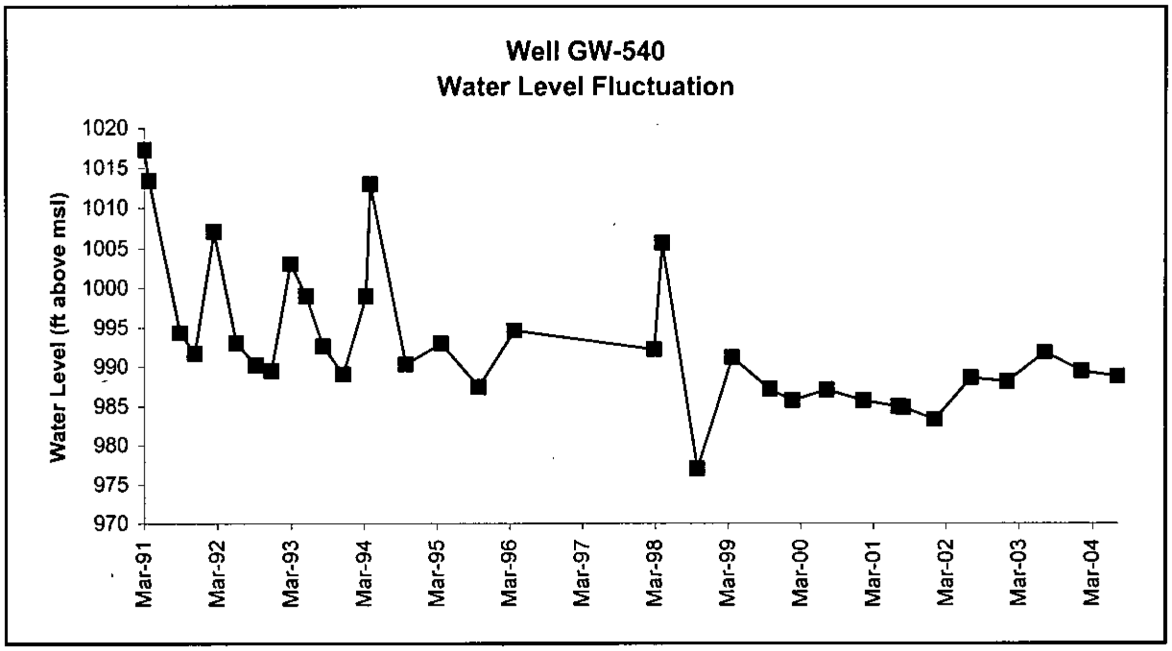
5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.4 pCi/L in January 2004) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.



Well GW-540
Water Level Fluctuation
Water Level (ft above msl)
1020
1015
1010
1005
1000
995
990
985
980
975
970
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	<5	ND	<25

GW-542

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VI
Y-12 GRID EAST COORDINATE: 51,641.74
Y-12 GRID NORTH COORDINATE: 27,466.22
SURFACE ELEVATION: 1,049.03 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/18/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 79.09 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,051.81 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.25 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	59.0	990.03
BOTTOM (filter pack or open hole):	76.5	972.53
MIDPOINT (filter pack or open hole):	67.8	981.28
PUMP INTAKE:	68.72	980.31
WATER LEVEL (average):	66.78	982.25

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	35		
CONVENTIONAL SAMPLING METHOD:	21 samples	03/17/91	04/01/97
LOW-FLOW SAMPLING METHOD:	14 samples	04/21/98	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/15/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.11 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-542

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1989, completed with a screened monitored interval from 59 to 76.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, less than 100 ft west (hydraulically downgradient) of Construction/Demolition Landfill VI. This closed landfill operated from 1994 to 2003 and received nonhazardous and nonradioactive solid wastes, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between March 1991 and April 1997, and the low-flow sampling method used to obtain 14 samples between April 1998 and July 2004.

This well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 67 ft bgs and exhibits moderate fluctuations (<7 ft). The result of a falling head permeability test performed in well GW-542 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 5.7×10^{-4} cm/s (1.62 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 78 – 166 mg/L, excluding suspecte outliers in April (208 mg/L) and October (36 mg/L) 1995;
- pH (field measurements) of 6.1 – 8.0;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Thirty-two groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.73 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in five groundwater samples: methylene chloride was detected in June 1992 (1 µg/L) and April 1993 (1 µg/L); acetone was detected in April 1998 (1 µg/L) and January 2004 (3.4 µg/L); and carbon disulfide was detected in October 1998 (1 µg/L). These results are probably analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.4 in October 1999 pCi/L) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Fourteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (19 pCi/L in July 2004) being substantially below the SDWA screening level for gross beta activity (50 pCi/L). Note that the maximum result is considered to be an outlier that is inconsistent with historical measurements; all other gross beta results are less than 7 pCi/L.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-543

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VI
Y-12 GRID EAST COORDINATE: 51,458.48
Y-12 GRID NORTH COORDINATE: 27,072.06
SURFACE ELEVATION: 1,021.19 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/02/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 96.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,024.01 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.25 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	76.2	944.99
BOTTOM (filter pack or open hole):	93.6	927.59
MIDPOINT (filter pack or open hole):	84.9	936.29
PUMP INTAKE:	85.58	935.61
WATER LEVEL (average):	61.15	960.04

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	36		
CONVENTIONAL SAMPLING METHOD:	21 samples	03/17/91	04/01/97
LOW-FLOW SAMPLING METHOD:	15 samples	10/15/97	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/21/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.44 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	5.5 µg/L	07/23/03	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-543

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1989, completed with a screened monitored interval from 76.2 to 93.6 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 grid system), about 250 ft southwest (hydraulically downgradient) of Construction/Demolition Landfill VI. This closed landfill operated from 1994 to 2003 and received nonhazardous and nonradioactive solid wastes, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between March 1991 and April 1997, and the low-flow sampling method used to obtain 15 samples between October 1997 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group (Chepultepec Dolomite). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 61 ft bgs and exhibit moderate fluctuations (<6 ft). The result of a falling head permeability test performed in well GW-543 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.7×10^{-4} cm/s (0.48 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 162 – 290 mg/L;
- pH (field measurements) of 6.4 – 7.6;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.75 in July 2000 mg/L) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.002 mg/L in April 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in five groundwater samples: 111TCA in October 1998 (1 μg/L); acetone in July 2001 (2 μg/L); bromoform in January 2002 (0.48 μg/L) and July 2003 (4 μg/L); dibromochloromethane in July 2003 (1.5 μg/L); and toluene in October 1998 (1 μg/L). These results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.54 pCi/L in September 1991) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	5 - 50	<7.5	<25

GW-544

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VI
Y-12 GRID EAST COORDINATE: 51,819.56
Y-12 GRID NORTH COORDINATE: 26,963.22
SURFACE ELEVATION: 1,042.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/30/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 111.80 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,045.19 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.25 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	91.0	951.53
BOTTOM (filter pack or open hole):	109.3	933.23
MIDPOINT (filter pack or open hole):	100.2	942.38
PUMP INTAKE:	100.84	941.69
WATER LEVEL (average):	57.94	984.59

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	36		
CONVENTIONAL SAMPLING METHOD:	21 samples	03/17/91	04/02/97
LOW-FLOW SAMPLING METHOD:	15 samples	10/16/97	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/21/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 26.99 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	20 µg/L	04/02/97	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-544

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1989, completed with a screened monitored interval from 91 to 109.3 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 grid), about 250 ft directly south (hydraulically downgradient) of Construction/Demolition Landfill (CDL) VI. Operation of CDL VI began in December 1993 and disposal of waste at the site ended in July 2002. The operating permit issued by the TDEC for the landfill, which is covered with a low-permeability re-compacted clay cap, allowed the disposal of nonhazardous and nonradioactive construction spoil and demolition debris (e.g., soil, concrete, masonry, wood, steel rebar, plastics, and roofing materials) generated from DOE operations at Y-12 and elsewhere on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between March 1991 and April 1997, and the low-flow sampling method used to obtain 15 samples between October 1997 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from bedrock in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is 58 ft bgs. Presampling depth-to-water measurements for the well indicate wide fluctuations (>25 ft) in seasonal groundwater surface elevations (Figure 1).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 178 – 310 mg/L;
- pH of 7.0 – 8.0 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, nitrate, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Thirty-five groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.92 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Eighteen groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.00233 mg/L in October 1999) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs have been detected in 12 groundwater samples from the well. Low concentrations of chloroform were detected in all 10 of the groundwater samples collected since February 2000, and acetone was detected (probable artifacts) in April 1997 (20 μg/L), April 1998 (3 μg/L), and July 2001 (2.2 μg/L). Chloroform and other trihalomethanes (bromodichloromethane, dibromochloromethane, and bromoform) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency [EPA] 2001). Because DBPs are carcinogenic and their natural formation in chlorinated drinking water is essentially unavoidable, the EPA established an MCL of 80 μg/L as the primary drinking water standard (effective January 2002) for total trihalomethanes. Monitoring results obtained to date show that the total trihalomethanes in the well remain below the MCL

The recent repeated detection of chloroform in the groundwater samples from the well coincides with a change in the laboratory responsible for performing the VOC analyses (Figure 1). The Y-12 Analytical Chemistry Organization (ACO) performed the VOC analyses of groundwater samples collected from the well between March 1991 and July 1999, whereas Severn Trent Laboratories (STL) performed VOC analyses of the samples collected from the well since February 2000. The instrument detection limit (IDL) for the analytical instrumentation used by STL enables the detection of estimated chloroform concentrations at lower reportable levels than the IDL for the analytical instrumentation used by the Y-12 ACO (about 2 μg/L). The first five chloroform results reported by STL (February 2000 through January 2002) were all less than 2 μg/L (Figure 1). This raises the possibility that groundwater samples collected from the well before February 2000 may have contained chloroform, but at very low concentrations that were below the IDL and therefore reported as non-detect values (e.g., <5 μg/L).

Assuming that CDL VI received only the nonhazardous construction spoil and demolition debris for which it was permitted, there is no reason to suspect that the landfill is the source of the trihalomethanes in the groundwater at well GW-544. A more likely source is from the local recharge of chlorinated water associated with Bldg. 9983-44, a portable manufactured building installed in 1984 or 1985 at a site located about 450 ft east (uphill) of the well. The building houses sanitary hand-washing and toilet facilities used by landfill workers on a daily basis throughout the operation of CDL VI and another closed landfill nearby (Y-12 Sanitary Landfill II). The restroom facilities are at the end of a potable (chlorinated) water-supply pipeline from Y-12, with the sink and toilet drains connected to a septic tank/drain field on the west-northwest side of the building. For much of the time the restroom facilities were in use, a bleeder line allowed continuous flow through the water-supply pipeline in order to avoid stagnation of the water in the pipeline and to prevent it from freezing during winter. Chlorinated water from the bleeder line discharged to the ground surface on the west side of Bldg. 9833-44. Additionally, in recent years the septic tank/drain field received continuous inflow of chlorinated water via a slow leak in the fill valve for a toilet in the restroom. Thus, infiltration associated with operation of the water-supply bleeder line and septic tank/drain field at Bldg. 9983-44 has been a long-term source for localized recharge of chlorinated water.

Chloroform is chemically stable, does not readily partition to soils, and is persistent and mobile in groundwater. Given these characteristics, chloroform entrained in the recharge from the

Bldg. 9983-44 area would be expected to move vertically though the vadose zone to the groundwater zone (water table). The groundwater zone in the Knox Group is characterized by preferential flow parallel with the geologic strike of the bedrock. Also, the orientation of the strike-parallel flowpaths (e.g., bedding-plane fractures) may or may not coincide with the flow direction(s) inferred from groundwater elevation isopleths, which generally mimic surface topographic contours. This flow pattern is reflected by the shape of the groundwater contaminant plume originating from the Chestnut Ridge Security Pits (CRSP), a closed hazardous waste landfill located on the crest of Chestnut Ridge northeast of CDLVI. The CRSP is the source of an elongated plume of dissolved VOCs extending at least 2600 ft downgradient to the east-northeast along the axis of the ridge crest (parallel with geologic strike), but only 500 ft north or south down the flanks of the ridge (across geologic strike), despite much steeper hydraulic gradients inferred from groundwater elevation isopleths. As noted previously, well GW-544 is directly downhill to the west of the Bldg. 9983-44, which is parallel with the geologic strike of the underlying bedrock (Chepultepec Dolomite), as indicated by the strike and dip measurement from an outcrop in Dunaway Branch west-northwest of the well (Hatcher et al. 1992). In addition to being hydraulically downgradient in the preferred direction of groundwater flow, well GW-544 is located between Bldg. 9983-44 and the natural groundwater discharge features (springs and seeps) in Dunaway Branch. Thus, any mobile contaminants entrained in the water recharged from the Bldg. 9983-44 bleeder line/septic drain field would be expected to migrate via advective transport in the direction of well GW-544 toward the discharge features west of the well.

In April 2004, the restroom facilities in Bldg. 9983-44 were permanently closed and the flow-control valve for the water supply pipeline to the building was turned off. Thus, the Bldg. 9983-44 septic tank/drain field no longer promotes local recharge of chlorinated water into the Knox Aquifer upgradient of well GW-544. With the presumed source of the chloroform no longer active, continued monitoring would be expected to eventually show reduced levels of chloroform in the groundwater at well GW-544. As shown by a time-series plot of the chloroform concentrations, a sharply increasing trend was reversed after the flow of chlorinated water ended (Figure 1).

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4 pCi/L in July 2004) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

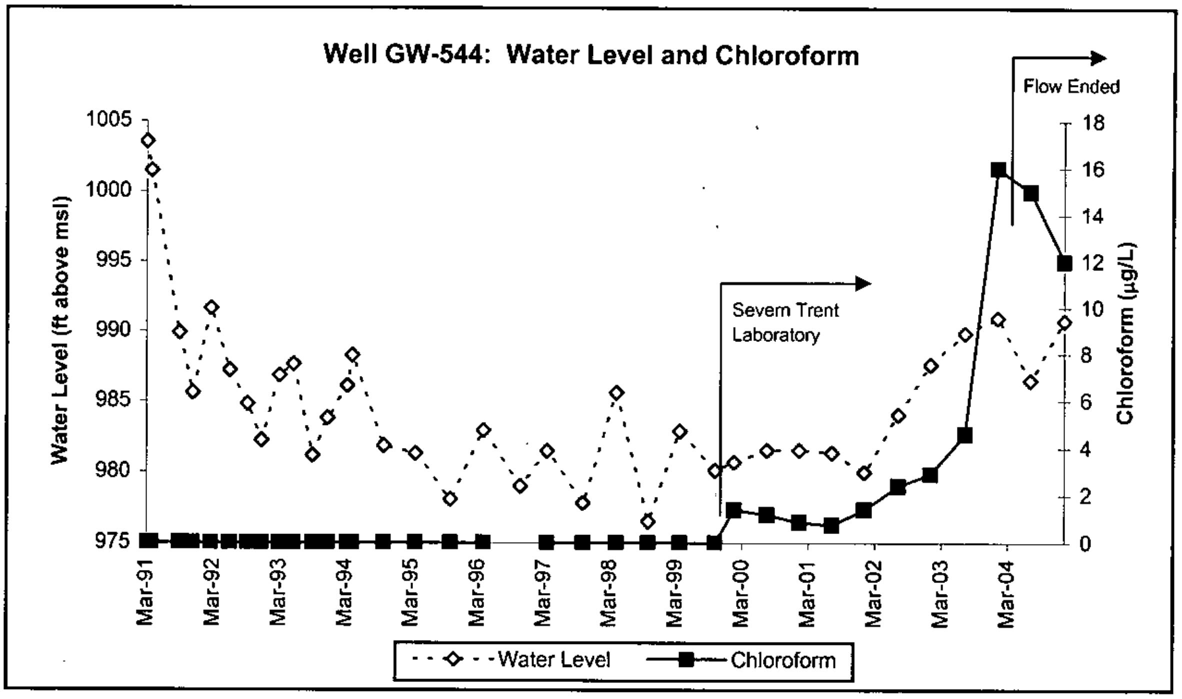
Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.73 pCi/L in August 1992) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hatcher, R.D., Jr., P.J. Lemiszki, R.B. Drier, R.H. Ketelle, R.R. Lee, D.A. Leitzke, W.M. McMaster, J.L. Forman, and S.Y. Lee. 1992. *Status Report on the Geology of the Oak Ridge Reservation*, ORNL/TM-12074, Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.



Well GW-544: Water Level and Chloroform
Flow Ended
Severn Trent Laboratory
Water Level (ft above msl)
Chloroform (µg/L)
1005
1000
995
990
985
980
975
18
16
14
12
10
8
6
4
2
0
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99
Mar-00
Mar-01
Mar-02
Mar-03
Mar-04
Water Level
Chloroform

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-557

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill V
Y-12 GRID EAST COORDINATE: 59,519.59
Y-12 GRID NORTH COORDINATE: 26,450.11
SURFACE ELEVATION: 1,078.63 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/02/88 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 136.07 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,081.36 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	112.9	965.73
BOTTOM (filter pack or open hole):	138.0	940.63
MIDPOINT (filter pack or open hole):	125.5	953.18
PUMP INTAKE:	123.57	955.06
WATER LEVEL (average):	114.45	964.18

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	15 samples	05/26/93	07/09/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/13/98	07/20/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/13/04	.	07/20/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 17.8 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	82 µg/L	07/09/97	Outliers
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-557

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1988, completed with a screened monitored interval from 112.9 to 138.0 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the southern flank of Chestnut Ridge directly south of Y-12, less than 100 ft south (hydraulically downgradient) of Industrial Landfill V, a landfill operated since 1994 and used for disposal of nonhazardous and nonradioactive combustible and decomposable solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Knox Group (Kingsport Formation/Longview Dolomite). The average static groundwater level in the well is 114 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (>15 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge. The average result of several falling head permeability tests performed in well GW-557 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 3.2×10^{-3} cm/s (9 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 158 – 206 mg/L;
- pH (field measurements) of 7 – 8.2;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-seven groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.1 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit, and both of these results (0.001 mg/L) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in four groundwater samples: acetone in July 1997 (82 µg/L), July 1998 (1 µg/L), and January 2000 (6 µg/L); 2-butanone in July 1998 (2 µg/L); and chloromethane in January 2002 (0.42 µg/L). These results may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE and this result (3.06 pCi/L in October 1994) is substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.66 pCi/L in October 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-560

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VII
Y-12 GRID EAST COORDINATE: 60,743.15
Y-12 GRID NORTH COORDINATE: 25,691.87
SURFACE ELEVATION: 945.76 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/30/88 PAIRED/CLUSTERED WITH: GW-576
TAG DEPTH (measured): 82.90 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 949.05 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	45.2	900.56
BOTTOM (filter pack or open hole):	69.0	876.76
MIDPOINT (filter pack or open hole):	57.1	888.66
PUMP INTAKE:	59.41	886.35
WATER LEVEL (average):	30.33	915.43

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	15 samples	05/26/93	07/14/97
LOW-FLOW SAMPLING METHOD:	13 samples	07/27/00	07/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/21/04	.	07/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 40.99 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS — Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	24 µg/L	04/02/96	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-560

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1988, completed with a screened monitored interval from 45.2 to 69 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 100 ft south (hydraúlically downgradient) of Construction/Demolition Landfill (CDL) VII. This landfill began operating following the closure of CDL VI in 2003 and is used for disposal of nonhazardous, nonradioactive solid waste, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 13 samples between July 2000 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Mascot Dolomite/Kingsport Formation). The average static groundwater level in the well is 30 ft bgs. Presampling depth-to-water measurements for the well indicate unusually wide (>40 ft) water-level fluctuations, with a generally decreasing trend in groundwater elevations between May 1993 and January 2002 followed by an overall rise in groundwater elevations though May 2003 (Figure 1). The average result of several falling head permeability tests performed in well GW-560 (Jones 2004) shows that the hydraulic conductivity of the bedrock near the well is about 4.88×10^{-3} cm/s (13.8 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 138 – 190 mg/L;
- pH (field measurements) of 7.16 – 7.9 (excluding an outlier of 4.3 in July 1997);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nineteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.66 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.001 mg/L in April 1994) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, acetone was detected (24 μg/L) in one sample (April 1996) and this result is considered an outlier.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.01 pCi/L in October 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.44 pCi/L in October 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

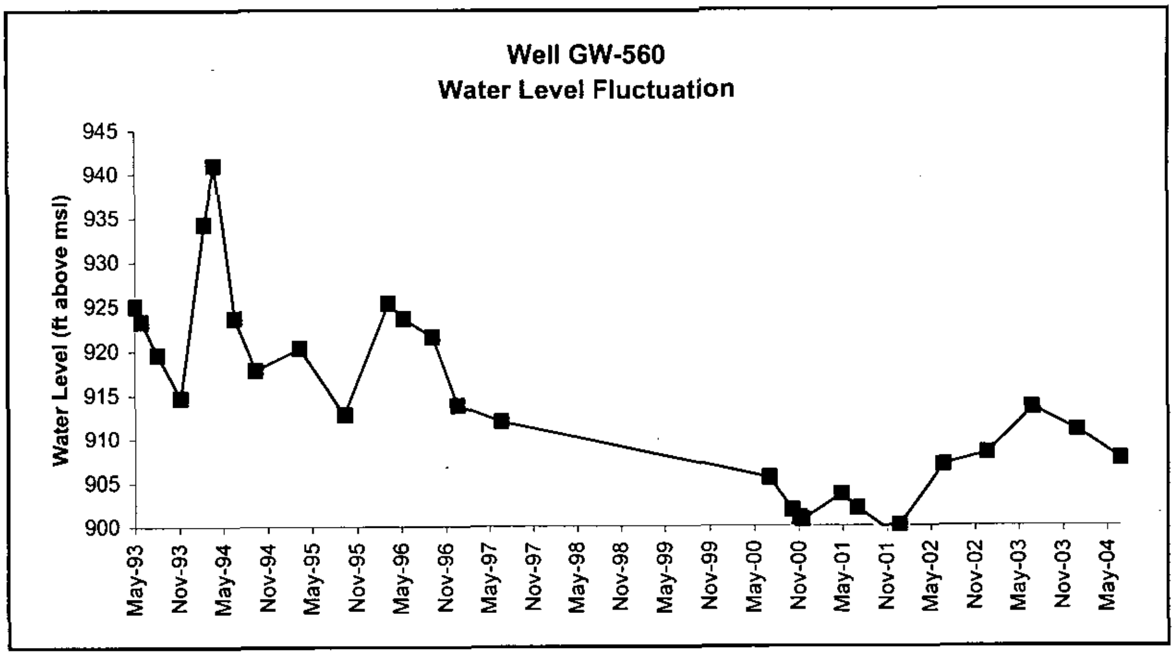

Well GW-560
Water Level Fluctuation
Water Level (ft above msl)
945
940
935
930
925
920
915
910
905
900
May-93
Nov-93
May-94
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-562

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VII
Y-12 GRID EAST COORDINATE: 61,640.17
Y-12 GRID NORTH COORDINATE: 26,276.29
SURFACE ELEVATION: 931.86 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/13/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 61.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 934.69 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	36.0	895.86
BOTTOM (filter pack or open hole):	60.0	871.86
MIDPOINT (filter pack or open hole):	48.0	883.86
PUMP INTAKE:	48.17	883.69
WATER LEVEL (average):	4.03	927.83

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	16 samples	05/26/93	07/14/97
LOW-FLOW SAMPLING METHOD:	18 samples	07/25/00	07/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/21/04	.	07/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 12.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	13 µg/L	04/02/96	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-562

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1989, completed with a screened monitored interval from 36 to 60 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 300 ft east (hydraulically downgradient) of Construction/Demolition Landfill (CDL) VII. This landfill began operating following the closure of CDL VI in 2003 and is used for disposal of nonhazardous, nonradioactive solid waste, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 18 samples between July 2000 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Knox Group (Longview Dolomite/Kingsport Formation). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 4 ft bgs and exhibit substantial (10 - 25 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge. The average result of several falling head permeability tests performed in well GW-562 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1×10^{-4} cm/s (0.29 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 168 – 238 mg/L;
- pH (field measurements) of 6.9 – 8.1 (excluding an outlier of 3.9 in July 1997);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.7 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater sample had a uranium concentration above the analytical reporting limit and this result (0.001 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, acetone (13 µg/L) and MC (1.4 µg/L) were each detected in one sample (April 1996 and July 2000, respectively). These results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.2 pCi/L in July 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10.6 pCi/L in July 2000) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-564

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VII
Y-12 GRID EAST COORDINATE: 59,865.28
Y-12 GRID NORTH COORDINATE: 25,872.94
SURFACE ELEVATION: 935.12 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/27/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 78.74 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 938.07 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	52.0	883.12
BOTTOM (filter pack or open hole):	81.0	854.12
MIDPOINT (filter pack or open hole):	66.5	868.62
PUMP INTAKE:	65.55	869.57
WATER LEVEL (average):	7.02	928.10

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	28			
CONVENTIONAL SAMPLING METHOD:	14	samples	05/26/93	07/15/97
LOW-FLOW SAMPLING METHOD:	14	samples	07/26/00	07/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/20/04	.	07/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.07 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-564

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1989, completed with a screened monitored interval from 52 to 81 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 grid), about 300 ft southwest (hydraulically downgradient) of Construction/Demolition Landfill VII, which is an operating Class IV disposal facility for nonhazardous solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 14 samples between July 2000 and July 2004.

The well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Knox Group. The average static groundwater level in the well is 7 ft bgs. Presampling depth-to-water measurements for the well indicate moderate (11 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 128 – 184 mg/L, excluding an outlier (81 mg/L) in January 2003;
- pH (field measurements) of 6.2 – 7.7;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, nitrate, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.6 mg/L in January 2002) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the groundwater sample collected in April 1994 had a uranium concentration above the applicable analytical reporting limit and the result for this sample (0.001 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in five groundwater samples collected from the well. Low (estimated) concentrations of chloroform were detected in the samples collected in October 2000 (0.39 µg/L), November 2000 (0.57 µg/L), December 2000 (0.81 µg/L), November 2001 (0.44 µg/L), and January 2002 (0.3 µg/L). The significance of these chloroform detections is not clear from the available data.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.89 pCi/L in July 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	ND	50 - 500	ND	<25

GW-601

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Oil Landfarm
Y-12 GRID EAST COORDINATE: 47,629.49
Y-12 GRID NORTH COORDINATE: 28,902.55
SURFACE ELEVATION: 999.09 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/31/89 PAIRED/CLUSTERED WITH: GW-368 GW-369
TAG DEPTH (measured): 358.61 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,002.80 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: STL
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	318.5	680.59
BOTTOM (filter pack or open hole):	356.0	643.09
MIDPOINT (filter pack or open hole):	337.3	661.84
PUMP INTAKE:	341.3	657.80
WATER LEVEL (average):	64.71	934.98

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	20		
CONVENTIONAL SAMPLING METHOD:	17 samples	03/05/90	03/25/94
LOW-FLOW SAMPLING METHOD:	3 samples	03/08/99	09/12/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/15/05	.	09/12/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.93 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level: # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	16	41.6 mg/L	06/27/93	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 μg/L):	16	192.6 μg/L	08/30/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-601

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1989, completed with an open-hole monitored interval from approximately 318 to 356 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well forms a cluster with wells GW-368 and GW-369 and is located in Bear Creek Valley (BCV) approximately 5,000 ft west of Y-12. The well cluster is on the steep northern (scarp) flank of Chestnut Ridge, approximately 300 ft directly south of the main channel of Bear Creek and 500 ft south of the Oil Landfarm waste management area (WMA). The Oil Landfarm WMA encompasses the following closed hazardous and nonhazardous waste management facilities: the Oil Landfarm, Boneyard/Burnyard (BYBY), Hazardous Chemical Storage Area (HCDA), and Sanitary Landfill I.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between March 1990 and March 1994, and the low-flow sampling method used to obtain three samples between March 1999 and September 2005. The sampling history includes a quarterly sampling frequency followed by a 5-year (March 1994–March 1999) and a 6-year period (March 1999–March 2005) when no samples were collected from the well.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the deep (>300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of Bear Creek. The Maynardville Limestone exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydrologic interaction between Bear Creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Deeper in the subsurface, below the shallow karst network, fractures provide the primary groundwater flowpaths, and the bulk permeability generally decreases with depth because of decreased fracture aperture and increased fracture spacing (Solomon et. al. 1992). Also, distinct lithologic and hydrologic characteristics differentiate seven hydrostratigraphic zones (numbered from bottom to top) in the Maynardville Limestone (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static water level in the well occurs at an average depth of about 65 ft bgs and exhibits maximum seasonal water-level fluctuations up to approximately 12 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-601 indicate westerly local flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Additionally, the well is located directly south of a reach of Bear Creek south of Sanitary Landfill I that loses substantial flow to the shallow karst network in the Maynardville Limestone and is believed to greatly facilitate the recharge of contaminated surface water into the groundwater flow system downgradient (south and west) of the Oil Landfarm WMA (DOE 1997).

Depth-to-water measurements recorded during one contemporaneous sampling event (i.e., within 24 hours) show a higher presampling groundwater elevation in well GW-601 (931.27 ft above msl) compared to well GW-368 (929.1 ft above msl), which is completed at a shallower depth (245 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint in each well (about 102 ft), the respective groundwater elevations indicate a slightly upward vertical hydraulic gradient (0.021) from the deep bedrock (GW-601) to the intermediate depth bedrock interval (GW-368). Note that the contemporaneous presampling groundwater elevations were recorded during seasonally low flow (September 2005) and, consequently, may not be representative of the vertical hydraulic gradients evident during seasonally high flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields sodium-, chloride-, and sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 270 – 584 mg/L;
- pH of 7.2 – 9.1 (field measurements);
- elevated concentrations of sodium (>40 mg/L), chloride (>70 mg/L), nitrate (>15 mg/L), and sulfate (>80 mg/L); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Elevated levels of nitrate in the groundwater samples are attributable to contamination from the former S-3 Ponds (see Section 5.1), but the elevated levels of sodium, chloride, and sulfate may reflect natural geochemical characteristics at depth in the Maynardville Limestone. Similarly, it is unclear if the unusually high levels of total iron (e.g., 3.14 mg/L in March 2005) in some samples are representative of concentrations in the groundwater or are potential artifacts related to corrosion of the steel riser casing in the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

As shown on Table 1, all the groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit and all of these results exceed the drinking water MCL for nitrate (10 mg/L). Elevated nitrate levels indicate that the open-hole interval in the well intercepts water-producing features that are hydraulically connected with the heterogeneous plume of inorganic, organic, and radiological contaminants originating from the former S-3 Ponds. Located hydraulically upgradient approximately 4,500 ft east-northeast of the well, these unlined surface impoundments received several million gallons of nitric-acid wastes generated at Y-12 between 1951 and 1984, and were filled and covered with a low-permeability cap during RCRA closure of the site in 1989. Nitrate is a principal component of the contaminant plume, is chemically stable and highly mobile in groundwater, and is believed to effectively delineate the primary groundwater flow/contaminant transport pathways in the Maynardville Limestone (DOE 1997).

Nitrate concentrations in the groundwater flow/transport pathways intercepted by the open-hole interval in this well are attributable to westward (downgradient) transport via strike-parallel flowpaths at depth in the Maynardville Limestone (>300 ft bgs). As illustrated by the most recent sampling results summarized below, the nitrate concentrations do not exhibit wide seasonal fluctuations, suggesting that the well does not have a direct hydraulic connection with the shallow karst network, where nitrate concentrations exhibit substantial fluctuations in response to seasonal (and episodic) flow conditions. Without evidence for a more direct hydraulic connection with the shallow karst network, the presence of nitrate in the groundwater from this well does not seem attributable to extensive down-dip inflow (recharge) of nitrate-contaminated surface water via the losing reach of Bear Creek noted in Section 3.0.

Nitrate (mg/L)			
GW-368 (225-245 ft bgs)		**GW-601 (318-356 ft bgs)**	
01/31/90	6	03/05/90	16
03/21/05	8.48	03/15/05	19.6
09/12/05	8.94	09/12/05	18.4

Both historical and more recent sampling results, as illustrated by the data summarized above, indicate that nitrate concentrations in the groundwater from well GW-601 are higher than evident shallower groundwater from well GW-368. In light of the upward vertical gradient noted in Section 4.0, the presence of nitrate in the groundwater in well GW-368 may be at least partially attributable to upward migration from the deeper flow system. Moreover, considering the depth of open-hole interval in each well relative to the hydrostratigraphic zones in the Maynardville Limestone (see Section 3.0), the higher levels of nitrate in well GW-601 potentially indicate greater relative flux of nitrate (and other similarly mobile contaminants) via more permeable strike-parallel flowpaths within hydrostratigraphic zones toward the bottom of the formation.

A time-series plot of the nitrate results reported for the groundwater samples collected to date shows an overall decreasing long-term trend (Figure 1). The long-term trend includes an indeterminate concentration trend through the early 1990’s, as illustrated by the nitrate levels evident in October 1990 (36 mg/L) and March 1994 (36.1 mg/L), with substantially lower (50%) levels subsequently evident, as indicated by nitrate results for samples collected in March 1999 (14 mg/L, the historical minimum value) and September 2005 (18.4 mg/L). The lower nitrate levels indicated by the more recent sampling results probably reflects the corresponding decrease in the relative flux of nitrate via the groundwater flow/transport pathways intercepted by the open-hole interval in the well. Substantially decreased flux of nitrate in the Maynardville Limestone occurred in response to the closure of the former S-3 Ponds in 1988 and the installation of a low-permeability cap at the site in 1989.

5.2 URANIUM

Three of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with each result (0.001 mg/L in September 1992, June 1993, and September 2005) being almost and order-of-magnitude below the MCL for uranium (0.03 mg/L) and within the range of background levels in the Maynardville Limestone. These results suggest that the water-producing features intercepted by the open-hole interval in the well are not hydraulically connected with the primary groundwater transport pathways for uranium from the former BYBY, which is located approximately 1,650 ft east-northeast, hydraulically upgradient of the well. Identified during the CERCLA RI as one of the principal sources of uranium in the Maynardville Limestone in BCV (DOE 1997), the BYBY was prioritized for CERCLA remedial action, which was completed in May 2002 and included the excavation and removal of uranium-bearing wastes from above and below the saturated zone. Additionally, the low (background) levels of uranium in the well so not indicate extensive down-dip inflow (recharge) of uranium-contaminated groundwater/surface water via the losing reach of Bear Creek noted in Section 3.0.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, CTET, chloroform, methylene chloride, PCE, TCE, 11DCE, 12DCE, 2-butanone, and 111TCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997).

Based on frequency of detection and concentration magnitude, TCE is the primary VOC detected in the groundwater samples collected to date (Table 2). This compound was detected in all the samples, with TCE concentrations above 100 µg/L, including the historical maximum concentration (180 µg/L in October 1990), reported for all but four of the samples. All the TCE results, including results for the samples collected most recently (March and September 2005), substantially exceed the drinking water MCL (5 µg/L), although the most recent concentrations are the lowest values detected to date. Of the other VOCs, CTET was detected the most frequently and is the only VOC other than TCE detected in the samples collected in March and September 2005 (Table 2). Also, aside from a few results for acetone and 2-butanone, which are suspected analytical artifacts, the results for all the other VOCs except TCE are estimated values below 5 µg/L and are less than applicable MCLs. Indeed, the general lack of other VOCs in the groundwater samples, particularly c12DCE, suggests minimal biotic degradation of the TCE (and other VOCs) in the groundwater near this well. This interpretation is supported by results for several indicator parameters, which suggest that selected geochemical characteristics are not within the optimum ranges known to promote biologically mediated degradation of chlorinated hydrocarbons in groundwater (Table 3).

The predominance of TCE in the groundwater samples from this well suggests that the primary source of the VOCs is the Rust Spoil Area (or nearby site within the Bear Creek floodplain). The Rust Spoil Area is a closed construction and demolition waste disposal site underlain by the Maynardville Limestone approximately 2,200 ft directly east (parallel with geologic strike) of the wells and is the suspected source of a TCE-dominated plume of dissolved VOCs in the shallow groundwater at the site (DOE 1997). Additional influx of VOCs into the Maynardville Limestone occurs from several potential sources within the Oil Landfarm WMA located hydraulically upgradient of the well to the north (Oil Landfarm and Sanitary Landfill I) and east-northeast (HCDA). However, the previously discussed results for nitrate and uranium suggests strike-parallel transport from an upgradient source(s) of TCE to the east of the well (the Rust Spoil Area), rather than down-dip inflow (recharge) from potential source areas to the north of the well.

As illustrated by the selected sampling results summarized below, similar levels of TCE occur in the groundwater from wells GW-368 and GW-601. Additionally, the most recent sampling results for both wells indicate that the TCE concentrations in deeper groundwater remain significantly higher than evident in wells completed at shallower depths in the Maynardville Limestone, including wells located at the Rust Spoil Area (e.g., GW-312). This is because the greater permeability of the shallow karst network facilitates more rapid flushing of the most contaminated groundwater by seasonal (and episodic) recharge/discharge cycles (DOE 1997).

TCE (µg/L)			
GW-368 (225-245 ft bgs)		**GW-601 (318-356 ft bgs)**	
01/31/90	120	03/05/90	110
03/21/05	62	03/15/05	85
05/12/05	50	09/12/05	72

A time-series plot of TCE concentrations reported for the groundwater samples collected to date (Figure 1), shows a clearly decreasing long-term trend between May 1990 (170 µg/L) and December 1994 (120 µg/L), and further reduced concentrations evident after the subsequent gaps in the sampling history for the well, with the TCE concentration reported for the sample collected in September 2005 (72 µg/L) being the historical minimum value. However, the rate of decrease appears to have slowed. For instance, the TCE concentration decreased almost 50% between October 1990 (180 µg/L; the historical maximum value) and March 1999 (96 µg/L), but only an additional 25% decrease through September 2005. Decreasing concentrations of TCE in the groundwater from this well are probably attributable to a combination of natural attenuation (dilution and dispersion) in the Maynardville Limestone and the reduced flux of TCE (and other VOCs) via the groundwater flow/transport pathways intercepted by the open-hole interval in the well.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.58 pCi/L in August 1990) being below the MCL for gross alpha activity (15 pCi/L). No samples collected since March 1994 had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (47.06 pCi/L in March 1990) being slightly below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). However, this maximum result is a suspected outlier because all other results were much lower, with the next highest result (25.5 pCi/L) reported for the sample collected in March 1994.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-601: summary of nitrate results

Sampling Date	Nitrate (mg/L)
03/05/90	16
05/22/90	30
08/06/90	33
10/23/90	36
01/25/91	25
05/04/91	37
08/30/91	38
10/31/91	30.42
03/19/92	32
06/08/92	34
09/12/92	31
12/17/92	32
03/28/93	32.1
06/27/93	41.6
09/19/93	30.5
12/21/93	31.9
03/25/94	36.1
03/08/99	14
03/15/05	19.6
09/12/05	18.4
MCL	**10**

Table 2. Well GW-601: summary of VOC results

Sampling Date	VOC (µg/L)						
	PCE	**TCE**	**12DCE**	**11DCE**	**111TCA**	**CTET**	**Chloroform**
03/05/90	2 J	110	.	.	.	.	.
05/22/90	.	170	.	0.9 J	.	3 J	1 J
08/06/90	.	170	.	.	.	4 J	.
10/23/90	1 J	180	.	0.7 J	1 J	5	1 J
01/25/91	1 J	170	2 J	.	0.7 J	4 J	.
05/04/91	.	150	.	.	.	4 J	.
08/30/91	1 J	170	1 J	1 J	0.7 J	3 J	0.9 J
10/31/91	.	160	.	.	0.9 J	5	0.7 J
03/19/92	1 J	130	1 J	.	.	2 J	.
06/08/92	.	150	.	1 J	.	4 J	0.7 J
09/12/92	1 J	140	1 J	0.8 J	.	3 J	.
12/17/92	.	130	.	.	.	3 J	.
03/28/93	1 J	140	2 J	.	.	4 J	1 J
06/27/93	.	140	.	.	.	.	.
09/19/93	1 J	120	.	0.7 J	0.5 J	2 J	0.6 J
03/25/94	1 J	98	.	.	.	2 J	.
12/21/94	1 J	120	1 J	0.8 J	0.5 J	3 J	0.7 J
03/08/99	.	96	.	.	.	.	.
03/15/05	2 J	85	.	.	.	1 J	.
09/12/05	.	72	.	.	.	1 J	.
MCL	**5**	**5**	**NA**	**7**	**200**	**5**	**80***
Sampling Date	**Other VOCs (µg/L)**						
03/05/90	Acetone (51)						
08/06/90	Methylene chloride (4 J)						
08/30/91	Acetone (15)						
09/12/05	Acetone (21), 2-butanone (9)						

Note: "." = Not detected; J = Estimated value; NA = Not applicable;
* = MCL is for total trihalomethanes

Table 3. Well GW-601: geochemical indicators for biodegradation of chlorinated hydrocarbons

Parameter	Units	Optimum Range (Wilson et al 1996)	March 2005	September 2005
Nitrate	mg/L	<1	19.6	18.4
Iron (II)	mg/L	>1	3.14*	1.46*
Sulfate	mg/L	<20	74.7	80
Dissolved Oxygen	ppm	<0.5	0.57**	3.11**
REDOX	mV	<50	115**	52**
pH	st. units	>5 and < 9	7.28**	7.51**

Note: *Results are for total iron; **Field measurement.

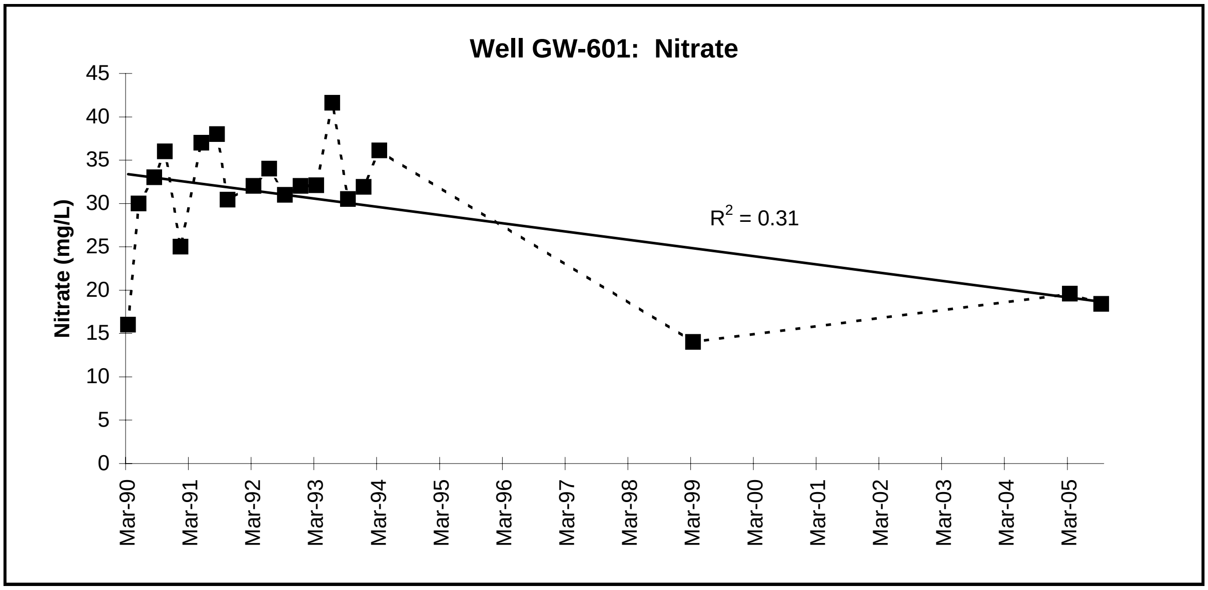


Figure 1

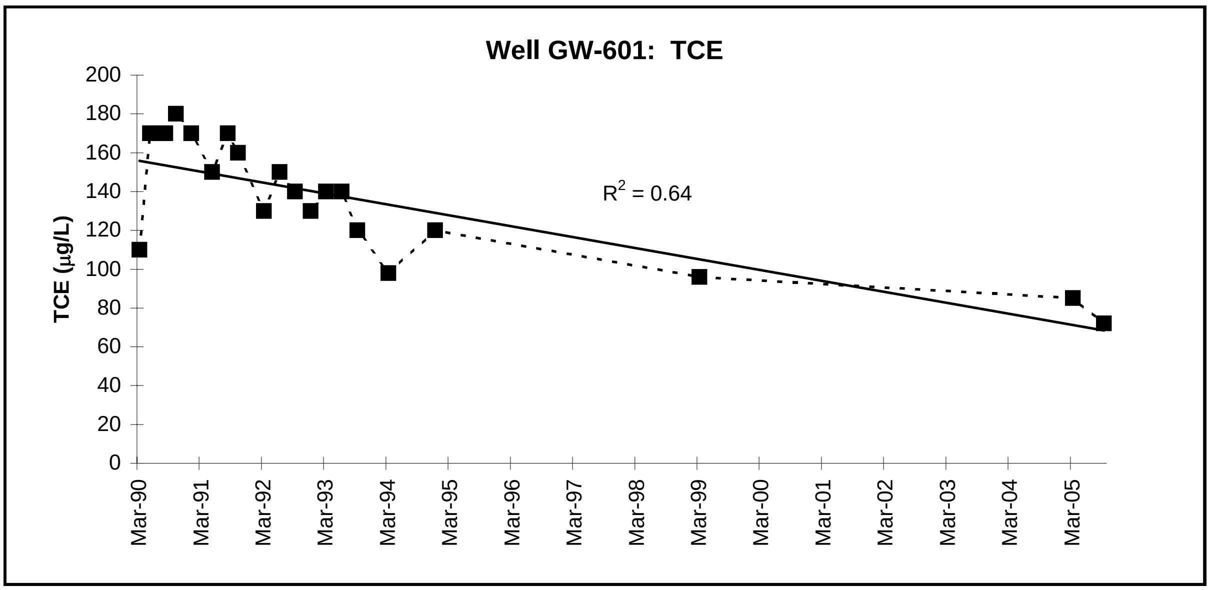


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	0.03 - 0.3	50 - 500	15 - 150	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-605

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket I
Y-12 GRID EAST COORDINATE: 62,001.50
Y-12 GRID NORTH COORDINATE: 28,706.83
SURFACE ELEVATION: 916.97 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/19/91 PAIRED/CLUSTERED WITH: GW-606
TAG DEPTH (measured): 42.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 919.06 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.25 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	28.2	888.77
BOTTOM (filter pack or open hole):	39.9	877.07
MIDPOINT (filter pack or open hole):	34.1	882.92
PUMP INTAKE:	33.91	883.06
WATER LEVEL (average):	8.94	908.03

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	41		
CONVENTIONAL SAMPLING METHOD:	25 samples	08/26/91	08/11/97
LOW-FLOW SAMPLING METHOD:	16 samples	03/12/98	07/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/07/04	.	07/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 1.29 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	36	0.33 mg/L	03/12/98	Indeterminate
SUMMED VOCs (5 μg/L):	37	466 μg/L	09/27/95	Indeterminate
GROSS ALPHA (15 pCi/L):	36	170 pCi/L	03/18/97	Indeterminate
GROSS BETA (50 pCi/L):	12	110 pCi/L	12/06/94	Decreasing

WELL GW-605

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1991, completed with a screened monitored interval from 28.2 to 39.9 ft bgs. The well forms a cluster with well GW-606 and is constructed with nominal 4.3-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) in the eastern Y-12 area, on the north side of the main channel of Upper East Fork Poplar Creek (UEFPC) about 1,300 ft west (hydraulically upgradient) of New Hope Pond (NHP). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through a concrete-lined diversion channel bordering the south and east sides of NHP/Lake Reality. Until December 1996, when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was diverted through the Lake Reality spillway, which discharges into the mainstream of UEFPC directly north (downstream) of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-one groundwater samples have been collected from the well, with the conventional sampling method used to obtain 25 samples between August 1991 and August 1997, and the low-flow sampling method used to obtain 16 samples between March 1998 and July 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher levels of uranium, VOCs, and gross beta than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling", whereby groundwater samples are collected with the low-flow sampling method one day and the conventional sampling method the next day, are needed to confirm the apparent sampling-method bias.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits minimal (<2 ft) seasonal fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are higher in well GW-605 than in well GW-606, which is completed at a greater depth (171 ft bgs) in the Maynardville Limestone. Based on the distance (128.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.011-0.028) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-605 indicate flow primarily to the east toward NHP, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMCICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 258 – 474 mg/L;
- pH of 6.3 – 7.53 (field measurements);
- elevated concentrations (>20 mg/L) of chloride and sulfate relative to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of sodium, potassium, and nitrate (<10% of total anions/cations);
- an unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for samples collected in July 1999 (RPD = -55.4%) and January 2000 (RPD = 44.8%); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the groundwater samples collected since January 1991, the principal contaminants present in the groundwater at this well are uranium, VOCs, and gross beta activity.

5.1 NITRATE

All but eight of the groundwater samples had nitrate concentrations at or above the analytical reporting limit (Table 1), with the historical maximum value (210 mg/L in July 1999) considered qualitative because of the ion-charge balance error determined for this sample (see Section 4.0). Excluding qualitative results, the maximum nitrate concentration (2.6 mg/L in July 2000) is not only substantially below the MCL for nitrate (10 mg/L), but appears to be an outlier compared to the other nitrate results, all but one of which are less than 1 mg/L. These results show that nitrate levels in the shallow groundwater from well GW-605 are significantly lower than nitrate levels in the deeper groundwater from well GW-606 (e.g., 14.7 mg/L in January 2003). Considering the consistently downward vertical hydraulic gradients indicated by presampling groundwater elevations in these wells, the higher nitrate levels in the deeper groundwater reflect the lateral, strike-parallel transport at depth in the Maynardville Limestone from the source(s) located within Y-12 west (hydraulically upgradient along strike) of the wells.

5.2 URANIUM

All but two groundwater samples had total uranium concentrations above the applicable analytical reporting limit (one sample was not analyzed for uranium; Table 1) and all of these results exceed the MCL for total uranium (0.03 mg/L). The specific source of the uranium in the shallow groundwater at this well has not been identified, but the well penetrates fill material containing low-level radioactive-contaminated debris (based on field scans), presumably derived from historical activities performed in Buildings 9201-1, 9201-2, and 9201-3 (DOE 1998). Considering the relatively neutral pH of the samples, the uranium is probably present as uranyl cations combined with available anions in the groundwater (Fetter 1993), including carbonate dissolved from the Maynardville Limestone, which may greatly increase the relative mobility of uranium in the groundwater flow system.

Aside from the uranium concentration reported for the groundwater sample collected in August 1993 (<0.001 mg/L), which is an outlier and a suspected analytical artifact, all of the other uranium results exceed the MCL, with a historical maximum value of 0.33 mg/L in March 1998 (Table 1). Note that the lowest uranium concentrations, including all of the results below 0.1 mg/L, were reported for samples obtained with the low-flow sampling method (although the historical maximum uranium value was reported for the first sample obtained with this method). As noted in Section 2.0, "paired sampling" results are needed to confirm if the lower uranium concentrations are an artifact of the change in groundwater sampling procedure or if they reflect a corresponding reduction in the relative flux of uranium along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Nevertheless, the sampling results obtained to date show that uranium concentrations in the shallow groundwater from well GW-605 remain at least an order-of-magnitude higher than uranium concentrations in the deeper groundwater from well GW-606 (e.g., 0.00536 mg/L in January 2004). This suggests that the source of the uranium is within the shallow flow system and, despite the vertically downward hydraulic gradients indicated by presampling groundwater elevations in these wells (see Section 3.0), minimal transport of uranium into the deeper flow system.

A time-series plot of the uranium concentrations, excluding the non-detect result noted above, shows two generally indeterminate concentration trends (Figure 1), one defined by the conventional sampling data (August 1991 – August 1997) and one defined by the low-flow sampling results (March 1998 – July 2003). Although the uranium concentrations reported for samples collected since July 1998 are much lower than evident in samples collected previously, the indeterminate nature of the concentrations trend suggest relatively unchanged flux of uranium. Both concentration trends also show significant temporal changes. However, with temporal peak concentrations evident for samples collected during seasonally high and low flow (Figure 1), there does not appear to be any clear and consistent relationship between uranium concentration fluctuations and seasonal groundwater flow conditions.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): PCE, TCE, 12DCE (c12DCE and t12DCE), CTET, chloroform (CLF), 11DCA, 11DCE, VC, MC, and bromodichloromethane. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide separating the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater extraction and treatment system began to intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near NHP, as required by the CERCLA Action Memorandum (DOE 1999). Groundwater is pumped from extraction well GW-845 at a rate of 25 gpm and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 ft to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

The primary VOCs in the groundwater samples are CTET, CLF, PCE, TCE, and 12DCE (c12DCE), with each compound detected (excluding false positive results) in all but four of the samples and the most recent sampling results (January and July 2004) showing CTET, PCE, and TCE concentrations above respective MCLs (Table 2). Secondary VOCs in the samples are VC, 11DCA, and 11DCE, which have been detected in only two samples collected since December 1995, with all the results for each compound being estimated values below 5 µg/L. A similarly low (estimated) concentration of bromodichloromethane was detected in one sample and t12DCE was detected in two samples. Additionally, the analytical results for the samples obtained with the conventional sampling method show substantially higher concentrations of CTET than indicated by the low-flow sampling results, but equivalent or somewhat higher concentrations of several other VOCs, notably PCE and 12DCE (Table 2). Assuming that the groundwater in the well contains a heterogeneous mixture of dissolved VOCs, it is not clear why the concentrations of individual compounds would exhibit different responses to the groundwater sampling method. Perhaps the higher pumping rate during conventional sampling induces upward flow of CTET-contaminated groundwater from the deeper in the Maynardville Limestone, which increases the CTET concentrations relative to other VOCs in the samples from the well, whereas low-flow sampling induces lateral inflow of PCE-, TCE-, and c12DCE-contaminated groundwater from the shallow flow system, resulting in samples with higher concentrations of these compounds relative to CTET. Results of "paired sampling" (see Section 2.0) are needed to determine if the VOC concentrations are biased by the groundwater sampling method.

As illustrated by the selected data summarized below, concentrations of VOCs in the groundwater samples from well GW-605, particularly CTET and CLF, used to be substantially lower than evident in samples of the deeper groundwater from well GW-606.

VOC	Concentration (µg/L)					
	Conventional Sampling		**Low-Flow Sampling**			
	August 1991		**July 1998**		**July 2004**	
	GW-605	**GW-606**	**GW-605**	**GW-606**	**GW-605**	**GW-606**
PCE	18	12	7	7	15	5
TCE	7	0.9 J	2 J	.	21	.
12DCE	17	2 J	5	.	41	.
CTET	26	2,800	170	120	11	72
CLF	4 J	600	16	140	5	120
Summed VOCs	74	3,618	200	269	93	197
Note: "." = Not detected; J = Estimated value below analytical reporting limit						

The large disparity between the recent and historical concentrations of CTET and CLF in these wells may reflect the change from the conventional to the low-flow sampling method. In light of the downward vertical hydraulic gradients indicated by presampling groundwater elevations in each well (see Section 3.0), the concentration trend suggests substantially greater natural attenuation of CTET in groundwater at depth in the Maynardville Limestone. Also, the concentrations of other VOCs in the samples from well GW-605, particularly TCE and 12DCE, are now substantially higher than reported for the samples from well GW-606, as illustrated by the data summarized above. This suggests that the source of these VOCs is separate from that of CTET.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples shows an indeterminate long-term concentration trend (Figure 2), as illustrated by the relative similarity between the summed VOC concentrations evident in August 1991 (73.6 μg/L) and July 2004 (93 μg/L). Also, conventional sampling and low-flow sampling results both show significant short-term concentration fluctuations, with temporal high summed VOCs typically determined for samples collected during seasonally low groundwater flow conditions. This relationship suggests that the lower summed VOC concentrations potentially result from seasonal (and episodic) recharge of uncontaminated (or less VOC-contaminated) groundwater, rather than wide temporal changes in the relative flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the well. Additionally, the long-term concentration trend for VOCs does not indicate any clear response to the full-time operation of groundwater extraction well GW-845.

5.4 GROSS ALPHA ACTIVITY

All but two groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (one sample was not analyzed for gross alpha activity; Table 1), and all but one of these results exceed the MCL for gross alpha activity (15 pCi/L). Elevated gross alpha activity in the groundwater at this well is attributable to uranium isotopes, which were detected (i.e., >MDA and CE) in samples collected in October 1996 (U-234 = 74.4 pCi/L and U-238 = 73.5 pCi/L), June 1998 (U-234 = 31.51 pCi/L and U-238 = 31.95 pCi/L), and July 1998 (U-234 = 18.56 pCi/L and U-238 = 18.99 pCi/L). As with the total uranium in the shallow groundwater at this well, the source of the uranium isotopes has not been identified, but may be related to contaminated debris placed as fill along the north bank of UEFPC or historical uranium enrichment activities performed in Buildings 9201-1, 9201-2, and 9201-3 (DOE 1998).

Excluding the non-detect (i.e., <MDA) gross alpha activity results reported for the groundwater sample collected in June 1996 (Table 1), which is an outlier compared to the other results and is a likely analytical artifact, the other samples exhibit a wide range of gross alpha activity, with the historical maximum value (170 pCi/L in March 1997) being about 650% higher than the historical minimum value (26.9 pCi/L in January 2001). Also, the lowest values for gross alpha activity, including all but one of results that are less than 50 pCi/L, were reported for samples obtained with the low-flow sampling method. The highest values for gross alpha activity, including all but one of the results that exceed 100 pCi/L, were reported for the samples collected with the conventional sampling method (Table 1). Results of "paired sampling" (see Section 2.0) are needed to determine if the groundwater sampling method influences the levels of gross alpha activity in the samples. In either case, the available data show that gross alpha activity in the shallow groundwater from well GW-605 is substantially higher than evident in the deeper groundwater from well GW-606 (e.g., 5 pCi/L in January 2003). Substantially higher gross alpha activity in the samples from well GW-605 suggests that a source of uranium isotopes is in the shallow subsurface near these wells. Although there is a downward vertical hydraulic gradient near these wells (see Section 3.0), there appears to be minimal downward transport of uranium isotopes (and alpha-particle emitting daughter products) into the deeper flow system.

A time-series plot of the results for gross alpha activity that exceed the MDA and CE shows two distinctive trends: a fluctuating but generally increasing trend indicated by conventional sampling data and a much less variable, indeterminate trend indicated by the low-flow sampling data

(Figure 3). It is not clear from the available data if these trends are influenced by the respective groundwater sampling method or if they reflect a fairly abrupt decrease in the relative flux of uranium isotopes along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, the results for gross alpha activity do not indicate any clear response to the operation of groundwater extraction well GW-845.

5.5 GROSS BETA ACTIVITY

All but three groundwater samples had gross beta activity above the applicable MDA and corresponding CE (one sample was not analyzed for gross beta activity; Table 1), and twelve of these results exceed the SDWA screening level (50 pCi/L) for gross beta activity. Elevated gross beta activity in the groundwater at this well is probably attributable to uranium isotopes (and related daughter products that emit beta particles) and reflects contamination associated with contaminated debris placed as fill along the north bank of UEFPC or historical uranium enrichment activities performed in Buildings 9201-1, 9201-2, and 9201-3 (DOE 1998).

Analytical results obtained in accordance with the RCRA post-closure permit for the UEFPC hydrogeologic regime show that Tc-99 is not the source of the elevated levels of gross beta activity reported for the groundwater samples. Seventeen samples collected since October 1998 were analyzed for Tc-99, a "signature" component of the contaminant plume emplaced in the western part of Y-12 during historical operation of the former S-3 Ponds. The only Tc-99 result that exceeds the MDA was reported for the sample collected in January 2001 (21.76 pCi/L), and this result is probably an analytical artifact (BJC 2002).

Excluding the non-detect (i.e., <MDA) results for gross beta activity (Table 1), the samples contained a wide range of gross beta activity, with the historical maximum value (110 pCi/L in January 1994) being about 650% higher than the historical minimum value (6.22 pCi/L in January 2001). Also, the lowest values for gross beta activity, including nine of the ten results below 25 pCi/L, were reported for samples obtained with the low-flow sampling method. Conversely, the highest values for gross beta activity, including all but one of the results that exceed 50 pCi/L, were reported for the samples collected with the conventional sampling method (Table 1). Thus, "paired sampling" (see Section 2.0) results are needed to determine if the sampling method influences the levels of gross beta activity in the groundwater samples. Also, as with gross alpha activity, the available data show that gross beta activity in the shallow groundwater from well GW-605 is consistently higher than evident in the deeper groundwater from well GW-606 (e.g., 7 pCi/L in January 2003). This too suggests minimal vertical transport of uranium isotopes (and beta particle-emitting daughter products) into the deeper flow system near these wells.

A time-series plot of the results for gross beta activity that exceed the MDA and CE shows two distinctive trends: a widely fluctuating, indeterminate trend indicated by conventional sampling data and a much less variable but similarly indeterminate trend indicated by the low-flow sampling data (Figure 4). Also, the conventional sampling data often show temporal "peak" gross beta activity during seasonally high groundwater (e.g., 110 pCi/L in January 1994), whereas the low-flow sampling results do not show any clear or consistent relationship between temporal peak gross beta activity and seasonal flow conditions.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC. (BJC). 2002. *Calendar Year 2001 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-605: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Method/Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
Conventional Sampling				
08/26/91	0.69	0.12	47.37	47.71
10/23/91	.	0.152	73.1	69.2
01/26/92	.	0.17	67.3	69.3
04/22/92	0.28	0.181	61	58.4
08/02/92	.	0.159	55.8	22.6
10/22/92	.	0.165	75.5	42.5
02/02/93	.	0.149	53.4	43.4
05/10/93	0.38	0.189	61.4	51.4
08/19/93	.	<0.001	29	27.4
11/10/93	0.25	0.19	83	58.1
02/02/94	0.39	0.234	112	56.7
06/03/94	0.3	0.165	95.3	66.4
09/25/94	.	0.246	104	39.5
12/06/94	0.32	0.222	128	110
03/13/95	1.3	0.23	115	73.6
06/18/95	0.6	0.18	89	55.2
09/27/95	0.64	0.16	94.3	47.2
12/12/95	0.392	0.18	97.3	31.4
02/15/96	0.29	0.14	Not Analyzed	Not Analyzed
06/08/96	.	0.23	<MDA	36.4
09/19/96	0.22	0.2	132	39.2
10/31/96	0.3	0.23	103	53.9
03/18/97	0.221	0.24	170	80
08/11/97	0.28	0.23	120	<MDA
Low-Flow Sampling				
03/12/98	0.36	0.33	130	35
07/27/98	0.773	0.0464	29	<MDA
02/11/99	0.45	Not Analyzed	39.27	17.73
07/20/99	[210]	0.0872	51.18	31.79
01/12/00	[0.22]	0.0847	48.06	14.87
07/17/00	2.6	0.0897	49.38	11.64
01/05/01	0.46	0.0779	26.9	6.22
07/10/01	0.17	0.0942	40.1	14
01/08/02	0.14	0.0983	48.42	14.94
07/08/02	0.5	0.114	51.84	21.23
01/08/03	0.34	0.0879	51.98	18.39
07/10/03	0.66	0.0833	48.96	26.23
01/07/04				
07/12/04				
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; [ ] = Result considered qualitative because of ion charge-balance error; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-605: summary of VOC results

Sampling Method/Date	Concentration (µg/L)					
	PCE	TCE	12DCE (Total)	c12DCE	CTET	CLF
Conventional Sampling						
08/26/91	18	7	17	NR	26	4 J
10/23/91	36	15	40	NR	21	32
01/26/92	23	10	22	NR	71	14
04/22/92	30	14	30	NR	180	19
08/02/92	52	22	45	NR	110	16
10/22/92	40	18	36	NR	78	15
02/02/93	25	8	22	NR	170	23
05/10/93	7	3 J	10	NR	50	20
08/19/93	32	10	30	NR	180	28
11/10/93	30	9	30	NR	160	29
02/02/94	11	4 J	10	NR	60	9
06/03/94	8	2 J	10	NR	93	18
09/25/94	21	6	19	NR	260	30
12/06/94	18	6	18	NR	100	13
03/13/95	15	4 J	12	NR	200	18
06/18/95	34	10	29	NR	320	37
09/27/95	65	25	54	NR	280	35
12/12/95	32	12	25	NR	150	20
02/15/96	21	8	21	NR	190	26
06/08/96	14	5	13	NR	250	23
09/19/96	13	4	.	NR	180	18
10/31/96	15	6	11	NR	180	FP
03/18/97	3 J	1 J	3 J	3 J	100	FP
08/11/97	7	2 J	5	5	170	16
Low-Flow Sampling						
03/12/98	.	.	.	.	4 J	.
07/27/98	35	43	79	79	42	11
02/11/99	12	14	24	24	10	12
07/20/99	27	30	55	55	25	11
01/12/00	15	16	26	27	11	7
07/17/00	54	57	100	100	62	10
01/05/01	21	22	39	39	17	12
07/10/01	15	16	23	23	11	7
01/08/02	76	82	141	140	53	11
07/08/02	33	33	50	50	19	12
01/08/03	38	47	63	63	21	19
07/10/03	61	66	97	95	36	14
01/07/04	45	44	66	66	24	11
07/12/04	15	21	41	41	11	5
MCL	**5**	**5**	**NA**	**70**	**5**	**80***

Table 2. (continued)

Sampling Method/Date	Concentration (µg/L)			
	11DCA	11DCE	VC	OTHER
Conventional Sampling				
08/26/91	1 J	.	.	Methylene chloride (0.6 J)
10/23/91	2 J	1 J	.	.
01/26/92	2 J	1 J	.	.
04/22/92	3 J	.	.	.
08/02/92	3 J	1 J	.	.
10/22/92	2 J	1 J	2 J	.
02/02/93	3 J	2 J	.	.
05/10/93	.	.	.	.
08/19/93	3 J	1 J	2 J	.
11/10/93	3 J	1 J	.	.
02/02/94	0.9 J	.	.	.
06/03/94	.	.	.	.
09/25/94	2 J	.	.	.
12/06/94	.	.	.	.
03/13/95	.	.	.	.
06/18/95	2 J	.	.	.
09/27/95	3 J	2 J	2 J	.
12/12/95	.	.	.	.
02/15/96	.	.	.	.
06/08/96	2 J	.	.	.
09/19/96	.	.	.	.
10/31/96	.	.	.	.
03/18/97	.	.	.	.
08/11/97	.	.	.	.
Low-Flow Sampling				
03/12/98	.	.	.	.
07/27/98	.	.	1 J	.
02/11/99	.	.	.	.
07/20/99	.	.	.	.
01/12/00	.	.	.	.
07/17/00	.	.	.	.
01/05/01	.	.	.	.
07/10/01	.	.	.	.
01/08/02	.	.	.	.
07/08/02	.	.	.	t12DCE (1 J)
01/08/03	.	.	.	Bromodichloromethane (1 J)
07/10/03	.	.	.	t12DCE (2 J)
01/07/04	.	.	.	.
07/12/04	.	.	.	.
MCL	NA	7	2	.

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported; * MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

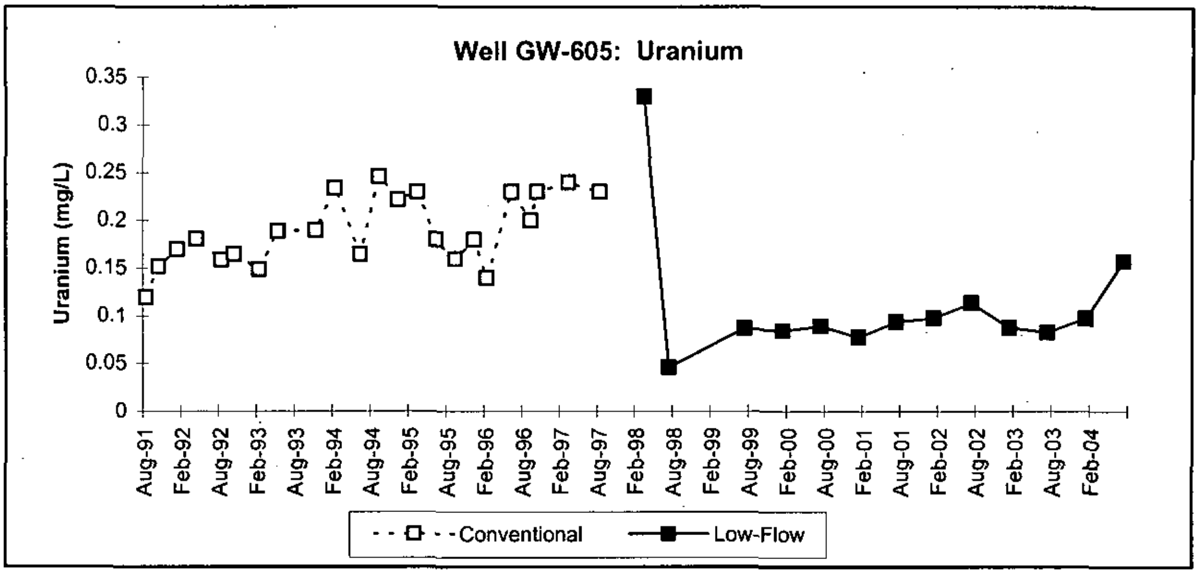


Figure 1

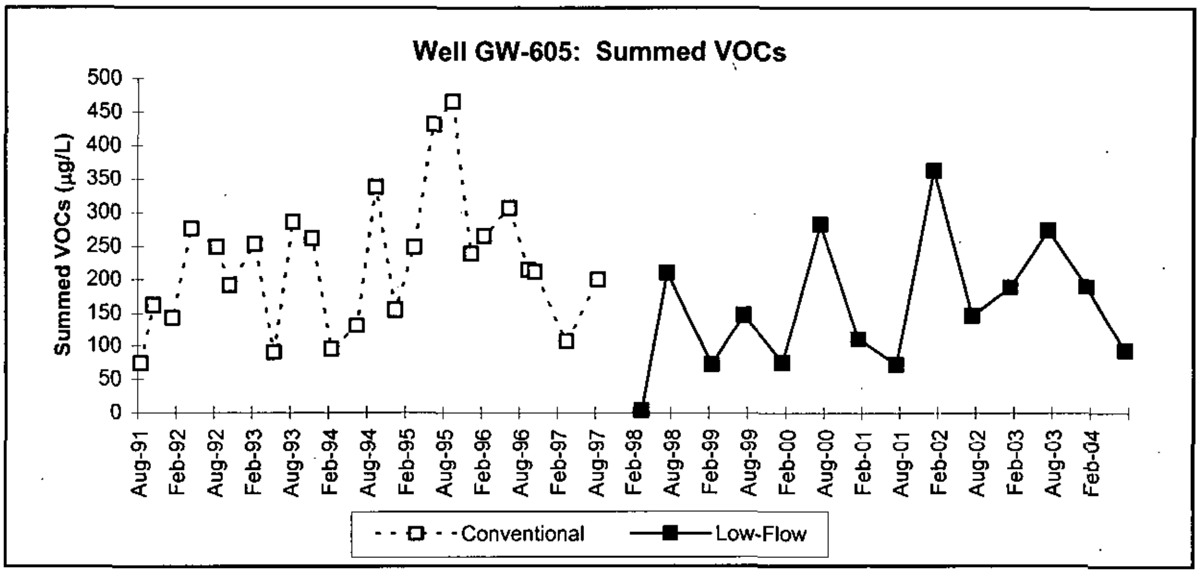


Figure 2

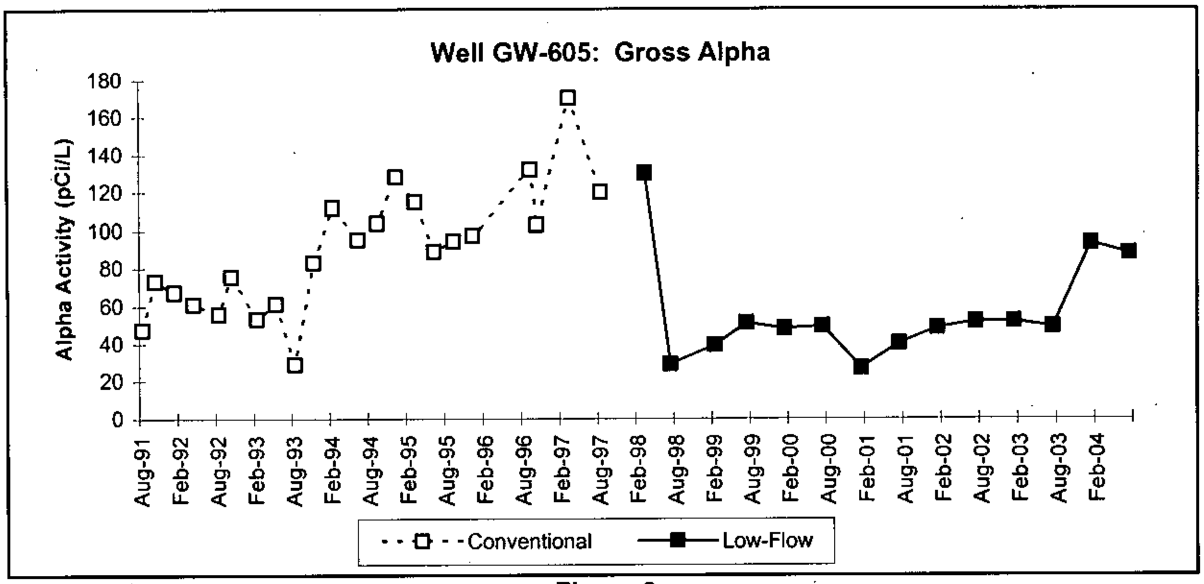


Figure 3

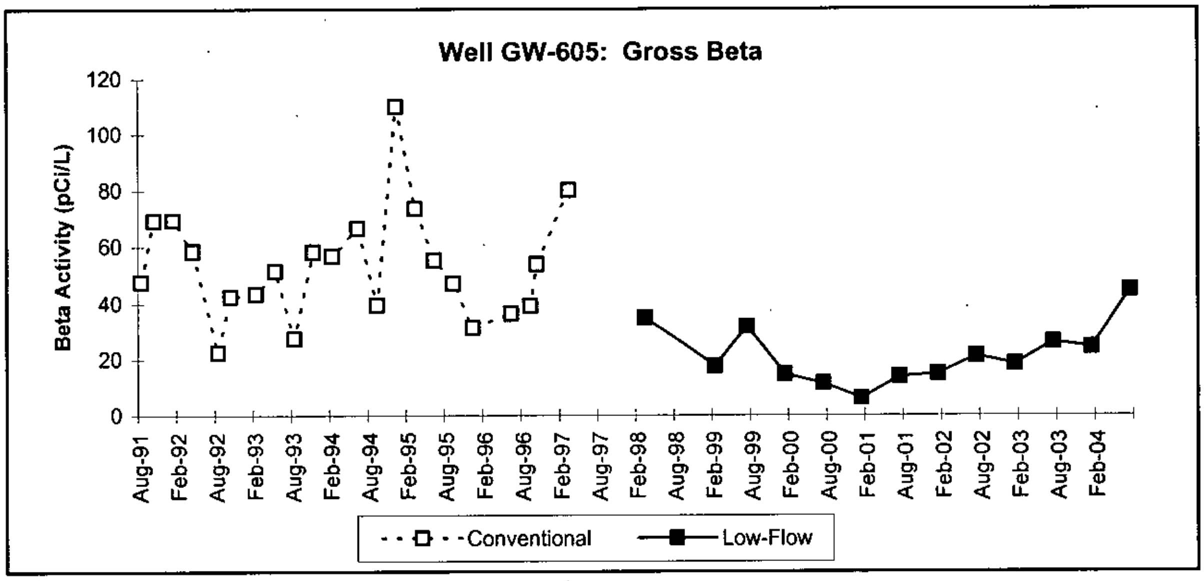


Figure 4

MAXIMUM CONCENTRATION: 2004

5 - 10	<0.015	50 - 500	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-606

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket I
Y-12 GRID EAST COORDINATE: 61,951.42
Y-12 GRID NORTH COORDINATE: 28,708.32
SURFACE ELEVATION: 916.98 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/20/91 PAIRED/CLUSTERED WITH: GW-605
TAG DEPTH (measured): 174.36 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 919.59 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.63 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.25 inches (outside diameter)
WELL SCREEN TYPE: SS/PPK/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	155.0	761.98
BOTTOM (filter pack or open hole):	171.0	745.98
MIDPOINT (filter pack or open hole):	163.0	753.98
PUMP INTAKE:	166.39	750.59
WATER LEVEL (average):	11.15	905.83

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	24 samples	08/26/91	07/31/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/12/98	07/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/07/04	.	07/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.88 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	3	14.7 mg/L	01/08/03	Increasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	38	3617.5 µg/L	08/26/91	Decreasing
GROSS ALPHA (15 pCi/L):	1	18.3 pCi/L	04/22/92	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-606

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1991, completed with a screened monitored interval from 155 to 171 ft bgs. The well forms a cluster with well GW-605 and is constructed with nominal 4.3-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot pre-packed, wire-wound). The well is located in Bear Creek Valley (BCV) in the eastern Y-12 area, on the north side of the main channel of Upper East Fork Poplar Creek (UEFPC) about 1,300 ft west (hydraulically upgradient) of New Hope Pond (NHP). Closed in 1988 and covered with a multi-layer, low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in UEFPC is directed through a concrete-lined diversion channel bordering the south and east sides of NHP/Lake Reality. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was permanently diverted through the Lake Reality spillway, which discharges into the mainstream of UEFPC directly north (downstream) of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well, with the conventional sampling method used to obtain 24 samples between August 1991 and July 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits moderate (<4 ft) seasonal fluctuations. Interestingly, the groundwater elevations indicated by presampling measurements obtained through October 1996 show the typical seasonal fluctuations, but similarly seasonal fluctuations are less clearly evident following the historical maximum groundwater elevation (908 ft above msl) observed in well GW-606 in March 1997 (Figure 1). What may have caused the sharp temporal rise in the groundwater elevation in the well or why the seasonal water-level fluctuations are less pronounced is not evident from the available data, but neither appear to be attributable to the hydrologic testing and full-time operation of a groundwater extraction well (GW-845) located about 2,500 ft directly east of well GW-606 (see Section 5.3). In any case, the presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-606 than in well GW-605, which is completed at a shallower depth (40 ft bgs) in the Maynardville Limestone. Based on the distance (128.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.011-0.028) during seasonally high and low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-606 indicate flow primarily to the east toward NHP, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 225 – 445 mg/L, excluding a suspected outlier (900 mg/L) in January 2000;
- pH of 6.9 – 10.61 (field measurements): note that samples collected from January 2001 through January 2002 exhibited characteristics of grout contamination (e.g., pH>8.5), which appears to have been alleviated by redevelopment of the well in June 2002;
- elevated concentrations of nitrate (>10 mg/L), chloride (>20 mg/L), and sulfate (>40 mg/L);
- low molar proportions of sodium and potassium (<10% of total cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples had nitrate (as N) at or above the analytical reporting limit (Table 1), including results for three samples that exceed the MCL for nitrate (10 mg/L). The potential source(s) of the nitrate has not been confirmed, but there are potential source areas within Y-12 west (hydraulically upgradient) of the well, including the contaminant plume emplaced in the Maynardville Limestone during historical operations of the S-2 Site, a closed former surface impoundment located near the southwest end of Y-12. Whatever the source, the elevated nitrate concentrations reflect eastward migration via strike-parallel groundwater flow/transport pathways at depth (>150 ft bgs) in the Maynardville Limestone. This interpretation is supported by the much lower nitrate levels typical of the groundwater samples from well GW-605 (e.g., 0.29 mg/L in July 2004) which, in light of the consistently downward vertical hydraulic gradients indicated by presampling groundwater elevations (see Section 3.0), discounts vertical recharge as the likely source of the nitrate in the deeper groundwater at well GW-606.

As shown on Figure 2, higher nitrate concentrations generally correspond with the change from conventional sampling to low flow sampling (Figure 2), although similar differences are not evident for other contaminants in the groundwater samples (e.g., VOCs). Additionally, the highest nitrate concentrations were reported for samples collected after the well was redeveloped in June 2002 (Figure 2). Moreover, the samples with the highest nitrate concentrations were obtained after the hydrologic testing and full-time operation of the groundwater extraction well (GW-845) being used to remove VOC-contaminated groundwater from the Maynardville Limestone about 2,500 ft east (hydraulically downgradient parallel with geologic strike) of well GW-606 (see Section 5.3). Thus, it is not clear if the higher nitrate concentrations reflect a corresponding increase in the relative flux of nitrate along the groundwater flow/transport pathways intercepted by the monitored interval in the well, or if the nitrate concentrations are artifacts of the sampling method and/or the redevelopment of the well, or if the higher nitrate concentrations are related to the long-term extraction of groundwater from well GW-845.

5.2 URANIUM

Twenty-nine groundwater samples had total uranium concentrations above the applicable analytical reporting limit (one sample was not analyzed for uranium; Table 1), with the historical maximum value (0.0074 mg/L in July 1997) being substantially below the MCL for total uranium (0.03 mg/L). Also, the uranium concentrations are substantially lower than evident in samples of the shallower groundwater from well GW-605 (e.g., 0.0833 mg/L in July 2003). This suggests that, despite the locally downward vertical gradients (see Section 3.0), there is not extensive transport of uranium from the shallow flow system into the deeper flow system near these wells.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): acetone, benzene, CTET, chloroform (CLF), methylene chloride (MC), toluene, PCE, TCE, and 12DCE. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide, located near the west end of Y-12, that separates the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater extraction and treatment system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Groundwater is pumped from the extraction well (GW-845) at a rate of 25 gpm and is treated on-site to remove particulates, iron, manganese, and VOCs. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

The primary VOCs in the groundwater samples are CTET and CLF, both of which were detected in all of the samples, with the most recent sampling results (January and July 2004) showing that concentrations of each compound remain above respective MCLs (Table 2). Tetrachloroethene is the only other VOC that has been consistently detected in the samples, with most concentrations being below 10 μg/L, including the most recent concentrations at or slightly above the MCL (5 μg/L). Additionally, the analytical results for the samples obtained with the conventional sampling method show substantially higher concentrations of CTET than indicated by the low-flow sampling results, but equivalent or somewhat lower concentrations of CLF and PCE. Assuming that the groundwater in the well contains a heterogeneous mixture of dissolved VOCs, it is not clear why the concentrations of individual compounds would exhibit different responses to the groundwater sampling method. The higher pumping rate during conventional sampling potentially induces greater relative inflow from water-producing features that transmit CTET-contaminated groundwater.

As illustrated by the data summarized below, concentrations of VOCs in the groundwater samples from well GW-606, particularly CTET and CLF, used to be substantially higher than evident in the samples of the shallower groundwater from well GW-605.

VOC	Concentration (μg/L)					
	Conventional Sampling		Low-Flow Sampling			
	August 1991		July 1998		July 2004	
	GW-605	GW-606	GW-605	GW-606	GW-605	GW-606
PCE	18	12	7	7	15	5
TCE	7	0.9 J	2 J	.	21	.
12DCE	17	2 J	5	.	41	.
CTET	26	2,800	170	120	11	72
CLF	4 J	600	16	140	5	120
Summed VOCs	74	3,618	200	269	93	197
Note: "." = Not detected; J = Estimated value below analytical reporting limit						

The large disparity between the recent and historical concentrations of CTET and CLF in these wells, in light of the downward vertical hydraulic gradients indicated by presampling groundwater elevations in each well (see Section 3.0), these concentrations suggest that recharge from the shallow flow system near these wells is not the likely source of the CTET and CLF deeper in the Maynardville Limestone. This interpretation is supported by the low concentrations other VOCs in the samples from well GW-606, particularly PCE and 12DCE, compared to samples from well GW-605. Moreover, the difference in the types and concentrations of VOCs suggests that the source of the compounds in the deeper groundwater from well GW-606 may be separate from the source of the compounds in the shallower groundwater at well GW-605.

A time-series plot of the CTET and CLF concentrations reported for each groundwater sample shows concurrently fluctuating and generally decreasing trends between August 1991 and July 1997, with somewhat divergent respective trends thereafter (Figure 3). While CTET concentrations remained relatively unchanged between July 1997 (67 μg/L) and July 2004 (72 μg/L), the concentrations of CLF increased from 66 μg/L in July 1997 to 430 μg/L in July 2000 and subsequently decreased to 120 μg/L in July 2004. Note that the apparent divergence in the CTET and CLF concentration trends coincides with the change from conventional sampling to low-flow sampling. Also, the recent decrease in the concentration of CLF generally corresponds with the full-time operation of groundwater extraction well GW-845, although the CTET concentrations do not exhibit any apparent response to the pumping well (Figure 3). Additionally, the concentrations of CTET and CLF (and other VOCs) do not appear to exhibit any direct response to the redevelopment of the well in July 2000.

5.4 GROSS ALPHA ACTIVITY

Thirty-one groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum value (18.3 pCi/L in April 1992) being slightly above the MCL for gross alpha activity (15 pCi/L). However, this result appears to be an outlier compared to the other results for gross alpha activity, none of which exceed 10 pCi/L. Also, the relatively low gross alpha activity in the samples contrasts with the much higher levels typically reported for samples of the shallower groundwater from well GW-605 (e.g., 87 pCi/L in January 2004), which suggests minimal local inflow of uranium isotopes into the deeper flow system in the Maynardville Limestone.

5.5 GROSS BETA ACTIVITY

Twenty-eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (26.6 in April 1992) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the MCL for gross beta activity). Also, as with gross alpha activity, the relatively low gross beta activity in the samples contrasts with higher levels reported for the samples of the shallower groundwater from well GW-605 (e.g., 44 pCi/L in July 2004), which likewise indicates little if any local inflow of uranium isotopes (and beta-particle emitting daughter products) into the deeper flow system in the Maynardville Limestone.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee,* DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-606: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
08/26/91	1.32	0.004	1.55	6.79
10/24/91	0.78	0.003	6.29	8.26
01/26/92	0.7	0.005	4.3	5.41
04/22/92	0.94	0.005	18.3	26.6
08/03/92	0.86	0.007	< CE	5.44
10/23/92	0.91	0.008	9.78	7.43
02/03/93	0.73	0.006	4.22	6.37
05/10/93	0.87	0.007	< CE	< CE
08/20/93	0.64	0.001	< CE	5.09
11/11/93	0.95	0.007	6.31	< CE
02/03/94	0.7	0.008	7.82	5.43
06/06/94	1	0.007	5.84	3.66
09/25/94	0.72	.	5.07	6.26
12/07/94	0.89	.	4.44	5.52
03/13/95	1.7	0.0073	5.65	5.55
06/18/95	1.4	0.0067	3.31	6.28
09/28/95	1.3	0.007	9.47	5.2
12/12/95	1.25	0.0063	7.58	5.39
02/22/96	1.29	0.0061	Not Analyzed	Not Analyzed
06/08/96	1.02	0.0072	<MDA	<MDA
09/19/96	0.78	0.0064	7.35	7.48
10/31/96	0.78	0.0067	4.56	<MDA
03/06/97	1.05	0.0068	8.5	<MDA
07/31/97	1.14	0.0074	5.5	<MDA
03/12/98	4.67	0.0027	5	<MDA
07/28/98	4.69	0.0022	<MDA	<MDA
02/15/99	5.1	Not Analyzed	6.74	5.3
07/21/99	4.6	.	5.74	3.89
01/12/00	2.65	.	5.93	4.9
07/17/00	6.3	0.00525	4.58	3.97
01/08/01	4.8	.	2.93	5.76
07/10/01	5.8	.	7.25	<MDA
01/08/02	5.5	.	<MDA	18.6
07/08/02	12	.	5.63	9.83
01/08/03	14.7	0.00547	8.64	7.49
07/10/03	11	0.00526	5.27	7.33
01/07/04	9.6	0.00536	7.84	7.3
07/12/04	8.4	0.00647	9.57	4.49
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-606: summary of VOC results

Date Sampled	Concentration (μg/L)				
	CTET	**CLF**	**MC**	**PCE**	**OTHER**
CONV					
08/26/91	2,800	600	32	12	Acetone (170);TOL (0.6 J);TCE (0.9 J);12DCE (2 J)
10/24/91	2,600	640	41	.	.
01/26/92	990	520	FP	9	12DCE (1 J)
04/22/92	1,500	500	24	.	TOL (25)
08/03/92	1,400	440	21	.	.
10/23/92	420	260	FP	6	.
02/03/93	1,100	310	FP	6	.
05/10/93	580	250	.	.	.
08/20/93	770	250	FP	6	.
11/11/93	500	250	FP	5	.
02/03/94	720	290	FP	8	.
06/06/94	120	97	.	2 J	.
09/25/94	1,100	250	.	9	12DCE (1 J)
12/07/94	780	280	58	.	.
03/13/95	720	250	49	.	.
06/18/95	120	100	.	4 J	.
09/28/95	380	160	1 J	7	12DCE (1 J)
12/12/95	1,000	220	.	10	.
02/22/96	650	210	.	.	.
06/08/96	670	220	.	.	.
09/19/96	380	150	.	6	.
10/31/96	850	240	.	12	.
03/06/97	810	210	.	.	TCE (16)
07/31/97	67	66	1 J	5	.
LF					
03/12/98	130	150	.	8	.
07/28/98	120	140	.	7	Acetone (2 J)
02/15/99	92	220	.	7	Benzene (3 J)
07/21/99	82	360	.	8	Benzene (3 J)
01/12/00	50	310	.	5	Benzene (2 J)
07/17/00	75	430	.	7	.
01/08/01	97	280	.	5	Benzene (1 J)
07/10/01	160	350	.	5	Benzene (1 J)
01/08/02	110	230	.	5	.
07/08/02	180	140	.	7	.
01/08/03	120	140	.	6	.
07/10/03	72	130	.	6	.
01/07/04	69	130	.	6	.
07/12/04	72	120	.	5	.
MCL	**5**	**80***	**NA**	**5**	.

Note: CONV=conventional sampling method; LF = low-flow sampling method; " ." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable;
* MCL for total trihalomethanes

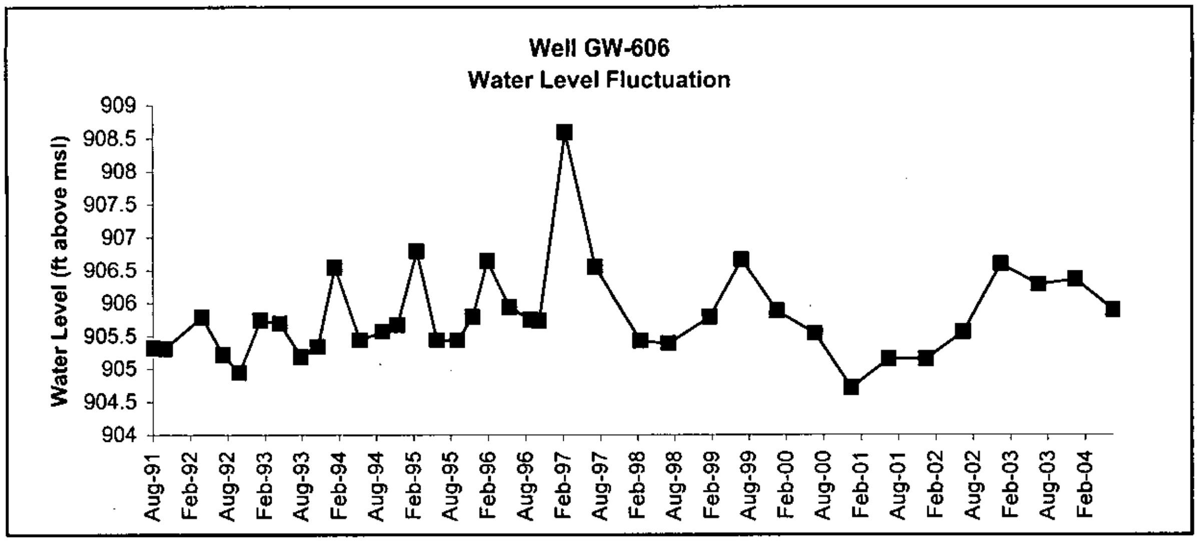


Figure 1

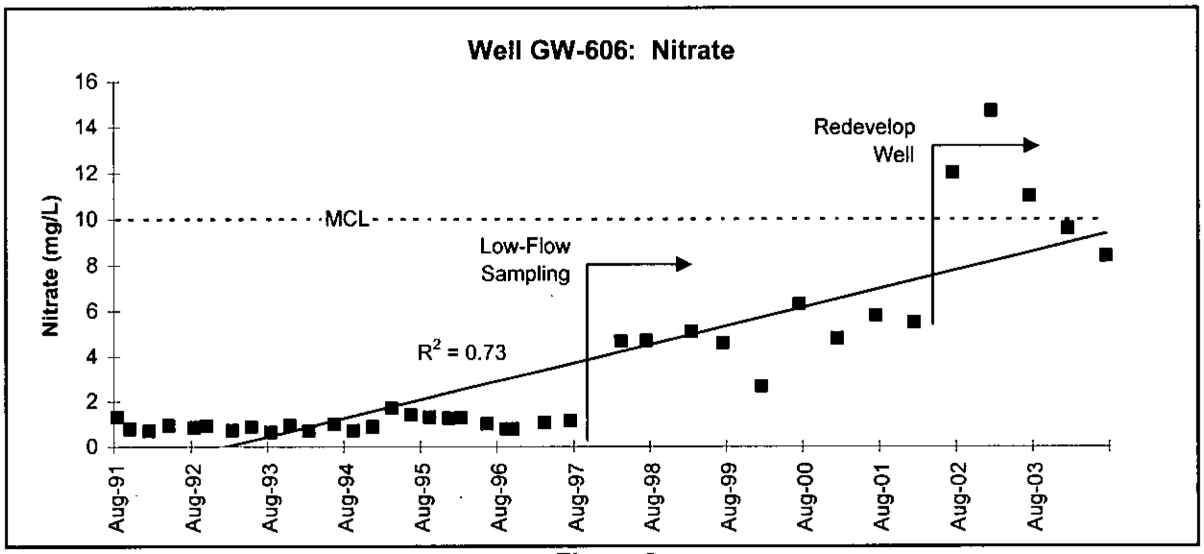


Figure 2

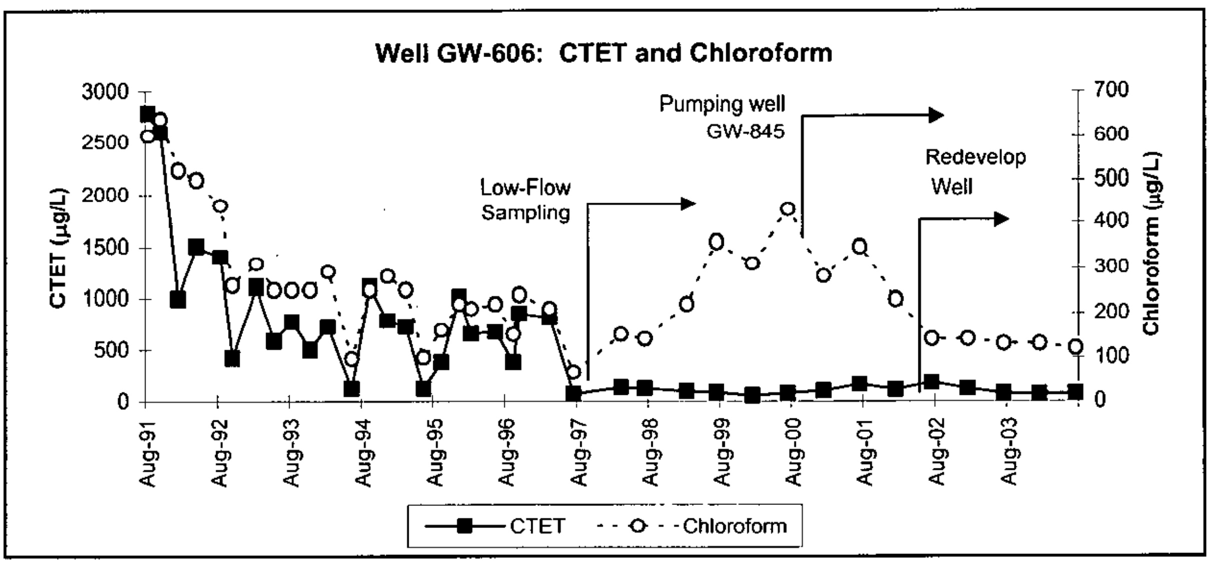


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-610

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 59,471.94
Y-12 GRID NORTH COORDINATE: 28,549.31
SURFACE ELEVATION: 1,056.78 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/02/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 120.21 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,059.44 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	105.1	951.68
BOTTOM (filter pack or open hole):	117.4	939.38
MIDPOINT (filter pack or open hole):	111.3	945.53
PUMP INTAKE:	112.3	944.44
WATER LEVEL (average):	81.33	975.45

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	25 samples	02/09/90	02/23/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/22/04	10/20/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/22/04	.	10/20/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 18.85 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-610

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1990, completed with a screened monitored interval from 105 to 117 ft bgs, and constructed nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge directly south of Y-12, approximately 200 ft northeast of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 25 samples between February 1990 and February 1996, and the low-flow sampling method used to obtain samples in April and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Copper Ridge Dolomite), which forms the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 81 ft bgs and exhibits moderate (about 19 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV (toward well GW-610), to the east along the axis of the ridge (parallel with geologic strike), and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 177 – 231 mg/L;
- pH of 6.5 – 8.92 (field measurements);

- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, none of the principal contaminants are generally present in the groundwater at this well.

5.1 NITRATE

Twenty-one groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (1 mg/L in January 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Six groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, all results being equal to the reporting limit (0.001 mg/L) and an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, four of the groundwater samples contained trace levels (1 µg/L or less) of PCE, which is a principal component of the dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via strike-parallel flowpaths in the Knox Group (e.g., bedding-plane fractures). Nevertheless, the presence of dissolved VOCs in the groundwater at this well indicates that there is a component of groundwater flow/contaminant to the north-northeast, possibly via "quickflow" conduits that cut across geologic strike (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.82 pCi/L in June 1993) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.79 pCi/L in January 1995) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-611

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,058.92
Y-12 GRID NORTH COORDINATE: 28,855.52
SURFACE ELEVATION: 1,045.43 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/19/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 120.26 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,048.38 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	101.5	943.93
BOTTOM (filter pack or open hole):	121.6	923.83
MIDPOINT (filter pack or open hole):	111.6	933.88
PUMP INTAKE:	112.05	933.38
WATER LEVEL (average):	99.45	945.98

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	25 samples	02/09/90	02/25/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/22/04	10/20/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/22/04	.	10/20/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 12.65 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	17	20 µg/L	11/30/94	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-611

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1990, completed with a screened monitored interval from 102 to 122 ft bgs, and nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot pre-packed, wire-wound). The well is located on the north flank of Chestnut Ridge directly south of Y-12, approximately 400 ft north of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 25 samples between February 1990 and February 1996, and the low-flow sampling method used to obtain samples in April 2004 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 99 ft bgs and exhibits moderate (about 13 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV (toward well GW-611); to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 156 – 332 mg/L;
- pH of 6.9 – 9.4 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-three groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit (Table 1). Although the nitrate concentrations are all below the drinking water MCL for nitrate (10 mg/L), many exceed the nitrate UTL applicable to Knox Group wells (2.7 mg/L). The source of the nitrate in the groundwater at the well is uncertain. Migration from the CRSP seems unlikely because the site did not receive nitrate wastes and elevated nitrate concentrations are not evident in groundwater at other wells located closer to the former waste disposal trenches. Nitrate is highly mobile in groundwater and the elevated levels in the groundwater at this well potentially reflect strike-parallel, advective transport from the contaminant plume emplaced during historical operations of the former S-2 Site. A closed surface impoundment located on the northern flank of Chestnut Ridge about 4,000 ft to the west (upgradient) of the well, the S-2 Site is a confirmed source of nitrate in the groundwater in the Maynardville Limestone and seasonal (presampling) groundwater elevations in monitoring wells at the site are typically about 50 ft higher that evident in well GW-611. Additionally, the monitored interval for the well is completed in the Copper Ridge Dolomite near the geologic contact with the underlying Maynardville Limestone, and the extent of nitrate-contaminated groundwater in the Maynardville Limestone downgradient of the S-2 Site suggests groundwater flow/contaminant transport toward a highly permeable interval that occurs within the top of the formation and lower part of the Copper Ridge Dolomite.

5.2 URANIUM

Six groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in January 1991, February 1992, June 1993, September 1993, and May 1994) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in all but two of the groundwater samples collected to date: CTET, 11DCA, 11DCE, and 111TCA (Table 2). These compounds are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site shows that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

As shown on Table 2, one or more VOCs were detected in each groundwater sample collected between February 1990 and February 1996, but the samples collected most recently (May and October 2004) did not contain VOCs. The historical data show 111TCA as the most frequently detected compound with the highest concentrations (historical maximum of 17 μg/L in May 1990 and November 1994). The other VOCs were infrequently detected, particularly CTET (detected in only two samples), and all the results for these compounds are estimated values below 5 μg/L (Table 1). The predominance of 111TCA in the samples and repeated detection of 11DCA suggests that the monitored interval in the well intercepts cross-strike groundwater flow/contaminant transport pathways for VOCs that originate primarily from the western disposal trenches at the CRSP.

The lack of VOCs in the groundwater samples collected most recently is consistent with the decreasing concentration trend indicated by a time-series plot of the summed concentrations of VOCs detected in each sample (Figure 1). The decreasing trend, which is evident from initial sampling following installation of the well, is probably attributable to reduced flux of VOCs in response to closure of the CRSP in 1988 and installation of the low-permeability cap in 1989. Additionally, the historical data show substantial temporal fluctuations, with summed VOC concentration "peaks" typically evident for samples collected during seasonally low groundwater flow conditions (summer and fall).

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.39 pCi/L in January 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.81 pCi/L in July 1992) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

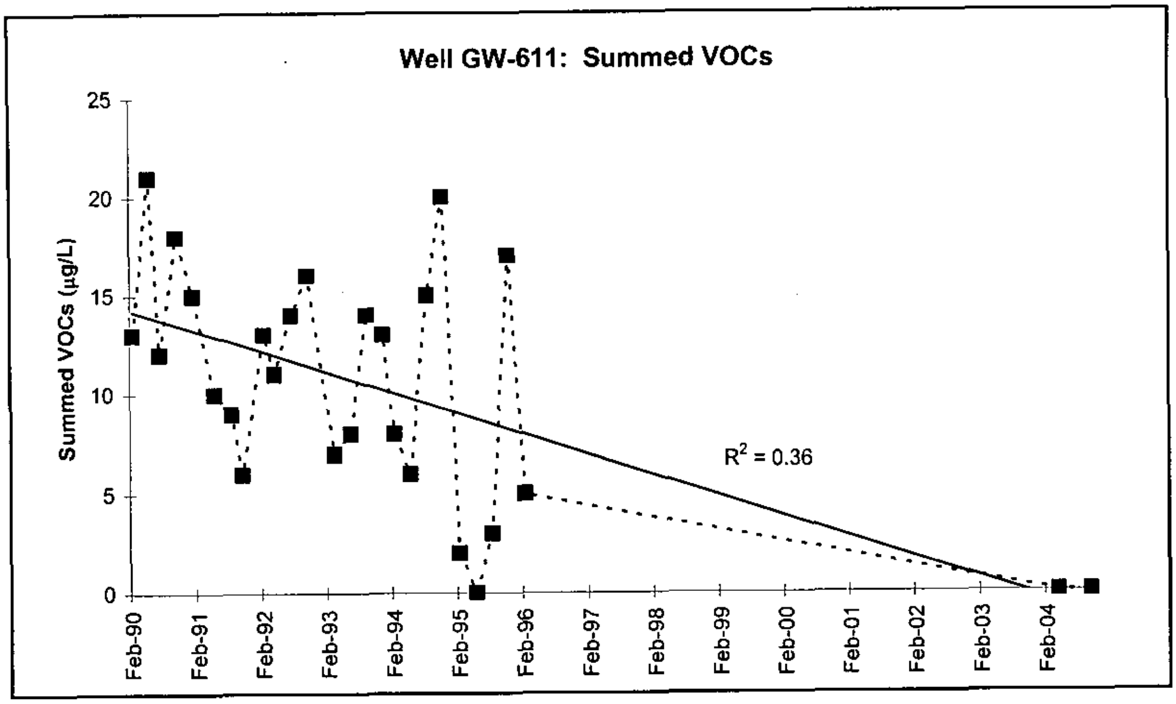
Table 1. Well GW-611: summary of nitrate results

Date Sampled	Nitrate as N (mg/L)
02/09/90	2.6
05/22/90	3
07/24/90	4
10/26/90	3
01/31/91	3
05/01/91	3
08/08/91	3
10/13/91	2.12
02/08/92	3
04/11/92	2.8
07/21/92	2.35
10/08/92	2.5
03/27/93	3.12
06/15/93	2.9
09/11/93	2.6
12/19/93	3
02/22/94	3.8
05/19/94	3.7
08/13/94	4
11/30/94	2.9
02/14/95	3.3
05/15/95	3.3
08/01/95	3.2
11/17/95	3.44
02/25/96	3.6
04/22/04	4.13
10/20/04	4.05

Table 2. Well GW-611: summary of VOC results

Date Sampled	Concentration (µg/L)			
	111TCA	11DCA	11DCE	CTET
02/09/90	13	.	.	.
05/22/90	17	2 J	2 J	.
07/24/90	12	.	.	.
10/26/90	15	1 J	2 J	.
01/31/91	14	1 J	.	.
05/01/91	10	.	.	.
08/08/91	8	1 J	.	.
10/13/91	.	2 J	2 J	2 J
02/08/92	10	2 J	1 J	.
04/11/92	9	2 J	.	.
07/21/92	10	2 J	2 J	.
10/08/92	12	2 J	2 J	.
03/27/93	7	.	.	.
06/15/93	8	.	.	.
09/11/93	10	2 J	2 J	.
12/19/93	9	2 J	2 J	.
02/22/94	8	.	.	.
05/19/94	6	.	.	.
08/13/94	10	2 J	3 J	.
11/30/94	17	3 J	.	.
02/14/95	.	1 J	1 J	.
05/15/95	.	.	.	.
08/01/95	.	1 J	2 J	.
11/17/95	12	2 J	2 J	1 J
02/25/96	4 J	.	1 J	.
04/22/04	.	.	.	.
10/20/04	.	.	.	.
MCL	**200**	**NA**	**7**	**5**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable



Well GW-611: Summed VOCs
Summed VOCs (µg/L)
25
20
15
10
5
0
$R^2 = 0.36$
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	<0.015	50 - 500	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-612

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,503.62
Y-12 GRID NORTH COORDINATE: 28,370.61
SURFACE ELEVATION: 1,128.65 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/01/89 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 256.28 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,131.03 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	230.6	898.05
BOTTOM (filter pack or open hole):	254.0	874.65
MIDPOINT (filter pack or open hole):	242.3	886.35
PUMP INTAKE:	247.6	881.03
WATER LEVEL (average):	121.09	1007.56

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	14 samples	02/10/90	10/05/04
LOW-FLOW SAMPLING METHOD:	4 samples	03/29/01	10/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/11/04	.	10/04/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 11.86 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	14	496 µg/L	08/12/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-612

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1989, completed with an open-hole monitored interval from 230 to 254 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located on the crest of Chestnut Ridge directly south of Y-12, near the approximate mid-point of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between February 1990 and October 2004, and the low-flow sampling method used to obtain four samples between March 2001 and October 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher VOC concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during May and August 2004, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias (Table 1); summed concentrations of VOCs detected in the samples obtained with the low-flow method are about 25 to 75% lower than the corresponding summed VOC concentrations for the samples obtained with the conventional sampling method. Also, samples obtained with the low-flow method were slightly more turbid, surprisingly, than the samples obtained with the conventional method, which may explain why the samples obtained with the low-flow method had elevated total iron concentrations that are substantially higher than reported for the (less turbid) samples obtained with the conventional sampling method (Table 1).

Inherent differences in the manner in which each sampling method induces flow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce flow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at a flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method appears to induce greater inflow of VOC-contaminated groundwater from water-producing features that are not proximal to the monitored interval, resulting in collection of groundwater samples with higher VOC concentrations than otherwise evident in samples obtained with the low-flow sampling method. It is not clear from the available data which method provides the most representative monitoring results with regard to the concentration of VOCs (and total iron) in the groundwater at the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 121 ft bgs and exhibits moderate (about 12 ft) temporal (seasonal) fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of the CRSP indicate radial flow directions, with components of flow to the north into BCV; to the east along the axis of the ridge, parallel with geologic strike of the bedrock; and south toward drainage features that traverse the broad southern flank of the ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that this well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 162 – 260 mg/L;
- pH of 7.2 – 8.8 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- total concentrations of trace metals (except boron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995); and
- boron concentrations of 0.105- 0.338 mg/L.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirteen groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.431 mg/L in May 2004) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Eleven groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L in February 1991, May 1991, August 1991, October 1991, February 1992, and July 1992) being below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample: PCE, TCE, 12DCE, 11DCE, TCFM, 11DCA, 12DCA, and 111TCA (Table 2). These compounds are components of a dissolved plume of VOCs that originates from the CRSP. These compounds are components of a dissolved plume of VOCs that originates from the CRSP. Historical operation of the former waste disposal trenches at this site emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast along the ridge crest (parallel with geologic strike) and at least 500 ft to the north and south down the ridges flanks. The existing network of monitoring wells at the site show that 111TCA, 11DCA, and 11DCE are the primary compounds in the groundwater near the western disposal trench area and PCE, TCE, and 12DCE are the principal compounds in the groundwater near the eastern disposal trench area. Some constituents of the VOC plume (e.g., 11DCA and 11DCE) are probably present as a result of the degradation of 111TCA. Elongation of the VOC plume along the axis of the ridge and the distribution of plume constituents indicate primarily west-to-east groundwater flow/contaminant transport via flowpaths (e.g., bedding-plane fractures) that parallel the geologic strike of the Knox Group strata. Vertical flow/transport occurs parallel with the dip of the strata, with cross-cutting fractures facilitating contaminant migration to the north and south (Shevenell 1994). The vertical extent of the VOC plume has not been determined, but based on the existing network of monitoring wells at the site, the plume extends at least 150 ft bgs near the western disposal trenches and 270 ft bgs near the eastern disposal trenches.

As noted in Section 2.0, the summed concentrations of VOCs detected in the groundwater samples obtained with the conventional sampling method are higher than the summed VOC concentrations for samples obtained with the low-flow sampling method. As illustrated by the "paired" sampling results summarized below, this is primarily attributable to differences in the concentrations of 111TCA.

VOC	Concentration (µg/L)			
	Low-Flow Sampling May 11, 2004	**Conventional Sampling May 12, 2004**	**Low-Flow Sampling October 4, 2004**	**Conventional Sampling October 5, 2004**
111TCA	16	44	21	40
11DCA	45	67	71	72
11DCE	25	43	41	50
12DCA	2 J	.	.	.
PCE	5	6	2 J	5
TCFM	.	.	.	2 J
SummedVOCs	93	160	134	169

Less significant differences are evident between respective "paired" sampling results for 11DCA and 11DCE, and there does not appear to be any significant difference between the results for PCE. Assuming a heterogeneous mixture of dissolved VOCs in the groundwater at the well, it is not clear why the sampling method influences the concentrations of some compounds and not others. Nevertheless, these findings suggest that the VOC results reflect the apparent tendency for the conventional sampling method to induce inflow of VOC-contaminated groundwater from water-producing features that are not proximal to the well (i.e., further into the formation).

Each groundwater sample collected to date contained 111TCA, 11DCA, and 11DCE, with PCE detected in all but two of the samples (Table 2); trace levels of 12DCE (4 µg/L), TCE (1 µg/L), and TCFM (3 µg/L) were each detected in one sample. Historical data show the highest concentrations for 111TCA and 11DCA, with respective maximum values of 410 µg/L and 170 µg/L in February 1990. The preponderance of these compounds suggests that the well intercepts groundwater flow/contaminant transport pathways for VOCs that originate primarily from the western disposal trenches at the CRSP. However, the most recent (May and October 2004) sampling results show substantially lower concentrations of both compounds, with 111TCA levels substantially below the drinking water MCL (200 µg/L). Results for 11DCE show a historical maximum value of 69 µg/L (August 1991); concentrations above 50 µg/L in all but four of samples collected to date; and concentrations that substantially exceed the MCL (7 µg/L) reported for the samples collected most recently (Table 2). Although detected in most of the samples, PCE is a secondary compound compared to the other VOCs, with a historical maximum value of 12 µg/L (February 1991) and concentrations below 10 reported for all but four of the samples, including each sample collected since February 1992.

As noted previously, some of the compounds in the CRSP VOC plume are present as a result of the degradation of related parent compounds. Abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), probably explains the frequent detection and relatively high concentrations of 11DCA and 11DCE in the groundwater samples from well GW-612. This is clearly illustrated by a time-series plot of the proportional distribution of 111TCA, 11DCA, and 11DCE concentrations in each groundwater sample collected to date (Figure 1), whereby a substantial decrease in the relative proportion of 111TCA is accompanied by a concurrent increase in the proportions of 11DCA and 11DCE. In contrast, aside from the trace of TCE detected in the sample collected in August 1991, the groundwater samples collected to date have not contained PCE degradation products, particularly 12DCE isomers, indicating that the monitored interval for the well does not intercept groundwater flow/transport pathways where biologically mediated degradation (reductive dechlorination) of PCE occurs.

Based on analytical results reported for samples obtained with the conventional sampling method, a time-series plot of the summed concentrations of VOCs detected in each sample (excluding false positive results) shows a clearly decreasing long term trend that spans two gaps in the sampling history for the well: July 1992 – August 1996 and August 1996 – May 2004 (Figure 2). Before the first sampling gap, the VOC data show a sharply decreasing trend following the historical maximum summed VOC concentration evident for the initial sample collected from the well in February 1990 (687 µg/L), with a total reduction of about 48% though October 1990 (337 µg/L), followed by a increasing trend through August 1991 (496 µg/L) and subsequent decrease through July 1992 (266 μg/L). The relatively rapid decrease, which was probably attributable primarily to substantially reduced flux of VOCs after closure of the CRSP in 1988 and installation of the low-permeability cap in 1989, suggests that the most highly contaminated groundwater has been flushed from the flow/transport pathways intercepted by the monitored interval in the well. Subsequent sampling results show that VOC concentrations continued the downward trend through August 1996 (266 μg/L) and October 2004 (169 μg/L). Note that the overall downward trend in summed VOC concentrations encompasses: (1) a substantial decrease in the concentration of 111TCA, with the most recent sampling results being an order-of-magnitude lower than the historical maximum value (410 μg/L in February 1990); (2) an initial decrease in 11DCA concentrations that has slowed considerably, as illustrated by the results for samples collected in July 1990 (160 μg/L), July 1996 (83 μg/L), and October 2004 (72 μg/L); (3) variable but relatively unchanged concentrations of 11DCE, as illustrated by the results reported for samples collected in July 1990 (46 μg/L), August 1996 (52 μg/L), and October 2004 (50 μg/L); and (4) no significant change in the relative concentrations of PCE, as illustrated by the PCE concentrations detected in the samples collected in May 1990 (8 μg/L), April 1991 (7 μg/L), and May 2004(6 μg/L).

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.1 pCi/L in August 2001) being below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.9 pCi/L in March 2001) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-612: Consecutive daily sampling results for summed VOCs and other selected analytes, May and October 2004

Analyte	Units	May 11-22, 2004		October 4-5, 2004	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.62	7.44	7.63	7.33
Dissolved Solids	mg/L	221	245	227	257
Suspended Solids	mg/L	3	<1	8	<1
Calcium	mg/L	39.3	49.7	41.7	53.2
Nitrate	mg/L	0.117	0.431	<0.028	0.377
Barium	mg/L	0.0167	0.0171	0.0223	0.0175
Iron	mg/L	1.23	0.134	5.55	0.206
Uranium	mg/L	<0.0005	0.00061	<0.0005	0.000923
Summed VOCs	µg/L	91	160	137	169
Gross Alpha Activity	pCi/L	<MDA	2.2	<MDA	<MDA
Gross Beta Activity	pCi/L	<MDA	<MDA	<MDA	<MDA

Table 2. Well GW-612: summary of VOC results

Sampling Method/Date	Concentration (µg/L)					
	111TCA	**11DCA**	**12DCA**	**11DCE**	**PCE**	**Other**
Conventional Sampling						
02/10/90	410	170	6	61	10	.
05/25/90	370	150	.	61	8	.
07/31/90	230	160	4 J	46	7	.
10/30/90	120	160	.	38	8	12DCE (4 J)
02/07/91	240	130	4 J	60	12	.
05/08/91	270	130	4 J	57	9	.
08/12/91	290	120	5	69	11	TCE (1 J)
10/17/91	220	110	3 J	50	11	.
02/12/92	160	110	.	43	7	.
04/10/92	200	130	5	56	7	.
07/24/92	160	130	4 J	54	9	.
08/29/96	120	83	4 J	52	7	.
05/12/04	44	67	.	43	6	.
10/05/04	40	72	.	50	5	TCFM (2 J)
Low-Flow Sampling						
03/29/01	26	41	.	24	.	.
08/22/01	21	34	.	22	.	.
05/11/04	16	45	.	25	5	.
10/04/04	21	71	2 J	41	2 J	.
MCL	**200**	**NA**	**NA**	**7**	**5**	**5** (TCE)

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable

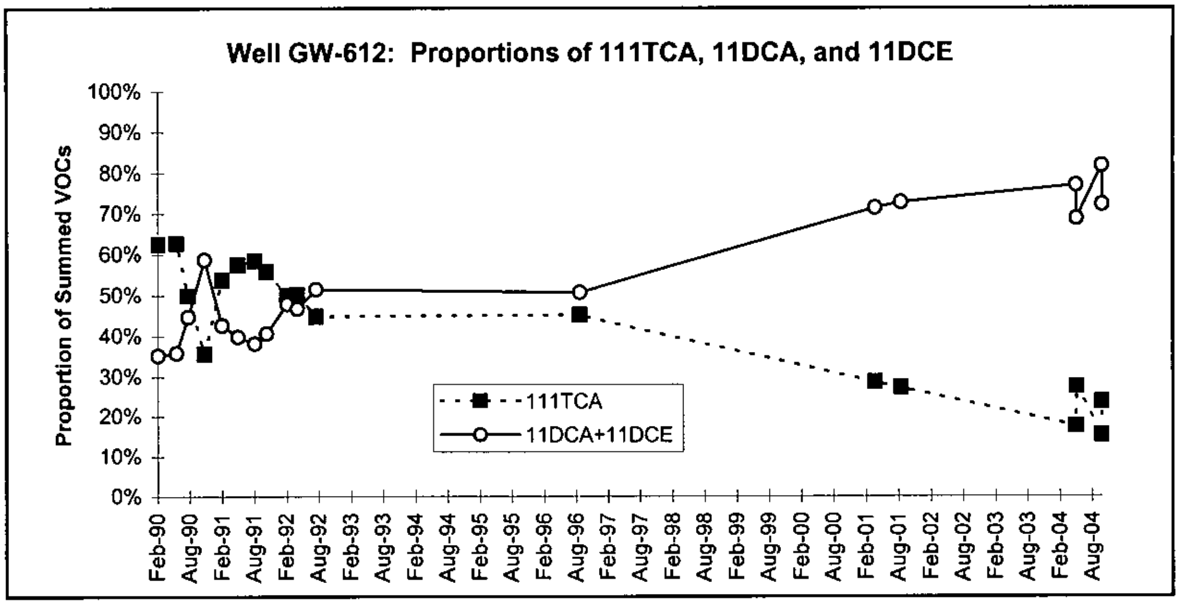


Figure 1

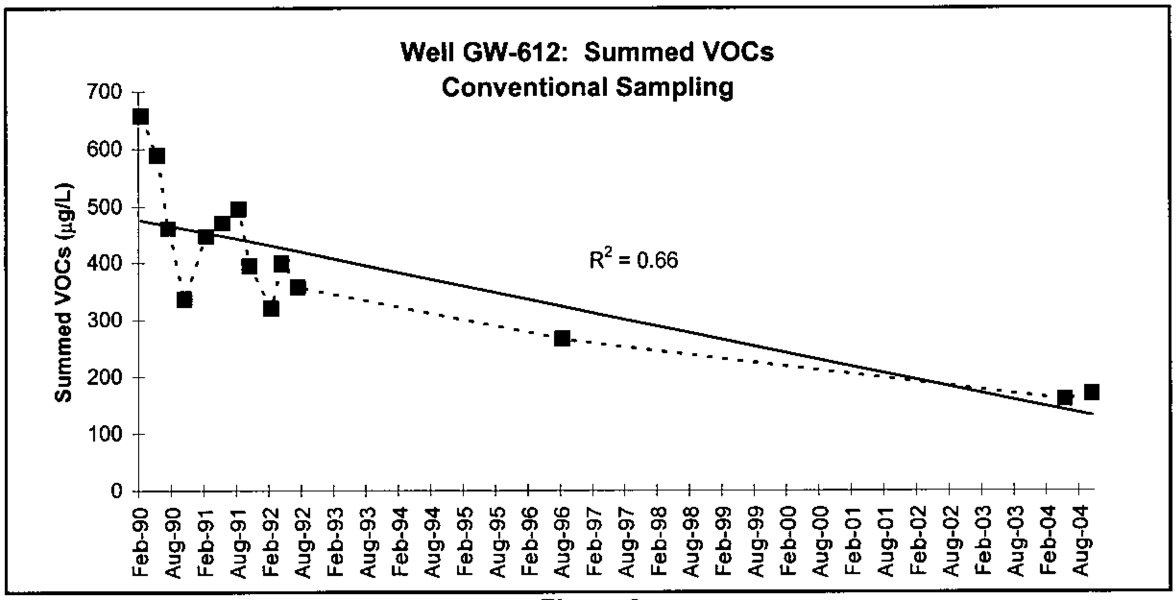


Figure 2

MAXIMUM CONCENTRATION: 2004

>1,000	0.3 - 3.0	5 - 50	ND	500 - 5,000
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-615

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 52,223.78
Y-12 GRID NORTH COORDINATE: 30,009.32
SURFACE ELEVATION: 1,014.17 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/13/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 246.84 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,017.55 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	222.5	791.67
BOTTOM (filter pack or open hole):	245.0	769.17
MIDPOINT (filter pack or open hole):	233.8	780.42
PUMP INTAKE:	68.62	945.55
WATER LEVEL (average):	9.29	1004.88

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	11 samples	05/16/90	08/18/92
LOW-FLOW SAMPLING METHOD:	5 samples	02/15/00	08/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/10/04	.	08/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.56 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	8	14,700 mg/L	08/30/00	Indeterminate
URANIUM (0.03 mg/L):	11	1.22 mg/L	08/19/04	Increasing
SUMMED VOCs (5 µg/L):	10	194 µg/L	01/11/91	Decreasing
GROSS ALPHA (15 pCi/L):	6	777 pCi/L	08/18/92	Indeterminate
GROSS BETA (50 pCi/L):	6	988 pCi/L	03/10/04	Indeterminate

WELL GW-615

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during February 1990, completed with an open-hole monitored interval from 223 to 245 ft bgs, nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12, adjacent to the south of the former S-3 Ponds. This site consists of four contiguous, unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988 and completed with an asphalt-paved parking lot. The surface impoundments were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12. Operation of the ponds created a large mound in the water table that dissipated after the site was closed and capped, and emplaced a large, heterogeneous reservoir of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eleven samples between May 1990 and August 1992 and the low-flow sampling method used to obtain five samples between February 2000 and August 2004. The sampling history includes a quarterly sampling frequency followed by a nearly eight-year period (September 1992 – February 2000) when no samples were collected from the well, and a subsequent four-year sampling hiatus (August 2000 – March 2004).

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and are a direct consequence of contamination associated with historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits minor seasonal fluctuations (<3 ft). Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-615 and the former S-3 Ponds indicate westward (strike-parallel) components of flow in Nolichucky Shale and cross-strike components of flow to the south-south west toward the Maynardville Limestone and the main channel of Bear Creek. However, as noted previously, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred strike-parallel flow directions that may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Dissolution of carbonate strata by the acidic seepage from the site also locally enhanced strata-bound groundwater flow (and contaminant transport) in directions parallel with geologic strike and dip. Moreover, present groundwater flow patterns differ substantially from those evident during the historical operations of the former S-3 Ponds, when the local mound created in the water table enabled groundwater flow to the east of the hydrologic divide near the west end of Y-12 that now separates the Bear Creek and Upper East Fork Poplar Creek drainage basins.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields moderately acidic, highly mineralized (nitrate-contaminated) sodium-bicarbonate groundwater generally characterized by:

- TDS >50,000 mg/L;
- pH of 5.8 – 6.7 (field measurements);
- extremely high concentrations of several inorganic analytes, as illustrated by the most recent (August 2004) sampling results for calcium (9,610 mg/L), sodium (2,430 mg/L), and nitrate (11,000 mg/L);
- analytical limitations associated with quantifying the very high concentrations of inorganic analytes probably explains the unacceptably high percentage difference between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance [CB] error exceeds 20%) determined for samples collected in April 1991 (CB = 63.8%), August 1991 (CB = 35.3%), October 1991 (CB = 22%) and May 1992 (CB = -98.4%); and
- very high total concentrations of several trace metals, notably barium (>400 mg/L) and strontium (>300 mg/L), that are several orders of magnitude above corresponding background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Aside from the very high levels of calcium, which was dissolved from the carbonate bedrock by the acid seepage from the former S-3 Ponds, and the similarly high levels of nitrate, a principal component of the wastes disposed at the site, the very high levels of sodium in the groundwater samples are consistent with the overall decrease in groundwater flux that occurs with depth in the low-permeability formations of the Conasauga Group (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow bedrock wells (i.e., <100 ft bgs) completed in these formations yield calcium-magnesium-bicarbonate groundwater, but a fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs (in BCV west of Y-12). The transition to sodium-enriched geochemistry of the groundwater is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Sampling results suggest that the geochemistry of the groundwater samples from this well appear to reflect the impact of the nitrate-enriched, acidic seepage from the S-3 Ponds on the sodium-bicarbonate groundwater at depth in the Nolichucky Shale.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these principal contaminants are present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations reported for each groundwater sample collected to date, including results considered qualitative because of ion charge-balance errors, exceed 1,000 mg/L, with concentration above 10,000 mg/L reported for each sample collected since March 1992 (Table 1). The source of the nitrate is the contaminant plume emplaced in the Nolichucky Shale during historical operations of the former S-3 Ponds. Nitrate is a primary component of the plume, is chemically stable and mobile in groundwater, and effectively traces the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (e.g., Tc-99). Based on the existing network of monitoring wells in the Nolichucky Shale west of the former S-3 Ponds, the extent of elevated nitrate concentrations (i.e., >10 mg/L) in the groundwater suggest: (1) transport/migration in the unconsolidated zone (water table interval) directly south toward the headwaters of Bear Creek; (2) westward transport/migration via shallow (<30 ft bgs) strike-parallel flowpaths (i.e., bedding-plane fractures) that terminate in the northern tributaries of Bear Creek located about 1,500 ft (NT-1) and 2,500 ft (NT-2) west of the former S-3 Ponds; (3) downward vertical migration driven by the greater density of the highly mineralized and acidic wastewater and the hydraulic head created by site operations; and (4) substantially slower migration via much longer and less permeable strike-parallel flowpaths deeper in the bedrock, with upward hydraulic gradients promoting upwelling of nitrate-contaminated groundwater into the shallow flow system near NT-1 and NT-2 (DOE 1997). Nitrate results reported for groundwater samples from this well are representative of concentrations within the strike- and dip-parallel flowpaths at depth in the Nolichucky Shale.

Excluding the qualitative nitrate results noted in Section 4.0, nitrate concentrations reported for the groundwater samples range from just under 8,000 mg/L in October 1990 to almost 15,000 mg/L in June 2000, with the most recent results (March and August 2004) being 11,000 mg/L (Table 1). These results reflect a generally indeterminate long-term concentration trend (Figure 1), skewed slightly upward by the nitrate concentration "spike" evident in August 2000 (14,700 mg/L). The indeterminate trend suggests minimal long-term change in the overall flux of nitrate along the (low-permeability) groundwater flow/transport pathways intercepted by the monitored interval in the well, which seems a little unusual considering that wastewater disposal at the former S-3 Ponds ceased more than 20 years ago and is probably a function of the low permeability of the flowpaths at depth in the Nolichucky Shale. In comparison, much lower nitrate concentrations are evident in groundwater from wells completed at shallower depths in the Nolichucky Shale, where ambient recharge/discharge cycles more rapidly flush nitrate and other similarly mobile contaminants from the more highly permeable flowpaths in the shallow flow system (DOE 1997).

5.2 URANIUM

All but one of the groundwater samples collected to date contained total uranium concentrations at least an order-of-magnitude higher than the drinking water MCL for uranium (0.03 mg/L), with the one non-detect result reported for the sample collected in August 2000 being an obvious outlier and likely analytical artifact (Table 1). As noted previously, the acidic groundwater in the Nolichucky Shale near the former S-3 Ponds contains elevated concentrations of numerous trace metals, some that were entrained in the acidic wastewater disposed at the site (e.g., uranium) and others that were dissolved from carbonate minerals in the underlying bedrock (e.g., barium). The uranium in the acidic groundwater near the site probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Thus, the distribution of elevated uranium concentrations in the Nolichucky Shale near the former S-3 Ponds is confined largely to the low-pH groundwater within approximately 500 ft of the site (DOE 1997). Additionally, the very high concentrations of uranium at depth in the Nolichucky Shale beneath the site reflect the downward, density- and head-driven movement of the highly mineralized, uranium-bearing wastewater, rather than vertical advective groundwater transport of the uranyl cations/complexes.

Excluding the suspected outlier result noted above, the uranium concentrations reported for the groundwater samples collected to date reflect a clearly increasing long-term trend (Figure 2), with results for the most recent samples (March and August 2004) being above 1 mg/L and at least 35% higher than the previous maximum concentration (0.877 mg/L in August 1992). The significance of this increasing uranium concentration trend, which spans significant gaps in the sampling history for the well (see Section 2.0), is not clear from the available data, but the trend potentially reflects a corresponding increase in the relative flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, increasing flux of uranium seems conspicuous considering that the disposal of wastewater at the former S-3 Ponds ceased more than 20 years ago and that similarly increasing flux of other contaminants, particularly nitrate, is not indicated by the historical data. Maybe the increasing flux of uranium corresponds with a temporal increase in the relative amount of uranium (and uranium isotopes) entrained in the wastewater disposed at the site.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: acetone, bromomethane, carbon disulfide, chloromethane, methylene chloride (MC), PCE, and 2-butanone (Table 2). These compounds are components of the contaminant plume originating from the former S-3 Ponds, but are typically present at substantially lower concentrations compared to other components of the plume (e.g., nitrate). This is because chlorinated solvents and other organic chemical were not extensively disposed at the site, with total volumes of organic wastes being substantially less than that of the inorganic wastes disposed at the site. Sampling results obtained to date are representative of dissolved VOC concentrations in the groundwater flow/transport pathways at depth in the Nolichucky Shale beneath the former S-3 Ponds. As with other contaminants in the groundwater at this well, the presence of dissolved VOCs reflects the downward, hydraulic head and density-driven movement of compounds entrained in the highly mineralized wastewater disposed at the site, rather than the vertical (advective) transport in the groundwater (DOE 1997). Note also that the historical maximum concentrations of each compound detected in the samples collected to date are relatively low (<250 μg/L) and do not suggest the presence of DNAPL in the subsurface near this well.

Based on the frequency of detection and relative concentrations, acetone and MC are the primary VOCs in the groundwater samples (Table 2). All but two of the samples collected through August 1992 contained acetone concentrations above 100 μg/L, although only a trace of acetone (2 μg/L) was detected in only one of the samples collected between February 2000 and August 2004. The sharply lower acetone concentrations follow the long-gap in the sampling history for the well (see Section 2.0) and coincide with the change to the low-flow sampling method. Conversely, although acetone and MC have similar solubility and mobility in groundwater, MC was detected at much lower concentrations that do not show any obvious difference coincident with the long sampling gap and/or the change in the sampling method. Aside from acetone and MC, other VOCs were detected only in six samples collected to date (Table 2), with the highest concentrations reported for bromomethane (29 μg/L), 2-butanone (27 μg/L), and chloromethane (15 μg/L). The apparently sporadic detection of these VOCs, some of which may be analytical artifacts, does not appear to be significant with respect to the groundwater migration/transport of contaminants from the former S-3 Ponds.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date spans the gaps in the sampling history for the well (see Section 2.0) and shows a clearly decreasing long-term trend (Figure 3). This decreasing trend is directly attributable to the sharply lower concentrations of acetone that follow a nearly 8-year gap in the sampling history and coincide with the change to the low-flow sampling method. However, MC concentrations have changed little over time, as illustrated by the MC results reported for the samples collected in July 1990 (6 μg/L), May 1992 (5 μg/L), and August 2004 (6 μg/L). Moreover, coincident changes (decrease or increase) in the concentrations of other contaminants (nitrate and uranium) are not evident. Thus, the lower acetone concentrations do not seem to be directly attributable to the change to the low flow sampling method. Also, assuming a heterogeneous mixture of acetone and MC (and other contaminants) in the groundwater, the similar solubility/mobility of these compounds suggests that the divergent concentration trends may not be attributable to differential advective migration/transport (flux) via the groundwater flowpaths intercepted by the monitored interval in the well. Perhaps the substantially lower concentrations of acetone reflect a corresponding decrease in the relative flux of acetone that is in some way related to the waste disposal history for the former S-3 Ponds. For example, the volume of acetone-bearing wastes disposed at the site may have decreased over time, while the amount of wastes containing MC remained more constant. Alternatively, the geochemical characteristics of the groundwater may more effectively (and selectively) degrade acetone relative to the other chlorinated hydrocarbons in the groundwater.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples collected to date were analyzed for gross alpha activity and results above the applicable MDA and corresponding CE were reported for all but four of these samples (Table 3), with all but four of these results substantially exceeding the MCL for gross alpha activity (15 pCi/L). Additionally, nine of the samples collected to date were analyzed for uranium isotopes and the analytical results show maximum U-234 and U-238 activities above 150 pCi/L and 350 pCi/L, respectively (Table 1). Note that there is no clear or consistent correlation between the isotopic uranium activities and gross alpha activity reported for corresponding samples (Table 3), probably because of analytical interferences associated with the very high TDS of the samples. The uranium isotopes, like total uranium, are probably present in the acidic groundwater as uranyl cations that were transported at depth in the Nolichucky Shale primarily as a consequence of the downward, density-driven vertical migration of the highly mineralized wastewater from the former S-3 Ponds (DOE 1997).

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples collected to date were analyzed for gross beta activity and results above the applicable MDA and corresponding CE were reported for all but three of these samples (Table 3), and all of these results are at least an order of magnitude higher than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). Although uranium isotopes and related daughter products contribute to the levels of gross beta activity, the primary beta-particle emitting radionuclide in the groundwater near the former S-3 Ponds is Tc-99, which is a "signature" component of the contaminant plume from this site (the only site to have received wastes that contained Tc-99) that is highly mobile in groundwater. Six of the samples collected to date were analyzed for Tc-99 and the results are fairly ambiguous (Table 3). The Tc-99 concentrations were below the respective CE reported for samples collected in August and October 1991, yet very high Tc-99 concentrations reported for the samples collected in May 1992 (6,650 pCi/L), which exceeds the SDWA screening level for a 4 mrem/yr dose equivalent from Tc-99 (3,470 pCi/L), and August 1992 (2,840 pCi/L). Substantially lower Tc-99 concentrations were reported for the samples collected in March (41 pCi/L) and August 2004 (38 pCi/L). Additionally, there is no clear or consistent correlation between Tc-99 concentrations and gross beta activity reported for corresponding samples (Table 3), probably because of analytical interferences associated with the very high TDS of the samples.

6.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-615: summary of results for nitrate and uranium

Sampling Date	Concentration (mg/L)	
	Nitrate (as N)	Total Uranium
05/16/90	13,400	0.438
07/25/90	7,950	0.396
10/14/90	7,720	0.653
01/11/91	10,900	0.414
04/10/91	[2,469]	0.35
08/05/91	[5,712]	0.38
10/08/91	[7,952]	0.38
03/15/92	10,657	0.48
05/15/92	[10,838]	0.622
08/18/92	11,371	0.37
02/15/00	12,300	0.877
06/08/00	11,700	0.786
08/30/00	14,700	<0.004
03/10/04	11,000	1.18
08/19/04	11,000	1.22
MCL	**10**	**0.03**

Note: [ ] = Result considered qualitative because of ion charge-balance error

Table 2. Well GW-615: summary of VOC results

Sampling Date	Concentration (µg/L)		
	Acetone	MC	Other
05/16/90	190	.	.
07/25/90	160	6	.
10/14/90	230	4 J	.
01/11/91	190	4 J	.
04/10/91	130	FP	.
08/05/91	73	4 J	.
10/08/91	89	FP	.
03/15/92	130	FP	PCE (1 J), 2-butanone (27), Carbon disulfide (1 J)
05/15/92	180	5	PCE (1 J)
08/18/92	160	FP	PCE (1 J), 2-butanone (25)
02/15/00	.	FP	.
06/08/00	.	FP	Bromomethane (29), Chloromethane (15)
08/30/00	.	FP	2-butanone (2 J), Carbon disulfide (1 J)
03/10/04	2 J	7	Carbon disulfide (2 J)
08/19/04	.	6	.
MCL	NA	5	PCE (5)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; FP = False positive result; NA = Not applicable

Table 3. Well GW-615: summary of radiological results

Date Sampled	Concentration (pCi/L)					
	Gross Alpha Activity	Gross Beta Activity	Tc-99	U-234	U-235	U-238
05/16/90	< CE	536.52	.	.	.	.
07/25/90	614	622.7	.	.	.	.
10/14/90	172.38	503.21	.	.	.	.
01/11/91	540	964	.	.	.	.
04/10/91	586.7	918.81	.	.	.	.
08/05/91	439	764	< CE	76.3	19.6	242
10/08/91	342	827	< CE	< CE	< CE	56.7
03/15/92	331	< CE	.	.	.	.
05/15/92	< CE	< CE	6650	20.5	< CE	61.6
08/18/92	777	837	2840	< CE	< CE	28.7
02/15/00	.	.	.	109.9	11.65	287
06/08/00	.	.	.	150.5	9.29	376.7
08/30/00	.	.	.	115.8	3.64	296.1
03/10/04	<MDA	988	41	120	6.2	290
08/19/04	<MDA	<MDA	38	150	8.4	390

Note: "." = Not analyzed; <CE = below the sample-specific counting error; >MDA = below the sample-specific minimum detectable activity

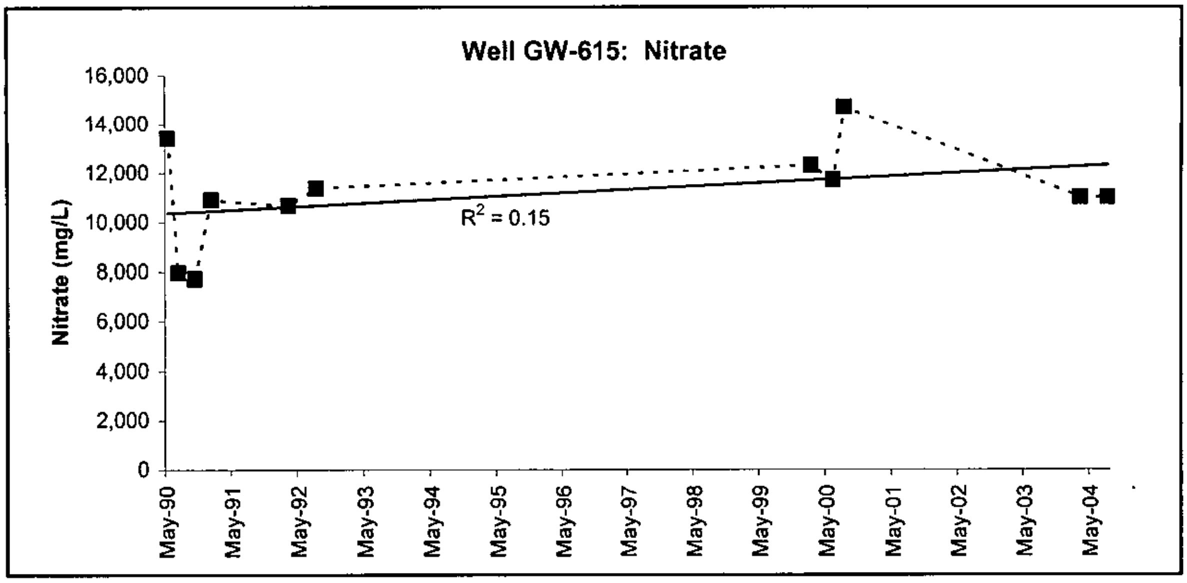


Figure 1

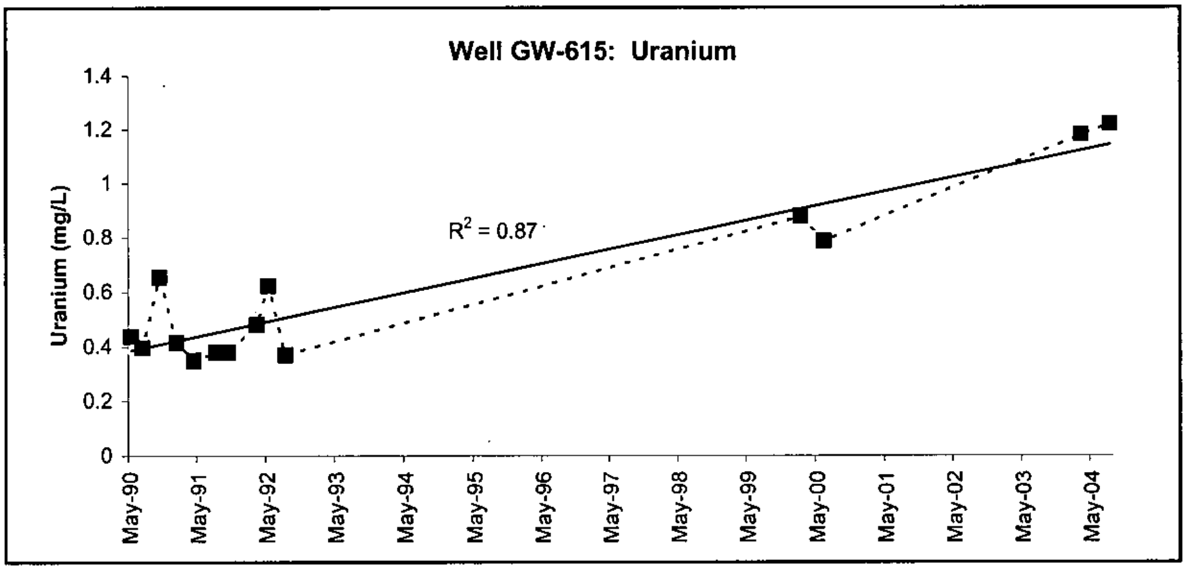


Figure 2

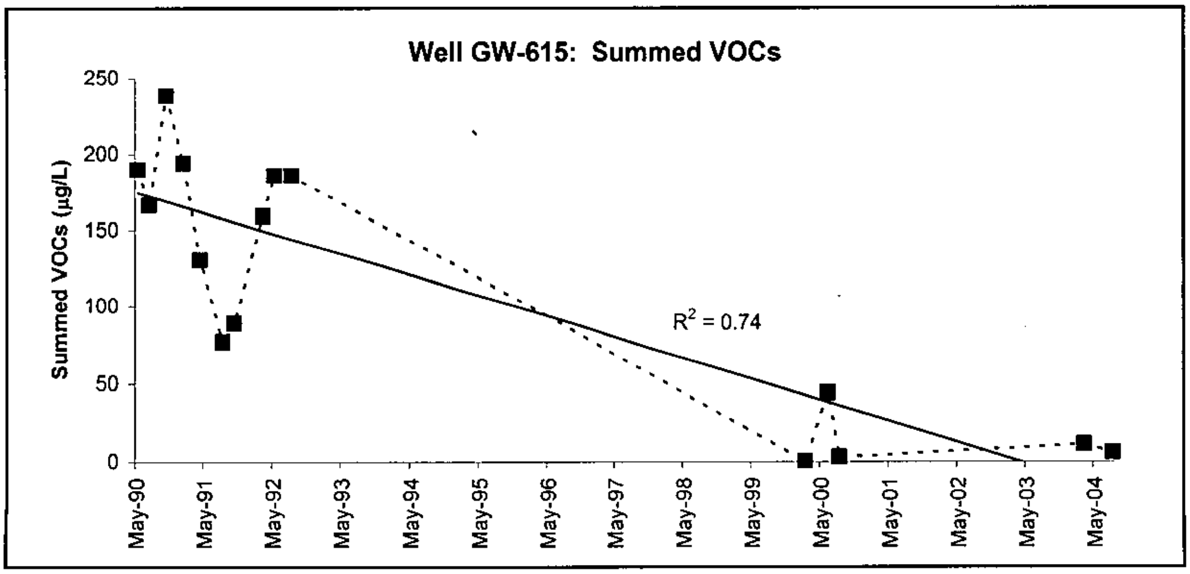


Figure 3

GW-615

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
100 - 1,000	ND	ND	ND	ND

GW-616

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,906.92
Y-12 GRID NORTH COORDINATE: 29,723.83
SURFACE ELEVATION: 1,009.81 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/10/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 270.59 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,011.81 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	219.1	790.71
BOTTOM (filter pack or open hole):	269.0	740.81
MIDPOINT (filter pack or open hole):	244.1	765.76
PUMP INTAKE:	263.0	746.81
WATER LEVEL (average):	8.01	1001.80

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	10 samples	05/17/90	09/08/92
LOW-FLOW SAMPLING METHOD:	4 samples	03/27/01	08/23/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/29/05	.	08/23/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.23 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	10	320 mg/L	09/08/92	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	0	< µg/L	.	
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	1	211 pCi/L	05/15/92	Outlier

WELL GW-616

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during March 1990, completed with an open-hole monitored interval from 219 to 269 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12, on the south side of Bear Creek approximately 350 ft southwest of the former S-3 Ponds (hereafter referenced as the S-3 Site). Located near the western end of Y-12, directly north of the headwaters of Bear Creek, the S-3 Site encompasses four contiguous, above-grade, unlined surface impoundments, each with a surface area of approximately 400 x 400 ft and an average total depth of approximately 15 ft. The ponds were used from 1951 to 1984 for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12, and were closed in 1988 in accordance with requirements of the RCRA regulations applicable to hazardous waste landfills. Closure of the site was completed in 1989 and included the neutralization and removal of liquid wastes and stabilization of neutralization sludge remaining in each pond, which were then filled with crushed limestone and covered with a multilayer low-permeability cap (completed with an asphalt-paved parking lot). Historical operation of the S-3 Site emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the subsurface that remains a primary source of groundwater and surface water contamination in BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between May 1990 and September 1992 and the low-flow sampling method used to obtain four samples between March 2001 and August 2005. The sampling history includes a quarterly sampling frequency followed by a nearly nine-year period (September 1992 – March 2001) when no samples were collected from the well.

Unusually high levels of TDS are a distinguishing characteristic of the groundwater samples from this well (see Section 4.0) and are a direct consequence of contamination associated with historical operation of the former S-3 Site.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Nolichucky Shale (Conasauga Group), which trends northeast-southwest along the northern slope of BCV, dips to the southeast at an angle of 45º - 55º, and is bordered on the southeast by the overlying Maynardville Limestone, a highly permeable karst aquifer that provides the principal pathway for subsurface contaminant migration in BCV. (Note that the well is located within the outcrop area of the Maynardville Limestone). The bulk of the groundwater flow in the Nolichucky Shale occurs in a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock). Also, it is suspected that the highly acidic wastes from the S-3 Site dissolved carbonate strata interbedded within the Nolichucky Shale and greatly enhanced the relative permeability of these strata-bound flowpaths within several hundred feet of the site.

Groundwater flow in the water table interval in the Nolichucky Shale is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals

(shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone.

The static water level in the well occurs at an average depth of about 8 ft bgs and exhibits minor (<3 ft) seasonal fluctuations. The direction(s) of groundwater flow near the well, as indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, is primarily westward, parallel with geologic strike of bedding in Nolichucky Shale, with cross-strike components of flow to the south-south west toward the Maynardville Limestone and the main channel of Bear Creek. Also, dissolution of carbonate strata by acidic seepage during historical operation of the S-3 Site locally enhanced strata-bound groundwater flow/contaminant transport in directions parallel with geologic strike and dip. Moreover, present groundwater flow patterns differ substantially from those evident during the historical operations of the former S-3 Site, when the local mound created in the water table enabled groundwater flow to the east of the hydrologic divide near the west end of Y-12 that now separates the Bear Creek and Upper East Fork Poplar Creek drainage basins.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the (unfiltered) groundwater samples collected to date show that the well yields nitrate-contaminated sodium-bicarbonate groundwater generally characterized by:

- TDS of 1,422 – 2,066 mg/L;
- pH of 9 – 9.95 (field measurements);
- low molar proportions of calcium, magnesium, and potassium, chloride, and sulfate (<5% of total anions /cations);
- high concentrations of sodium (>500 mg/L) and nitrate (>200 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Although dominated by the high concentrations of nitrate, which is a primary component of the contaminant plume emplaced during historical operation of the S-3 Site, the sodium-bicarbonate geochemistry of the groundwater from this well is consistent with other wells completed at similar depths in the Nolichucky Shale west of Y-12 and is believed to reflect the overall decrease in groundwater flux that occurs with depth in the low-permeability formations of the Conasauga Group in BCV (Solomon et al. 1992). Most of the water table and shallow bedrock wells (i.e., <100 ft bgs) completed in these formations yield calcium-magnesium-bicarbonate groundwater, but a fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs (in BCV west of Y-12). The transition to sodium-enriched geochemistry of the groundwater is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Note that the high levels of TDS may cause analytical interferences for some laboratory analytes, including gross alpha activity and gross beta activity.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected to date, nitrate is the principal contaminant present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the drinking water MCL for nitrate (10 mg/L) and, as shown in the following data summary, all of the results exceed 200 mg/L, including the most recent sampling results (March and August 2005). Nitrate is the principal component of the contaminant plume emplaced during historical operations of the S-3 Site. Chemically stable and mobile in groundwater, nitrate is believed to effectively trace the groundwater transport pathways followed by other similarly mobile components of the contaminant plume (DOE 1997). Additionally, the greater density of the highly mineralized acidic wastewater disposed at the site promoted density-driven vertical migration via strike- and dip-parallel flowpaths in the Nolichucky Shale.

Sampling Date	Nitrate (mg/L)
05/17/90	202
07/26/90	[405]
10/15/90	216
01/12/91	[417]
04/12/91	246
07/27/91	240
10/07/91	222
03/23/92	291
05/15/92	260
09/08/92	320
03/27/01	277
08/09/01	265
03/29/05	228
08/23/05	265
MCL	**10**
Note: [ ] = qualitative result because of ion charge balance error	

As shown in the above data summary, only two of the nitrate results exceed 400 mg/L and the these results are considered to be qualitative because of the ion charge balance error (i.e., the percent difference between respective summed milliequivalent concentrations of the major cations and anions exceeds 20%). The bulk of the remaining results are less than 250 mg/L, with the historical minimum value of 202 mg/L in May 1990. Also, unlike nitrate concentrations in groundwater from other wells near the S-3 Site that monitor more permeable flowpaths at shallower depths in the Nolichucky Shale, the levels of nitrate in the groundwater from this well do not exhibit clearly seasonal fluctuations. Indeed, a time-series plot of the nitrate results is dominated by the long gap in the sampling history for the well, but shows a fairly indeterminate concentration trend (Figure 1), as illustrated by the similar concentrations of nitrate detected in the groundwater samples collected in April 1991 (246 mg/L), August 2001 (265 mg/L), and August 2005 (265 mg/L). This trend does not reflect any clear response to the closure or capping of the S-3 Site and suggests minimal change in the relative flux of nitrate via the low-permeability flowpaths at depth in the Nolichucky Shale down-dip of the S-3 Site.

5.2 URANIUM

Thirteen groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.012 mg/L in September 2005) being below the MCL for uranium (0.03 mg/L). In light of the relatively high levels of nitrate in the groundwater from this well, the low levels of uranium seem somewhat conspicuous because, as noted previously, uranium was entrained in the wastewaters disposed at the S-3 Site. The uranium in the acidic seepage probably occurred as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). Consequently, elevated concentrations of uranium are generally restricted to the acidic groundwater in the Nolichucky Shale within approximately 500 ft of the site (DOE 1987). Moreover, the basic pH and low REDOX of the groundwater from this well (e.g., field measurements in August 2005 show pH = 9.84 and REDOX = -26 mV) indicate reducing geochemical conditions that, in the presence of reduced species of iron (total iron = 1.1 mg/L in August 2005), promote removal of uranium from solution (Fetter 1993).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, no VOCs have been detected in the groundwater samples collected from the well to date.

5.4 GROSS ALPHA ACTIVITY

Low levels of gross alpha activity slightly above the applicable MDA and corresponding CE were reported for the samples collected in April 1991 (6.4 pCi/L) and October 1991 (7.24 pCi/L), both being less than the MCL for gross alpha activity (15 pCi/L). Uranium isotopes are the most abundant alpha-particle emitting radionuclides in the contaminant plume emplaced during historical operation of the S-3 Site and the low (background) levels of gross alpha activity in the groundwater from this well reflect a corresponding lack of uranium isotopes in the Nolichucky Shale down-dip of the site. The migration/transport of uranium isotopes are greatly restricted by the geochemical factors described in Section 5.2.

5.5 GROSS BETA ACTIVITY

Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, including one value (211 pCi/L in May 1992) that exceeds the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity), but is a suspected outlier compared to the other results. Also, none of groundwater samples collected since May 1992 had gross beta activity above the applicable MDA and corresponding CE.

As with the low levels of gross alpha activity, the lack of elevated gross beta activity in the groundwater samples seems conspicuous in light of the elevated nitrate levels, especially considering that Tc-99, a beta-particle emitting radionuclide, is a “signature” component of the contaminant plume emplace during historical operation of the S-3 Site (the former S-3 Ponds were the only site at Y-12 that received wastes containing Tc-99). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Consequently, the distribution of Tc-99 in the shallow groundwater flow system in the Nolichucky Shale downgradient of the S-3 Site, as indicated by the extent of elevated gross beta activity (>50 pCi/L) defined by the network of wells to the south and west (and east) of the site, closely mirrors that of nitrate from the site, which is also highly mobile in groundwater. However, with the low levels of gross beta activity indicating a corresponding lack of Tc-99, it appears that the reducing geochemistry of the groundwater, which promotes removal of uranium (and uranium isotopes) from solution as noted in Section 5.2, likewise similarly inhibits the transport/migration of Tc-99 in the groundwater at depth in the Nolichucky Shale.

6.0 REFERENCES

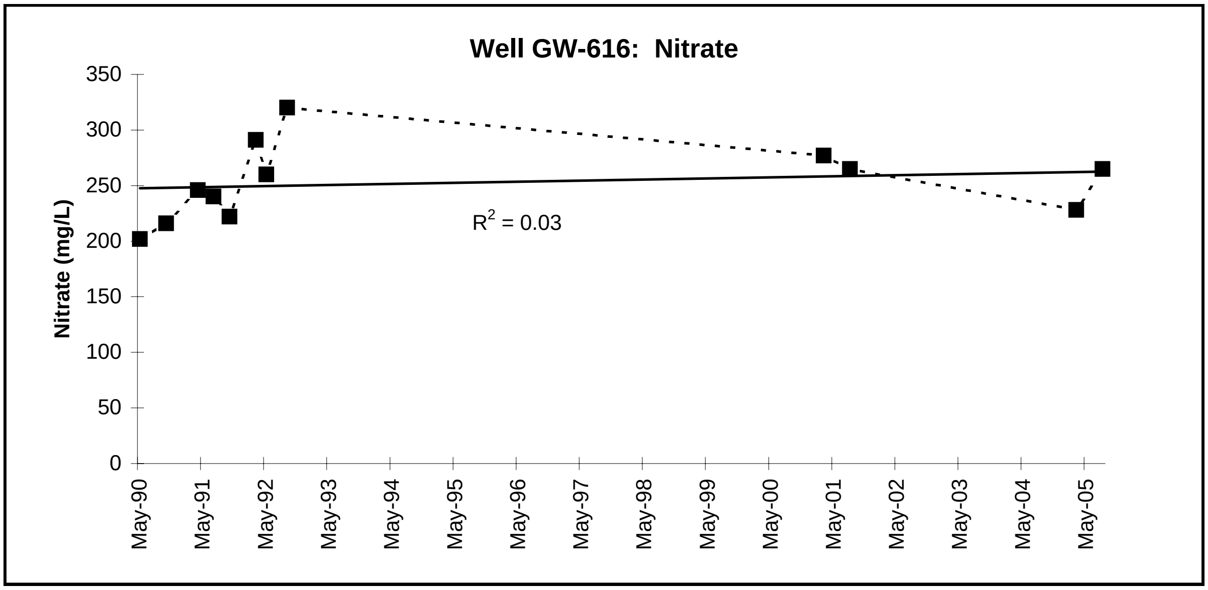
Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.



Well GW-616: Nitrate
Nitrate (mg/L)
350
300
250
200
150
100
50
0
R^2 = 0.03
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05

Figure 1

MAXIMUM CONCENTRATION: 2003

<5	ND	5 - 50	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-618

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket E
Y-12 GRID EAST COORDINATE: 54,738.12
Y-12 GRID NORTH COORDINATE: 29,798.46
SURFACE ELEVATION: 982.64 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/15/90 PAIRED/CLUSTERED WITH: GW-617
TAG DEPTH (measured): 38.30 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 985.14 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	26.0	956.64
BOTTOM (filter pack or open hole):	37.0	945.64
MIDPOINT (filter pack or open hole):	31.5	951.14
PUMP INTAKE:	32.70	949.94
WATER LEVEL (average):	11.30	971.34

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	41		
CONVENTIONAL SAMPLING METHOD:	27 samples	05/14/90	05/06/97
LOW-FLOW SAMPLING METHOD:	14 samples	11/04/97	10/22/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	04/28/03	.	10/22/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.07 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	38	136 µg/L	05/06/97	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-618

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1990, completed with a screened monitored interval from 26 to 37 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-617 and is located in the southwestern Y-12 area, east of Bldg. 9720-13 and the Former Roofing Waste Pile (FRWP), which was used from mid-1986 to mid-1987 as a temporary storage area for mercury-contaminated roofing waste materials generated at Y-12. No releases of contaminants from the FRWP have been documented and the site is not considered a likely source of groundwater contamination (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between May 1990 and May 1997, and the low-flow sampling method used to obtain four samples between November 1997 and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements for the well show that the static groundwater level in the well occurs at an average depth of about 11 ft bgs and exhibits minor (<5 ft) seasonal fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>300 mg/L);
- pH (field measurements) of 5.9 – 7.1;
- relatively high sodium concentrations (>15 mg/L) compared to other wells completed at similar depths in the Maynardville Limestone
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Also, as illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical conditions in groundwater at this well are conducive to the biotic degradation of chlorinated hydrocarbons, which may account for the presence of some of the dissolved VOCs in the well (see Section 5.3).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the 38 groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for all but two of the groundwater samples, one of which was not analyzed for nitrate. The historical maximum nitrate concentration (4.89 mg/L in April 1991) is less than the MCL for nitrate (10 mg/L). Although the nitrate concentrations in samples from this well are below the MCL, they exceed the applicable UTL (2.7 mg/L) and most likely reflect low-level nitrate contamination from one or more upgradient source areas. Nitrate is chemically stable and highly mobile in groundwater and is believed to effectively trace the primary groundwater flow and contaminant transport pathways in the Maynardville Limestone. Known sources of nitrate that are hydraulically upgradient of this well include the contaminant plumes emplaced during historical operations of the S-3 Ponds (1951-1984) and the S-2 Site (1943-1951). The S-3 Ponds, former unlined surface impoundments used primarily for the disposal of nitric acid wastes generated at Y-12, are covered with a multilayer low-permeability cap (and asphalt parking lot) constructed during RCRA closure of the site in 1988. Operation of the former S-3 Ponds emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants in the Nolichucky Shale west-northwest of the well. Nitrate is a principal component of the plume and it enters the Maynardville Limestone upgradient of the well via inflow of contaminated groundwater from the Nolichucky Shale and from the buried tributaries of UEFPC that channel contaminants into the Maynardville Limestone (DOE 1998). The groundwater system in the Maynardville Limestone west-southwest of the well also received nitrate and other inorganic, organic, and radiological contaminants during historical operations of the S-2 Site, which is an unlined waste site excavated into the lower slope of Chestnut Ridge that received an unknown volume of corrosive and toxic aqueous wastes.

5.2 URANIUM

Five groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.001 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each groundwater sample contained one or more of the following VOCs: acetone, ethylbenzene, PCE, TCE, c12DCE, t12DCE, and VC. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources within Y-12, including the S-2 Site, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The primary VOCs in the groundwater samples are PCE, TCE, and 12DCE; each compound was detected in all but one of the groundwater samples, with respective historical maximum concentrations above 60 μg/L for 12DCE and 40 μg/L for PCE and TCE. In contrast, VC was detected in less than half (18 of 38) of the samples, and acetone and ethylbenzene were detected in one sample each (both results are probably analytical artifacts). Based on the analytical results reported for the samples collected since May 1997, c12DCE is the primary 12DCE isomer, with the most recent monitoring data showing c12DCE concentrations substantially below the MCL (70 μg/L). The most recent monitoring data also show that PCE levels fluctuate above and below the MCL (5 μg/L), with concentrations of TCE remaining above the MCL (5 μg/L). Although VC has been detected much more sporadically than PCE, TCE, or 12DCE (Table 2), all but one of the results equals or exceeds the MCL (2 μg/L), including the concentration detected in the most recent sample. Additionally, some of these VOCs, particularly c12DCE, t12DCE, and VC, are probably present as a natural consequence of the biologically mediated degradation (reductive dechlorination) of PCE and TCE in the groundwater (Chapelle 1996). As noted in Section 4.0, several indicator parameters suggest that the geochemical conditions in groundwater at this well (particularly the low dissolved oxygen and negative REDOX) are conducive to the biotic degradation of these VOCs.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows a temporally variable but generally decreasing long-term concentration trend (Figure 1). Summed VOC concentrations determined from conventional sampling show substantial temporal fluctuations, with the highest concentrations typically evident in samples obtained during seasonally high groundwater flow conditions (winter and spring). The low-flow sampling results for VOCs exhibit less temporal variability, with the highest concentrations typically reported for the samples obtained during seasonally low-flow conditions (summer and fall). Additionally, decreasing concentration trends are not evident for all of the VOCs, as illustrated by the VC concentrations reported for the groundwater samples collected in January 1992 (2 μg/L) and October 2003 (3 μg/L). The overall decrease in VOC concentrations probably reflects a combination of reduced flux from the source area(s) and the cumulative effects of natural attenuation processes, including biotic degradation. However, it is not clear from the available data if the cyclical changes in VOC concentrations are significant with respect to the relative flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in this well, or if the apparent change in the pattern of cyclical concentration peaks is related in some way to the change from conventional sampling to low-flow sampling.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.99 pCi/L in April 1992) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (37.6 pCi/L in April 1992) being less than the SDWA screening level for gross beta activity (50 pCi/L). However, the historical maximum value for gross beta activity may be an outlier because only one other result exceeds 10 pCi/L.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-618: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	April 2003	October 2003
Nitrate < 1 mg/L	0.17	1.8
Iron (II) > 1 mg/L	0.04	0.18
Sulfate < 20 mg/L	20.1	17.9
Dissolved Oxygen < 0.5 ppm	0.44**	0.47**
REDOX < 50 mV	-31**	-78**
pH >5 and < 9 st. units	6.63 **	6.7 **
Note: *Results are for total iron; **Field measurement.		

Table 2. Well GW-618: summary of VOC results

Date Sampled	VOC Concentration (μg/L)					
	PCE	TCE	12DCE			VC
			Total	c12DCE	t12DCE	
01/13/91	14	12	34	NR	NR	.
04/09/91	17	12	58	NR	NR	4 J
07/12/91	5	11	67	NR	NR	4 J
10/02/91	22	18	65	NR	NR	5
01/19/92	15	15	50	NR	NR	3 J
04/16/92	12	11	42	NR	NR	2 J
07/29/92	.	2 J	32	NR	NR	11
10/10/92	7	13	36	NR	NR	4 J
01/12/93	23	27	41	NR	NR	.
05/05/93	27	30	34	NR	NR	.
09/16/93	10	19	39	NR	NR	.
12/08/93	43	41	36	NR	NR	.
02/07/94	9	13	11	NR	NR	.
05/05/94	36	29	28	NR	NR	.
08/21/94	7	7	34	NR	NR	5
12/03/94	26	24	30	NR	NR	.
02/27/95	22	21	19	NR	NR	.
05/25/95	22	20	30	NR	NR	.
09/13/95	20	23	40	NR	NR	2 J
12/06/95	49	37	33	NR	NR	.
03/06/96	10	17	21	NR	NR	.
06/04/96	22	23	27	NR	NR	.
11/11/96	9	21	52	NR	NR	.
05/06/97	1 J	4 J	30	30	.	2 J
11/04/97	3 J	8	29	29	.	5
06/01/98	11	8	15	15	.	1 J
11/30/98	19	16	23	23	.	2 J
05/26/99	12	12	22	22	.	.
11/01/99	13	12	19	19	.	.
11/09/99	7	11	25	25	.	3 J
05/23/00	5	7	26	26	.	.
11/08/00	3 J	5	29	29	.	4 J
05/02/01	7	11	19	19	.	.
10/29/01	5	11	23	23	.	2 J
05/09/02	4 J	11	17	17	.	.
11/07/02	7	16	31.5	31	0.5	3 J
04/28/03	7	14	17	17	.	.
10/22/03	4 J	7	24	24	.	3 J
MCL	**5**	**5**	**NA**	**80**	**NA**	**2**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

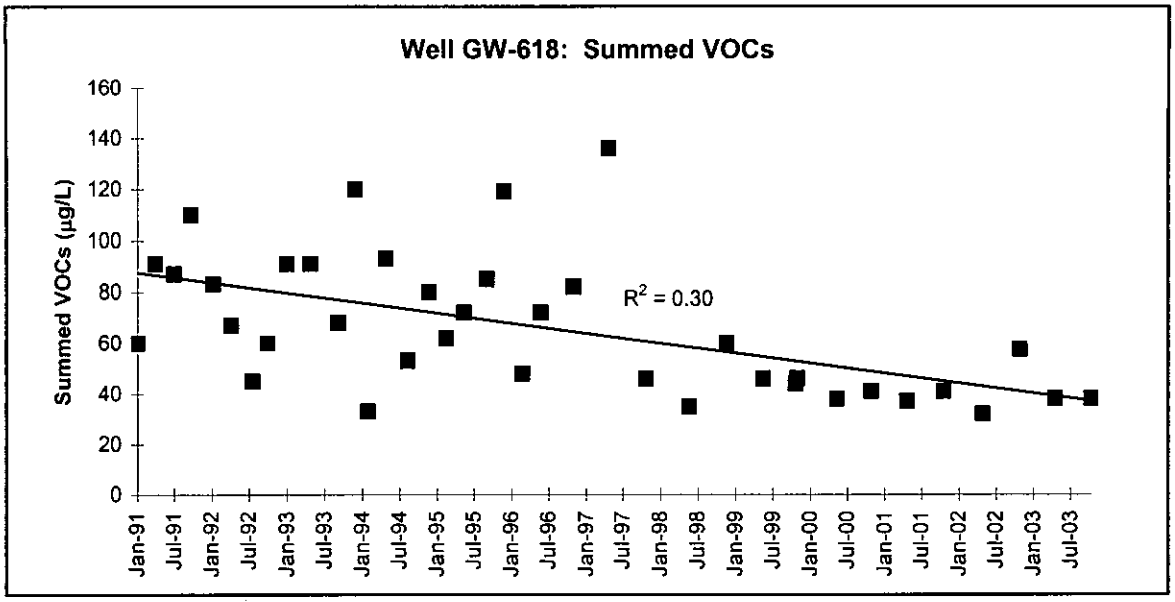

Well GW-618: Summed VOCs
Summed VOCs (µg/L)
160
140
120
100
80
60
40
20
0
$R^2 = 0.30$
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	5 - 50	ND	<25

GW-620

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Fire Training Facility
Y-12 GRID EAST COORDINATE: 52,894.57
Y-12 GRID NORTH COORDINATE: 29,564.54
SURFACE ELEVATION: 1,012.84 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/27/90 PAIRED/CLUSTERED WITH: GW-619
TAG DEPTH (measured): 77.91 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,015.57 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	61.7	951.14
BOTTOM (filter pack or open hole):	75.0	937.84
MIDPOINT (filter pack or open hole):	68.4	944.49
PUMP INTAKE:	70.27	942.57
WATER LEVEL (average):	22.8	990.04

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	44		
CONVENTIONAL SAMPLING METHOD:	27 samples	05/10/90	05/06/97
LOW-FLOW SAMPLING METHOD:	17 samples	12/01/97	10/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/29/04	.	10/21/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: X LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 27.17 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	39	2,340 µg/L	07/14/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-620

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1990, completed with a screened monitored interval from 61.7 to 75 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-619 and is located in Bear Creek Valley (BCV) in the southwestern section of Y-12, about 100 ft east of the Fire Training Facility (FTF).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 27 samples between May 1990 and May 1997, and the low-flow sampling method used to obtain 17 samples between December 1997 and October 2004.

Groundwater samples from the well exhibit conspicuous geochemical characteristics that may be attributable to localized contamination from cement grout circulated into the bedrock during installation/construction of the well (see Section 4.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements for the well show that the static groundwater level in the well typically occurs at an average depth of about 23 ft bgs and exhibits substantial (>25 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-620 indicate components of flow to the north/northeast toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chemically distinctive calcium-carbonate groundwater characterized by:

- TDS 51 – 558 mg/L, excluding an outlier (20,056 mg/L) in April 1991;
- pH (field measurements) of 7.6 – 12.3 (>11.5 in six samples collected since October 1999);
- unusually low bicarbonate (<1 mg/L);
- unusually high concentrations of potassium (>10 mg/L);
- nitrate concentrations above 1 mg/L;
- low molar proportions of chloride, magnesium, and sodium (<10% of total anions/cations), although the percent difference (error) between respective summed milequivalent concentrations of anions and cations typically (in more than half of the samples) exceeds 20% (negatively and positively); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The atypical geochemistry of the groundwater samples from this well may reflect contamination from cement grout circulated into the bedrock during its installation. Unlike other wells at Y-12 that experienced grout contamination, however, the geochemical characteristics of the groundwater samples have not improved over time, as illustrated by the ion charge balance error (24.3 %) evident for the most recent sample (October 2004).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Thirty-nine of the groundwater samples were analyzed for nitrate and concentrations at or above the applicable analytical reporting limit were reported for all of the samples, with the highest value (7.042 mg/L in May 1998) being less than the drinking water MCL for nitrate (10 mg/L). However, the historical maximum value may be an outlier because all but five of the remaining nitrate results are less than 2 mg/L.

5.2 URANIUM

Uranium concentrations at or above the applicable analytical reporting limit were reported for the groundwater samples collected in September 1993 (0.001 mg/L), May 1995 (0.0012 mg/L), and September 1995 (0.00051 mg/L); these results are substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 1): acetone, chloroethane, total xylene, PCE, TCE, toluene, 11DCE, 12DCA, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the FTF in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The primary VOCs in the groundwater samples are PCE, TCE, and 12DCE, which were detected in all but eight of the groundwater samples, with historical maximum concentrations above 1,000 μg/L for 12DCE (total), 900 μg/L for PCE, and 300 μg/L for TCE (Table 1). The most recent monitoring data show that the concentrations of each compound, except for one PCE result (6 μg/L in October 2004), are below respective drinking water MCLs. Other VOCs were detected infrequently and have substantially lower historical maximum concentrations (<100 μg/L). Also, it appears that the 12DCA and 12DCE (total) results reported for the sample collected in October 1991 were juxtaposed, with the likely 12DCE result (1,100 μg/L) reported for 12DCA and the likely 12DCA result (<5 μg/L) reported for 12DCE (see Table 1).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample, excluding the suspect 12DCA result reported for the sample collected in October 1991, show a clearly decreasing long-term concentration trend (Figure 1). The overall trend also exhibits cyclic concentration fluctuations that appear to have changed over time and may be related in some way to the groundwater sampling method. Summed concentrations of VOCs detected in the samples obtained with the conventional sampling method (May 1990 – May 1997) are typically highest during seasonally low flow conditions (summer and fall). Conversely, the summed concentrations of VOCs detected in the samples obtained with the low-flow sampling method (December 1997 – October 2003) show more distinctive cyclical fluctuations, with higher concentrations typically evident during seasonally high flow conditions (winter and spring).

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (10 pCi/L in October 2003) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirty-one groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (39.3 pCi/L in January 1992) being slightly below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The elevated levels of gross beta activity may be related to the elevated potassium concentrations in the grout-contaminated groundwater samples from the well (see Section 4.0). Potassium-40 (K-40) is a beta-emitting isotope and, based on the natural ratio of K-40 to total K (K-40 = 0.0119% total K; Brownlow 1979), should be present in the groundwater samples. The elevated potassium (and gross beta activity) may be related to fire suppressants (e.g., "Blue K") used to extinguish fires at the nearby Fire Training Facility.

6.0 REFERENCES

Brownlow, A.H. 1979. *Geochemistry.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

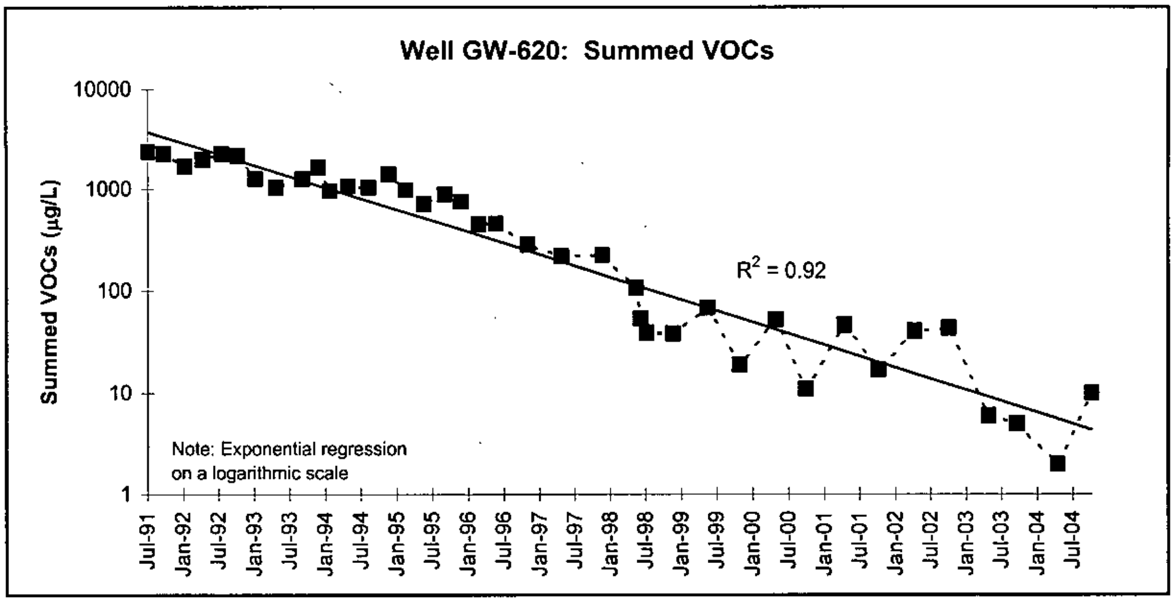
Table 1. Well GW-620: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	PCE	TCE	12DCE (Total)	c12DCE
01/12/91	.	.	800	NR
04/06/91	770	270	1,200	NR
07/14/91	910	330	1,100	NR
10/04/91	820	290	.	NR
01/22/92	470	270	940	NR
04/22/92	790	280	860	NR
07/31/92	800	310	980	NR
10/20/92	840	320	960	NR
01/20/93	540	170	560	NR
05/06/93	430	150	400	NR
09/17/93	530	190	540	NR
12/09/93	780	230	620	NR
02/07/94	440	150	370	NR
05/09/94	500	160	410	NR
08/23/94	500	150	390	NR
12/03/94	750	190	470	NR
02/28/95	490	140	350	NR
05/30/95	330	100	280	NR
09/15/95	440	120	330	NR
12/07/95	360	100	290	NR
03/07/96	210	64	170	NR
06/04/96	200	60	170	NR
11/13/96	220	59	.	NR
05/06/97	110	29	74	74
12/01/97	93	32	94	94
05/26/98	31	18	56	56
06/19/98	28	8	16	NR
07/20/98	12	6	21	NR
12/02/98	14	6	18	18
05/27/99	25	11	26	26
11/08/99	11	2 J	6	6
05/10/00	23	9	20	20
10/10/00	8	.	3 J	3 J
04/25/01	18	7	15	15
10/18/01	11	2 J	4 J	4 J
04/23/02	15	7	17	17
10/15/02	17	7	13	13
05/07/03	4 J	.	2 J	2 J
10/01/03	3 J	1 J	1 J	1 J
04/29/04	2 J	.	.	.
10/21/04	6	2 J	2 J	2 J
MCL	**5**	**5**	**NA**	**80**

Table 1. (continued)

Date Sampled	VOC Concentration (µg/L)			
	Toluene	Total Xylene	Acetone	Other
01/12/91	.	.	.	.
04/06/91	.	.	.	.
07/14/91	.	.	.	.
10/04/91	13	.	.	12DCA (1,100)
01/22/92	.	.	.	111TCA (19)
04/22/92	.	.	.	.
07/31/92	.	FP	93	12DCA (8), 11DCE (22)
10/20/92	.	.	FP	.
01/20/93	.	.	.	.
05/06/93	.	.	60	.
09/17/93	.	.	.	.
12/09/93	.	.	FP	.
02/07/94	.	.	FP	.
05/09/94	.	.	.	.
08/23/94	.	.	.	.
12/03/94	.	.	.	.
02/28/95	.	.	.	.
05/30/95	.	.	.	.
09/15/95	.	.	.	.
12/07/95	.	.	FP	.
03/07/96	.	.	.	.
06/04/96	.	.	23	.
11/13/96	.	.	.	.
05/06/97	.	2 J	FP	Chloroform (1J)
12/01/97	1 J	.	FP	111TCA (2 J)
05/26/98	1 J	1 J	FP	.
06/19/98	1 J	.	.	.
07/20/98	.	.	.	.
12/02/98	.	.	.	.
05/27/99	2 J	4 J	.	.
11/08/99	.	.	.	.
05/10/00	.	.	.	.
10/10/00	.	.	.	.
04/25/01	2 J	4 J	.	.
10/18/01	.	.	.	.
04/23/02	1 J	.	.	.
10/15/02	2 J	4 J	.	.
05/07/03	.	.	.	.
10/01/03	.	.	.	.
04/29/04	.	.	.	.
10/21/04	.	.	.	.
MCL	**5**	**5**	**NA**	

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported



Well GW-620: Summed VOCs
Summed VOCs (µg/L)
10000
1000
100
10
1
R^2 = 0.92
Note: Exponential regression on a logarithmic scale
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04

Figure 1

MAXIMUM CONCENTRATION: 2005

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	<0.015	500 - 5,000	ND	ND

GW-624

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 43,007.38
Y-12 GRID NORTH COORDINATE: 29,421.33
SURFACE ELEVATION: 919.52 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/05/90 PAIRED/CLUSTERED WITH: GW-625
TAG DEPTH (measured): 30.60 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 922.15 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	14.4	905.12
BOTTOM (filter pack or open hole):	27.2	892.32
MIDPOINT (filter pack or open hole):	20.8	898.72
PUMP INTAKE:	21.9	897.65
WATER LEVEL (average):	8.78	910.93

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	11		
CONVENTIONAL SAMPLING METHOD:	7 samples	06/28/90	10/12/05
LOW-FLOW SAMPLING METHOD:	4 samples	06/22/98	10/11/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/15/05	.	10/11/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.5 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	8	5856 µg/L	07/15/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-624

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1990, completed with a screened monitored interval from 14.4 to 27.2 ft bgs; and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-625 and is located in Bear Creek Valley (BCV) west of Y-12, approximately 150 ft directly south of the southwestern-most section of the Bear Creek Burial Grounds (BCBG) waste management area (WMA), near a northern tributary (NT) of Bear Creek that trends northeast-southwest across the central section of the WMA. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eleven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain seven samples between June 1990 and October 2005, and the low-flow sampling method used to obtain four samples between June 1998 and October 2005. The sampling history includes an initial quarterly sampling frequency followed by two prolonged (7-year) periods (June 1991 – June 1998 and July 1998 – June 2005) when no samples were collected from the well.

An evaluation of the monitoring data available through December 2004 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method before June 1998 had substantially lower contaminant (VOC) concentrations than samples subsequently obtained with the low-flow sampling method. However, results of “paired” sampling performed during June and October 2005, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, do not confirm the suspected sampling-method bias. As illustrated by the data summarized in Table 1, groundwater samples obtained with each sampling method have similar geochemical characteristics and the VOC results are inconclusive. For example, the summed concentration of VOCs detected in the sample collected with the low-flow method in June 2005 is approximately 5% higher than the summed concentration of VOCs detected in the sample collected the next day with the conventional sampling method, whereas the reverse is evident from the sampling results obtained in October 2005, with the summed VOC concentrations for the low-flow method being more than 20% lower than evident in the sample obtained with the conventional sampling method. In the absence of more conclusive indications of bias attributable to the sampling method, the difference between the historical conventional sampling VOC data and the more recent low-flow sampling results for VOCs may conservatively be attributable to an overall increase in VOC concentrations over the long term (see Section 5.3).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Depth-to-water measurements obtained for hydrologic monitoring and groundwater sampling purposes show that the static groundwater level in the well typically occurs at an average depth of about 9 ft bgs and exhibit seasonal fluctuations of about 5 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-624 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-624 may be primarily eastward (parallel with geologic strike) toward discharge areas in NT-7, the main channel of which is less than 50 ft east of the well.

As noted in previously, well GW-624 is paired with well GW-625, which is completed with a an open-hole interval from 231.5 – 283 ft in the Nolichucky Shale. However, none of the depth to water measurements for these wells are contemporaneous and, consequently, are not suitable for determining the vertical hydraulic gradient indicated by respective groundwater elevations in each well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 198 – 358 mg/L;
- pH (field measurements) of 7 – 7.4;
- moderately negative REDOX (e.g., -92 mV in October 2005);
- low molar proportions of chloride, sulfate, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Groundwater samples from the well appear to be characterized by slightly elevated chloride concentrations (e.g., 18.1 mg/L in October 2005) relative to much lower levels (<2 mg/L) typical of groundwater samples from other wells in BCV that are completed at similarly shallow depths (<30 ft bgs) in the Nolichucky Shale. It is possible the chloride concentrations reflect localized geochemical characteristics. Also, because the groundwater contains chlorinated hydrocarbons (see Section 5.3), the elevated levels also may be at least partially attributable to the biologically mediated degradation of these compounds, which often results in the accumulation of inorganic chloride (Hinchee et al. 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

No groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

Eight groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.008 mg/L in December 1990) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): PCE, TCE, c12DCE, t12DCE, 11DCE, VC, 11DCA, 12DCA, 111TCA, benzene, CTET, chloroethane, chloroform, MC, TCFM, and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113. Waste disposal areas within Burial Ground A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the plume of dissolved VOCs in the shallow groundwater at this well (DOE 1997). Waste disposal trenches in this area, particularly Burial Ground A-South, also are the suspected source of DNAPL (primarily PCE and TCE) that was encountered more at than 300 ft bgs in a well installed directly south (down-dip) of this area (Haase and King 1990).

The primary VOCs in the groundwater samples are PCE, TCE, c12DCE, and VC, each of which has a historical maximum concentration above 500 µg/L (Table 2). Moreover, the most recent sampling results (June and October 2005) show that the concentrations of each of these VOCs remain about two orders-of-magnitude higher than their respective drinking water MCLs. Secondary compounds in the groundwater samples are 11DCE and 11DCA, which have historical maximum values above 100 µg/L and were detected in each sample collected to date, with the most recent results showing 11DCE concentrations more than an order-of-magnitude higher than the MCL (7 µg/L). Most of the other VOCs were detected in samples collected the most recently, and only the maximum concentration of benzene (33 µg/L in July 1998) exceeds the applicable MCL (Table 2). Additionally, as noted in Section 2.0, the results obtained from "paired" sampling in June and October 2005 show that the VOC concentrations in the groundwater samples from the well do not show any clear bias attributable to the sampling method. This is illustrated by the VOC results summarized below, which do not display any consistent difference that appears to correlate in any way with the groundwater sampling method.

VOC	Concentration (µg/L)			
	Low-Flow Sampling June 15, 2005	**Conventional Sampling June 16, 2005**	**Low-Flow Sampling October 11, 2005**	**Conventional Sampling October 12, 2005**
PCE	310	280	420	550
TCE	380	320	410	500
c12DCE	1,600	1,600	2,100	2,500
t12DCE	5 J	4 J	6	7
11DCE	98	94	120	130
VC	220	190	240	380
111TCA	5 J	8	11	11
12DCA	.	7	.	.
11DCA	130	120	170	180
CTET	2 J	2 J	2 J	1 J
Chloroform	16	15	23	23
Benzene	19	19	24	25
Freon-113	13	12	22	20
TCFM	19	19	25	26
Note: "." = Not detected; J = Estimated value below laboratory reporting limit				

Many of the VOCs in the groundwater samples, particularly c12DCE and VC, are probably present in the groundwater as a consequence of biotic degradation (sequential dechlorination) of related parent compounds (PCE and TCE) which, as noted in Section 2.0, also may account for the elevated chloride levels typical of the samples. Also, the dissolved petroleum hydrocarbons (benzene) in the groundwater may serve as electron donors for biotic dechlorination of PCE and related compounds (Chapelle 1996). However, the VOC results do not show concentration trends potentially indicative of biotic degradation, such as decreasing concentrations of parent compounds (e.g., PCE) and concurrently increasing concentrations of degradation daughter products (e.g., c12DCE). Nevertheless, results for several indicator parameters, suggest that the geochemical conditions in the groundwater at this well are within the optimum range for biotic degradation of chlorinated hydrocarbons, although the REDOX conditions do not suggest the strongly reducing (methanongenic) conditions necessary to transform VC to chloroethane (Chapelle 1996), which may explain why the VC concentrations in the shallow groundwater at this well remain very high relative to the MCL (2 µg/L). It is possible that the monitored interval in the well intercepts groundwater flowpaths for VOCs transported from source areas deeper in the flow system (e.g., DNAPL) where geochemical conditions may be more amenable to biotic degradation.

The presence of benzene is a distinguishing characteristic of the VOC data for this well. Indeed, a review of the historical data indicates that, excluding benzene results for wells located in areas of Y-12 known to be impacted by historical releases from petroleum fuel underground storage tanks (USTs) and benzene results for other wells (and springs) that are obvious outliers compared to available data for the sampling location, benzene concentrations above the drinking water MCL (5 µg/L) have been reported only for the groundwater samples from the following wells, all of which are located within the BCBG WMA.

Well No.	Depth (ft bgs)	Benzene Concentration (µg/L) / Sampling Date			
		Maximum		Most Recent	
GW-014	13.2	180	11/05/87	4	10/19/05
GW-046	20.3	240	07/09/03	72	07/07/05
GW-068	83.6	51	10/18/05	51	10/18/05
GW-071	219	1,300	06/30/05	1,200	10/20/05
GW-082	34.4	99	08/07/03	ND	10/13/05
GW-117	530	6	11/13/87	ND	09/17/92
GW-118	575	67	11/19/88	1	10/10/93
GW-119	510	20	07/06/88	ND	09/17/92
GW-624	27.2	33	07/15/98	25	10/12/05

Of these, well GW-082 is located on the southwest side of Burial Grounds C-West, and all of the remaining wells are located near Burial Ground A-South: wells GW-014, GW-071, and GW-119 along the eastern boundary; wells GW-117 and GW-118 along the southern boundary; and wells GW-046, GW-068, and GW-624 near the western boundary. Note also the wide range in the total depth of these wells, particularly wells GW-117, GW-118, and GW-119, each of which is artesian. The apparent “clustering” of these wells suggest that benzene is a distinguishing component of the groundwater plume of dissolved VOCs originating from the waste disposal trenches in Burial Ground-A South.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples encompasses the gaps in the sampling history for the well (June 1991 – June 1998 and July 1998 – June 2005) and shows an indeterminate or possibly decreasing long-term concentration trend (Figure 1). Also, results for several individual compounds show such wide temporal variability that evaluation of the long-term trend seems too subjectively influenced by selection of the start date for the trend. For example, the concentrations of PCE and TCE indicated by the conventional sampling results from June 1990 (570 µg/L and 550 µg/L, respectively) and October 2005 (550 µg/L and 500 µg/L, respectively) suggest an indeterminate long-term trend, whereas a clearly decreasing trend for both compounds is indicated when the October 2005 results are compared to the PCE and TCE concentrations evident in September 1990 (790 µg/L and 690 µg/L, respectively).

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.89 pCi/L in June 1990) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.57 pCi/L in December 1990) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Haase, S. and H.L. King. 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant*, Y/TS-629, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-624: Consecutive daily sampling results for summed VOCs and other selected analytes, June and October 2005

Analyte	Units	June2005		October 2005	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.11	7.14	7.05	7.1
Dissolved Oxygen	ppm	0.53	6.52	2.39	0.84
REDOX	mV	-18	49	-92	-53
Dissolved Solids	mg/L	309	306	319	334
Suspended Solids	mg/L	Not detected	8	Not detected.	5
Calcium	mg/L	91.7	92.3	92.4	98.7
Chloride	mg/L	11.6	11	18.1	13
Barium	mg/L	0.0619	0.07	0.0917	0.11
Iron	mg/L	0.843	0.621	1.05	0.525
Summed VOCs	µg/L	2,817	2,690	3,573	4,353

Table 2. Well GW-624: summary of VOC results

Sampling Date	Concentration (µg/L)			
	PCE	**TCE**	**12DCE**	**c12DCE**
06/28/90	570	550	3,800	NR
09/21/90	790	690	5,400	NR
12/07/90	240	250	1,600	NR
03/24/91	71	68	330	NR
06/21/91	140	160	800	NR
06/22/98	450	440	1,800	NR
07/15/98	300	1,000	3,500	NR
06/15/05	310	380	1,605	1,600
06/16/05c	280	320	1,604	1,600
10/11/05	420	410	2,106	2,100
10/12/05c	550	500	2,507	2,500
MCL	**5**	**5**	**NA**	**70**
Sampling Date	**Concentration (µg/L)**			
	11DCE	**VC**	**111TCA**	**11DCA**
06/28/90	58	750	47	190
09/21/90	76	970	62	270
12/07/90	26	190	26	89
03/24/91	6	29	6	22
06/21/91	18	180	15	50
06/22/98	58	310	24	140
07/15/98	160	620	33	210
06/15/05	98	220	5	130
06/16/05c	94	190	8	120
10/11/05	120	240	11	170
10/12/05c	130	380	11	180
MCL	**7**	**2**	**200**	**NA**
Sampling Date	**Concentration (µg/L)**			
	Chloroform	**Benzene**	**TCFM**	**Freon-113**
06/28/90	12	14	.	.
09/21/90	18	21	.	.
12/07/90	.	.	.	.
03/24/91	.	.	.	.
06/21/91	.	4 J	.	.
06/22/98	.	.	.	.
07/15/98	.	33	.	.
06/15/05	16	19	19	13
06/16/05c	15	19	19	12
10/11/05	23	24	25	22
10/12/05c	23	25	26	20
MCL	**80***	**5**	**NA**	**NA**

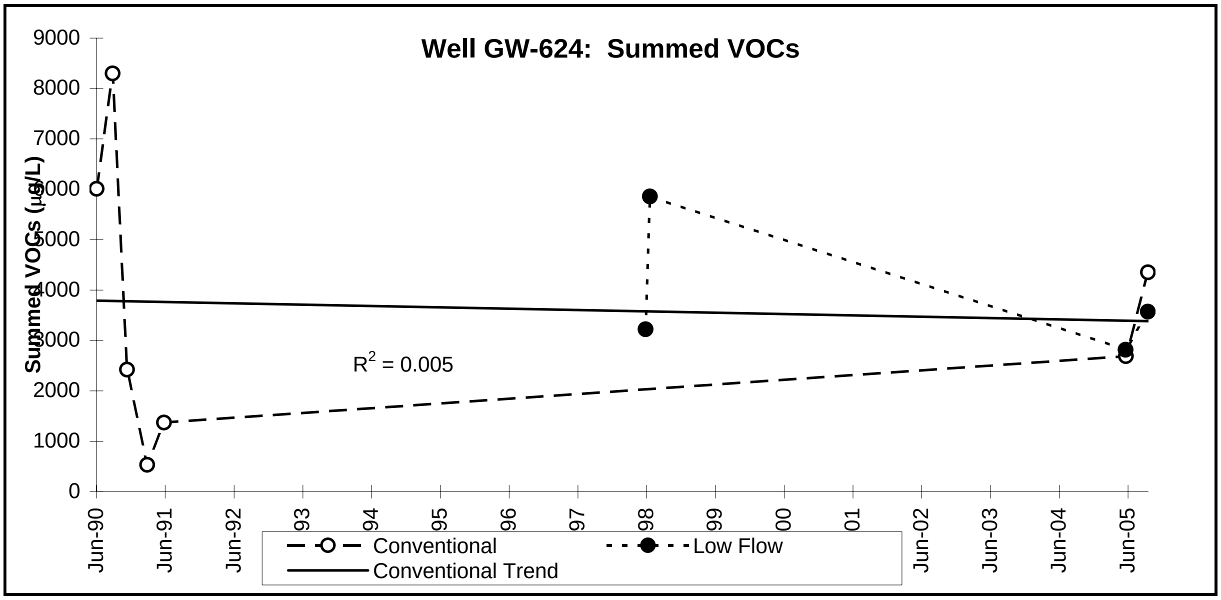
Table 2. Well GW-624: summary of VOC results (cont'd)

Sampling Date	Compound/Concentration (µg/L)
06/28/90	Chloroethane (6), MC (1 J), 12DCA (11)
06/21/91	12DCA (4 J)
06/15/05	CTET (2 J), t12DCE (5)
06/16/05c	CTET (2 J), t12DCE (4 J), 12DCA (7)
10/11/05	CTET (2 J), t12DCE (6)
10/12/05c	CTET (1 J), t12DCE (7)
Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable NR = Not reported; * = MCL is for total trihalomethanes; c = "paired" sample, conventional method	

Table 3. Well GW-624: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005		October 2005	
		LF	Conv.	LF	Conv.
Nitrate	< 1 mg/L	<0.028	<0.028	<0.028	<0.028
Iron (II)	> 1 mg/L	0.843*	0.621*	1.05*	0.525*
Sulfate	< 20 mg/L	3.37	3.67	2.25	3.15
Dissolved Oxygen	< 0.5 ppm	0.53**	6.52**	2.39**	0.84**
REDOX	< 50 mV	-18**	49**	-92**	-53**
pH	>5 and < 9 st. units	7.11**	7.14**	7.05**	7.1**

Note: LF = Low-flow sampling; Conv. = Conventional sampling;
*Results are for total iron; **Field measurements.



Well GW-624: Summed VOCs
Summed VOCs (µg/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
R^2 = 0.005
Jun-90
Jun-91
Jun-92
Jun-02
Jun-03
Jun-04
Jun-05
Conventional
Low Flow
Conventional Trend

Figure 1

MAXIMUM CONCENTRATION: 2005

<5	ND	50 - 500	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-626

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,772.01
Y-12 GRID NORTH COORDINATE: 29,535.32
SURFACE ELEVATION: 939.95 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/15/89 PAIRED/CLUSTERED WITH: GW-627
TAG DEPTH (measured): 80.92 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 942.87 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	63.0	876.95
BOTTOM (filter pack or open hole):	78.0	861.95
MIDPOINT (filter pack or open hole):	70.5	869.45
PUMP INTAKE:	73.3	866.67
WATER LEVEL (average):	23.45	916.76

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	24		
CONVENTIONAL SAMPLING METHOD:	18 samples	02/14/90	10/12/05
LOW-FLOW SAMPLING METHOD:	6 samples	06/23/98	10/11/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	.	06/15/05	.	10/11/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.03 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	20	10838 µg/L	02/11/02	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-626

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1989, completed with a screened monitored interval from 63 to 78 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-627, and is located in Bear Creek Valley (BCV) west of Y-12, directly west of the southwest corner of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, most of the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between February 1990 and October 2005, and the low-flow sampling method used to obtain six samples between June 1998 and October 2005. The sampling history includes an initial period of quarterly sampling (February 1990 and October 1993), with subsequent sampling performed semiannually in 1998, 2002, and 2005.

An evaluation of the monitoring data available through December 2004 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method before June 1998 had lower contaminant (VOC) concentrations than samples subsequently obtained with the low-flow sampling method. Thus, it was not clear if the change in sampling method explained the apparent increase in VOC concentrations or if the higher concentrations are the result of a corresponding increase in the relative flux of VOCs along the flowpaths intercepted by the monitored interval in the well. Results of "paired" sampling performed during June and October 2005, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, do not confirm sampling-method bias. As illustrated by the data summarized in Table 1, groundwater samples obtained with each sampling method have similar geochemical characteristics and the VOC results are inconclusive. For example, the summed concentration of VOCs detected in the sample collected with the low-flow method in June 2005 (81 µg/L) is approximately 50% lower than the summed concentration of VOCs detected in the sample collected the next day with the conventional sampling method (191 µg/L), whereas the sampling results obtained in October 2005 show the summed VOC concentrations for the low-flow method (351 µg/L) being about 20% higher than evident in the sample obtained with the conventional sampling method (290 µg/L). In the absence of more conclusive indications of bias attributable to the sampling method, the difference between the historical conventional sampling and the more recent low-flow sampling results for VOCs may be conservatively assumed to reflect an overall increase in VOC concentrations over the long term (see Section 5.3).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow (<100 ft bgs) bedrock interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within the water table interval, which is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static groundwater level in the well typically occurs at an average depth of about 24 ft bgs and exhibits seasonal fluctuations of about 7 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-626 indicate south and southeasterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

As noted previously, well GW-626 is paired with well GW-627, which is completed with a open-hole interval at significantly greater depth (250 ft bgs). Depth-to-water measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-626 are typically lower than evident in well GW-627. Based on the distance between the monitored interval midpoint (elevation) in each well (191.06), these respective groundwater elevations indicate upward vertical hydraulic gradients (0.021 –0.005) from the intermediate depth bedrock interval (GW-627) to the shallow bedrock interval (GW-626).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-bicarbonate groundwater generally characterized by:

- TDS of 104 – 349 mg/L;
- pH (field measurements) of 7.28 – 8.9;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- unusually low concentrations of magnesium (<5 mg/L);
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Four groundwater samples collected to date had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.113 mg/L in October 2005) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.004 mg/L in August 1993) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, benzene, bromodichloromethane (BCDM), CTET, chloroethane, chloroform, ethylbenzene, freon-113 (F113), MC, PCE, toluene, TCE, TCFM, VC, xylenes, 11DCA, 12DCA, 11DCE, c12DCE, t12DCE, 4-methyl-2-pentanone (4M2P), 111TCA, 112TCA, and 1,1,2-trichloro-1,2,2-trifluoroethane, which is also known as Freon-113 (F-113). Waste disposal areas within Burial Ground A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the plume of dissolved VOCs in the shallow groundwater at this well (DOE 1997). Waste disposal trenches in Burial Ground A-South also are the suspected source of DNAPL (primarily PCE and TCE) that was encountered more than 300 ft bgs in a well installed directly south (down-dip) the area (Haase and King 1990).

The primary VOCs in the groundwater samples are PCE, TCE, and c12DCE, each of which have a historical maximum concentration above 800 µg/L (Table 2), although the value for c12DCE (7,213 µg/L) appears to be an outlier compared to subsequent results for c12DCE and historical data for total 12DCE. Additionally, the most recent sampling results (June and October 2005) show that the concentrations of these VOCs remain above their drinking water MCLs (5 µg/L, 5 µg/L, and 70 µg/L, respectively). Secondary compounds in the groundwater samples are 11DCE, 11DCA, and 11TCA, at least one of which was detected in all but one of the samples collected to date. However, the historical maximum concentrations for 11DCE (340 µg/L in December 1991), 11DCA (290 µg/L in February 2002), and 111TCA (290 µg/L in December 1991) appear to be outliners compared to the other data for each compound (Table 2). Aside from the primary and secondary VOCs, the remaining compounds were detected infrequently, mostly in samples collected since February 2002. Excluding a few outlier results (e.g., 1,200 µg/L for VC in February 2002), few concentrations of these VOCs exceed 100 µg/L (the majority are less than 10 µg/L), and the most recent results show concentrations below MCLs for applicable compounds.

As noted in Section 2.0, the results of “paired” sampling performed in June and October 2005 show that the VOC concentrations in the groundwater samples from the well do not exhibit any bias attributable to the sampling method. This is clearly illustrated by the VOC results summarized below, which do not exhibit any consistent difference that appears to correlate with the groundwater sampling method.

VOC	Concentration (µg/L)			
	Low-Flow Sampling June 15, 2005	Conventional Sampling June 16, 2005	Low-Flow Sampling October 11, 2005	Conventional Sampling October 12, 2005
PCE	13	24	71	49
TCE	9	20	47	34
c12DCE	54	130	200	180
11DCE	2 J	4 J	7	5
VC	.	.	.	1 J
111TCA	.	2 J	2 J	2 J
12DCA	.	1 J	2 J	1 J
11DCA	3 J	8	11	10
Chloroform	.	2 J	7	4 J
F-113	.	.	4 J	4 J
Note: "." = Not detected; J = Estimated value below laboratory reporting limit				

Some of the VOCs in the groundwater samples, particularly c12DCE, are probably present in the groundwater as a consequence of biologically-mediated degradation (sequential dechlorination) of related parent compounds (PCE and TCE). Also, the dissolved petroleum hydrocarbons in the groundwater may serve as electron donors for biotic dechlorination of PCE and related compounds (Chapelle 1996). However, the VOC results do not show concentration trends potentially indicative of biotic degradation, such as concurrently decreasing and increasing trends, respectively, for parent compounds (e.g., PCE) and degradation daughter products (e.g., c12DCE). Also, results for several indicator parameters suggest that the geochemical conditions in the groundwater at this well are not especially conducive to biotic degradation of chlorinated hydrocarbons. It is possible that the monitored interval in the well intercepts groundwater flowpaths for VOCs transported from source areas deeper in the flow system (e.g., DNAPL) where geochemical conditions may be more amenable to biotic degradation.

A time-series plot of the summed concentrations of VOCs detected in the groundwater samples collected to date not only encompasses several extended periods when samples were not collected from the well (October 1993 – June 1998; July 1998 – February 2002; and July 2002 – June 2005), but is largely dominated by the historical maximum summed VOC concentration (10,838 µg/L) evident in February 2002. Excluding the February 2002 outlier (Figure 1), which is attributable to a very high concentration of c12DCE (7,213 µg/L), a plot of the summed VOC concentrations shows a widely variable but increasing trend between June 1990 (12.6 µg/L) and December 1991 (2,792 µg/L) followed by an equally variable but decreasing trend though August 1993 (348 µg/L), with the more recent sampling results suggesting a subsequent indeterminate concentration trend through October 2005 (351 µg/L). These results suggest that there has not been any substantial overall change in the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Two of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (1.82 pCi/L in March 1991) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nine groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (25.9 pCi/L in March 1992) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). However, this result is a suspected outlier because all other gross beta results are less than 7 pCi/L.

6.0 REFERENCES

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Haase, S. and H.L. King. 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant*, Y/TS-629, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-626: Consecutive daily sampling results for summed VOCs and other selected analytes, June and October 2005

Analyte	Units	June2005		October 2005	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	8.38	Not measured	7.8	7.64
REDOX	mV	90	135	131	134
Dissolved Solids	mg/L	144	172	192	183
Suspended Solids	mg/L	Not detected	Not detected	Not detected	Not detected
Calcium	mg/L	35.3	45.6	61.8	55.6
Chloride	mg/L	1.39	2.26	3.45	3.09
Barium	mg/L	0.156	0.16	0.2	0.182
Iron	mg/L	Not detected	Not detected	Not detected	Not detected
Summed VOCs	µg/L	81	191	351	290

Table 2. Well GW-626: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	**TCE**	**12DCE**	**c12DCE**	**11DCE**
02/14/90	3 J	4 J	16	NR	.
06/25/90	2 J	3 J	7	NR	.
09/18/90	1 J	2 J	5	NR	.
12/05/90	18	24	170	NR	8
03/23/91	8	11	70	NR	4 J
06/20/91	5	7	32	NR	2 J
09/26/91	13	21	110	NR	6
12/22/91	730	890	280	NR	[340]
03/29/92	500	310	500	NR	19
06/25/92	38	43	300	NR	14
09/27/92	32	38	270	NR	10
12/11/92	150	140	1,400	NR	24
03/10/93	140	110	1,200	NR	28
04/26/93	29	34	400	NR	6
08/02/93	29	35	250	NR	9
10/20/93	32	36	330	NR	12
06/23/98	8	8	67	NR	2 J
07/14/98	11	11	93	NR	4 J
02/11/02	920	710	7,213	[7,200]	120
07/25/02	320	190	1,502	1,500	38
06/15/05	13	9	54	54	2 J
06/16/05c	24	20	130	130	4 J
10/11/05	71	47	200	200	7
10/12/05c	49	34	180	180	5
MCL	**5**	**5**	**NA**	**70**	**7**

Table 2. Well GW-626: summary of VOC results (cont'd)

Sampling Date	Concentration (µg/L)				
	VC	111TCA	12DCA	11DCA	Chloroform
02/14/90	.	1 J	.	2 J	.
06/25/90	.	0.6	.	.	.
09/18/90	.	.	.	.	.
12/05/90	.	5	.	15	.
03/23/91	.	2 J	.	6	.
06/20/91	.	.	0.8	3 J	.
09/26/91	.	5	2 J	11	0.9
12/22/91	47	[290]	3 J	.	5
03/29/92	.	14	.	42	.
06/25/92	.	8	.	24	.
09/27/92	.	6	5	20	2 J
12/11/92	120	20	.	48	.
03/10/93	72	17	.	51	.
04/26/93	.	4 J	4 J	18	.
08/02/93	.	6	.	19	.
10/20/93	.	6	3 J	19	.
06/23/98	.	.	.	4 J	.
07/14/98	.	1 J	1 J	7	.
02/11/02	[1,200]	44	[32]	[290]	[100]
07/25/02	42	13	7	65	24
06/15/05	.	.	.	3 J	.
06/16/05c	.	2 J	1 J	8	2 J
10/11/05	.	2 J	2 J	11	7
10/12/05c	1	2 J	1 J	10	4 J
MCL	**2**	**200**	**5**	**NA**	**80***

Sampling Date	Compound/Concentration (µg/L)
02/14/90	Acetone (5)
12/22/91	Acetone (74), BDCM (2 J), Chloroethane (10), BTEX (71), CTET (50)
12/11/92	Acetone (75), 4M2P (20)
02/11/02	Benzene (190), CTET (8), MC (6), t12DCE (13), TCFM (3 J), 112TCA (2 J)
07/25/02	Benzene (4 J), t12DCE (2 J)
10/11/05	F-113 (4 J)
10/12/05c	F-113 (4 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; [ ] = suspected outlier; NA = Not applicable; NR = Not reported; * = MCL is for total trihalomethanes; c = "paired" sample, conventional method

Table 3. Well GW-626: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		June 2005		October 2005	
		LF	Conv.	LF	Conv.
Nitrate	< 1 mg/L	0.0452	0.0971	<0.028	0.113
Iron (II)	> 1 mg/L	<0.05*	<0.05*	<0.05*	<0.05*
Sulfate	< 20 mg/L	1.55	1.96	1.71	2.01
Dissolved Oxygen	< 0.5 ppm	7.79**	7.8**	0.59**	1.56**
REDOX	< 50 mV	90**	135**	131**	134**
pH	>5 and < 9 st. units	8.38**	NM	7.8**	7.64**

Note: LF = Low-flow sampling; Conv. = Conventional sampling; NM = Not measured

*Results are for total iron; **Field measurements.

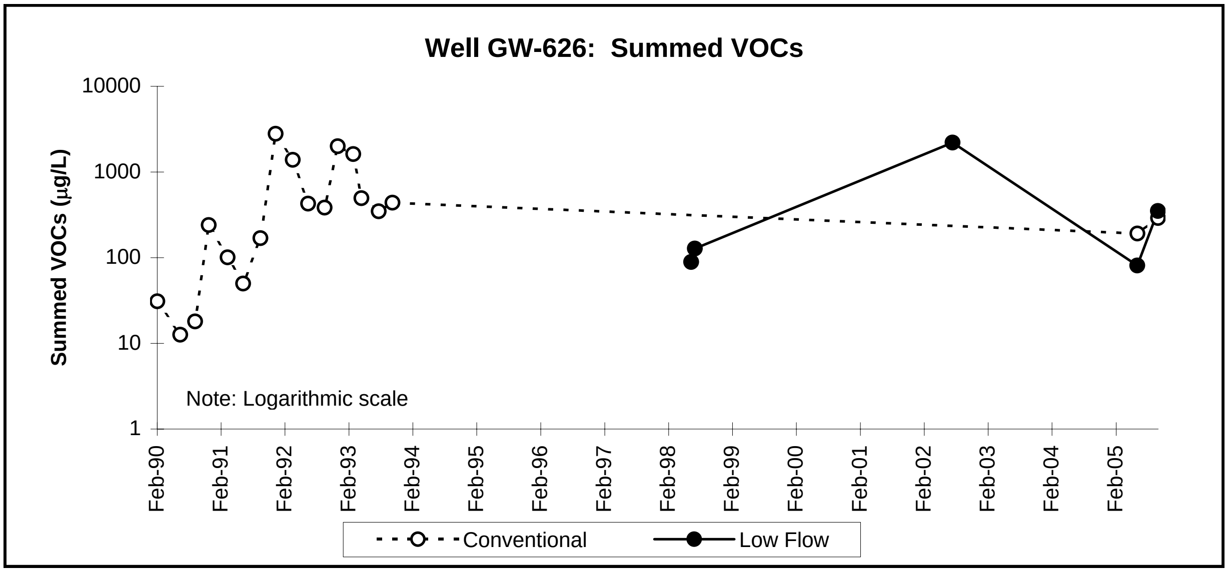

Well GW-626: Summed VOCs
Summed VOCs (µg/L)
10000
1000
100
10
1
Note: Logarithmic scale
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Conventional
Low Flow

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	500 - 5,000	ND	<25

GW-627

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE:	42,774.10
Y-12 GRID NORTH COORDINATE:	29,505.05
SURFACE ELEVATION:	940.39 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	.
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	12/11/89	PAIRED/CLUSTERED WITH:	GW-626
TAG DEPTH (measured):	270.96 ft below top of casing (TOC)		
MEASURING POINT ELEVATION:	943.51 ft above msl	MEASURING POINT:	TOWW
WELL BORE DIAMETER:	10.63 inches		
WELL CASING MATERIAL:	SF25		
WELL CASING DIAMETER:	7 inches (outside diameter)		
WELL SCREEN TYPE:	.		
DEDICATED SAMPLING EQUIPMENT:	Well Wizard	Sampling Port No.: .	Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	254.0	686.39
BOTTOM (filter pack or open hole):	270.0	670.39
MIDPOINT (filter pack or open hole):	262.0	678.39
PUMP INTAKE:	255.88	684.51
WATER LEVEL (average):	20.63	919.76
GEOLOGIC FORMATION:	Nolichucky Shale	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	46		
CONVENTIONAL SAMPLING METHOD:	30 samples	02/13/90	08/23/00
LOW-FLOW SAMPLING METHOD:	16 samples	03/11/98	08/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/25/04	.	08/04/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	X	OTHER:	.	
WATER LEVEL FLUCTUATION:	5.29 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	42	1,236 µg/L	08/04/04	Increasing
GROSS ALPHA (15 pCi/L):	1	19 pCi/L	07/29/02	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-627

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1989; completed with an open-hole monitored interval from 254 to 270 ft bgs; and completed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in the central part of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included oils, machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, the waste-disposal units in the BCBG waste-management area were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 30 samples between February 1990 and August 2000, and the low-flow sampling method used to obtain 16 samples between March 1998 and August 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially lower contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during February and October 2000, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias. As shown by the data summarized in Table 1, groundwater samples obtained with each sampling method have similar geochemical characteristics (aside from the less strongly negative REDOX evident for the samples obtained with the conventional sampling method), but the samples obtained with the low-flow method have substantially higher VOC concentrations.

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of clean groundwater into the well, and effectively dilutes the VOC concentrations.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1%

of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static groundwater level in the well typically occurs at an average depth of about 21 ft bgs and exhibit seasonal fluctuations up to 6 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-627 indicate south and southeasterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-627 may be primarily westward (parallel with geologic strike) toward discharge areas in a northern tributary of Bear Creek (NT-7) that traverses the west-central section of the BCBG waste management area approximately 300 ft east of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields mineralized, chloride-enriched, sodium-bicarbonate groundwater generally characterized by:

- TDS of 650 – 803 mg/L;
- pH (field measurements) of 8.6 – 11.0;
- unusually high concentrations of chloride (>40 mg/L), carbonate (>50 mg/L), and fluoride concentrations (>5 mg/L);
- low molar proportions of calcium, magnesium, potassium and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

These geochemical characteristics reflect the decrease in groundwater flux that occurs with depth in the low-permeability Conasauga Group formations (e.g., Nolichucky Shale) in BCV (Solomon et al. 1992). Most of the water table and shallow (i.e., <100 ft bgs) bedrock wells in these formations yield calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Further reduced groundwater flux deeper in the bedrock is indicated by a general increase in TDS and a gradational transition from sodium-bicarbonate groundwater to sodium-chloride groundwater.

Elevated chloride levels in the groundwater samples from this well potentially reflect natural geochemical conditions or contamination from inorganic wastes disposed at the BCBG. Additionally, the groundwater in the well contains a mixture of dissolved chlorinated hydrocarbons (see Section 5.3) and elevated chloride concentrations may be a consequence of the biologically mediated degradation (dechlorination) of these compounds (Hinchee et al. 1995). As illustrated by the recent monitoring data summarized in Table 2, most of the geochemical characteristics of the groundwater (particularly the REDOX conditions) appear to be conducive to biotic degradation of VOCs.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on the respective monitoring data reported for the groundwater samples collected from the well since January 1991, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Only the nitrate concentration reported for the groundwater sample collected in July 1993 (0.2 mg/L) exceeds applicable analytical reporting limit and this results is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Five groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.001 mg/L) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples (Table 3): acetone, chloroethane, PCE, TCE, toluene, 11DCA, 11DCE, c12DCE and t12DCE. Waste disposal areas within BG-A (North and South), which received about two million gallons of waste oils and coolants, are the most likely source of the plume of dissolved VOCs in the shallow groundwater at this well (DOE 1997). Moreover, PCE and TCE were first detected in the groundwater sample collected in June 1990 following the January 1990 discovery of a free-phase mixture of PCE and TCE (DNAPL) in the Nolichucky Shale at a depth of 260 to 330 ft down dip of BG-A South (Haase and King 1990). The presence of the dissolved VOCs in the groundwater at this well reflects their westward transport from the DNAPL via strike-parallel flowpaths in the Nolichucky Shale more than 250 ft bgs VOCs (DOE 1997).

The primary VOCs in the groundwater samples are PCE, TCE, and 11DCA, each of which was detected in all but four of the samples (Table 3). Historical maximum concentrations exceed 500 µg/L for PCE, 200 µg/L for TCE, and 50 µg/L for 11DCA, with the most recent monitoring data showing that the concentrations of PCE and TCE remain substantially above respective drinking water MCLs (Table 3). Secondary compounds in the samples are 11DCE, 12DCE (c12DCE and t12DCE) and VC. These VOCs have been detected primarily in the groundwater samples obtained with the low-flow sampling method (12DCE was not detected in any of the samples obtained with the conventional sampling method), with historical maximum concentrations below 40 µg/L, and the most recent monitoring results showing VC and 11DCE concentrations remain above respective MCLs (Table 3). Acetone, chloroethane, and toluene have been detected the least frequently (four samples or less). Also, as noted in Section 2.0 and illustrated by the data summarized in Table 4, VOC concentrations detected in samples obtained with the conventional method are substantially lower than the corresponding VOC concentrations detected in samples obtained with the low flow method.

The time-series plots of the summed concentrations of VOCs detected in the groundwater samples (Figure 1) show increasing long-term concentration trends obtained with the conventional sampling method (Figure 2) and low-flow sampling method (Figure 3). For example, the low-flow sampling data show that the concentration of PCE (and other VOCs) increased by an order-of-magnitude between June 1998 (51 μg/L) and February 2000 (500 μg/L), dropped sharply in August 2000 (340 μg/L), which may be an artifact of the consecutive daily low-flow/conventional sampling (see Section 2.0), and again steadily increased through August 2004 (830 μg/L). Also, the primary and secondary VOCs in the samples exhibit concurrently increasing concentration trends, which suggest an overall increase in the advective flux of VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater samples collected in September 1991 (3.41 pCi/L), June 1995 (4.26 pCi/L), and July 2002 (19 pCi/L). The latter result exceeds the drinking water MCL for gross alpha activity (15 pCi/L), but is an outlier compared to the other gross alpha results.

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (22 pCi/L in September 1996) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Haase, S. and H.L. King. 1990. *Report and Preliminary Assessment of the Occurrence of Dense, Nonaqueous Phase Liquids in the Bear Creek Burial Grounds Hazardous Waste Disposal Unit at the Oak Ridge Y-12 Plant,* Y/TS-629, prepared by Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-627: consecutive daily conventional/low-flow sampling results for selected analytes

Analyte	Units	February 2000		August 2000	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	9.54	9.03	8.98	8.71
Dissolved Oxygen	ppm	0.07	0.5	2.43	1.71
REDOX	mV	-286	-27	-272	-28
Dissolved Solids	mg/L	803	788	731	740
Suspended Solids	mg/L	1	.	.	.
Sodium	mg/L	300	297	294	294
Chloride	mg/L	42.9	39.4	43.7	32.2
Barium	mg/L	0.0472	0.0474	0.0482	0.0464
Iron	mg/L	0.159	0.146	0.298	0.0915
Summed VOCs	µg/L	773	93	480	104

Notes: "." = *Not detected*

Table 2. Well GW-627: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	February 2004	August 2004
Nitrate < 1 mg/L	<0.02	<0.02
Iron (II) > 1 mg/L	0.138*	0.0904*
Sulfate < 20 mg/L	7.74	6.31
Dissolved Oxygen < 0.5 ppm	0**	0.97**
REDOX < 50 mV	-123**	-178**
pH >5 and < 9 st. units	9.17**	9.13**

Note: *Results are for total iron; **Field measurement.

Table 3. Well GW-627: summary of VOC results

Date Sampled	VOC Concentration (µg/L)				
	PCE	TCE	12DCE		
			Total	c12DCE	t12DCE
Conventional Sampling					
03/24/91	6	.	.	NR	NR
06/22/91	16	2 J	.	NR	NR
09/25/91	19	3 J	.	NR	NR
12/18/91	10	.	.	NR	NR
03/26/92	15	2 J	.	NR	NR
06/24/92	29	5	.	NR	NR
09/26/92	30	4 J	.	NR	NR
12/09/92	48	6	.	NR	NR
03/09/93	39	6	.	NR	NR
04/23/93	51	7	.	NR	NR
07/28/93	74	10	.	NR	NR
10/20/93	37	5	.	NR	NR
03/14/94	30	4 J	.	NR	NR
06/23/94	44	7	.	NR	NR
09/15/94	37	5	.	NR	NR
12/09/94	44	7	.	NR	NR
03/28/95	62	9	.	NR	NR
06/22/95	47	7	.	NR	NR
09/25/95	55	8	.	NR	NR
12/10/95	58	9	.	NR	NR
03/28/96	47	8	.	NR	NR
09/06/96	56	9	.	NR	NR
02/08/97	83	16	.	NR	NR
09/09/97	84	15	.	NR	NR
02/23/00	73	15	.	.	.
08/23/00	80	17	.	.	.
Low-Flow Sampling					
03/11/98	10	9	5	3 J	2 J
06/18/98	53	45	6	NR	NR
07/16/98	61	46	5	NR	NR
09/01/98	250	79	8	5	3 J
03/24/99	360	120	10	7	3 J
08/26/99	470	150	11	8	3 J
02/21/00	500	170	8	8	.
08/22/00	340	85	5	5	.
02/13/01	350	92	6	6	.
07/26/01	390	120	8	8	.
02/11/02	550	160	14	12	2 J
07/29/02	530	190	16	14	2 J
02/04/03	590	220	19	17	2 J
08/05/03	810	210	20	17	3 J
02/25/04	700	230	20	17	3 J
08/04/04	830	220	24	21	3 J
MCL	**5**	**5**	**NA**	**70**	**100**

Table 3 (continued)

Date Sampled	VOC Concentration (µg/L)			
	VC	11DCE	11DCA	Other
Conventional Sampling				
03/24/91	.	.	.	.
06/22/91	.	.	2 J	.
09/25/91	.	.	2 J	.
12/18/91	.	.	.	.
03/26/92	.	.	1 J	.
06/24/92	.	.	3 J	.
09/26/92	.	.	3 J	.
12/09/92	.	.	4 J	.
03/09/93	.	.	3 J	.
04/23/93	.	.	5	.
07/28/93	0.8	1 J	6	.
10/20/93	.	.	3 J	.
03/14/94	.	.	3 J	Acetone (16)
06/23/94	.	.	4 J	.
09/15/94	.	.	4 J	.
12/09/94	.	.	4 J	.
03/28/95	.	.	5	.
06/22/95	.	.	4 J	.
09/25/95	.	.	5	.
12/10/95	.	.	4 J	.
03/28/96	.	1 J	4 J	.
09/06/96	.	1 J	5	.
02/08/97	.	3 J	8	Acetone (77)
09/09/97	1 J	1 J	7	.
02/23/00	.	.	5	.
08/23/00	.	.	7	.
Low-Flow Sampling				
03/11/98	6	9	30	.
06/18/98	6	8	29	Toluene (1 J)
07/16/98	6	6	27	.
09/01/98	10	11	37	Chloroethane (1 J)
03/24/99	11	13	48	.
08/26/99	12	15	57	.
02/21/00	17	16	62	.
08/22/00	7	9	34	.
02/13/01	13	11	41	.
07/26/01	11	12	49	.
02/11/02	18	19	68	.
07/29/02	20	23	70	.
02/04/03	21	28	88	Chloroethane (2 J)
08/05/03	22	25	82	Chloroethane (2 J)
02/25/04	29	28	96	Chloroethane (1 J)
08/04/04	28	34	100	.
MCL	**2**	**7**	**NA**	**NA**

Notes: "." = Not detected; J = Estimated value below the analytical reporting limit; NR = Not reported; NA = Not applicable

Table 4. Well GW-627: comparison of conventional and low-flow sampling results for VOCs

VOC	VOC Concentration (µg/L)					
	February 2000			August 2000		
	Low-Flow Sampling	Conventional Sampling	% Change	Low-Flow Sampling	Conventional Sampling	% Change
PCE	500	73	-85%	340	80	-76%
TCE	170	15	-91%	85	17	-80%
c12DCE	8	.	-100%	5	.	-100%
11DCE	8	.	-100%	9	.	-100%
VC	16	.	-100%	7	.	-100%
11DCA	17	5	-71%	34	7	-79%
Notes: "." = Not detected						

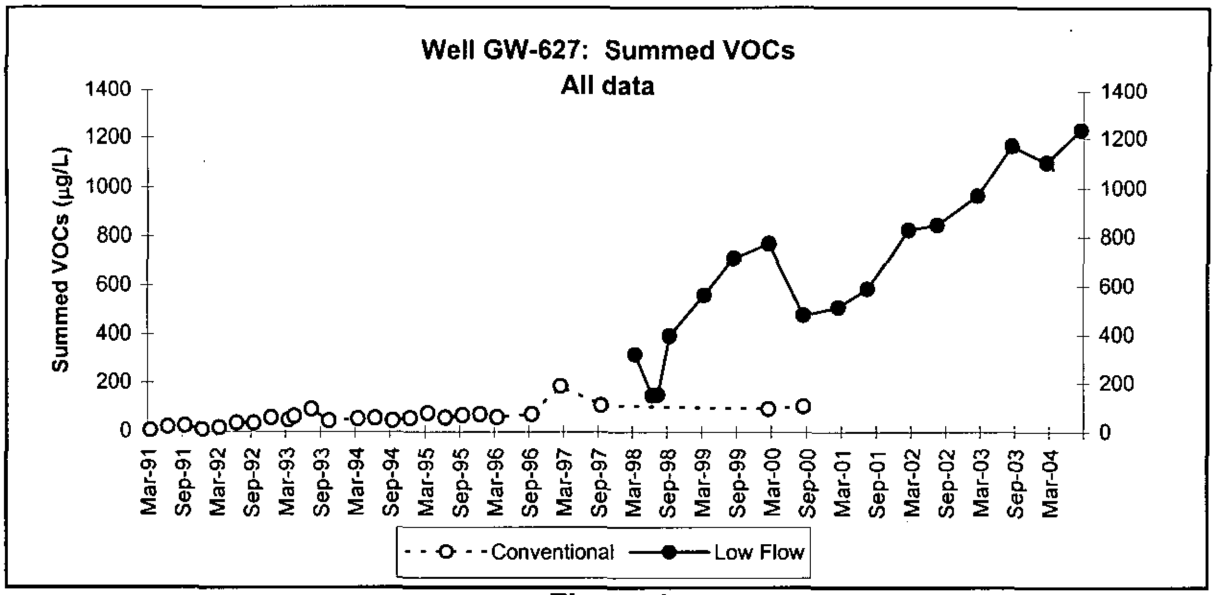


Figure 1

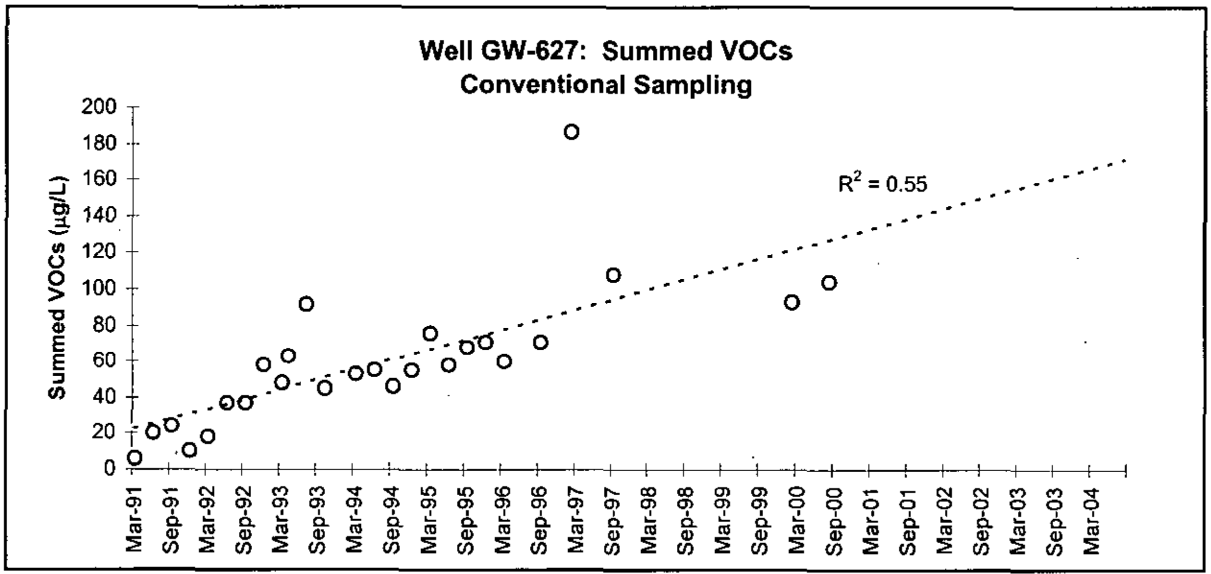


Figure 2

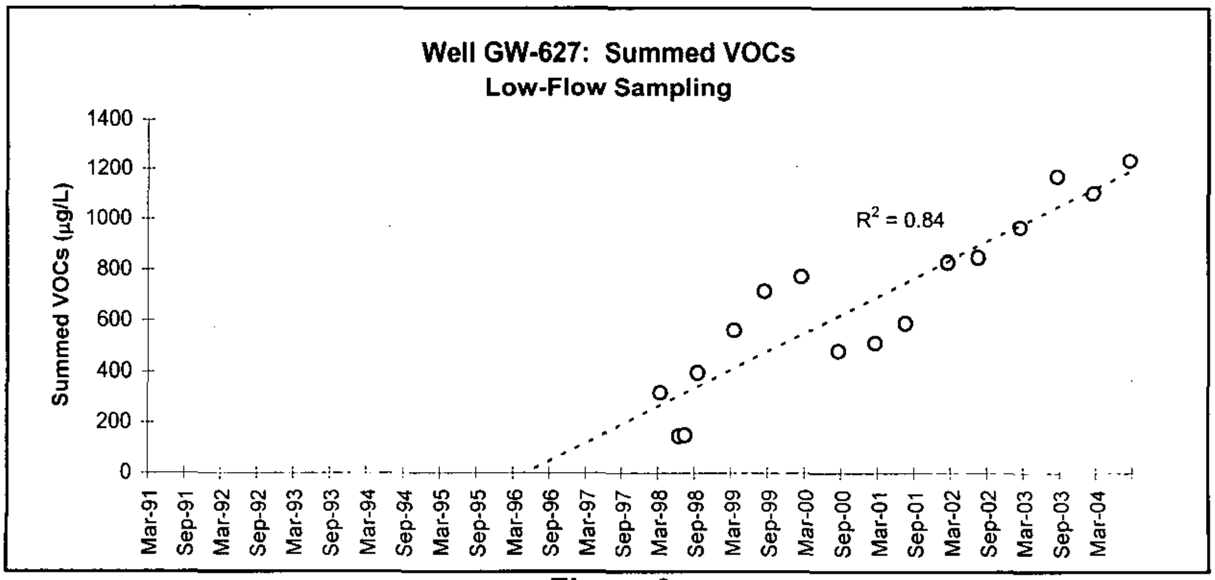


Figure 3

MAXIMUM CONCENTRATION: 2003

<5	ND	ND	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-631

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Rust Garage Area
Y-12 GRID EAST COORDINATE: 53,144.93
Y-12 GRID NORTH COORDINATE: 30,202.77
SURFACE ELEVATION: 1,004.10 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/02/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 15.36 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,004.00 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.5 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.0	1000.10
BOTTOM (filter pack or open hole):	16.0	988.10
MIDPOINT (filter pack or open hole):	10.0	994.10
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	6.97	997.13

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	03/11/91	03/01/94
LOW-FLOW SAMPLING METHOD:	2 samples	05/13/03	10/07/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/13/03	.	10/07/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.06 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	13.4 mg/L	11/03/92	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	12	56 µg/L	03/11/91	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-631

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1990, completed with a screened monitored interval from 4 to 16 ft bgs, and constructed with 4.5-inch diameter PVC riser casing and well screen (0.01 slot). The well is located in Bear Creek Valley, at the Rust Garage Area near the west end of Y-12, about 650 ft directly east of the former S-3 Ponds, a major source of groundwater contamination at Y-12 that was closed and capped in accordance with a RCRA closure plan in 1988. The S-3 Ponds consisted of four unlined and contiguous surface impoundments that were used from 1951 to 1984 primarily for percolation/evaporation of nitric acid effluent (with depleted uranium in solution) discharged into the ponds via a pipeline (the Abandoned Nitric Acid Pipeline) connected to process buildings in the central Y-12 area. Operation of the site emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants into the Conasauga Group (Nolichucky Shale) and created a mound in the water table (which dissipated after disposal of wastes in the ponds ceased) that enabled transport/migration of contaminants into areas that now lie east of the hydrologic divide separating the Bear Creek and Upper East Fork Poplar Creek watersheds. Additionally, operation of the Rust Garage Area emplaced a dissolved plume of petroleum hydrocarbons in the shallow groundwater that intermingled with the contaminant plume originating from the former S-3 Ponds.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between March 1991 and March 1994, and the low-flow sampling method used to obtain samples in May and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 7 ft below ground surface. Note that the large monitored (screened) interval in the well is intended to straddle the water table during seasonally high and low flow conditions and facilitate detection of light non-aqueous phase liquids (LNAPL). Presampling depth-to-water measurements for the well indicate moderate fluctuations (<4 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- low to moderate TDS (<150 mg/L <300 mg/L);
- pH (field measurements) of 3.9 – 5;
- unexpectedly low nitrate concentrations (<15 mg/L) considering the location of the well relative to the former S-3 Ponds;
- unusually low concentrations of calcium (<20 mg/L) and magnesium (<10 mg/L) along with unusually high chloride (>50 mg/L) and sodium (>15 mg/L); and
- total (unfiltered sample) concentrations of several trace metals, notably manganese (>2 mg/L) and strontium (>50 mg/L), that exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion, which is based on the analytical results reported for five groundwater samples collected from the well since January 1991.

5.1 NITRATE

Each groundwater sample had nitrate concentrations above the analytical reporting limit, with concentrations above the MCL for nitrate (10 mg/L) evident in November 1992 (13.4 mg/L) and June 1993 (14 mg/L). However, nitrate concentrations below 1 mg/L were reported for the samples collected most recently (May and October 2003). Considering the location of the well relative to the former S-3 Ponds, the low nitrate levels in the shallow groundwater at the well are somewhat unexpected, particularly considering the nitrate levels evident in other nearby wells, such as wells GW-107 (nitrate >100 mg/L), GW-108 (nitrate >15,000 mg/L), and GW-109 (nitrate >10,000 mg/L), which form a cluster less than 200 ft southeast of well GW-631. It is not clear from the available data why the nitrate levels in the groundwater at this well are so low.

5.2 URANIUM

Two groundwater samples had uranium concentrations at the applicable analytical reporting limit (0.001 mg/L in June 1991 and March 1992) and substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in each groundwater sample collected from the well before CY 2003: PCE, TCE, 12DCE, 11DCA, chloromethane, methylene chloride, benzene, ethylbenzene, toluene, and xylene (BTEX). The historical maximum concentrations of PCE (38 µg/L in December 1991) and benzene (12 µg/L in March 1991) exceed the respective MCLs (both 5 µg/L). A time-series plot of the summed concentration of VOCs shows a clearly decreasing trend that spans a nine-year gap in the sampling history (Figure 1). No VOCs were detected in the samples collected from the well in May and October 2003.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.2 pCi/L in May 1993) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (12 pCi/L in March 1994) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

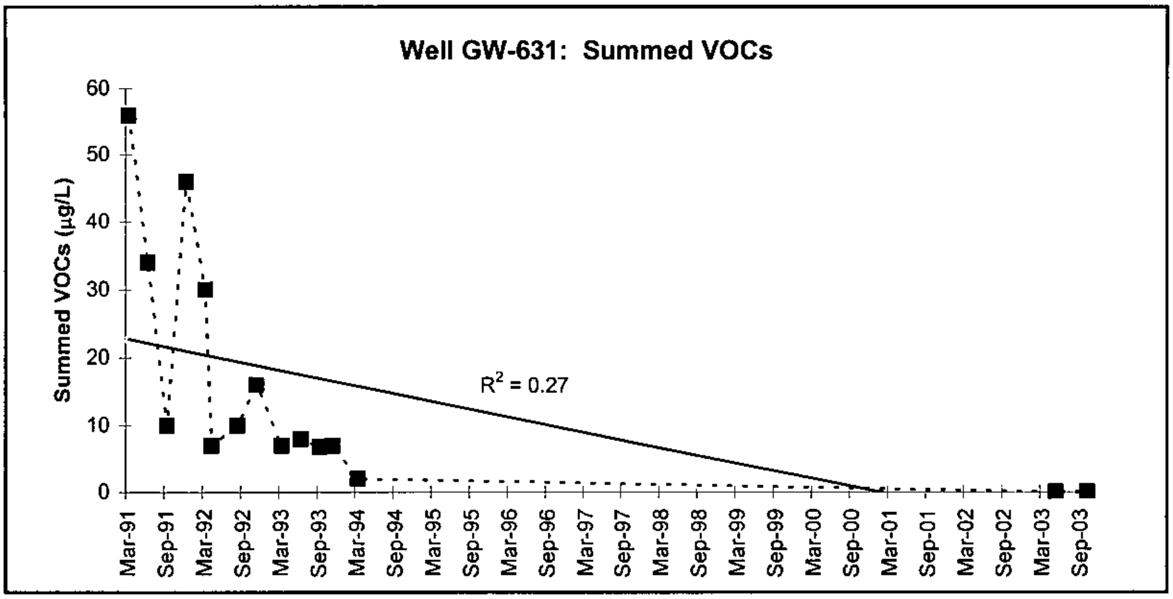

Well GW-631: Summed VOCs
Summed VOCs (µg/L)
60
50
40
30
20
10
0
R^2 = 0.27
Mar-91
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03

Figure 1

MAXIMUM CONCENTRATION: 2004

>1,000	<0.015	500 - 5,000	ND	500 - 5,000
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-633

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Rust Garage Area
Y-12 GRID EAST COORDINATE: 53,100.41
Y-12 GRID NORTH COORDINATE: 30,144.56
SURFACE ELEVATION: 996.66 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/03/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 15.15 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 996.43 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.5 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	3.5	993.16
BOTTOM (filter pack or open hole):	15.0	981.66
MIDPOINT (filter pack or open hole):	9.3	987.41
PUMP INTAKE:	12.23	984.43
WATER LEVEL (average):	3.49	993.17

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	17 samples	03/11/91	10/08/03
LOW-FLOW SAMPLING METHOD:	8 samples	06/08/00	10/26/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/05/04	.	10/26/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.15 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	18	5,501 mg/L	09/20/93	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	23	1,757 µg/L	05/05/04	Increasing
GROSS ALPHA (15 pCi/L):	7	288 pCi/L	12/14/91	Indeterminate
GROSS BETA (50 pCi/L):	21	6,100 pCi/L	06/08/00	Decreasing

WELL GW-633

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during May 1990, completed with a screened monitored interval from 3.5 to 15 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). Note that the proportionately long (11.5 ft) monitored interval for the well is intended to straddle the water table and facilitate the detection of immiscible petroleum products. The well is located in Bear Creek Valley (BCV) near the west end of Y-12, at the Rust Garage (RG) about 700 ft southeast of the former S-3 Ponds. The RG once housed several petroleum fuel underground storage tanks (USTs) and associated service lines and dispenser, a fuel unloading station, and drum storage area for used oil (DOE 1998). Located directly west of the RG, the former S-3 Ponds were four unlined surface impoundments that were used from 1951 to 1984 primarily for the percolation/evaporation of nitric acid effluent (with depleted uranium in solution) piped from process buildings in the central section of Y-12. Each pond contains several feet of sludge produced during the neutralization of the liquid wastes prior to RCRA closure of the site in 1988, when the ponds were filled with aggregate and covered with a multilayer low-permeability cap (including an asphalt-paved parking lot).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well, with the conventional sampling method used to obtain 17 samples between March 1991 and October 2003, and the low-flow sampling method used to obtain eight samples between June 2000 and October 2004. Note that the sampling history spans a six-year period (March 1994 – June 2000) when samples were not collected from the well.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher nitrate concentrations and lower VOC concentrations and gross beta activities than samples obtained with the low-flow sampling method (AJA 2001). However, as illustrated by the data summarized in Table 1, the results of "paired sampling" performed during May and October 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, do not confirm the sampling-method bias. Thus, the significant difference between the historical conventional sampling results and the more recent low-flow sampling results probably reflect a corresponding change in contaminant flux at some time during the six-year gap (March 1994 to June 2000) in the sampling history for the well.

Very high total dissolved solids (TDS) and acidic pH are distinguishing characteristics of the groundwater samples from this well and are a direct consequence of contamination emplaced during the historical operation of the former S-3 Ponds (see Section 5.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 3 ft bgs and exhibits moderate (<5 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-633 indicate southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 4,316 – 33,798 mg/L, excluding an outlier (1,326 mg/L) in November 1993;
- pH of 5.1 – 5.84 (field measurements), excluding an outlier (9) in November 1993;
- high concentrations (>1,000 mg/L) of nitrate and calcium;
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations);
- various causes (low ion concentrations and/or elevated detection limits) of an unacceptably high relative percent difference (RPD) between respective summed millequivalent concentrations of anions and cations (i.e., the ion-charge balance error exceeds 20%) determined for samples collected June 1991 (RPD = -70.2%), September 1991 (RPD = 23.4%), August 1992 (RPD = -24%), November 1993 (RPD = -62.9%), and March 1994 (RPD = 40.9%); and
- elevated total concentrations of several trace metals, particularly barium (>8 mg/L) and strontium (>4 mg/L), that substantially exceed the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, which are based on respective monitoring data reported for the 21 groundwater samples collected from the well since March 1991, the principal contaminants present in the groundwater at this well are nitrate, VOCs, and gross beta activity.

5.1 NITRATE

Each groundwater sample contained nitrate concentrations of at least 800 mg/L, with concentrations above 1,000 mg/L reported for all but two of the samples (Table 1). The source of the nitrate is the former S-3 Ponds, the operation of which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale and created a mound in the water table that facilitated contaminant transport/migration east of the hydrologic divide separating the Bear Creek and UEFPC watersheds. Nitrate and other inorganic contaminants within the plume (e.g., uranium) were principal components of the wastes disposed at the site, but some of the inorganic contaminants (e.g., barium and strontium) were dissolved from bedrock minerals. With concentrations in excess of 10,000 mg/L, nitrate is the primary inorganic contaminant in the plume. Based on the network of existing monitoring wells completed in the Nolichucky Shale east of the former S-3 Ponds, elevated nitrate concentrations (i.e., >10 mg/L) extend laterally at least 5,000 ft eastward (parallel with geologic strike) and vertically (parallel with geologic dip) at least 150 ft bgs. The distribution of nitrate in the groundwater is believed to reflect: (1) relatively rapid transport/migration via shallow groundwater flow/transport pathways (<30 ft bgs) which terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC within 1,000 ft of the former S-3 Ponds; and (2) substantially slower migration deeper in the bedrock via much longer strike-parallel groundwater flow/transport pathways (e.g., bedding-plane fractures), possibly bound to a relatively narrow band near the middle of the Nolichucky Shale, toward basement sumps in Bldgs. 9204-4, 9201-5, 9201-4, and 9204-2 (DOE 1998).

Excluding the nitrate results that are considered qualitative because of ion charge-balance errors determined for the applicable groundwater samples (see Section 4.0), all of the samples had nitrate concentrations exceed 1,000 mg/L (Table 2), including the samples collected most recently (May and October 2004). Nevertheless, the nitrate concentrations detected in the samples obtained with the low-flow sampling method since May 2003 (1,390 mg/L) are the lowest ever reported for the well and are substantially below the historical maximum value (5,501 mg/L in September 1993). These results illustrate the clearly decreasing long-term concentration trend shown by a time-series plot of the nitrate data (Figure 1), which spans a 6-year gap (March 1994 – June 2000) in the sampling history for the well. Decreasing concentrations of nitrate (and other inorganic contaminants) in the shallow groundwater at this well suggest that the center of mass of the S-3 Ponds contaminant plume in the Nolichucky Shale east of the site currently lies along geologic strike to the east of the well (DOE 1998).

Excluding the nitrate results for groundwater samples with unacceptable ion charge-balance errors (see Section 4.0), a times-series plot of the nitrate concentrations shows two trend lines separated by gap in the sampling history (Figure 1). Both trends reflect decreasing nitrate concentrations and show substantial temporal variability. The decreasing concentration trends are consistent with continued eastward migration of the center of mass of the S-3 Ponds contaminant plume (DOE 1998), although this seems an unlikely explanation for the wide temporal concentration changes. Additionally, there is not any consistent relationship between seasonal flow conditions and temporal fluctuations in nitrate concentrations, with temporal "peak" concentrations reported for samples collected during both seasonally high and low groundwater flow conditions (Figure 1).

5.2 URANIUM

Total uranium concentrations at or above the applicable analytical reporting limits were detected in all of the groundwater samples (Table 1), although the historical maximum concentration (0.011 mg/L in March 1994) is less than the MCL (0.03 mg/L). However, the historical maximum value appears to be an outlier compared to the other uranium results, all of which are less than the uranium UTL (0.005 mg/L) applicable to this well (HSW 1996). As noted previously, uranium (and uranium isotopes) was entrained in the nitric-acid wastes disposed at the former S-3 Ponds and is a primary component of the contaminant plume originating from the site. Assuming a heterogeneous mixture of nitrate and uranium within the contaminant plume, the combination of relatively low uranium levels with very high nitrate concentrations seems conspicuous, especially considering that the acidic pH of the groundwater (see Section 4.0) would be expected to accommodate uranium species (uranyl cations) known to form mobile complexes in groundwater (Fetter 1993). Nevertheless, other nearby wells at the RG (e.g., wells GW-505 and GW-631) also yield groundwater samples with similarly low uranium concentrations. This suggests that local geochemical conditions may selectively enhance the relative attenuation of uranium compared to that of nitrate.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 3): benzene, bromoform, chloroform (CLF), dimethylbenzene (DMB), ethylbenzene, methylene chloride (MC), PCE, styrene, toluene, TCE, 11DCE, and 12DCE (c12DCE). Although some of these compounds (e.g., PCE) are confirmed components of the contaminant plume originating from the former S-3 Ponds, others (e.g., benzene) are not, and their presence in the groundwater at well GW-633 indicates transport/migration from other potential sources of VOCs, including former petroleum fuel underground storage tanks at the RG that are known local sources of the petroleum hydrocarbons in the shallow groundwater (DOE 1998).

Based on frequency of detection and relative concentrations, the primary VOCs in the groundwater samples are benzene and PCE, both of which were detected in all of the samples (Table 3), with the most recent sampling results (May and October 2004) showing benzene concentrations above 850 µg/L and PCE concentrations at or above 200 µg/L. Secondary VOCs in the samples are CLF, MC, TCE, and toluene, each of which was detected (excluding false positive results) in all but six of the samples (Table 3), with the most recent sampling results showing TCE and toluene concentrations above respective MCLs (5 µg/L). The remaining VOCs have been more consistently and frequently detected in samples collected since June 2000 and show a wide range of concentrations, including estimated values below 5 µg/L for several compounds (e.g., 11DCE) and dimethylbenzene concentrations above 100 µg/L (Table 3).

As illustrated by the data summarized below, the concentrations of some of the VOCs in the groundwater samples, notably PCE and benzene, have increased substantially since the early 1990s, whereas the concentrations of other compounds in the samples, including TCE and 12DCE (total), have not.

VOC	Concentration (µg/L)							
	March 1991	March 1992	March 1993	March 1994	June 2000	April 2002	May 2003	May 2004
PCE	70	91	60	57	200	180	290	240
TCE	8	11	7	4 J	9	8	8	8
12DCE	2 J	.	3 J	.	7	10	9	14
Chloroform	FP	40	24	12	26	20	18	18
MC	18	FP	18	FP	35	36	30	28
Benzene	3 J	3 J	6	6	650	840	1,200	1,300
Toluene	3 J	3 J	3 J	5	150	4 J	6	3 J
DMB	5	.	1 J	.	250	110	130	140
Note: "." = Not detected; J = Estimated value below analytical reporting limit								

It is not clear from the available data why individual compounds exhibit such divergent long-term concentration trends. Results from "paired" sampling during May and October 2003 (see Section 2.0) suggest that the divergent trends probably are not artifacts of the change from conventional sampling to low-flow sampling. Likewise, the divergent concentrations trends are probably not sampling and/or analytical artifacts. Assuming the groundwater contains a generally heterogeneous mixture of dissolved VOCs, differential advective flux (different transport rates for different compounds) in the shallow flow system also seems unlikely.

A time-series plot of summed VOCs in samples from the well shows an increase in VOC concentrations that spans a six-year time gap in the sampling history of the well (Figure 2). Although originally interpreted as a potential artifact of the change in sampling methods (see Section 2.0), this significant increase in VOC concentrations probably reflects increased contaminant flux from the S-3 Site contaminant plume and the RG.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for nine groundwater samples exceed the MDA and corresponding CE (Table 2), and all but two of these results exceed the MCL for gross alpha activity (15 pCi/L). However, none of the samples collected since April 2002 had gross alpha activity above the MDA, although the apparent lack of gross alpha activity may be an artifact of the elevated MDAs (e.g., MDA = 290 pCi/L in October 2003). The high MDAs reflect the analytical interferences caused the very high TDS in the (unfiltered) samples. Nevertheless, available data do not indicate the presence of alpha particle-emitting isotopes in the groundwater at this well; five samples were analyzed for uranium isotopes, with U-234 and U-235 values that exceed the corresponding MDA and CE reported only for the sample collected in December 1991 (U-234 = 246 pCi/L and U-238 = 287 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample had gross beta activity above the MDA and corresponding CE (Table 2), with the most recent sampling results (May and October 2004) showing values above 2,000 pCi/L, which is several orders-of-magnitude higher than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The primary source of the gross beta activity is Tc-99, which is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (the only site at Y-12 to receive wastes containing Tc-99). As shown in the following data summary, Tc-99 was detected (i.e., > MDA and CE) at very high concentrations in five of the seven samples that were analyzed for Tc-99.

Sampling Date	Tc-99 (pCi/L)	Gross Beta Activity (pCi/L)
09/19/91	<CE	852
12/14/91	27,200	584
04/30/92	7,920	441
08/14/92	2,740	512
11/04/92	<CE	40
06/08/00	6,600	6,100
10/24/00	7,500	4,100

The Tc-99 results substantially exceed the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in Nolichucky Shale east of the former S-3 Ponds, the extent of elevated (>50 pCi/L) gross beta activity in the groundwater suggests that the distribution of Tc-99 closely mirrors that of nitrate (see Section 5.1). Accordingly, the sampling results for well GW-633 are representative of gross beta/Tc-99 activity at shallow depths in relatively short groundwater flow/transport pathways that terminate in buried storm drains and utilities, building basement sumps, and the buried northern tributaries and original mainstem of UEFPC (DOE 1998).

Aside from the unusually low levels of gross beta activity reported for the groundwater samples collected in November 1992 (40 pCi/L), March 1993 (75.6 pCi/L), and November 1993 (43.8 pCi/L), which are all outliers compared to the other results (Table 2), the remaining samples had gross beta activity ranging between 261 pCi/L (March 1994) and 6,100 pCi/L (June 2000). Also, gross beta activity above 2,000 pCi/L was reported for each sample collected since June 2000, whereas all the samples collected before then had gross beta activity below 1,000 pCi/L. Moreover, the results of "paired" sampling in May and October 2003 suggest that the difference in gross beta activity is not an artifact of the groundwater sampling method (see Section 2.0). Thus, the higher levels of gross beta activity potentially reflect a significant increase in the relative flux of Tc-99 along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

Excluding the suspected outliers noted above, a times-series plot of the other results for gross beta activity shows two trend lines separated by the six-year gap in the sampling history for the well (Figure 3). Data obtained before the sampling gap define an indeterminate trend and the data obtained after the sampling gap show a generally decreasing trend. Also, there is not any consistent relationship between seasonal flow conditions and temporal fluctuations in gross beta activity, with temporal "peak" concentrations reported for samples collected during both seasonally high and low groundwater flow conditions.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-633: Consecutive daily sampling results for summed VOCs and other selected analytes, May and October 2003

Analyte	Units	May 13-14, 2003		October 7-8, 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	5.53	5.51	5.6	5.61
Dissolved Solids	mg/L	8,620	9,250	9,010	8,860
Suspended Solids	mg/L	2	13	<1	28
Calcium	mg/L	2,030	2,020	1,820	2.030
Nitrate	mg/L	1,390	1,530	1,540	1,210
Barium	mg/L	9.32	9.23	8.03	8.99
Strontium	mg/L	4.86	4.85	4.27	4.76
Summed VOCs	µg/L	1,704	1,742	1,167	1,735
Gross Alpha Activity	pCi/L	<MDA	<MDA	<MDA	<MDA
Gross Beta Activity	pCi/L	4,000	4,200	2,900	3,900

Table 2. Well GW-633: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
03/11/91	5,380	0.004	< CE	603.66
06/20/91	[3,289]	0.005	84.07	268.39
09/19/91	[3,686]	0.003	56.7	852
12/14/91	5,470	0.004	288	584
03/06/92	4,613	0.003	< CE	709
04/30/92	4,583	0.002	123	441
08/14/92	[6,387]	0.002	175	512
11/04/92	4,448	0.003	25.4	40
03/03/93	3,874	0.003	13.5	75.6
06/21/93	4,300	0.003	< CE	364
09/20/93	5,501	0.002	< CE	581
11/19/93	[841]	0.003	2.85	43.8
03/03/94	[861]	0.011	< CE	261
06/08/00	2,200	0.0018	<MDA	6,100
10/24/00	1,890	0.0022	34	4,100
04/23/02	1,520	0.00156	<MDA	3,000
10/17/02	1,510	0.00191	<MDA	3,700
05/13/03	1,390	0.00135	<MDA	4,000
05/14/03	1,530	0.00146	<MDA	4,200
10/07/03	1,540	0.00196	<MDA	2,900
10/08/03	1,210	0.00155	<MDA	3,900
05/05/04	1,280	0.000928	<MDA	2,600
10/26/04	1,270	0.00147	>MDA	2,400
MCL	**10**	**0.03**	**15**	**50***

Note: [ ] = Result considered qualitative because of ion charge-balance error; * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 3. Well GW-633: summary of VOC results

Date Sampled	Concentration (µg/L)						
	PCE	**TCE**	**12DCE (Total)**	**c12DCE**	**11DCE**	**CLF**	**MC**
03/11/91	70	8	2 J	NR	1 J	FP	18
06/20/91	88	11	0.9 J	NR	1 J	37	24
09/19/91	64	8	2 J	NR	0.8 J	24	FP
12/14/91	93	10	.	NR	1 J	35	28
03/06/92	91	11	.	NR	.	40	FP
04/30/92	85	9	.	NR	1 J	33	32
08/14/92	76	8	2 J	NR	.	30	FP
11/04/92	79	9	.	NR	.	31	32
03/03/93	60	7	3 J	NR	.	24	18
06/21/93	74	8	4 J	NR	2 J	28	29
09/20/93	78	8	3 J	NR	1 J	27	24
11/19/93	30	2 J	.	NR	0.8 J	6	FP
03/03/94	57	4 J	.	NR	1 J	12	FP
06/08/00	200	9	7	7	.	26	35
10/24/00	170	8	11	11	.	24	38
04/23/02	180	8	10	10	3 J	20	36
10/17/02	170	6	10	10	.	17	27
05/13/03	290	8	9	9	3 J	18	30
05/14/03	240	8	8	8	3 J	20	33
10/07/03	140	6	21	21	2 J	12	19
10/08/03	230	9	8	8	3 J	23	32
05/05/04	240	8	14	14	3 J	18	28
10/26/04	200	4 J	14	14	2 J	13	17
MCL	**5**	**5**	**NA**	**70**	**7**	**80**	**NA**

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported; * MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

Table 3. (continued)

Sampling Date	Concentration (µg/L)				
	Benzene	Ethylbenzene	Toluene	Dimethylbenzene	Styrene
03/11/91	3 J	.	3 J	5	.
06/20/91	1 J	.	1 J	.	.
09/19/91	2 J	.	1 J	.	.
12/14/91	2 J	.	2 J	1	.
03/06/92	3 J	.	3 J	.	.
04/30/92	3 J	.	3 J	.	.
08/14/92	3 J	.	FP	.	.
11/04/92	5	3 J	4 J	3 J	.
03/03/93	6	.	3 J	1 J	.
06/21/93	8	.	6	4 J	.
09/20/93	10	1 J	8	6	.
11/19/93	4 J	.	4 J	3 J	.
03/03/94	6	.	5	.	.
06/08/00	650	34	150	250	.
10/24/00	560	26	55	190	.
04/23/02	840	20	4 J	110	.
10/17/02	850	8	2 J	95	.
05/13/03	1,200	7	6	130	.
05/14/03	1,200	32	13	180	.
10/07/03	900	.	1 J	62	1
10/08/03	1,200	25	9	190	.
05/05/04	1,300	.	3 J	140	.
10/26/04	870	1 J	.	48	.
MCL	**5**		**5**		

Note: "." = Not detected; J = Estimated value below analytical reporting limit

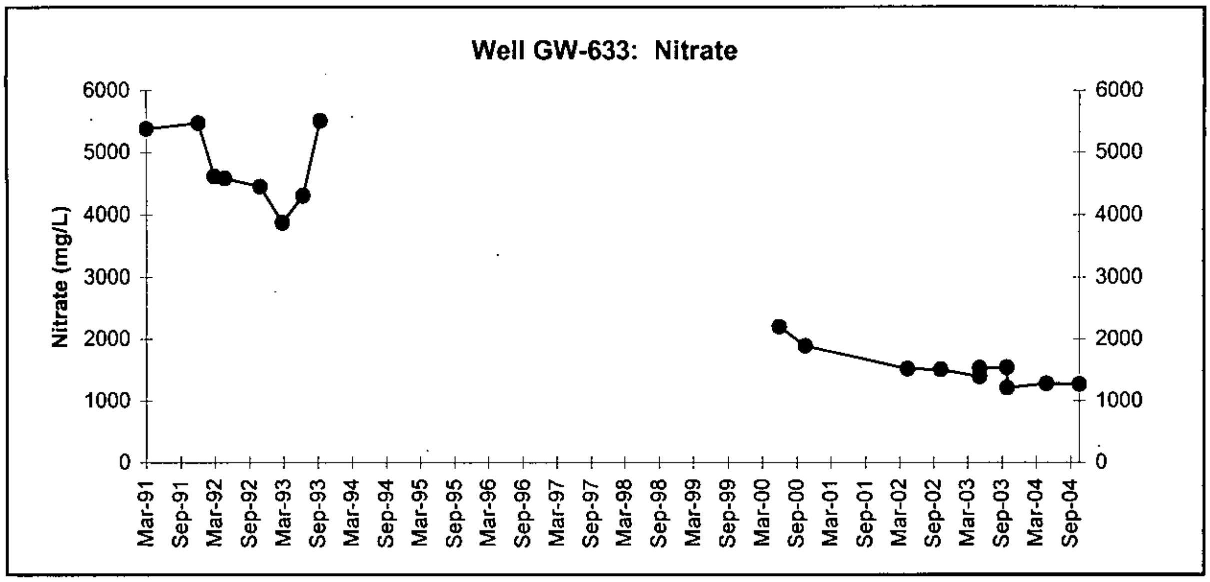


Figure 1

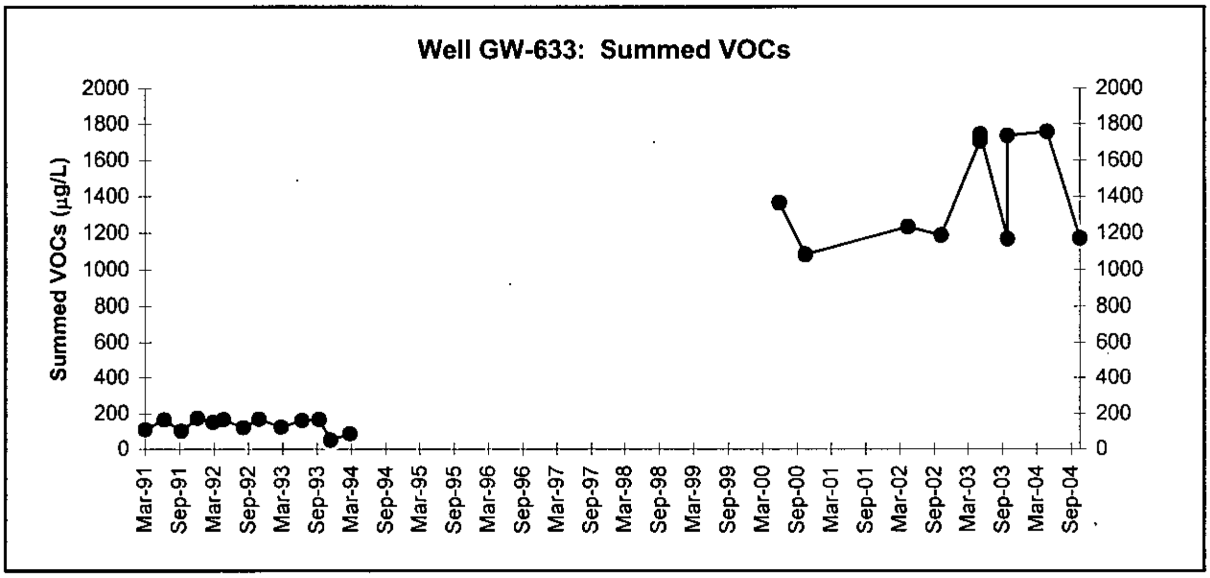


Figure 2

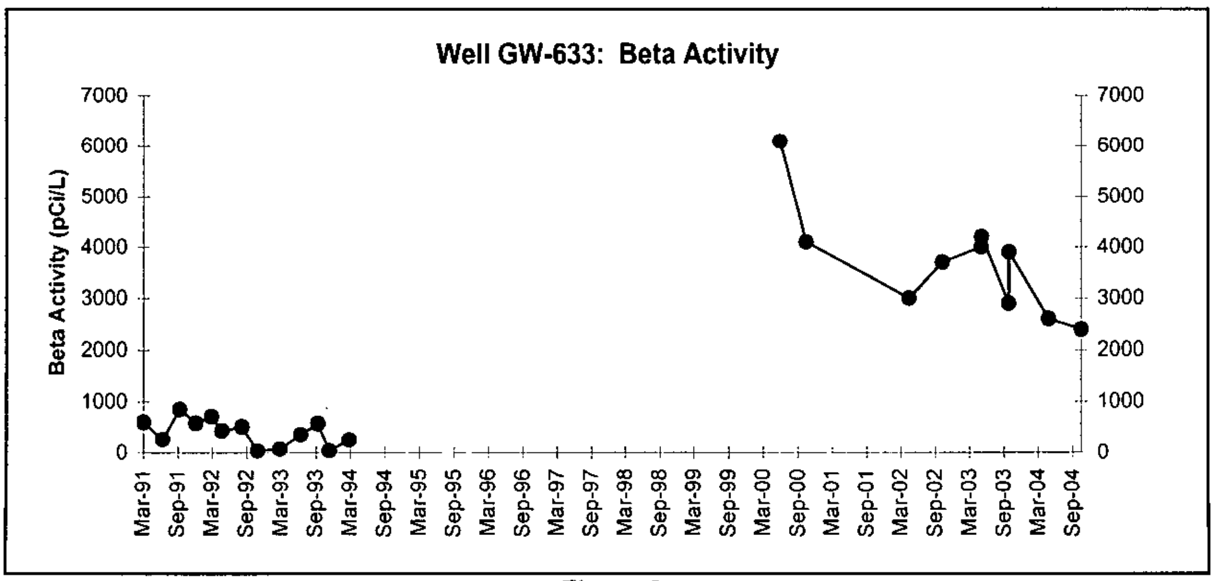


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-639

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 45,259.76
Y-12 GRID NORTH COORDINATE: 29,626.12
SURFACE ELEVATION: 937.98 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/15/90 PAIRED/CLUSTERED WITH: GW-640 GW-641
TAG DEPTH (measured): 129.64 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 940.70 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	95.5	842.48
BOTTOM (filter pack or open hole):	125.5	812.48
MIDPOINT (filter pack or open hole):	110.5	827.48
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	8.9	929.08

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	13 samples	12/06/90	10/15/93
LOW-FLOW SAMPLING METHOD:	14 samples	04/05/01	11/11/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/10/04	06/08/04	09/14/04	11/11/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.74 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-639

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1990, completed with an open-hole monitored interval from 95.5 to 125.5 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well forms a cluster with wells GW-640 and GW-641 and is located in Bear Creek Valley west of Y-12, about 750 ft north of Bear Creek Road and 1,000 ft east (hydraulically upgradient) of the Bear Creek Burial Grounds (BCBG) waste management area. The BCBG encompass several closed former hazardous waste disposal units, including numerous waste disposal trenches that received a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. The various components of the BCBG are covered by low-permeability, multilayer caps installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between December 1990 and October 1993, and the low-flow sampling method used to obtain 14 samples between April 2001 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 9 ft bgs. Presampling depth-to-water measurements for the well indicate moderate water-level fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 526 – 587 mg/L;
- pH (field measurements) of 8.9 – 9.7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion. Contaminant concentrations in the well are based on the analytical results reported for 26 groundwater samples collected from the well since January 1991.

5.1 NITRATE

None of the groundwater samples analyzed for nitrate (between March 1991 and November 2001) had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

Three of the groundwater samples (between March 1991 and May 2003) had uranium concentrations above the analytical reporting limit, with the concentration (0.001 mg/L in each sample) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in three of the 24 groundwater samples analyzed for VOCs: benzene (2 μg/L) in November 2001, acetone (0.4 μg/L) in November 2003; and toluene (0.1 μg/L) in September 2004. These results may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Three of the groundwater samples (between March 1991 and May 2003) had gross alpha activity above the applicable MDA and corresponding CE, with the maximum activity (2.15 pCi/L in September 1991) being substantially below the MCL for gross alpha activity (15 pCi/L November 1991).

5.5 GROSS BETA ACTIVITY

One of the groundwater samples (between March 1991 and May 2003) had gross beta activity above the applicable MDA and corresponding CE, and the result (3.61 pCi/L) is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	50 - 500	ND	ND

GW-653

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek Burial Grounds
Y-12 GRID EAST COORDINATE: 42,317.29
Y-12 GRID NORTH COORDINATE: 29,660.39
SURFACE ELEVATION: 928.85 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/10/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 41.53 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 931.84 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	26.3	902.55
BOTTOM (filter pack or open hole):	39.0	889.85
MIDPOINT (filter pack or open hole):	32.7	896.20
PUMP INTAKE:	33.51	895.34
WATER LEVEL (average):	19.39	909.46

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 40

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	26 samples	03/23/91	08/05/03
LOW-FLOW SAMPLING METHOD:	14 samples	03/10/98	08/04/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/25/04	.	08/04/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.94 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	38	212 µg/L	02/03/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-653

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1990, completed with a screened monitored interval from 26.3 to 39 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located at the Bear Creek Burial Grounds (BCBG) waste management area (WMA), about 500 ft west of Burial Ground (BG) A-South. The BCBG includes numerous hazardous and nonhazardous waste disposal units that received a mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) generated at Y-12. Liquid wastes included about two million gallons of waste oils and machine coolants, and borax waste water, all or most of which may have contained varying amounts of radioisotopes (primarily uranium isotopes). In 1989, the waste-disposal units in the BCBG WMA were covered with multi-layer, low-permeability caps installed during RCRA closure of the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Forty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 26 samples between March 1991 and August 2003, and the low-flow sampling method used to obtain 14 samples between March 1998 and August 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method had substantially different contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). However, results of "paired" sampling performed during February and October 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, do not confirm the apparent sampling-method bias. As illustrated by the data summarized in Table 1, groundwater samples obtained with each sampling method have similar geochemical characteristics and the VOC results are somewhat inconclusive, with the highest and lowest summed VOC concentrations reported for the samples obtained with the low-flow method. Thus, the difference between the conventional sampling and low-flow sampling results are probably attributable to an overall increase in VOC concentrations (see Section 5.3).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (the Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek that traverse the Nolichucky Shale and are probably the ground surface expression of large-scale cross-strike fractures (or fracture zones) in the bedrock (DOE 1997). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements for the well show that the static groundwater level in the well typically occurs at an average depth of about 19 ft bgs and exhibit seasonal fluctuations up to 8 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring in the vicinity of well GW-653 indicate south and southwesterly flow toward the Maynardville Limestone and the main channel of Bear Creek. However, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Consequently, the direction(s) of groundwater flow in the vicinity of well GW-653 may be primarily westward (parallel with geologic strike) toward discharge areas in a northern tributary of Bear Creek (NT-8) approximately 400 ft west of the well.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields distinctive and unique calcium-magnesium-bicarbonate groundwater generally characterized by:

- extremely low TDS (<50 mg/L), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths;
- pH (field measurements) of about 4.4 - 5.9;
- very low concentrations of all the major anions and cations, including calcium (2 mg/L), magnesium (1 mg/L), and bicarbonate (15 mg/L); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Only the nitrate concentration reported for the groundwater sample collected in August 1999 (0.04766 mg/L) exceeds the applicable analytical reporting limit, and this result is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Nine groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.002 mg/L in March and June 1991) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): acetone, PCE, TCE, 11DCA, 11DCE, 12DCE (c12DCE), and 111TCA. Each of these compounds, except acetone, is a confirmed component of a plume of dissolved VOCs in the groundwater downgradient of the waste disposal areas within BG-A North and BG-A South. Considering the shallow depth of the well and the hydrogeologic characteristics of the Nolichucky Shale, the VOCs are probably moving westward via strike-parallel groundwater flow/transport pathways that discharge into the northern tributary of Bear Creek (NT-8) west the BCBG WMA (DOE 1997).

The primary VOCs in the groundwater samples are PCE, TCE and 12DCE (c12DCE); at least one of these compounds was detected in each groundwater sample (Table 2). The bulk of the results for PCE and TCE are estimated values below 5 µg/L, whereas the historical maximum concentration of 12DCE exceeds 150 µg/L. Also, the most recent monitoring results show concentrations of PCE, TCE and c12DCE below respective drinking water MCLs (Table 2). Acetone was detected only in one sample and is considered to be an outlier.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample (Figure 1) shows an indeterminate trend between March 1991 (17 µg/L) and August 1999 (24 µg/L), followed by an increasing trend through March 2003 (100 µg/L), then significantly lower VOC concentrations from August 2003 (55 µg/L) through August 2004 (38 µg/L). Although the increasing trend nearly coincides with the change from conventional sampling to low-flow sampling, the higher VOC concentrations do not appear to be an artifact of the latter sampling method (see Section 2.0 and Table 3). Thus, the increasing concentration trend probably reflects a corresponding increase in the relative flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, the VOC data show cyclic temporal concentration fluctuations that correlate with seasonal groundwater flow conditions: summed VOC concentrations are highest in the samples collected during seasonally high flow conditions (winter and spring). This relationship suggests seasonally (and episodically) variable flux of dissolved VOCs along the groundwater flow/transport pathways monitored by the well. Furthermore, the recent decrease in concentrations suggests that a "pulse" of dissolved VOCs may have been intercepted by the monitored interval of the well.

5.4 GROSS ALPHA ACTIVITY

Fourteen groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (12.9 pCi/L) being slightly below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (19 pCi/L in December 1994) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-653: consecutive daily conventional/low-flow sampling results for selected analytes

Analyte	Units	February 2003		August 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	5.08	4.74	4.79	4.46
Dissolved Oxygen	ppm	4.4	3.62	2.87	3.7
REDOX	mV	264	235	247	291
Dissolved Solids	mg/L	34	28	28	37
Suspended Solids	mg/L	.	16	.	46
Calcium	mg/L	2.02	2.22	2.03	2.31
Chloride	mg/L	1.09	1.05	1.04	0.98
Barium	mg/L	0.034	0.0407	0.0336	0.0463
Iron	mg/L	.	0.342	.	0.463
Summed VOCs	ug/L	212	168	55	79

Notes: "." = Not detected

Table 2. Well GW-653: summary of VOC results

Date Sampled	VOC Concentration (μg/L)						
	PCE	TCE	12DCE (Total)	c12DCE	11DCA	11DCE	111TCA
Conventional Sampling							
03/23/91	4 J	.	13	NR	.	.	.
06/21/91	2 J	.	9	NR	.	.	.
09/15/91	3 J	0.7 J	8	NR	.	.	.
12/11/91	3 J	0.7 J	7	NR	.	.	.
03/24/92	3 J	.	10	NR	.	.	.
06/14/92	2 J	.	6	NR	.	.	.
09/04/92	2 J	.	6	NR	.	.	.
12/02/92	3 J	1 J	9	NR	.	.	.
03/01/93	2 J	.	7	NR	.	.	.
10/10/93	2 J	.	7	NR	.	.	.
02/26/94	5	2 J	20	NR	2 J	.	0.7 J
06/09/94	2 J	0.6 J	6	NR	.	.	.
09/13/94	2 J	.	9	NR	.	.	.
12/07/94	2 J	.	10	NR	.	.	.
03/27/95	3 J	1 J	21	NR	1 J	.	.
06/20/95	2 J	.	17	NR	.	.	.
09/20/95	2 J	1 J	15	NR	.	.	.
12/08/95	4 J	2 J	31	NR	2 J	1 J	FP
03/26/96	4 J	2 J	31	NR	2 J	1 J	.
08/28/96	2 J	.	13	NR	.	.	.
02/06/97	3 J	2 J	26	26	2 J	1 J	1 J
09/03/97	.	.	6	6	.	.	.
02/04/03	8	6	140	140	9	5	.
08/05/03	6	3 J	64	64	4 J	2 J	.
Low-Flow Sampling							
03/10/98	2 J	1 J	23	23	2 J	1 J	.
09/01/98	1 J	.	7	7	.	.	.
03/23/99	3 J	2 J	32	32	2 J	.	.
08/19/99	2 J	.	22	22	.	.	.
02/17/00	8	5	89	89	5	.	.
08/21/00	5	3 J	66	66	4 J	.	.
02/12/01	8	6	130	130	10	4 J	.
07/25/01	10	6	120	120	9	4 J	.
02/12/02	11	8	170	170	12	5	2 J
07/25/02	10	6	130	130	9	4 J	.
02/03/03	9	7	180	180	11	5	.
08/04/03	4 J	2 J	45	45	3 J	1 J	.
02/25/04	4 J	2 J	45	45	3 J	1 J	.
08/04/04	2 J	.	34	34	2 J	.	.
MCL	**5**	**5**	**NA**	**70**	**NA**	**7**	**200**

Notes: "." = Not detected; J = Estimated concentration; FP = False positive; NR = Not reported; NA = Not applicable

Table 3. Well GW-653: comparison of conventional and low-flow sampling results for VOCs

VOC	VOC Concentration (µg/L)					
	February 2003			August 2003		
	Low-Flow Sampling	Conventional Sampling	% Change	Low-Flow Sampling	Conventional Sampling	% Change
PCE	9	8	-11%	4 J	6	+50%
TCE	7	6	-14%	2 J	3 J	+50%
c12DCE	180	140	-22%	45	64	+42%
11DCE	5	5	-	1 J	2 J	+100%
11DCA	11	9	-18%	3 J	4 J	+33%
Notes: "." = Not detected; J = Estimated value below the analytical reporting limit						

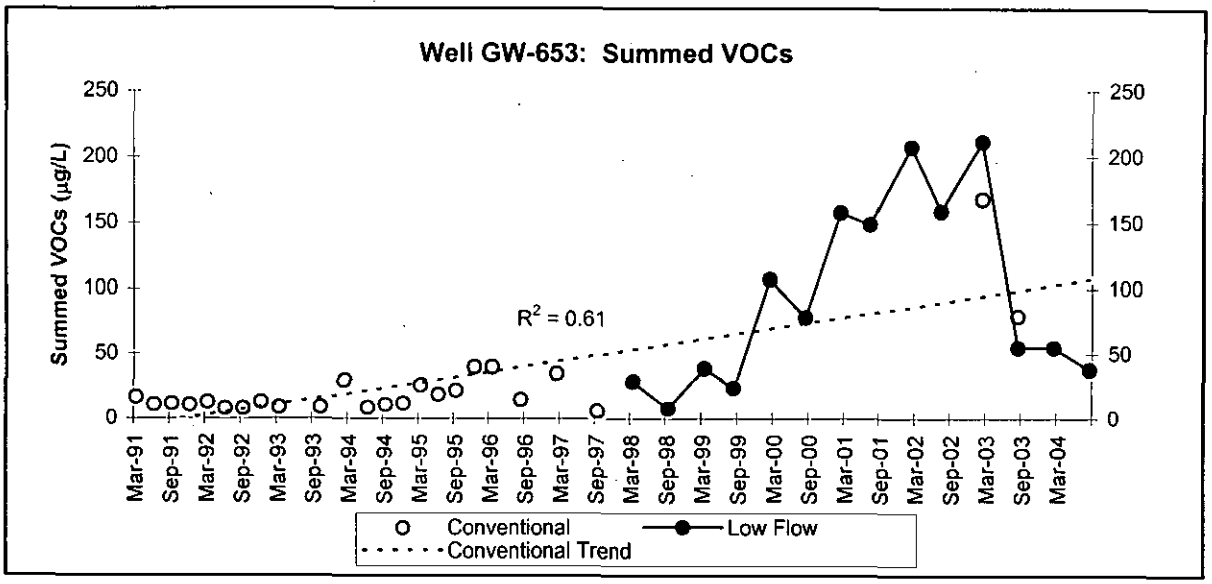

Well GW-653: Summed VOCs
Summed VOCs (µg/L)
250
200
150
100
50
0
R^2 = 0.61
Mar-91
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Conventional
Low Flow
Conventional Trend

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	>5,000	.	.

GW-658

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: East End Fuel Facility
Y-12 GRID EAST COORDINATE: 62,146.20
Y-12 GRID NORTH COORDINATE: 29,638.24
SURFACE ELEVATION: 942.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/31/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 20.64 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 944.80 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	6.9	935.14
BOTTOM (filter pack or open hole):	19.1	922.94
MIDPOINT (filter pack or open hole):	13.0	929.04
PUMP INTAKE:	13.83	928.21
WATER LEVEL (average):	8.09	933.95

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	20		
CONVENTIONAL SAMPLING METHOD:	14 samples	03/09/91	03/19/97
LOW-FLOW SAMPLING METHOD:	6 samples	06/22/98	05/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/10/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.85 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	18	77,800 µg/L	05/08/92	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-658

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1990, completed with a screened monitored interval from 6.9 to 19.1 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). Note that the large monitored (screened) interval in the well is intended to straddle the water table during seasonally high and low flow conditions and facilitate detection of light non-aqueous phase liquids (LNAPL). The well is located near Bldg. 9754-2 at the East End Fuel Facility, which is in Bear Creek Valley near the east end of Y-12, at the intersection of First Street and Agate Drive.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between March 1991 and March 1997, and the low-flow sampling method used to obtain six samples between June 1998 and May 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of Upper East Fork Poplar Creek (UEFPC) and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits minor (<2 ft) seasonal fluctuations. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-658 indicate south and southeasterly flow toward the Maynardville Limestone and the UEFPC drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 216 – 624 mg/L;
- pH (field measurements) of 5.6 – 6.5;
- low molar proportions of chloride, potassium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit.

5.2 URANIUM

Four groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.005 mg/L in August 1992) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 1): acetone, benzene, ethylbenzene, total xylene, toluene, MC, 1,2-dichloropropane (12DCP), TCE, 12DCE, 12DCA, and 111TCA. These compounds are components of a plume of dissolved VOCs, dominated by petroleum hydrocarbons, emplaced during historical operations of three former underground storage tanks (USTs) at the Bldg. 9754-2 Fuel Facility. The USTs (the Garage Underground Tanks and the East End Fuel Facility) were used to store gasoline, diesel fuel, spent chlorinated solvents and waste oils; they were excavated and removed during RCRA closure of the site in 1989 (DOE 1998). The RCRA closure addressed cadmium-contaminated soils at the site, which were excavated and removed, but did not encompass groundwater remediation, including recovery of free-product.

The primary compounds in the groundwater samples are petroleum hydrocarbons; concentrations of benzene, ethylbenzene, total xylene, and toluene reported for all but one of the groundwater samples exceed 1,000 µg/L, with respective historical maximum concentrations of 20,000 µg/L, 2,300 µg/L, 43,000 µg/L, and 12,000 µg/L (Table 1). The substantially lower concentrations of these compounds reported for the sample collected in March 1992 are possibly outliers. Also, the most recent sampling results show that the summed concentrations of these petroleum hydrocarbons remain above 10,000 µg/L and most results substantially exceed respective drinking water MCLs. Presampling measurements show very low levels of dissolved oxygen in the groundwater at this well (e.g., 0.78 in May 2004), and anaerobic conditions are not conducive to biotic degradation of petroleum hydrocarbons. This may explain why the concentrations of these compounds remain so high considering that the gasoline and diesel USTs were removed from service 15 years ago.

Aside from the petroleum hydrocarbons, 12DCA is the only other VOC consistently detected in the groundwater samples; 12DCA was detected in all but four of the samples, with four of the concentrations exceeding 1,000 µg/L or more (Table 1). The conspicuously low 12DCA concentration evident in March 1992 (34 µg/L) and the non-detect 12DCA result for the sample collected in October 2002 are possible outliers. The remaining VOCs have been detected sporadically, with TCE, 12DCE, and 111TCA detected only in one sample each.

Excluding the analytical results for the sample collected in March 1992, a time-series plot of summed benzene, ethylbenzene, total xylene, and toluene concentrations reported for each groundwater sample (Figure 1) shows a progressively increasing concentration trend between March 1991 (8,100 µg/L) and November 1993 (32,300 µg/L) followed by a more widely fluctuating but decreasing trend through May 2004 (21,500 µg/L). Interestingly, a plot of the summed concentrations of 12DCA and the other VOCs generally mirrors that of the petroleum hydrocarbons (Figure 2). This suggests a common source (the USTs) for both types of VOCs, with the increasing and decreasing concentration trends reflecting corresponding changes in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in this well.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (14.2 pCi/L in May 1992) being slightly below the drinking water MCL for gross alpha activity (15 pCi/L). However, compared to the other gross alpha results which are all less than 5 pCi/L, the historical maximum value is an outlier.

5.5 GROSS BETA ACTIVITY

Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (21.2 pCi/L in May 1992) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-658: summary of VOC results

Date Sampled	VOC Concentration (µg/L)				
	Benzene	Toluene	Ethylbenzene	Total Xylene	12DCA
03/09/91	4,300	900	300	2,600	.
06/18/91	7,200	1,100	230	1,600	.
09/26/91	9,300	2,200	730	2,400	.
12/14/91	10,000	2,200	710	4,100	940
03/12/92	430	110	.	82	34
05/08/92	20,000	12,000	1,400	43,000	1,400
08/20/92	12,000	8,400	1,400	2,300	900
11/10/92	11,000	4,800	880	4,500	1,000
03/11/93	10,000	5,700	1,100	6,800	560
06/23/93	13,000	8,400	1,400	6,400	790
09/27/93	14,000	9,300	1,500	7,500	1,000
11/19/93	4,800	3,400	760	4,000	370
06/22/98	7,800	10,000	2,300	.	870
08/28/98	15,000	10,000	1,800	.	1,100
04/24/02	7,800	4,800	920	8,800	570
10/17/02	8,700	4,900	1,400	8,800	.
05/13/03	6,300	4,300	1,400	8,900	440
05/10/04	7,900	4,200	1,100	8,300	690
MCL	**5**	**1,000**	**700**	**10,000**	**5**

Date Sampled	VOC Concentration (µg/L)					
	MC	12DCP	Acetone	TCE	12DCE	111TCA
03/09/91	.	.	.	.	.	.
06/18/91	.	.	.	.	.	43
09/26/91	.	.	.	.	730	.
12/14/91	68	.	.	.	.	.
03/12/92	24	.	74	.	.	.
05/08/92	.	.	.	.	.	.
08/20/92	.	.	.	.	.	.
11/10/92	130	.	200	300	.	.
03/11/93	120	.	.	.	.	.
06/23/93	.	.	.	.	.	.
09/27/93	.	.	.	.	.	.
11/19/93	.	.	.	.	.	.
06/22/98	500	.	.	.	.	.
08/28/98	.	.	.	.	.	.
04/24/02	.	.	.	.	.	.
10/17/02	.	.	.	.	.	.
05/13/03	.	10	30	.	.	.
05/10/04	.	15	51	.	.	.
MCL	**5**	**5**	**NA**	**5**	**70***	**200**

Notes: "." = Not detected; * MCL is for c12DCE

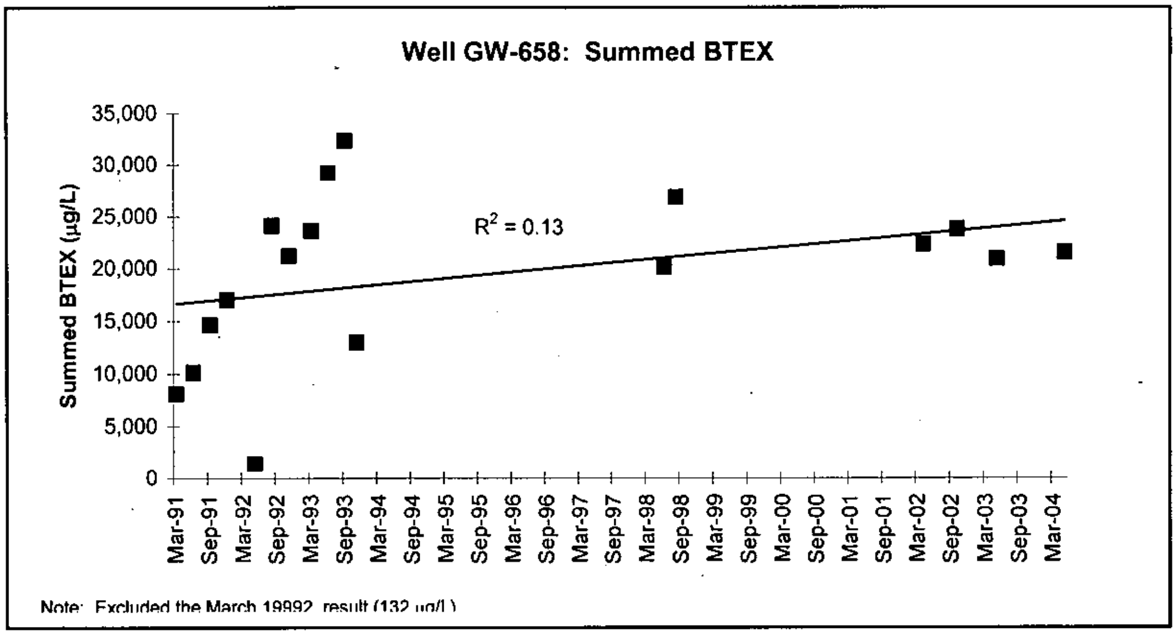


Figure 1

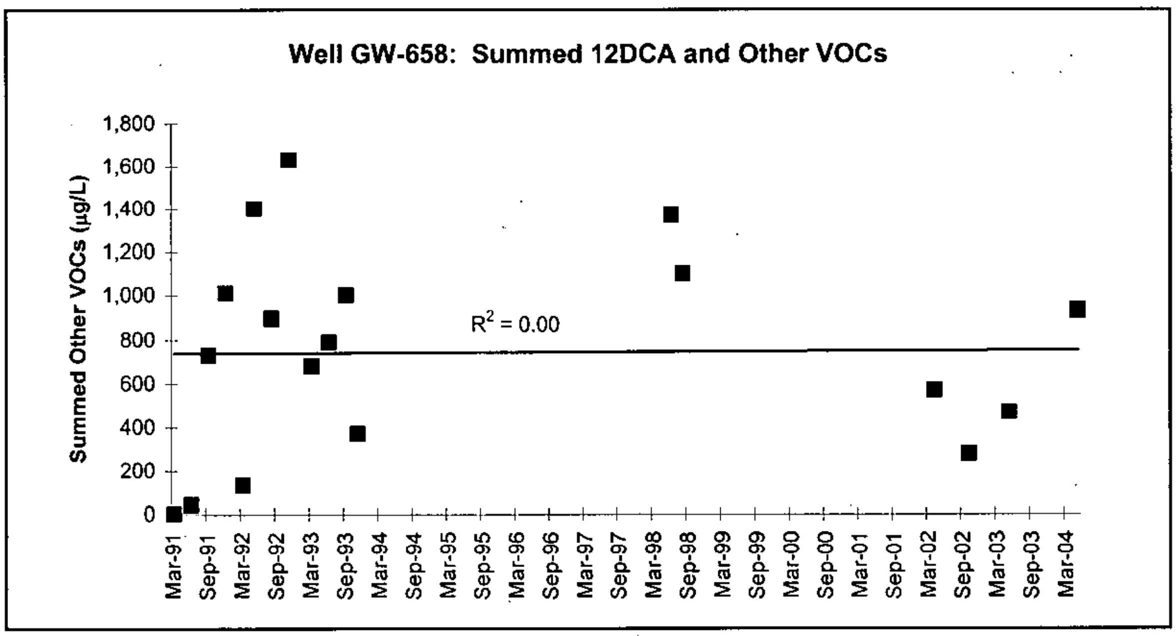


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	ND	25 - 50

GW-679

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Filled Coal Ash Pond
Y-12 GRID EAST COORDINATE: 56,765.81
Y-12 GRID NORTH COORDINATE: 27,266.55
SURFACE ELEVATION: 1,024.20 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/27/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 134.28 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,026.90 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	117.0	907.20
BOTTOM (filter pack or open hole):	132.0	892.20
MIDPOINT (filter pack or open hole):	124.5	899.70
PUMP INTAKE:	126.3	897.90
WATER LEVEL (average):	44.96	979.25

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	2 samples	04/19/04	10/12/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/19/04	.	10/12/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: X LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.43 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-679

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1990, completed with a screened monitored interval from 117 to 132 ft bgs, and constructed nominal 2.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the southern flank of Chestnut Ridge approximately one-half mile south of Y-12, about 400 ft west of the northwestern side of the Filled Coal Ash Pond (FCAP). The FCAP occupies the former basin behind an earthen dam, constructed in 1955 across a northern tributary of McCoy Branch, which had filled with fly-ash slurry pumped from the Y-12 Steam Plant. The final approved ROD for FCAP (DOE 1996) required dam stabilization and wetlands construction as CERCLA corrective actions at the site, which were completed in 1997 (DOE 1997).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Two groundwater samples have been collected from the well to date; the low-flow sampling method was used to obtain the samples in April and October 2004.

Groundwater samples from the well exhibit conspicuous geochemical characteristics (see Section 4.0) potentially attributable to localized contamination from cement (grout). Redevelopment of the well before sampling also may be necessary to obtain more representative (i.e., the least grout-contaminated) groundwater samples.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Chepultepec Dolomite), which forms a series of prominent hills across the broad southern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 45 ft bgs and exhibits moderate (about 10 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-679 indicate radial flow directions, with components of flow eastward and southeastward toward FCAP.

4.0 GEOCHEMICAL CHARACTERISTICS

Based on analytical results for the groundwater samples collected to date, this well appears to yield calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 164 and 210 mg/L;
- strongly basic pH of 9.24 and 9.27 (field measurements);

- unusually low levels of calcium (<6 mg/L) coupled with atypical high potassium concentrations (>40 mg/L) and carbonate alkalinity (>30 mg/L);
- elevated total (unfiltered sample) concentrations of lithium (>0.1 mg/L); and
- total concentrations of trace metals (except lithium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusual geochemistry of the groundwater samples, in particular the atypical levels of carbonate and bicarbonate, strongly basic pH, and unusually high potassium concentrations, are evident in other wells at Y-12 and are believed to be the result of localized contamination by cement grout circulated into the surrounding bedrock during their installation and construction.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, gross beta activity is the principal contaminant present at somewhat elevated concentrations in the groundwater samples from this well.

5.1 NITRATE

Both groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, and these results are less than 1 mg/L and are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Both groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit, and these results are less than 0.00075 mg/L and are orders-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Neither of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

Neither of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

Both groundwater samples collected to date had gross beta activity above the MDA and corresponding CE, and these results (35 pCi/L in April 2004 and 30 pCi/L in October 2004) are below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). The elevated levels of gross beta activity may be related to the elevated potassium concentrations in the grout-contaminated groundwater samples from the well. Potassium-40 (K-40) is a beta-emitting isotope and, based on the natural ratio of K-40 to total K (K-40 = 0.0119% total K; Brownlow 1979), should be present in the groundwater samples.

6.0 REFERENCES

Brownlow, A.H. 1979. *Geochemistry.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/02-1410&D3, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/01-1596&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-680

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Filled Coal Ash Pond
Y-12 GRID EAST COORDINATE: 57,934.81
Y-12 GRID NORTH COORDINATE: 27,223.75
SURFACE ELEVATION: 999.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/15/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 122.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,001.50 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	107.0	892.80
BOTTOM (filter pack or open hole):	120.0	879.80
MIDPOINT (filter pack or open hole):	113.5	886.30
PUMP INTAKE:	115.3	884.50
WATER LEVEL (average):	25.78	974.02

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	2 samples	06/07/04	10/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/07/04	.	10/13/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.1 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-680

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1990, completed with a screened monitored interval from 107 to 120 ft bgs, and constructed nominal 2.5-inch diameter PVC (#40) riser casing and well screen (0.01 slot). The well is located on the southern flank of Chestnut Ridge approximately one-half mile south of Y-12, about 300 ft east of the northeastern side of the Filled Coal Ash Pond (FCAP). The FCAP occupies the former basin behind an earthen dam, constructed in 1955 across a northern tributary of McCoy Branch, which had filled with fly-ash slurry pumped from the Y-12 Steam Plant. The final approved ROD for FCAP (DOE 1996) required dam stabilization and wetlands construction as CERCLA corrective actions at the site, which were completed in 1997 (DOE 1997).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Two groundwater samples have been collected from the well to date; the low-flow sampling method was used to obtain the samples in June and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Chepultepec Dolomite), which subcrops south of the ridge crest and forms a series of prominent hills across the broad southern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 26 ft bgs and exhibits minor (about 2 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-680 indicate components of flow to the west and southwest toward FCAP.

4.0 GEOCHEMICAL CHARACTERISTICS

Based on analytical results for only the groundwater samples collected to date, this well appears to yield calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 168 and 170 mg/L;
- neutral pH of 7.63 and 7.54 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);

- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, none of the principal contaminants are present at elevated concentrations in the groundwater from this well.

5.1 NITRATE

Both groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, and these results are less than 1 mg/L and are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Neither of the groundwater samples collected to date had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Neither of the groundwater samples collected to date contained VOCs.

5.4 GROSS ALPHA ACTIVITY

Neither of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

Neither of the groundwater samples collected to date had gross beta activity above the applicable MDA.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/02-1410&D3, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee,* DOE/OR/01-1596&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	7.5 - 15	<25

GW-683

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket A
Y-12 GRID EAST COORDINATE: 41,552.33
Y-12 GRID NORTH COORDINATE: 28,281.78
SURFACE ELEVATION: 969.45 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/03/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 199.83 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 972.23 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/PPCK/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	133.9	835.55
BOTTOM (filter pack or open hole):	196.8	772.65
MIDPOINT (filter pack or open hole):	165.4	804.10
PUMP INTAKE:	171.22	798.23
WATER LEVEL (average):	85.48	883.97

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	35		
CONVENTIONAL SAMPLING METHOD:	19 samples	05/24/91	08/21/97
LOW-FLOW SAMPLING METHOD:	16 samples	02/17/98	08/16/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/19/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.23 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	11	32 mg/L	10/12/93	Decreasing
URANIUM (0.03 mg/L):	19	0.11 mg/L	10/12/93	Decreasing
SUMMED VOCs (5 µg/L):	0	< µg/L	01/18/00	
GROSS ALPHA (15 pCi/L):	17	35.8 pCi/L	10/12/93	Indeterminate
GROSS BETA (50 pCi/L):	6	93.2 pCi/L	09/19/91	Decreasing

WELL GW-683

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1990, completed with a screened monitored interval from about 133.9 to 196.8 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire wound). The well is located on the steep northern flank of Chestnut Ridge, about two miles west of Y-12 and 500 ft directly south of the confluence of the main channel of Bear Creek and a northern tributary (NT) of the creek (NT-8) that drains the western sections of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). This well is a component of Exit Pathway Picket A, which consists of a series of wells (GW-056, GW-683, GW-684, and GW-685) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of Bear Creek Valley (BCV) and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between May 1991 and August 1997, and the low-flow sampling method used to obtain 16 samples between February 1998 and August 2004.

The well does note exhibit distinguishing sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 85 ft bgs and exhibits seasonal fluctuations up to about 12 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket A indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 500 mg/L;
- pH of 6.5 – 8.4 (field measurements);
- sporadically elevated levels of TSS (>50 mg/L), with preservation of these samples (i.e., acidification to a pH below 2) often resulting in elevated concentrations of aluminum (>2 mg/L) and iron (>3 mg/L);
- low molar proportions of chloride, potassium, sodium and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals (except aluminum and iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of the principal contaminants have been detected in the groundwater at this well.

5.1 NITRATE

All but one of the groundwater samples that were analyzed for nitrate had a concentration above the analytical reporting limit (Table 1), with results for 11 samples exceeding the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 11,000 ft east-northeast of the Exit Pathway Picket A, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek, which receives substantial influx of nitrate (and other contaminants) from the catchments of northern Bear Creek tributaries (NT-1 and NT-2) west of the former S-3 Ponds (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations detected in the groundwater samples range between the historical minimum and maximum values of 0.5 mg/L (March 1994) and 32 mg/L (October 1993), respectively (Table 1). Most of the nitrate results are less than the MCL, with the concentrations reported for the most recently collected samples (March and August 2004) being less than 1 mg/L. Also, the nitrate concentrations exhibit clearly seasonal concentration fluctuations, but the relationship between seasonally high and low concentrations abruptly changed after July 1999. Before then, nitrate concentrations were typically highest (including the historical maximum value) in the samples collected during seasonally low groundwater flow conditions (summer and fall) and were typically lowest (including the historical minimum value) in samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests recharge of uncontaminated (i.e., less-nitrate contaminated) groundwater during seasonally high flow conditions. After July 1999, the opposite relationship between nitrate concentrations and seasonal flow conditions is evident, with the highest concentrations typically reported for samples collected during seasonally high flow and the lowest nitrate concentrations typically reported for the samples collected during seasonally low flow. This relationship suggests recharge of nitrate-contaminated groundwater (i.e., increased nitrate flux) during seasonally high flow conditions. Note that the change in the seasonal fluctuations of nitrate concentrations does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of nitrate concentrations in the groundwater samples shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 2). The long-term decrease in nitrate concentrations is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap (DOE 1997).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the results for 20 samples exceeding the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of Exit Pathway Picket A, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated groundwater and surface water from the catchments of the northern Bear Creek tributaries (NT-7 and NT-8) that traverse the BCBG WMA. However, the CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 6,500 ft east of Exit Pathway Picket A. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited uranium mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

Uranium concentrations detected in the groundwater samples range over several orders-of-magnitude (Table 1), with respective historical minimum and maximum concentrations of 0.004 mg/L (March 1994) and 0.11 mg/L (October 1993), and the most recent sampling results (February and August 2004) show concentrations below the MCL. The uranium results also are characterized by wide temporal (seasonal) concentration fluctuations which, like the nitrate results, exhibit distinctly different relationships before and after July 1999. Before then, uranium concentrations were typically highest (including the historical maximum value) in the samples collected during seasonally low groundwater flow conditions (summer and fall) and were typically lowest (including the historical minimum value) in samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests seasonal (and episodic) recharge of uncontaminated (or less uranium-contaminated) groundwater during seasonally high flow conditions. After July 1999, the opposite relationship between uranium concentrations and seasonal flow conditions is evident, with the highest concentrations typically reported for samples collected during seasonally high flow and the lowest nitrate concentrations typically reported for the samples collected during seasonally low flow. This relationship suggests seasonal (and episodic) recharge of uranium-contaminated groundwater (i.e., increased uranium flux) during seasonally high flow conditions. As with the nitrate results, the change in seasonal concentration fluctuations for uranium does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of uranium concentrations in the groundwater samples shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 3). The long-term decrease in uranium levels in the groundwater at this well is attributable to the reduced flux of uranium as a result of the closure of the former S-3 Ponds and BCBG and the installation of low-permeability caps at each site. Additionally, following a fairly steady concentration decrease between January 2000 (0.0667 mg/L) and July 2002 (0.0231 mg/L), uranium levels have remained near 0.01 mg/L (i.e., below the MCL for uranium) through July 2004 (Figure 3), with the concentration evident in August 2003 (0.0103 mg/L) being the lowest value since March 1995 (0.0061 mg/L). The recent decrease in uranium concentrations probably reflects a corresponding decrease in the relative flux of uranium (and uranium isotopes) via the groundwater flow/transport pathways intercepted by the monitored interval in the well, which may be directly attributable to the CERCLA remedial action at the BYBY.

5.3 VOLATILE ORGANIC COMPOUNDS

Aside from false positive results, low concentrations (estimated values below 5 µg/L) of acetone, benzene, ethylbenzene, TCE, and 12DCE were detected in a total of six groundwater samples collected to date. Of these VOCs, TCE and 12DCE are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone in BCV, and the maximum concentrations of these compounds do not exceed applicable MCLs (5 and 70 µg/L, respectively).

5.4 GROSS ALPHA ACTIVITY

All but one of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with results for 17 of the samples exceeding the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (and alpha-emitting daughters) transported from the former BYBY (see Section 5.2) are the source elevated gross alpha activity in the shallow groundwater at this well, as illustrated by the following data for samples that have been analyzed for U-234 and U-238.

Date Sampled	Activity (pCi/L)		
	Gross Alpha	**U-234**	**U-238**
03/05/98	Not reported	5.5	7.9
07/13/98	Not reported	6.8	8.07
01/09/01	27	9.7	18
07/10/01	19	8.7	15
03/31/03	7.81	3.9	4.74
08/20/03	14.52	2.44	2.09
02/19/04	14.54	2.52	3.35
08/16/04	7.9	3.35	3.86

Results for gross alpha activity that exceed the MDA and CE range between historical minimum and maximum values of 2 pCi/L (March 1995) and 36 pCi/L (October 1993), with the most recent results (February and August 2004) being below the MCL (Table 1). Also, the levels of gross alpha activity exhibit the same large temporal (seasonal) fluctuations that are characteristic of the nitrate and uranium concentrations in the samples. As with the nitrate and uranium concentrations, the gross alpha activity reported for samples collected before July 1999 show temporal highs and lows during seasonally low and seasonally high groundwater flow conditions, respectively, whereas the reverse is evident after July 1999. This reversal in the apparent correlation between gross alpha activity and seasonal flow conditions, as noted previously with nitrate and uranium concentrations, does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of the gross alpha activity reported for the groundwater samples shows an indeterminate or slightly decreasing long-term trend totally dominated by wide (seasonal) fluctuations (Figure 4). Also, gross alpha activity appears to have decreased following the temporal "peak" in January 2000 (31 pCi/L), with the results reported for samples collected in March 2003 (7.81 pCi/L) and August 2004 (7.9 pCi/L) being the lowest levels evident since March 1996 (7.95 pCi/L). This decreasing trend probably reflects corresponding decreases in the relative flux of U-234 and U-238 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. As noted in the discussion of decreasing total uranium concentrations, the reduced flux of uranium isotopes may be attributable to the CERCLA remedial actions completed at the BYBY (see Section 5.2).

5.5 GROSS BETA ACTIVITY

All but three of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for six samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). There are two potential sources of the gross beta activity in the groundwater at this well: uranium isotopes (and related decay products) and Tc-99. As noted in the discussion of results for gross alpha activity, the former BYBY is the source of the uranium isotopes. However, the contaminant plume emplaced during historical operation of the former S-3 Ponds is the source of the Tc-99, which is a beta particle-emitting radionuclide detected (i.e., >MDA and CE) in the samples collected in March 1994 (166 pCi/L), September 1994 (67 pCi/L), January 2001 (49 pCi/L), July 2001 (33 pCi/L), and March 2003 (9 pCi/L); Tc-99 was not detected in the samples collected most recently (February and July 2004). These Tc-99 results reflect a clearly decreasing long-term concentration trend and are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. This radionuclide is a "signature" component of the contaminant plume from the S-3 Ponds, the only site at Y-12 which received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

Results for gross beta activity that exceed the MDA and CE range between historical minimum and maximum values of 6 pCi/L (March 1995) and 93 pCi/L (September 1991), with the most recent results (February and August 2004) being substantially below the SDWA screening level (Table 1). Also, the levels of gross beta activity exhibit the same large temporal (seasonal) fluctuations that are characteristic of gross alpha activity (and nitrate and uranium concentrations) in the samples. As with gross alpha activity, the gross beta activity results reported for samples collected before July 1999 show temporal highs and lows during seasonally low and seasonally high groundwater flow conditions, respectively, whereas the reverse is evident after July 1999. This reversal in the apparent correlation between gross beta activity and seasonal flow conditions, as noted previously with gross alpha activity (and nitrate and uranium concentrations), does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of the gross beta activity reported for the groundwater samples shows a generally decreasing long-term trend that is dominated by wide (seasonal) fluctuations (Figure 5). Also, gross beta activity appears to have decreased following the temporal "peak" in January 2001 (77 pCi/L), with the result reported for the sample collected in August 2004 (7.67 pCi/L) being the lowest level evident since March 1995 (6 pCi/L). This decreasing trend reflects corresponding decreases in the relative flux of Tc-99 and uranium isotopes via the groundwater flow/transport pathways intercepted by the monitored interval in the well. As noted previously, the reduced flux of U-234 and U-238 may be attributable to the CERCLA remedial actions completed at the BYBY (see Section 5.2).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

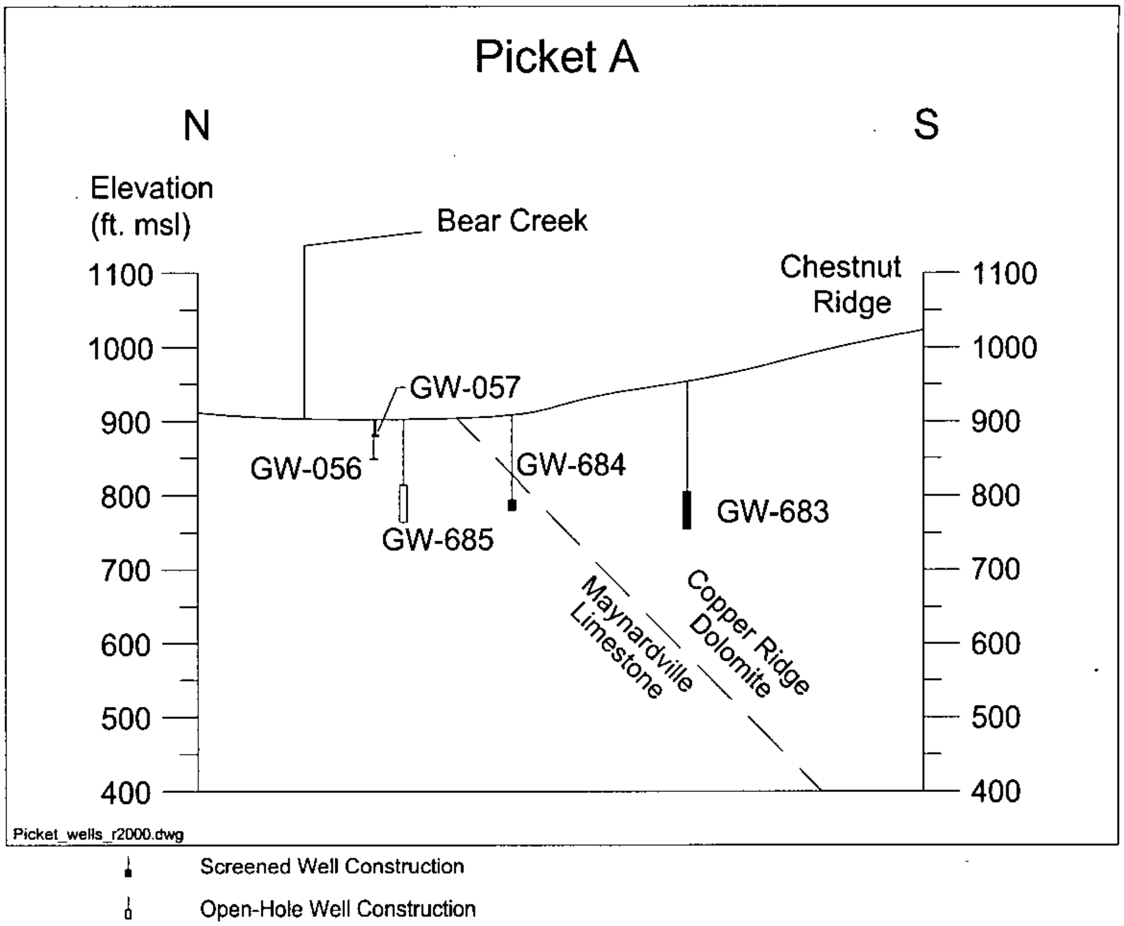
Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-683: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
05/24/91	<0.2	0.039	19.89	37.65
09/19/91	19.64	0.088	27.8	93.2
12/12/91	6.4	0.032	12.6	27.4
03/26/92	3.02	0.021	<MDA	12.7
06/15/92	15.7	0.07	28.5	54.2
09/06/92	22	0.091	25.4	57.8
12/11/92	16	0.085	27.7	58.6
03/04/93	2.7	0.022	7.31	15.8
04/23/93	2.3	0.013	5.33	10.6
07/12/93	10.01	0.061	12.5	26.2
10/12/93	32	0.11	35.8	64.4
03/04/94	0.5	0.004	3.35	<MDA
09/20/94	12	0.08	22.2	34.3
03/09/95	1.3	0.0061	2.02	6
08/06/95	9.3	0.058	25	42.8
03/15/96	14.5	0.024	7.95	<MDA
07/29/96	9.6	0.051	26.1	34
02/17/97	3.41	0.031	16	<MDA
08/21/97	10.1	0.034	19	26
02/17/98	2.73	0.023	8	14
08/03/98	6.5	0.0339	11	22
02/11/99	4.88	0.0446	26	20
07/29/99	1.692	0.0247	16	21
01/18/00	9.4	0.0667	31	42
07/12/00	1.93	0.0203	11	8.5
01/09/01	13.1	0.058	27	77
07/10/01	8.38	0.0452	19	27
01/14/02	13.3	0.0485	20	46
07/09/02	2.65	0.0231	15	20
03/31/03	1.9	0.0119	7.81	9.1
08/20/03	1.5	0.0103	14.52	19.32
02/19/04	0.87	0.0114	14.54	16.02
08/16/04	0.8	0.0116	7.9	7.67
MCL	**10**	**0.03**	**15**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)



Picket A
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-057
GW-056
GW-684
GW-683
GW-685
Maynardville
Limestone
Copper Ridge
Dolomite
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

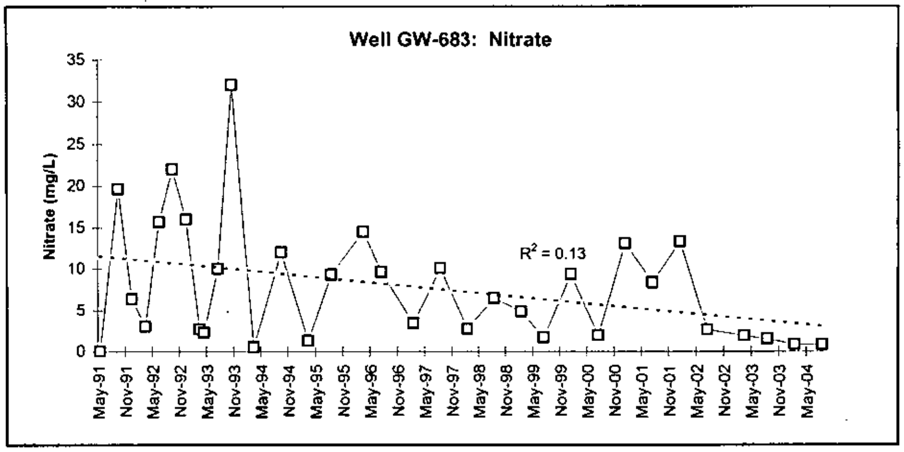


Figure 2

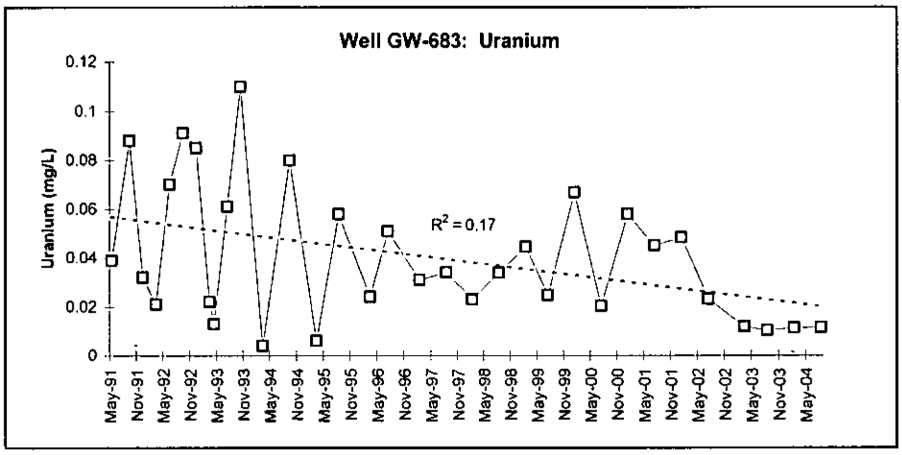


Figure 3

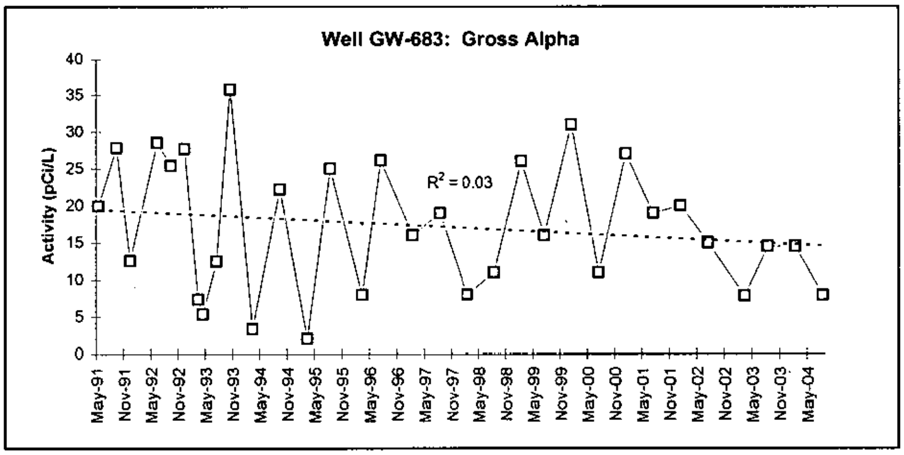


Figure 4

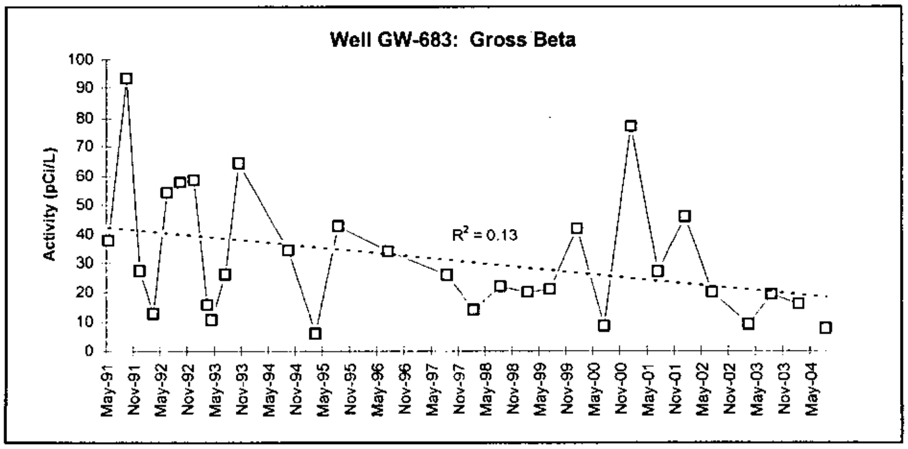


Figure 5

MAXIMUM CONCENTRATION: 2004

<5	0.015 - 0.03	ND	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-684

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket A
Y-12 GRID EAST COORDINATE: 41,353.53
Y-12 GRID NORTH COORDINATE: 28,524.52
SURFACE ELEVATION: 895.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/09/90 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 132.21 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 898.83 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/PPCK/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	106.4	789.13
BOTTOM (filter pack or open hole):	129.6	765.93
MIDPOINT (filter pack or open hole):	118.0	777.53
PUMP INTAKE:	119.70	775.83
WATER LEVEL (average):	12.15	883.38

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	35		
CONVENTIONAL SAMPLING METHOD:	19 samples	05/30/91	08/21/97
LOW-FLOW SAMPLING METHOD:	16 samples	02/12/98	08/16/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/19/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.69 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	7	18.9 mg/L	10/12/93	Decreasing
URANIUM (0.03 mg/L):	17	0.114 mg/L	10/12/93	Decreasing
SUMMED VOCs (5 µg/L):	1	14 µg/L	03/10/95	Outlier
GROSS ALPHA (15 pCi/L):	13	38.2 pCi/L	10/12/93	Indeterminate
GROSS BETA (50 pCi/L):	4	77.5 pCi/L	06/15/92	Decreasing

WELL GW-684

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1990, completed with a screened monitored interval from 106.4 to 129.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire wound). The well is located in Bear Creek Valley at the base of the steep northern flank of Chestnut Ridge, about two miles west of Y-12 stainless and 300 ft directly south of the confluence of the main channel of Bear Creek and a northern tributary (NT) of the creek (NT-8) that drains the western sections of the Bear Creek Burial Grounds (BCBG) waste management area (WMA). This well is a component of Exit Pathway Picket A, which consists of a series of wells (GW-056, GW-683, GW-684, and GW-685) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between May 1991 and August 1997, and the low-flow sampling method used to obtain 16 samples between February 1998 and August 2004.

The well does note exhibit distinguishing sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits seasonal fluctuations up to about 3 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket A indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 175 – 450 mg/L;
- pH of 6.9 – 8.4 (field measurements);
- low molar proportions of chloride, potassium, sodium and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, each of the principal contaminants are present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), with results for seven samples exceeding the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 11,000 ft east-northeast of the Exit Pathway Picket A, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek, which receives substantial influx of nitrate (and other contaminants) from the catchments of northern Bear Creek tributaries (NT-1 and NT-2) west of the former S-3 Ponds (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations detected in the groundwater samples range between the historical minimum and maximum values of 0.98 mg/L (July 1999) and 18.9 mg/L (October 1993), respectively (Table 1). Most of the nitrate results are less than the MCL, with the concentrations reported for the most recently collected samples (February and August 2004) being less than 2 mg/L. Also, the nitrate concentrations exhibit clearly seasonal concentration fluctuations, but the relationship between seasonally high and low concentrations appear to have changed after July 1999. Before then, nitrate concentrations typically were highest in the samples collected during seasonally low groundwater flow conditions (summer and fall) and typically were lowest in samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests recharge of uncontaminated (or less nitrate-contaminated) groundwater during seasonally high flow conditions. After July 1999, the opposite relationship between nitrate concentrations and seasonal flow conditions is evident, with the highest concentrations typically reported for samples collected during seasonally high flow and the lowest nitrate concentrations typically reported for the samples collected during seasonally low flow. This relationship suggests recharge of nitrate-contaminated groundwater (i.e., increased nitrate flux) during seasonally high flow conditions. Note that the change in seasonal concentration fluctuations for nitrate does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of nitrate concentrations in the groundwater samples shows a decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 3). The long-term decrease in nitrate concentrations is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap (DOE 1997).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the results for 17 samples exceeding the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of Exit Pathway Picket A, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated groundwater and surface water from the catchments of the northern Bear Creek tributaries (NT-7 and NT-8) that traverse the BCBG WMA. However, the CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 6,500 ft east of Exit Pathway Picket A. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

Uranium concentrations detected in the groundwater samples range between respective historical maximum and minimum concentrations of 0.114 mg/L (October 1993) and 0.011 mg/L (March 1995), and the most recent sampling results (February and August 2004) show concentrations below the MCL (Table 1). The uranium results also are characterized by wide temporal (seasonal) concentration fluctuations which, like the nitrate results, exhibit distinctly different relationships with seasonal groundwater flow conditions evident before and after July 1999. Before then, uranium concentrations typically were highest in the samples collected during seasonally low groundwater flow conditions (summer and fall), and typically were lowest in samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests seasonal (and episodic) recharge of uncontaminated (or less uranium-contaminated) groundwater during seasonally high flow conditions. The opposite relationship between uranium concentrations and seasonal flow conditions is evident after July 1999, with the highest concentrations typically reported for samples collected during seasonally high flow and the lowest concentrations typically reported for the samples collected during seasonally low flow. This relationship suggests seasonal (and episodic) recharge of uranium-contaminated groundwater (i.e., increased uranium flux) during seasonally high flow conditions. As with the nitrate results, the change in seasonal concentration fluctuations for uranium does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of uranium concentrations in the groundwater samples shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations, although the samples collected since March 1995 show much less temporal variability than previous data (Figure 3). The long-term decrease in uranium levels in the groundwater at this well is attributable to the reduced flux of uranium as a result of the closure former S-3 Ponds and the BCBG and the installation of low-permeability caps at each site. Additionally, the uranium concentrations reported for groundwater samples collected since January 2002 suggest a more steeply decreasing trend than previously evident, with the concentration reported for the sample collected in August 2003 (0.0185 mg/L) being the lowest value reported for the well since July 1999 (0.0178 mg/L). The recent decrease in uranium concentrations may be attributable to the CERCLA remedial action at the BYBY.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, low concentrations of acetone, ethylbenzene, methylene chloride, TCE, and 12DCE were detected in a total of five groundwater samples collected to date, most recently the sample collected in August 1995. Of these VOCs, TCE and 12DCE are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone in BCV, and the maximum concentrations of these compounds (2 µg/L for both VOCs) do not exceed applicable drinking water MCLs (5 and 70 µg/L, respectively).

5.4 GROSS ALPHA ACTIVITY

All of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with results for 13 of the samples exceeding the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (and alpha-emitting daughters) transported from the former BYBY (see Section 5.2) are the source elevated gross alpha activity in the shallow groundwater at this well, as illustrated by the following data for samples that have been analyzed for U-234 and U-238.

Date Sampled	Activity (pCi/L)		
	Gross Alpha	**U-234**	**U-238**
02/12/98	Not reported	7.33	7.33
07/13/98	Not reported	4.83	11.37
01/09/01	22	6.3	12
07/10/01	21	7.5	12
03/26/03	12.24	4.23	7.81
08/18/03	10..94	3.68	6.04
02/19/04	14.45	3.42	6.62
08/16/04	8.72	5.35	5.85

Results for gross alpha activity that exceed the MDA and CE range between historical minimum and maximum values of 1.6 pCi/L (September 1991) and 38 pCi/L (October 1993), with the most recent results (February and August 2004) being below the MCL (Table 1). Also, the levels of gross alpha activity exhibit the same large temporal (seasonal) fluctuations that are characteristic of the nitrate and uranium concentrations in the samples. As with the nitrate and uranium concentrations, the gross alpha activity reported for samples collected before July 1999 show temporal highs and lows during seasonally low and seasonally high groundwater flow conditions, respectively, whereas the reverse is evident after July 1999. This reversal in the apparent correlation between gross alpha activity and seasonal flow conditions, as noted previously with nitrate and uranium concentrations, does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of the gross alpha activity reported for the groundwater samples shows an indeterminate long-term trend that is dominated by wide (seasonal) fluctuations (Figure 4). Also, gross alpha activity appears to have steadily decreased following the temporal "peak" in January 2002 (23 pCi/L), with the result reported for the sample collected in August 2004 (8.72 pCi/L) being the lowest level evident since April 1993 (5.89 pCi/L). This decreasing trend probably reflects a corresponding decrease in the relative flux of U-234 and U-238 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. As noted in the discussion of decreasing total uranium concentrations, the reduced flux of uranium isotopes may be attributable to the CERCLA remedial actions completed at the BYBY (see Section 5.2).

5.5 GROSS BETA ACTIVITY

All but two of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for six samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). There are two primary sources of the gross beta activity in the groundwater at this well: uranium isotopes (see Section 5.4) and Tc-99, a beta particle-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, the only site at Y-12 that received wastes containing Tc-99 (DOE 1998). As shown in the following data summary, Tc-99 was detected (i.e., >MDA and CE) in each sample collected to date that was analyzed for this radionuclide.

Date Sampled	Tc-99 Activity (pCi/L)
03/04/94	125
09/20/94	101
01/09/01	35
07/10/01	30
03/26/03	7.42
08/18/03	6.8
02/19/04	10.5
08/16/04	11.03

These Tc-99 levels are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99 and show a substantial decrease from the Tc-99 levels evident during the mid-1990s. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

Results for gross beta activity that exceed the MDA and CE range between historical minimum and maximum values of 13 pCi/L (March 1992) and 77 pCi/L (June 1992), with the most recent results (February and August 2004) being substantially below the SDWA screening level (Table 1). Also, the levels of gross beta activity exhibit the same large temporal (seasonal) fluctuations that are characteristic of gross alpha activity (and nitrate and uranium concentrations) in the samples. As with gross alpha activity, the gross beta activity results reported for samples collected before July 1999 show temporal highs and lows during seasonally low and seasonally high groundwater flow conditions, respectively, whereas the reverse is evident after July 1999. This reversal in the apparent correlation between gross beta activity and seasonal flow conditions, as noted previously with gross alpha activity (and nitrate and uranium concentrations), does not coincide with the transition from conventional sampling to low-flow sampling and, therefore, does not appear to be an artifact of the sampling method.

A time-series plot of the gross beta activity reported for the groundwater samples shows an indeterminate or slightly decreasing long-term trend totally dominated by wide (seasonal) fluctuations (Figure 5). Also, gross beta activity appears to have decreased following the temporal "peak" in January 2001 (49 pCi/L) to less than 20 pCi/L through August 2004. This decreasing trend reflects corresponding decreases in the relative flux of Tc-99 (and uranium isotopes) via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Substantially reduced flux of Tc-99 is attributable to closure of the former S-3 Ponds and installation of the low-permeability cap (DOE 1997), and installation of remedial/removal systems near the site (1998-2001).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-684: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration			
	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
05/30/91	9	0.038	14.89	36.26
09/19/91	18.89	0.081	1.59	<MDA
12/12/91	6.32	0.032	12.8	34.3
03/27/92	4.31	0.02	8.46	12.9
06/15/92	17.6	0.059	25.1	77.5
09/06/92	18	0.069	17.3	73.6
12/14/92	15.6	0.091	28.5	64.7
03/03/93	4.3	0.026	9.05	20.9
04/22/93	4.1	0.019	5.89	27.5
07/11/93	10.3	0.062	21.2	46.6
10/12/93	18.9	0.114	38.2	63.6
03/04/94	4.3	0.014	8.37	20.1
09/20/94	12	0.081	16.4	40.2
03/10/95	2.9	0.011	8.41	17.4
08/06/95	8.8	0.041	16.1	47.7
03/16/96	3.68	0.022	14.8	14.6
07/29/96	9.02	0.041	19.4	31.1
02/18/97	3.14	0.025	13	<MDA
08/21/97	9.15	0.034	13	38
02/16/98	4.55	0.027	12	23
08/04/98	5.2	0.0311	22	34
02/10/99	4.13	0.0285	14	28
07/29/99	0.9878	0.0178	14	24
01/13/00	5.96	0.0347	14	29
07/12/00	1.53	0.0199	9.5	11
01/09/01	6.42	0.0362	22	40
07/10/01	6.93	0.0402	21	34
01/14/02	9.95	0.0454	23	49
07/09/02	4.36	0.0269	17	31
03/26/03	1.5	0.0257	12.24	15.19
08/18/03	2.6	0.0185	10.94	20.66
02/19/04	1.7	0.02	14.45	18.4
08/16/04	1.7	0.0208	8.72	19.39
MCL	**10**	**0.03**	**15**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

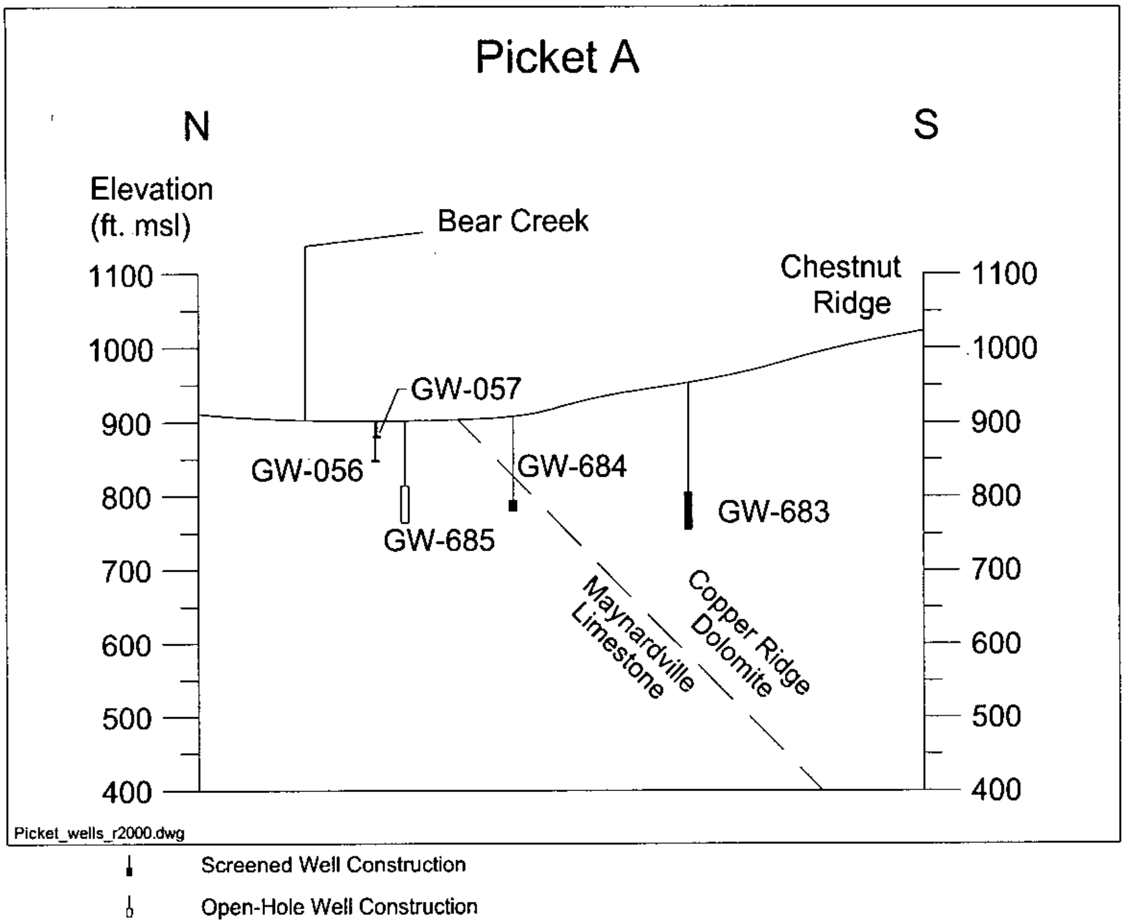

Picket A
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-057
GW-056
GW-684
GW-685
GW-683
Maynardville
Limestone
Copper Ridge
Dolomite
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

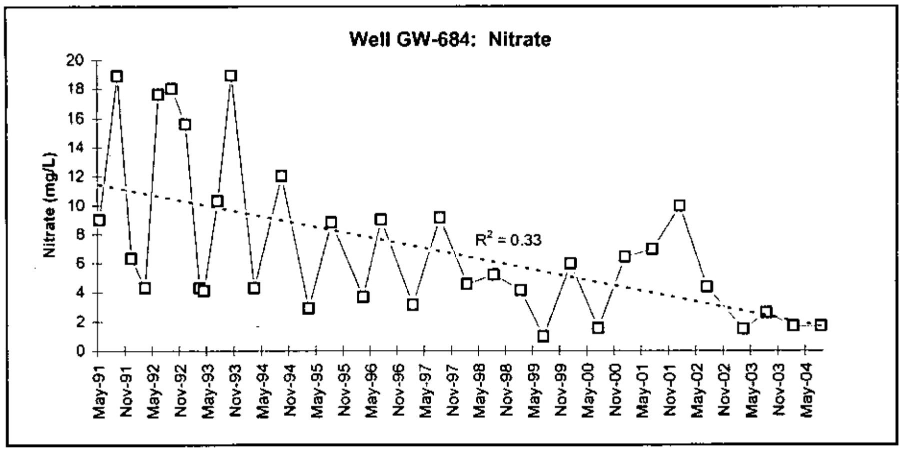


Figure 2

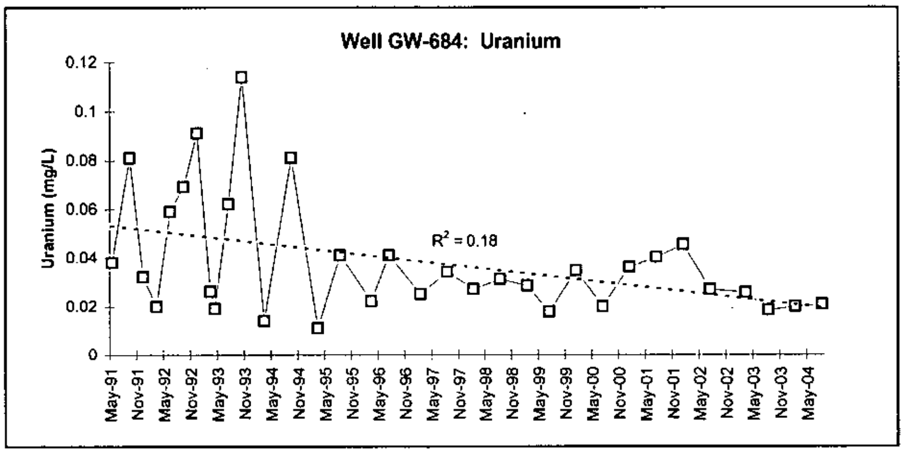


Figure 3

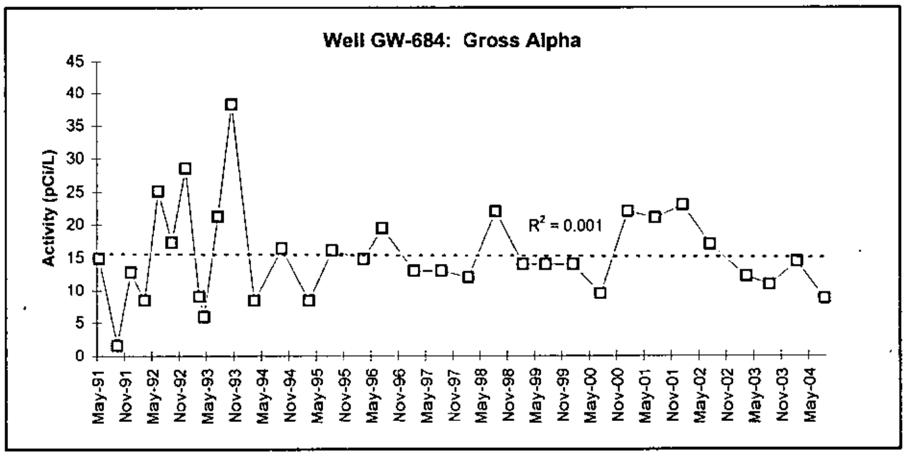


Figure 4

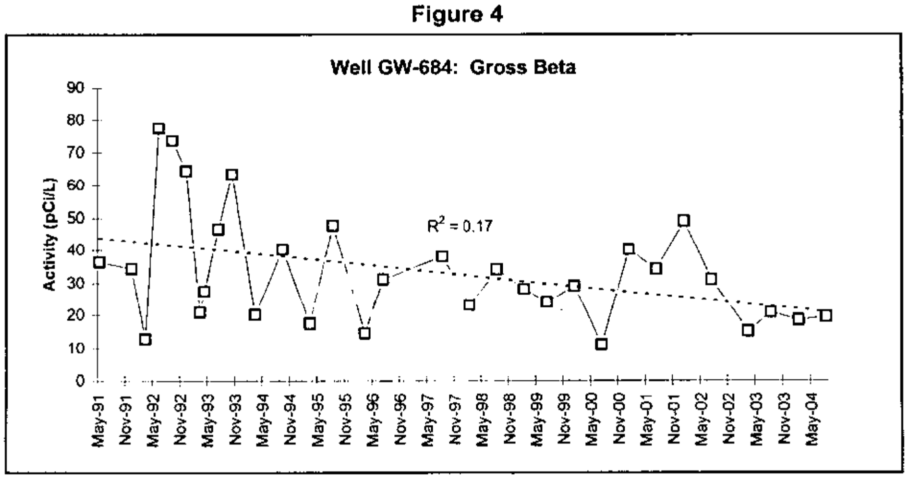


Figure 5

GW-684

MAXIMUM CONCENTRATION: 2003

<5	ND	50 - 500	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-690

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Coal Pile Trench
Y-12 GRID EAST COORDINATE: 55,989.75
Y-12 GRID NORTH COORDINATE: 29,787.18
SURFACE ELEVATION: 967.71 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/90 PAIRED/CLUSTERED WITH: GW-691
TAG DEPTH (measured): 53.25 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 967.36 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 8.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	40.8	926.91
BOTTOM (filter pack or open hole):	52.8	914.91
MIDPOINT (filter pack or open hole):	46.8	920.91
PUMP INTAKE:	48.35	919.36
WATER LEVEL (average):	11.07	956.64

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	5		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/08/96	06/08/96
LOW-FLOW SAMPLING METHOD:	4 samples	06/19/00	11/18/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	.	05/27/03	.	11/18/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.17 pre-sampling measurements (ft)
TDS: H (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	5	790 µg/L	06/08/96	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	1	51.8 pCi/L	06/08/96	Anomalous Result

WELL GW-690

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1990, completed with a screened monitored interval from 40.8 to 52.8 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-691 and is located in the south-central Y-12 area, about 200 ft east of the coal stockpile for the Y-12 Steam Plant.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Five groundwater samples have been collected to date, with the conventional sampling method used to obtain one sample in June 1996, and the low-flow sampling method used to obtain four samples between October June 2000 and November 2003.

The unfiltered groundwater samples from this well are distinguished by high TDS attributable to very high sulfate (see Section 4.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 11 ft bgs and exhibits minor (<2 ft) seasonal fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields highly mineralized, sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- high TDS (>900 mg/L);
- pH (field measurements) of 6.7 – 7.2;
- very high sulfate concentrations (>350 mg/L);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Although elevated sulfate levels in groundwater from the Maynardville Limestone may reflect the geochemical influence of secondary minerals in the bedrock (e.g., pyrite), the extremely high sulfate concentrations in the groundwater at this well most likely reflect contamination. Sulfur leached from the coal stockpile for the Y-12 Steam Plant, which is hydraulically upgradient along geologic strike to the west of the well, is the most likely source of the sulfate. There are other potential non-specific sources within Y-12, such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Five groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (4.32 mg/L in May 2000) being less than the MCL for nitrate (10 mg/L).

5.2 URANIUM

The uranium concentration reported for the groundwater sample collected in June 1996 (0.00093 mg/L) exceeds the applicable analytical reporting limit, but is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each groundwater sample contained each of the following VOCs: PCE, TCE, and 12DCE (Table 1). The source of the VOCs in the groundwater at this well has not been determined, but each compound is a known component of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The highest concentrations have been reported for PCE (720 µg/L) and 12DCE (71 µg/L), with the most recent sampling results showing that PCE and TCE concentrations remain above respective MCLs (Table 1). Although there are significant gaps in the sampling history for this well, the available monitoring results show clearly decreasing summed VOC concentrations (Figure 1). The decreasing concentration trend is primarily attributable to PCE levels, which dropped by almost 95% between June 1996 (720 µg/L) and November 2003 (48 µg/L). The decreasing VOC concentrations potentially reflect corresponding decreases in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity reported for the sample collected in June 2000 (6.3 pCi/L) exceeds the applicable MDA and corresponding CE, but is less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity reported for the groundwater samples collected in June 1996 (51.8 pCi/L) and May 2003 (15 pCi/L) exceed the applicable MDA and corresponding CE. The June 1996 result slightly exceeds the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

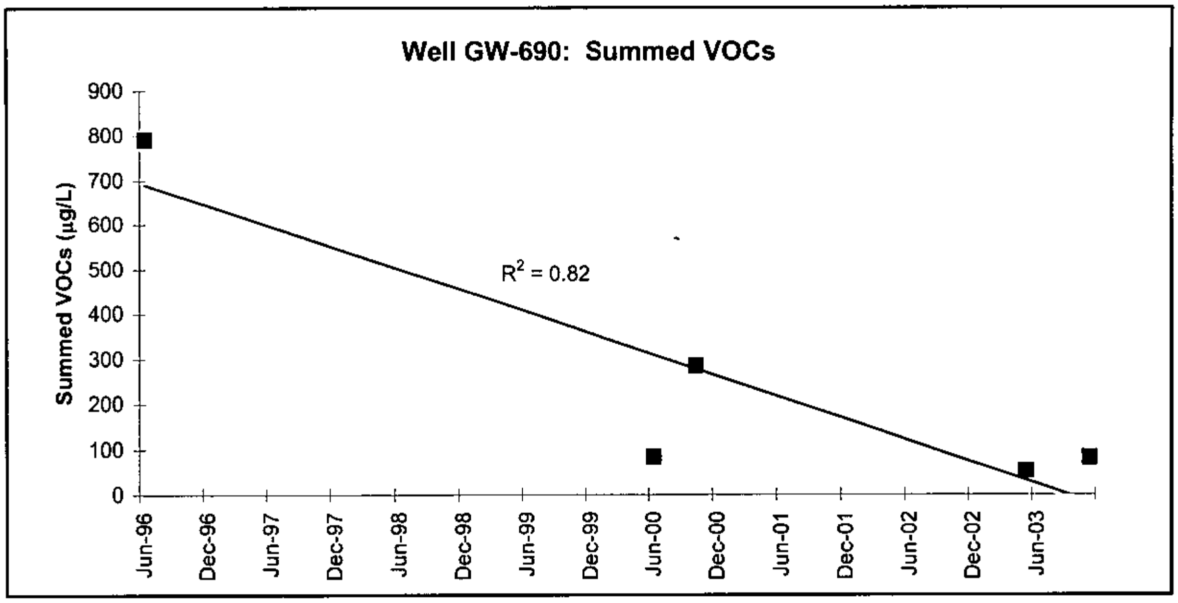
HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-690: summary of VOC results

Date Sampled	VOC Concentration (μg/L)			
	PCE	**TCE**	**Total 12DCE**	**c12DCE**
06/08/96	720	26	44	NR
06/19/00	66	6	12	12
10/25/00	180	34	71	71
05/27/03	42	4 J	6	6
11/18/03	48	7	27	27
MCL	**5**	**5**	**NA**	**70**

Notes: NR = Not reported; NA = Not applicable



Well GW-690: Summed VOCs
Summed VOCs (µg/L)
900
800
700
600
500
400
300
200
100
0
$R^2 = 0.82$
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	<0.015	500 - 5,000	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-691

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Coal Pile Trench
Y-12 GRID EAST COORDINATE: 55,983.33
Y-12 GRID NORTH COORDINATE: 29,794.10
SURFACE ELEVATION: 968.09 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/24/90 PAIRED/CLUSTERED WITH: GW-690
TAG DEPTH (measured): 20.39 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 968.59 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 12 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	8.0	960.09
BOTTOM (filter pack or open hole):	20.0	948.09
MIDPOINT (filter pack or open hole):	14.0	954.09
PUMP INTAKE:	14.5	953.59
WATER LEVEL (average):	11.78	956.31

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	3		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/08/96	06/08/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/09/04	11/17/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/09/04	.	11/17/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.68 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	3	1319 µg/L	06/09/04	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-691

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during October 1990, completed with a screened monitored interval from 8 to 20 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01-inch slot wire-wound). The well forms a cluster with well GW-690 and is located in Bear Creek Valley (BCV) in the west-central Y-12 area, approximately 150 ft directly east of the Coal Pile Trench, which underlies the coal stockpile for the Y-12 Steam Plant.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Three groundwater samples have been collected from the well, with the conventional sampling method used to obtain a sample in June 1996 and the low-flow sampling method used to obtain samples in June and November 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs. Also, groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are lower in well GW-691 than in well GW-690, which is completed at a greater depth (53 ft bgs) in the Maynardville Limestone. Based on the distance between the monitored interval midpoint (elevation) in each well (33 ft), the contemporaneous groundwater elevations indicate an upward vertical gradient (0.026) from the shallow bedrock interval (GW-690) to the water table interval (GW-691).

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-691 indicate flow primarily to the east, parallel with the original main channel of UEFPC and geologic strike in the Maynardville Limestone. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement dewatering sumps (DOE 1998).

4.0 GEOCHEMCICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields highly mineralized, sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 1,462 – 1,980 mg/L;
- pH of 6.3 – 6.8 (field measurements);
- extremely high concentrations (>1,000 mg/L) of sulfate;
- low molar proportions of chloride, nitrate, potassium, and sodium (<10% of total anions/cations);
- unusually elevated total (unfiltered sample) concentrations of manganese (>9 mg/L); and
- total concentrations of trace metals (except manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

High TDS, attributable to the very high sulfate levels, and the elevated manganese concentrations appear to be distinguishing characteristics of the groundwater samples from the well. Sulfur leached from the coal stockpile overlying the Coal Pile Trench is the most likely source of the sulfate and likewise may be the source of the manganese in the groundwater at this well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Two of the groundwater samples collected to date had nitrate concentrations at or above the analytical reporting limit, and both of these results (0.217 mg/L in June 2004 and 1.08 mg/L in November 2004) are substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Each groundwater sample collected to date had a total uranium concentration above the applicable analytical reporting limit, with the highest value (0.0016 mg/L in June 1996) being an order-of-magnitude below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the data summary below, each of the groundwater samples collected to date contained PCE, TCE, and 12DCE (c12DCE), with the most recent results indicating a substantial increase in PCE concentrations, relatively unchanged levels of TCE, and lower levels of 12DCE.

Date Sampled	**Concentration (µg/L)**			
	PCE	**TCE**	**Total 12DCE**	**c12DCE**
06/08/96	120	7	27	NR
06/09/04	1,300	10	9	9
11/17/04	980	8	7	7
MCL	**5**	**5**	**NA**	**70**
Note: J = Estimated value; NA = Not applicable; NR = Not reported				

Note that the lowest PCE concentration was reported for the groundwater sample obtained with the conventional sampling method; consequently, the substantial concentration increase indicated by the recent low-flow sampling results may be an artifact of the change in the sampling method. In any case, the compounds detected in the samples are all components of an essentially contiguous commingled plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide separating the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). Additionally, the upward hydraulic gradients indicated by presampling groundwater elevations in wells GW-690/GW-691 (see Section 3.0) suggest that the presence of VOCs in the shallow groundwater at well GW-691 may be at least partially attributable to local upward migration/transport of VOCs from deeper in the flow system of the Maynardville Limestone.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee*, Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	5 - 50	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-692

LOCATION

HYDROGEOLOGIC REGIME:	East Fork Regime
FUNCTIONAL AREA:	Coal Pile Trench
Y-12 GRID EAST COORDINATE:	56,001.20
Y-12 GRID NORTH COORDINATE:	29,653.12
SURFACE ELEVATION:	964.55 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	.
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	10/25/90
PAIRED/CLUSTERED WITH:	GW-693
TAG DEPTH (measured):	53.05 ft below top of casing (TOC)
MEASURING POINT ELEVATION:	964.38 ft above msl
MEASURING POINT:	TOWW
WELL BORE DIAMETER:	8.5 inches
WELL CASING MATERIAL:	SS304
WELL CASING DIAMETER:	4.5 inches (outside diameter)
WELL SCREEN TYPE:	SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT:	Well Wizard
Sampling Port No.:	.
Port Depth :	. (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	41.0	923.55
BOTTOM (filter pack or open hole):	53.0	911.55
MIDPOINT (filter pack or open hole):	47.0	917.55
PUMP INTAKE:	48.17	916.38
WATER LEVEL (average):	9.14	955.41
GEOLOGIC FORMATION:	Maynardville Limestone	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	4		
CONVENTIONAL SAMPLING METHOD:	2 samples	03/01/96	06/08/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/08/04	11/17/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	06/08/04	.	11/17/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	X	
WATER LEVEL FLUCTUATION:	1.18 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	3	30 µg/L	11/17/04	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-692

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed during October 1990, completed with a screened monitored interval from 41 to 53 ft bgs. The well forms a cluster with well GW-693 and is located in Bear Creek Valley (BCV) in the west-central Y-12 area, approximately 250 ft southeast of the Coal Pile Trench, which underlies the coal stockpile for the Y-12 Steam Plant. This is a flush-mounted well, and at some point the manhole was damaged and possibly allowed inflow of surface water runoff until August 2004 when the manhole was replaced.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Four groundwater samples have been collected from the well, with the conventional sampling method used to obtain samples in March and June 1996, and the low-flow sampling method used to obtain samples between June and November 2004.

The groundwater samples collected in June 2004 contained very high (227 mg/L) total suspended solids (TSS). A much lower but significant level of TSS (39 mg/L) also was reported for the sample in November 2004, which was after the manhole was replaced (see Section 1.0). Consequently, both samples contained unusually high total concentrations of several trace metals, particularly iron (>10 mg/L), aluminum (>5 mg/L), and manganese (>1 mg/L), that were dissolved from the solids by the acid preservative, which reduced the sample pH below 2. This is clearly illustrated by the substantial disparity between the total concentrations of these (and other) trace metals detected in the unfiltered and filtered samples collected in June 2004.

Analyte	Concentration (mg/L)	
	Unfiltered Sample	Filtered Sample
Calcium	97.5	95.5
Magnesium	24.5	23.2
Potassium	6.65	4.66
Sodium	12.8	12.7
Suspended Solids	227	Not analyzed
Aluminum	8.13	<0.2
Arsenic	0.0083	<0.005
Barium	0.124	0.0603
Beryllium	0.00077	<0.001
Chromium	0.0181	<0.01
Copper	0.0244	<0.02
Iron	14.4	<0.05
Lead	0.0249	<0.0005
Lithium	0.0253	0.0142
Manganese	0.188	<0.005
Mercury	0.00521	<0.0002
Nickel	0.0172	<0.005
Strontium	0.318	0.293
Thallium	0.000505	0.00255
Uranium	0.000966	<0.0005
Zinc	0.224	<0.05

These results suggest that the low-flow sampling activities disturbed the silt, clay, and other similarly fine-grained material distributed within the filter pack surrounding the well screen and/or settled onto the bottom of the well. This material probably remains in place because the initial development of the well and the few subsequent groundwater sampling events did not completely flush this material from the well/filter pack. Assuming that the intake for the dedicated sampling pump in the well is near the midpoint of the monitored interval, the filter pack may be the source of the suspended material because the low-flow sampling procedure would not be expected to disturb sediments on the bottom of the well, which would be approximately 6 ft below the pump intake. Alternatively, continued collection of samples with high TSS may indicate that the intake for the sampling pump is closer to the materials settled on the bottom of the well than to the monitored interval midpoint. In either case, the well should be redeveloped to ensure collection of representative groundwater samples, or the conventional sampling method should be used to ensure collection of the least turbid samples.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone. Most groundwater flow in this uppermost formation of the Conasauga Group occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-692 indicate flow primarily to the east, parallel with the original main channel of UEFPC and geologic strike in the Maynardville Limestone. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields somewhat mineralized, sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 570 – 778 mg/L;
- pH of 7 – 7.3 (field measurements);
- elevated concentrations of sulfate (>100 mg/L);
- low molar proportions of chloride, nitrate, potassium, and sodium (<10% of total cations); and
- as discussed in Section 2.0, total concentrations of several trace metals that are sampling artifacts related to the preservation of unfiltered samples containing high levels of TSS. The elevated TSS may reflect impacts from inflow of surface water during the time period when the manhole was damaged (see Section 1.0).

Elevated sulfate concentrations appear to be a distinguishing characteristic of the groundwater samples from the well. Sulfur leached from the coal stockpile overlying the Coal Pile Trench is the most likely source of the sulfate.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Two of the groundwater samples collected to date had nitrate concentrations at or above the analytical reporting limit, and both of these results are less than 1 mg/L and are an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Each groundwater sample collected to date had a total uranium concentration above the applicable analytical reporting limit, with the highest value (0.000968 mg/L in June 2004) being several orders-of-magnitude below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

As shown in the data summary below, chloroform was detected in each of the groundwater samples collected to date, with PCE, TCE, and c12DCE detected in the samples collected most recently (June and November 2004).

Date Sampled	Concentration (µg/L)			
	Chloroform	**PCE**	**TCE**	**c12DCE**
06/08/96	14	.	.	NR
06/08/04	12	4 J	1 J	5
11/17/04	8	8	2 J	12
MCL	**80***	**5**	**5**	**70**

Note: J = Estimated value; NR = Not reported; * = MCL is for total trihalomethanes

These compounds are all components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide separating the Bear Creek and UEFPC watersheds. East of the flow divide in the UEFPC watershed, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

5.4 GROSS ALPHA ACTIVITY

Two of the groundwater samples collected to date had gross alpha activity above the applicable MDA and CE, with the highest value (15 pCi/L in June 2004) equaling the drinking water MCL for gross alpha activity. This somewhat elevated gross alpha activity is probably related to the high level of suspended solids (>200 mg/L) in samples from the well (see Section 2.0).

5.5 GROSS BETA ACTIVITY

One of the groundwater samples collected to date had gross beta activity above the applicable MDA and CE, and this result (16 pCi/L in November 2004) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

5 - 10	0.03 - 0.3	<5	7.5 - 15	25 - 50
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-694

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket B
Y-12 GRID EAST COORDINATE: 44,893.28
Y-12 GRID NORTH COORDINATE: 28,844.77
SURFACE ELEVATION: 938.58 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/07/91 PAIRED/CLUSTERED WITH: GW-695
TAG DEPTH (measured): 207.27 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 941.98 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	153.0	785.58
BOTTOM (filter pack or open hole):	204.5	734.08
MIDPOINT (filter pack or open hole):	178.8	759.83
PUMP INTAKE:	178.7	759.88
WATER LEVEL (average):	24.92	914.26

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	23		
CONVENTIONAL SAMPLING METHOD:	17 samples	06/19/91	08/01/96
LOW-FLOW SAMPLING METHOD:	6 samples	03/05/98	07/19/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/01/05	.	07/19/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.97 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	14	48.9 mg/L	09/20/92	Decreasing
URANIUM (0.03 mg/L):	21	0.3 mg/L	12/28/93	Decreasing
SUMMED VOCs (5 μg/L):	18	180 μg/L	06/19/91	Decreasing
GROSS ALPHA (15 pCi/L):	17	108 pCi/L	12/28/93	Decreasing
GROSS BETA (50 pCi/L):	11	161 pCi/L	12/28/93	Decreasing

WELL GW-694

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 1991, completed with an open-hole monitored interval from 153 to 204.5 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket B, which consists of a series of wells (GW-694, GW-695, GW-703, GW-704, GW-705, and GW-706) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between June 1991 and August 1996, and the low-flow sampling method used to obtain six samples between March 1998 and July 2005. Note that the samples collected in March and July 1998 were collected specifically for the CERCLA Remedial Investigation (RI) for BCV and were analyzed by a different laboratory (DOE 1997).

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate depth (100 to 300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 25 ft bgs and exhibits seasonal fluctuations of about 9 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket B indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone. Moreover, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-694 are typically higher than evident in well GW-695, which is completed at a shallower depth (62.6 ft bgs) in the Maynardville Limestone (Figure 1). Based on the distance between the monitored interval midpoint (elevation) in each well (121.3 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.004 – 0.042) from the deeper bedrock interval (GW-694) to the shallow bedrock interval (GW-695).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 150 – 662 mg/L;
- pH of 6.6 – 7.62 (field measurements);
- nitrate concentrations that exceed the drinking water MCL (10 mg/L);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, all of these contaminants are present in the groundwater at this well.

5.1 NITRATE

All but two of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), including 14 samples with concentrations that exceed the drinking water MCL (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located about 7,200 ft east-northeast (hydraulically upgradient) of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, most of the groundwater samples had nitrate concentrations above the MCL, with the highest concentrations reported for samples collected in September 1992 (48.9 mg/L) and November 1992 (47 mg/L). However, all the samples collected since March 1996 had nitrate concentrations below the 10 mg/L MCL. Additionally, the nitrate concentrations exhibit apparently seasonal fluctuations, with the lowest concentrations typically reported for samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests dilution of nitrate from seasonal (and episodic) recharge of less contaminated groundwater via the flow/transport pathways intercepted by the monitored interval in the well. Also, the magnitude of the temporal fluctuations indicated by nitrate results reported for the samples obtained with the conventional sampling method is notably greater than indicated by the nitrate results reported for the samples obtained with the low-flow sampling method. This may be at least partially attributable to inherent differences in the manner in which each sampling method induces flow of groundwater into the well. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features (e.g., conduits or fractures) that may not be proximal to the well. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features more proximal to the well.

A time-series plot of nitrate results shows a generally decreasing long-term concentration trend dominated by wide fluctuations (Figure 2). The rate of decrease appears to have slowed substantially, as illustrated by the nitrate concentrations detected in the groundwater samples collected in June 1992 (40.5 mg/L), August 1996 (3.57 mg/L), July 2002 (3.69 mg/L), and July 2005 (5.7 mg/L). Interestingly, the latter results suggest that the nitrate levels may have increased slightly since the mid-1990s. Nevertheless, the overall decrease from the nitrate concentrations evident in the early-1990s undoubtedly reflects the substantially reduced flux of nitrate in the Maynardville Limestone in response to the closure of the former S-3 Ponds in 1988 and installation of the low-permeability cap at the site in 1989.

5.2 URANIUM

All but two of the groundwater samples collected to date had uranium concentrations above the analytical reporting limit (Table 1), and each of these samples had concentrations that exceed the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV that are hydraulically upgradient of Exit Pathway Picket B, including the contaminant plume originating from the S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. Also, the CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 2,500 ft east of Exit Pathway Picket B. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited mobility under the neutral pH conditions typical of the groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

As noted previously, total uranium concentrations reported for most of the groundwater samples, including the samples collected most recently (March and July 2005), exceed the 0.03 mg/L MCL (Table 1). Uranium concentrations reported for the samples collected in March and July 1998 are the only results that are below the MCL, appear to be outliers (too low) compared to the other data, and may be analytical artifacts. Additionally, the uranium concentrations exhibit apparently seasonal fluctuations, with the highest concentrations typically reported for samples collected during seasonally low groundwater flow conditions (summer and fall). This relationship suggests increased flux of uranium from seasonal (and episodic) recharge of uranium-contaminated groundwater via the flow/transport pathways intercepted by the monitored interval in the well. Note also that this contrasts with the relationship between nitrate concentrations and seasonal flow conditions, as discussed in Section 5.1, which may indicate largely separate sources of the uranium (BYBY) and nitrate (S-3 Site) in the groundwater from this well. Additionally, as noted in the discussion of nitrate results for the well, the uranium results reported for the samples obtained with the conventional sampling method likewise exhibit significantly more temporal variation than indicated by the uranium results reported for the samples obtained with the low-flow sampling method, probably because of the inherent differences in the manner in which each sampling method induces flow of groundwater into the well.

A time-series plot of the uranium results shows a generally decreasing long-term trend dominated by wide fluctuations (Figure 3), although the rate of decrease appears to have slowed, as illustrated by the uranium concentrations detected in the groundwater samples collected in December 1993 (0.3 mg/), August 1996 (0.062 mg/L), January 2002 (0.0393 mg/L), and July 2005 (0.0324 mg/L). Nevertheless, the overall decrease in uranium concentrations probably reflect the substantially reduced flux of uranium in response to the CERCLA remedial action at the BYBY in 2001 as well as the previous closure and capping of the S-3 Ponds in 1988/1989.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater sample collected to date (Table 2): PCE, TCE, 12DCE, 11DCE, 111TCA, 11DCA, CTET, benzene, chlorobenzene, toluene, 2-butanone, and acetone. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the BYBY, Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 2,200 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket B. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOC in the groundwater samples is TCE, which was detected in all but two of the samples collected to date and is the only compound detected in any of the samples collected since July 2002 (Table 2). The historical maximum concentration of TCE is 41 µg/L (September 1991), although this result appears to be an outlier compared to the other TCE concentrations, which are all less than 20 µg/L. Moreover, TCE concentrations in all the samples collected since March 1996 have been below the 5 µg/L drinking water MCL (Table 2). Of the other VOCs detected in the groundwater samples, 12DCE has been detected the most frequently, with a historical maximum concentration of 38 µg/L (September 1991), which is substantially below the MCL (70 µg/L). No other VOCS were detected at concentrations greater than 5 µg/L with the exception of acetone in June 1991 (180 µg/L; suspected outlier) and toluene in March (12 µg/L) and July 1998 (11 µg/L).

As shown on Figure 4, a time-series plot of TCE concentrations detected in the groundwater samples collected to date shows a variable but generally decreasing long-term concentration trend between September 1991 (41 µg/L) and August 1996 (3 µg/L). However, the trend shows little if any concentration change thereafter, as illustrated by the TCE results reported for the samples collected in July 1998 (3 µg/L), July 2002 (3 µg/L), and July 2005 (2 µg/L). The overall decrease in TCE levels in the groundwater at this well probably reflects reduced flux of TCE (and other VOCs) in response to corrective actions at the primary sources of VOCs in BCV west of Y-12, including the closure of the Oil Landfarm WMA and the installation of low-permeability caps at the site, and the CERCLA remedial actions at the BYBY/HCDA, which involved the excavation and removal of contaminated soils above and below the saturated zone (BJC 2004).

5.4 GROSS ALPHA ACTIVITY

All but three of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 1), including 17 results that exceed the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (and alpha-emitting daughters) are the source of elevated gross alpha activity in the groundwater at this well. The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the groundwater at the Exit Pathway Picket B wells (DOE 1997). As with total uranium (see Section 5.2), U-234 and U-238 leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the (limestone) bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

As noted previously, most of the groundwater samples had gross alpha activity that exceeded the drinking water MCL (15 pCi/L). The historical maximum concentration of 108 pCi/L in December 1993 is a suspected outlier, with all other results below 65 pCi/L. Gross alpha activity reported for all samples collected since January 1992 has been below the water MCL, with the most result reported for the sample collected in October 2005 (12 pCi/L) being the historical minimum value (above the MDA).

A time-series plot of the available results for gross alpha activity shows a variable but generally decreasing long-term trend (Figure 5). This concentration trend generally mirrors the similar trend defined by the sampling results for total uranium and likewise may be attributed to reduced flux of uranium isotopes in response to the CERCLA remedial action at the BYBY and the previous closure/capping of the former S-3 Ponds. Thus, the decreasing levels of gross alpha activity suggest a corresponding decrease in the relative flux of uranium isotopes along the groundwater flowpaths intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), including eleven results that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is most likely Tc-99, which was detected (i.e., >MDA and CE) in a series of groundwater samples collected between March 1993 and August 1996. Analytical results for these samples show a maximum Tc-99 concentration of 4,290 pCi/L (March 1993), which is the only value that exceeds the Tc-99 SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent, and is an outlier compared to the other Tc-99 concentrations. In any case, Tc-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate, which reflects their common source and their similar transport characteristics in the groundwater.

As noted previously, most of the groundwater samples had gross beta activity above 50 pCi/L, with a historical maximum value of 161 pCi/L (December 1993). However, as shown by the data summarized in Table 1, results below 50 pCi/L were reported for all the samples collected since August 1995. Additionally, the gross beta results reported for the samples obtained with the conventional sampling method (i.e., before March 1998) exhibit significantly more temporal variation than indicated by the gross beta results reported for the samples subsequently obtained with the low-flow sampling method.

A time-series plot of the results for gross beta activity shows a generally decreasing long-term trend dominated by wide fluctuations, some of which may be attributable to inherent analytical variability (Figure 6). These fluctuations often correspond with seasonal flow conditions, whereby the lowest gross beta activities are reported for samples collected during seasonally high groundwater flow conditions (winter and spring). Also, the rate at which the levels of gross beta activity have decreased over the long term appears to have slowed considerably, with the results reported for the samples collected in July 1998 (3.85 pCi/L) and July 2005 (34 pCi/L) suggesting an increasing trend.

6.0 REFERENCES

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-694: summary of results for nitrate, total uranium, gross alpha activity, and gross beta activity

Sampling Date	Concentration (mg/L)		Activity (pCi/L)	
	Nitrate	Total Uranium	Gross Alpha Activity	Gross Beta Activity
06/19/91	12	0.047	23.68	48.38
09/13/91	36.66	0.23	55.48	143.17
11/22/91	40.23	0.139	48.8	131
03/24/92	10.58	0.11	33.6	58.5
06/21/92	40.5	0.14	46.5	128
09/20/92	48.9	0.187	30.7	45.8
11/18/92	47	0.243	64.3	160
03/23/93	10	0.115	31.8	34.6
06/06/93	29.25	0.121	56.9	88.4
09/22/93	31	0.198	50.9	112
12/28/93	29.2	0.3	108	161
03/02/94	7.9	0.1	37	30
12/13/94	16	0.131	63.4	85.9
03/30/95	20	0.13	51.2	75.8
08/31/95	16	0.12	43.1	62.1
03/18/96	13.2	0.12	43.6	41.7
08/01/96	3.57	0.062	<MDA	<MDA
[03/05/98]	.	.	<MDA	6.24
[07/13/98]	.	.	<MDA	3.85
01/29/02	4.79	0.0393	22	14
07/17/02	3.69	0.0355	15	20
03/01/05	5.8	0.0308	13	20
07/19/05	5.7	0.0324	12	34
MCL	**10**	**0.03**	**15**	**50***

Note: [ ] = RI sample; "." = Not detected; * = SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-694: summary of VOC results

Sampling Date	Concentration (µg/L)				
	PCE	TCE	12DCE	11DCE	111TCA
06/19/91	.	.	.	.	.
09/13/91	2 J	41	38	4 J	2 J
11/22/91	.	14	.	2 J	.
03/24/92	.	6	7	.	.
06/21/92	.	11	11	.	.
09/20/92	.	16	16	1 J	.
11/18/92	.	12	11	.	.
03/23/93	.	14	9	.	.
06/06/93	.	14	11	.	0.5
09/22/93	.	11	11	.	.
12/28/93	.	15	13	.	.
03/02/94	.	8	9	1 J	.
12/13/94	.	12	8	.	.
03/30/95	.	13	.	.	.
08/31/95	.	19	23	.	.
03/18/96	.	8	7	.	.
08/01/96	.	3 J	.	.	.
[03/05/98]	2 J	4 J	.	.	.
[07/13/98]	.	3 J	1 J	.	.
01/29/02	.	.	.	.	.
07/17/02	.	3 J	.	.	.
03/01/05	.	3 J	.	.	.
07/19/05	.	2 J	.	.	.
MCL	**5**	**5**	**NA**	**7**	**200**

Sampling Date	Compound/Concentration (µg/L)
06/19/91	Acetone (180)
09/13/91	Benzene (0.9 J), CTET (0.9 J), 11DCA (1 J), Chlorobenzene (1)
[03/05/98]	Toluene (12), 2-Butanone (6)
[07/13/98]	Toluene (11), 2-Butanone (4 J)

Note: [ ] = RI Sample**;** "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

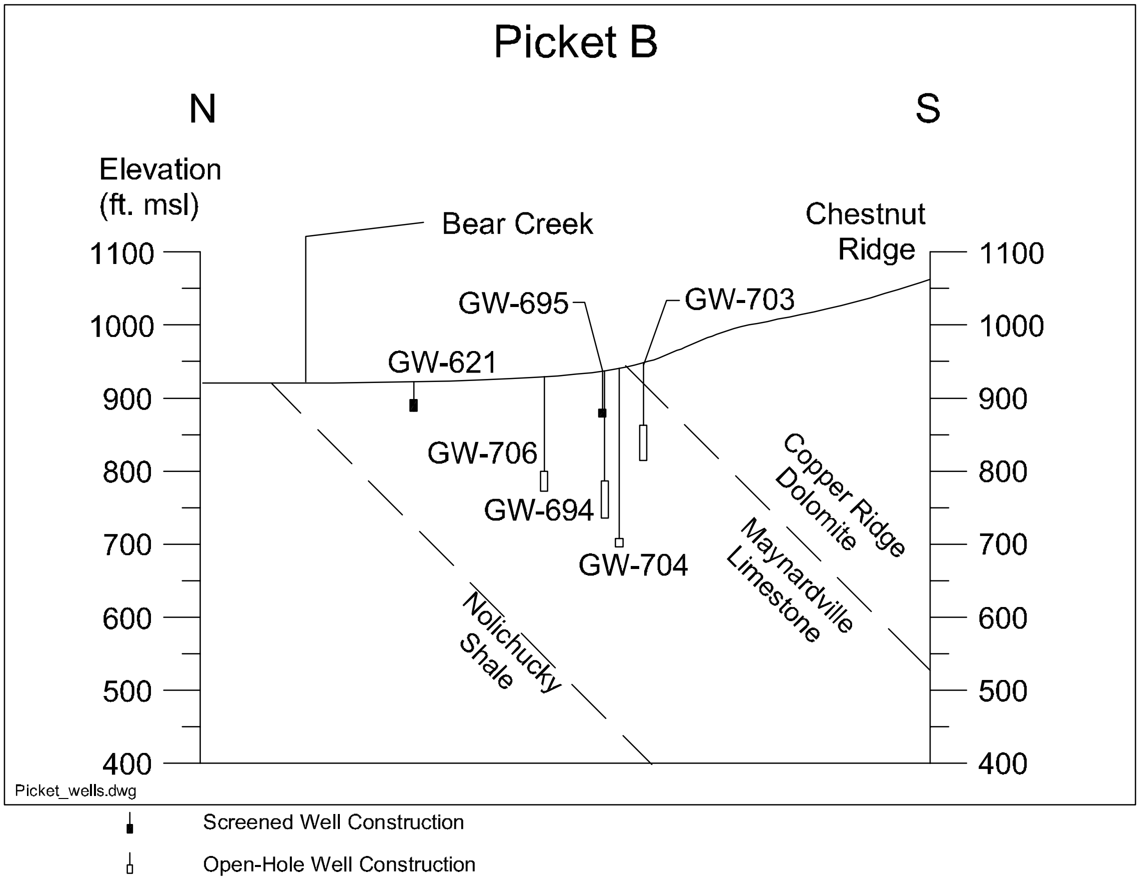

Picket B
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-695
GW-703
GW-621
GW-706
GW-694
GW-704
Copper Ridge
Dolomite
Maynardville
Limestone
Nolichucky
Shale
Picket_wells.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

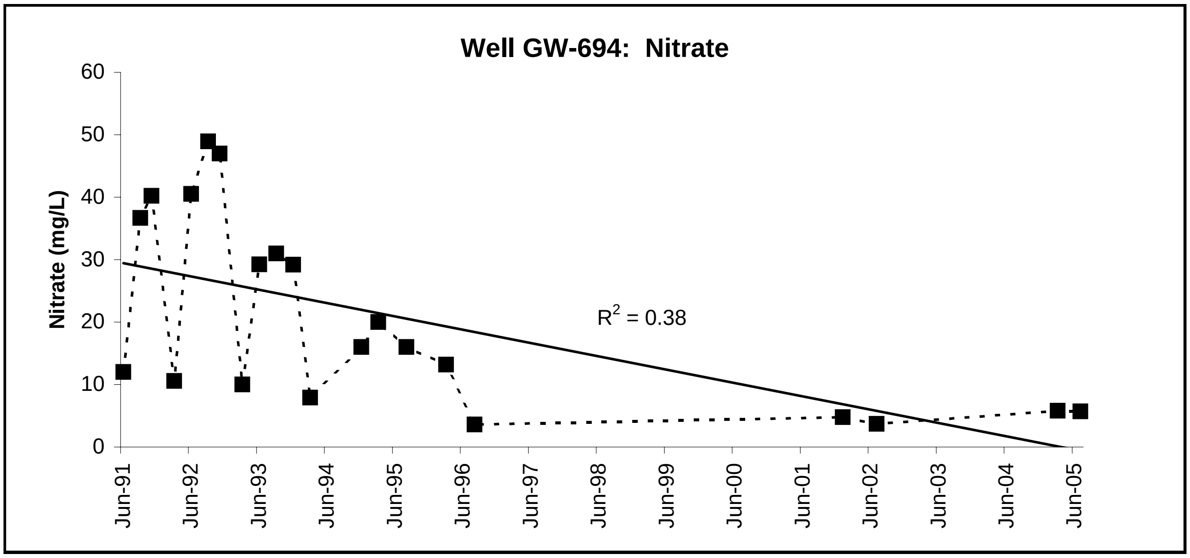


Figure 2

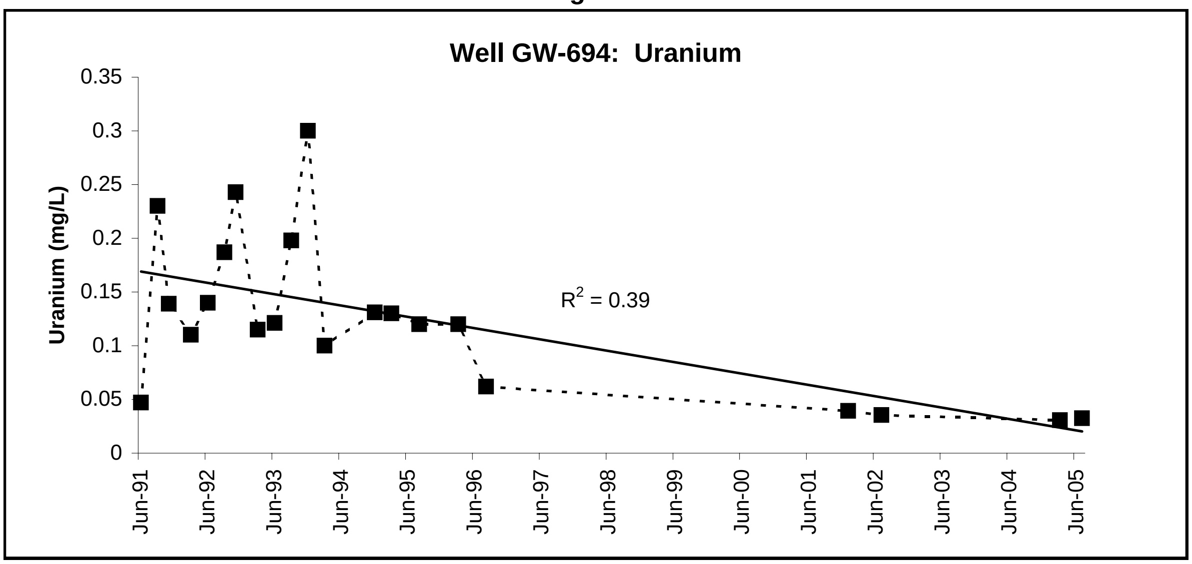


Figure 3

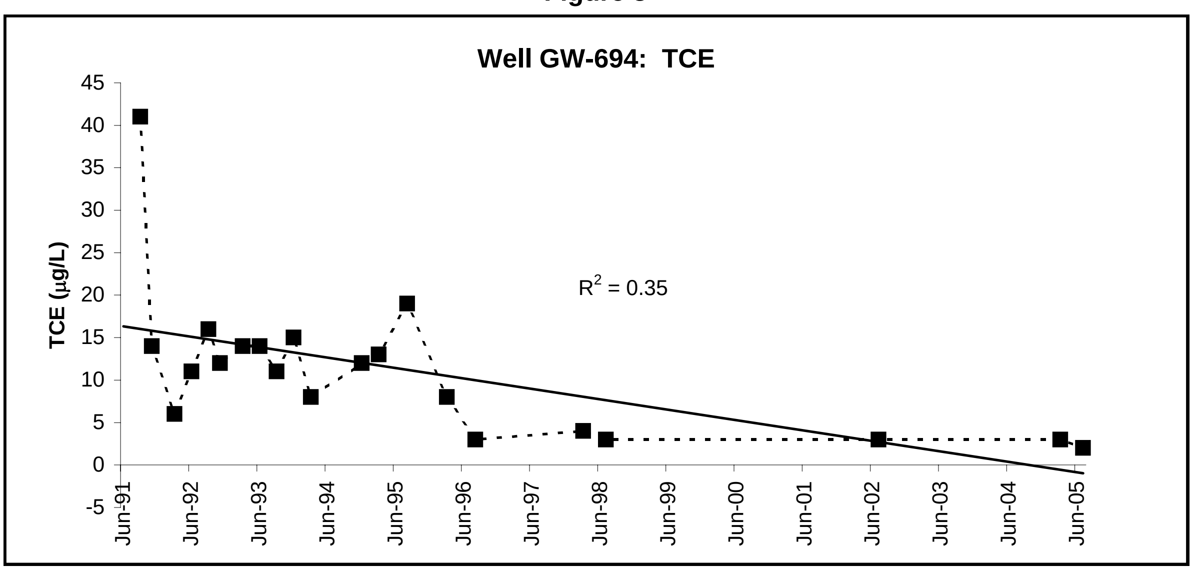


Figure 4

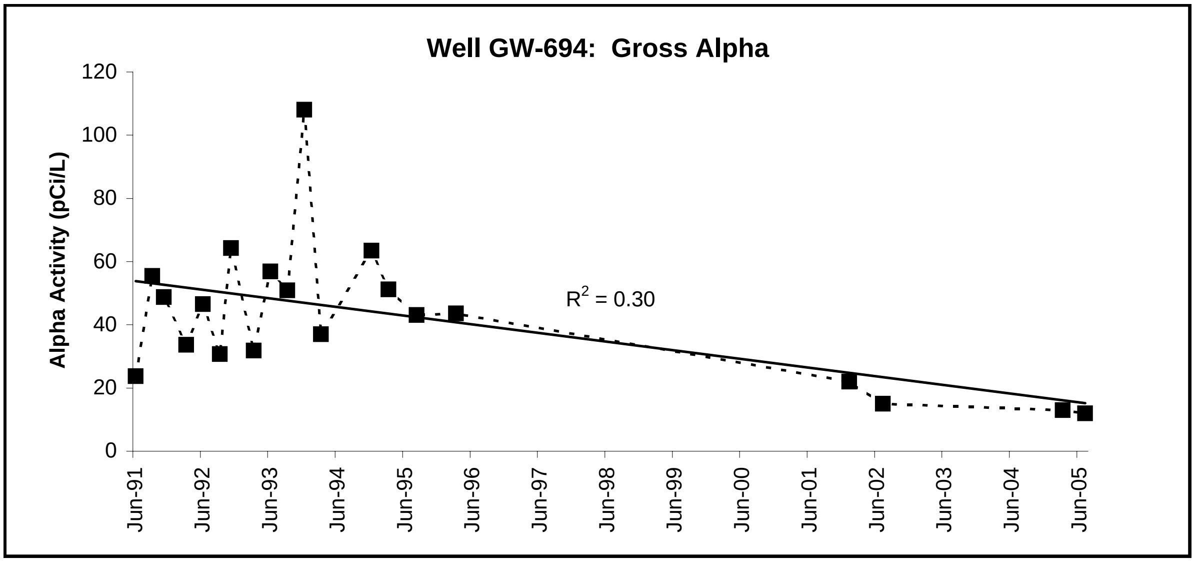


Figure 5

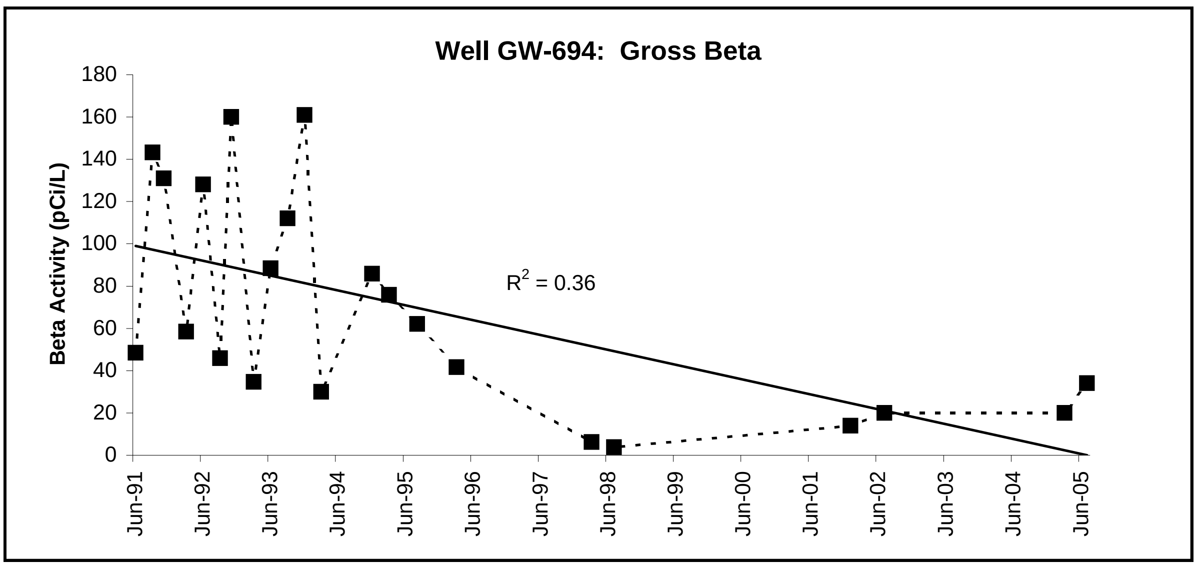


Figure 6

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	5 - 50	<7.5	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-695

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket B
Y-12 GRID EAST COORDINATE: 44,868.30
Y-12 GRID NORTH COORDINATE: 28,844.73
SURFACE ELEVATION: 937.22 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/21/91 PAIRED/CLUSTERED WITH: GW-694
TAG DEPTH (measured): 65.28 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 939.54 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.88 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	50.6	886.62
BOTTOM (filter pack or open hole):	62.6	874.62
MIDPOINT (filter pack or open hole):	56.6	880.62
PUMP INTAKE:	57.68	879.54
WATER LEVEL (average):	25.86	911.36

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	33		
CONVENTIONAL SAMPLING METHOD:	19 samples	06/18/91	08/19/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/17/98	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/03/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.1 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	9	16 mg/L	06/09/93	Increasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	22	105 µg/L	02/17/97	Increasing
GROSS ALPHA (15 pCi/L):	2	26 pCi/L	01/16/03	Outliers
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-695

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 1991, completed with a screened monitored interval from 50.6 to 62.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket B, which consists of a series of wells (GW-694, GW-695, GW-703, GW-704, GW-705, and GW-706) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between June 1991 and August 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 26 ft bgs and exhibits seasonal fluctuations up to about 8 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket B indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 200 – 350 mg/L;
- pH of 7.1 – 8.7 (field measurements);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate, VOCs, and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), including twelve samples with concentrations that exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 7,200 ft east-northeast (hydraulically upgradient) of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations detected in the groundwater samples range between the historical minimum and maximum values of 0.25 mg/L (March 1992) and 12 mg/L (July 2001 and January 2002), respectively (Table 1). As noted previously, most of the nitrate concentrations are less than the MCL, with all but one of the samples with nitrate above the MCL collected since July 2000. Also, unlike other nitrate levels evident in groundwater samples from other wells in Exit Pathway Picket B (e.g., GW-704), the nitrate concentrations do not exhibit any clear of consistent seasonal fluctuations, as indicated by the temporal "peak" concentrations evident for samples collected during seasonally high and low groundwater flow conditions. A time-series plot of nitrate results shows an increasing long-term concentration trend (Figure 2), which probably reflects a corresponding increase in the relative flux of nitrate via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.2 URANIUM

All but one of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00969 mg/L in February and July 2004) being less than the drinking water MCL for uranium (0.03 mg/L). Nevertheless, the most recent uranium results reflect an order-of-magnitude increase from the uranium concentrations evident during the early 1990s (e.g., 0.009 mg/L in November 1991).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): acetone, methylene chloride, TCE, 11DCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 μg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 2,200 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket B. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are TCE and 12DCE (Table 2), with one or both compounds detected in all but two of the samples. Each compound was detected at relatively low concentrations, most of which are estimated values below 5 μg/L. The most recent sampling results show TCE concentrations at the MCL (5 μg/L) and c12DCE concentrations at least an order-of-magnitude below the MCL (70 μg/L). Aside from TCE and 12DCE, trace concentrations (1 μg/L or less) of methylene chloride, 11DCE, and 111TCA were detected in one sample each, and acetone was reported (42 μg/L and 94 μg/L) for two samples (both results are suspected outliers).

A time-series plot of TCE concentrations in the groundwater samples shows a generally increasing long-term trend with proportionally large temporal fluctuations (Figure 3), some of which may be attributed to analytical variability often associated with relatively low VOC concentrations (most of the TCE results are estimated values). Also, the temporal concentration fluctuations do not exhibit any consistent relationship with groundwater flow conditions, as illustrated by the equal concentrations of TCE reported for samples collected during seasonally high and low groundwater flow conditions (e.g., 5 μg/L in February and July 2004). Moreover, the concentrations of 12DCE detected in the groundwater samples do not exhibit an increasing trend (Table 2), as illustrated by the 12DCE results for the samples collected in March 1993 (2 μg/L), February 1998 (2 μg/L), and July 2004 (1 μg/L). Assuming the plume of dissolved VOCs in the Maynardville Limestone contains a heterogeneous mixture of compounds, it is not clear from the available data why the concentrations of individual compounds exhibit divergent concentration trends or if such variations are significant with respect to the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Twenty-two groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest values (25 pCi/L in July 2000 and 26 pCi/L in January 2003) being the only results to exceed the drinking water MCL for gross alpha activity (15 pCi/L). Both of these results appear to be outliers compared to the other results for gross alpha activity, which are all 10 pCi/L or less.

5.5 GROSS BETA ACTIVITY

All but two of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1). All but the historical maximum value (50 pCi/L in January 2002) are less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which was detected (i.e., >MDA and CE) in the samples collected in January 2001 (39 pCi/L), July 2001 (48 pCi/L), January 2002 (45 pCi/L), and July 2002 (45 pCi/L). Note that all the Tc-99 results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent. Technetium-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

A time-series plot of gross beta activity reported for the groundwater samples shows a generally increasing long-term trend dominated by wide temporal fluctuations, some of which may be attributed to inherent analytical variability (Figure 4). Also, the results for gross beta activity do not exhibit any clear or consistent relationship with seasonal groundwater flow conditions. Additionally, the levels of gross beta activity appear to have decreased following the temporal "peak" value in January 2002 (50 pCi/L).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-695: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
06/18/91	1	15.89
09/13/91	1.57	12.13
11/22/91	1.66	14
03/25/92	NA	12.3
06/21/92	2.4	16.2
09/20/92	2.24	19.8
11/19/92	3.4	2.8
03/24/93	5.7	15.7
06/09/93	NA	14.5
09/22/93	6.2	30.9
12/21/93	7.7	16.9
02/21/94	9.8	21.2
12/07/94	6.4	NA
03/29/95	8.5	17.2
08/30/95	6.8	17.4
03/14/96	8.64	17.5
07/23/96	8.99	14.4
08/19/97	NA	18
02/01/97	8.81	NA
02/17/98	9.92	27
07/30/98	8.4	25
02/15/99	10.7	25
08/02/99	9.144	29
01/24/00	8.85	35
07/13/00	11.6	34
01/16/01	10.9	42
07/16/01	12	46
01/15/02	12	50
07/15/02	10.8	42
01/16/03	10.4	48
07/15/03	9.15	30
02/03/04	11.6	39
07/21/04	9.49	30
MCL	**10**	**50***

Note: NA = Not analyzed; * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-695: summary of VOC results

Date Sampled	Concentration (µg/L)			
	TCE	12DCE (Total)	c12DCE	OTHER
06/18/91	3 J	.	NR	Acetone (42)
09/13/91	2 J	.	NR	.
11/22/91	.	.	NR	.
03/25/92	2 J	.	NR	.
06/21/92	2 J	.	NR	.
09/20/92	2 J	.	NR	.
11/19/92	.	.	NR	.
03/24/93	4 J	2 J	NR	.
06/09/93	.	.	NR	.
09/22/93	4 J	.	NR	.
12/21/93	4 J	2 J	NR	11DCE (0.5 J)
02/21/94	4 J	2 J	NR	.
12/07/94	4 J	2 J	NR	.
03/29/95	4 J	.	NR	.
08/30/95	3 J	2 J	RN	.
03/14/96	5	4 J	NR	111TCA (1 J)
07/23/96	5	3 J	NR	.
02/17/97	7	3 J	3 J	Acetone (94), Methylene chloride (1 J)
08/19/97	5	.	.	.
02/17/98	7	2 J	2 J	.
07/30/98	5	2 J	2 J	.
02/15/99	8	5	5	.
08/02/99	4 J	3 J	3 J	.
01/24/00	6	3 J	3 J	.
07/13/00	6	3 J	3 J	.
01/16/01	6	3 J	3 J	.
07/16/01	7	3 J	3 J	.
01/15/02	5	3 J	3 J	.
07/15/02	5	2 J	2 J	.
01/16/03	6	4 J	4 J	.
07/15/03	6	2 J	2 J	.
02/03/04	5	2 J	2 J	.
07/21/04	5	1 J	1 J	.
MCL	**5**	**NA**	**70**	.

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

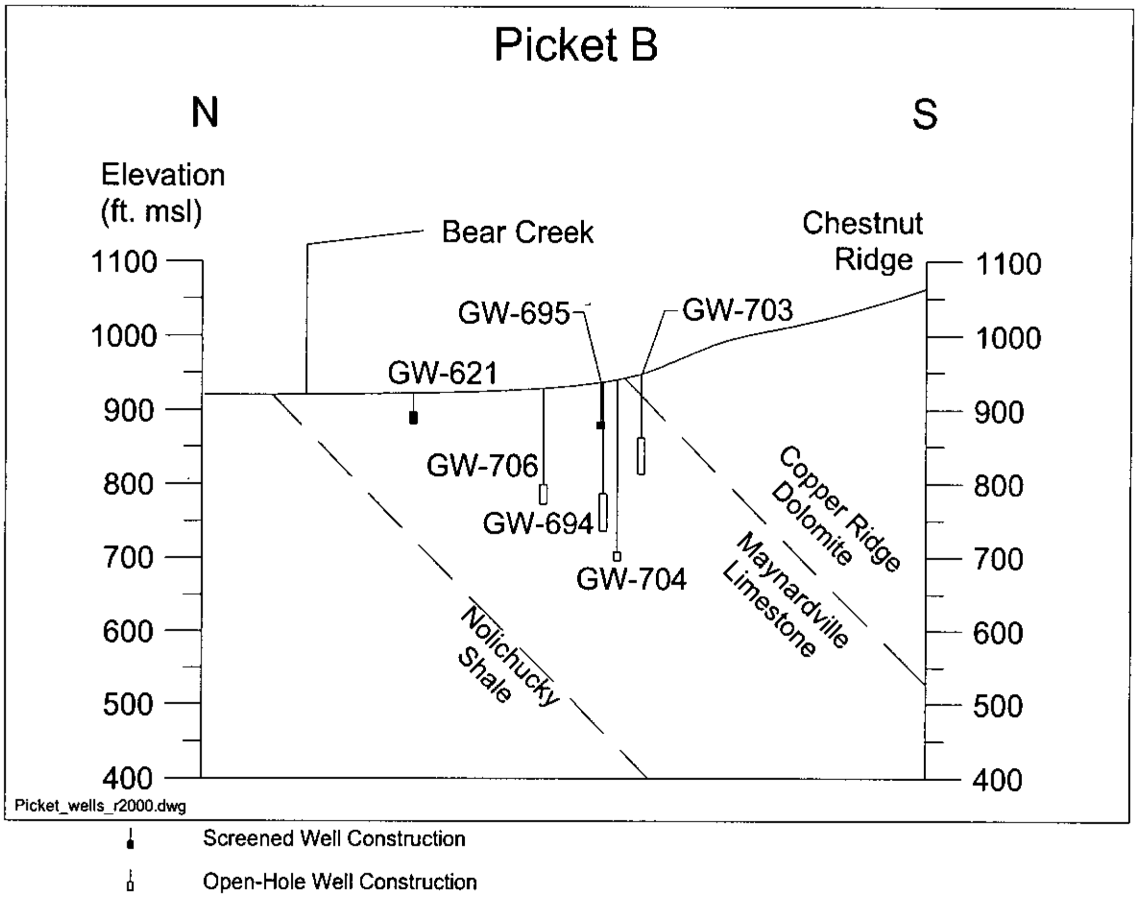

Picket B
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-695
GW-703
GW-621
GW-706
GW-694
GW-704
Copper Ridge
Dolomite
Maynardville
Limestone
Nolichucky
Shale
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

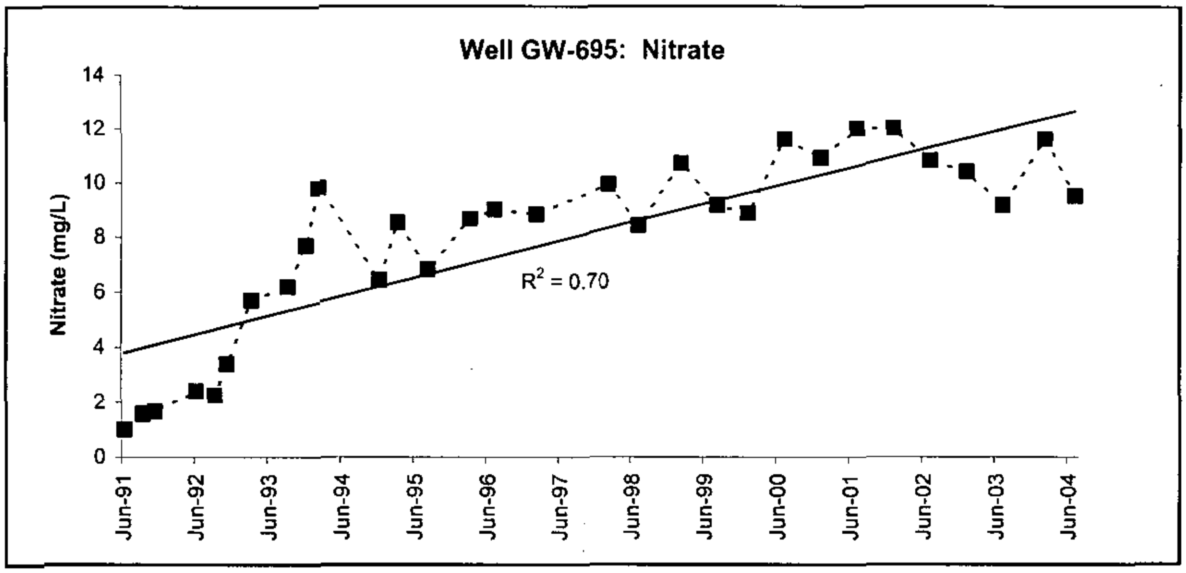


Figure 2

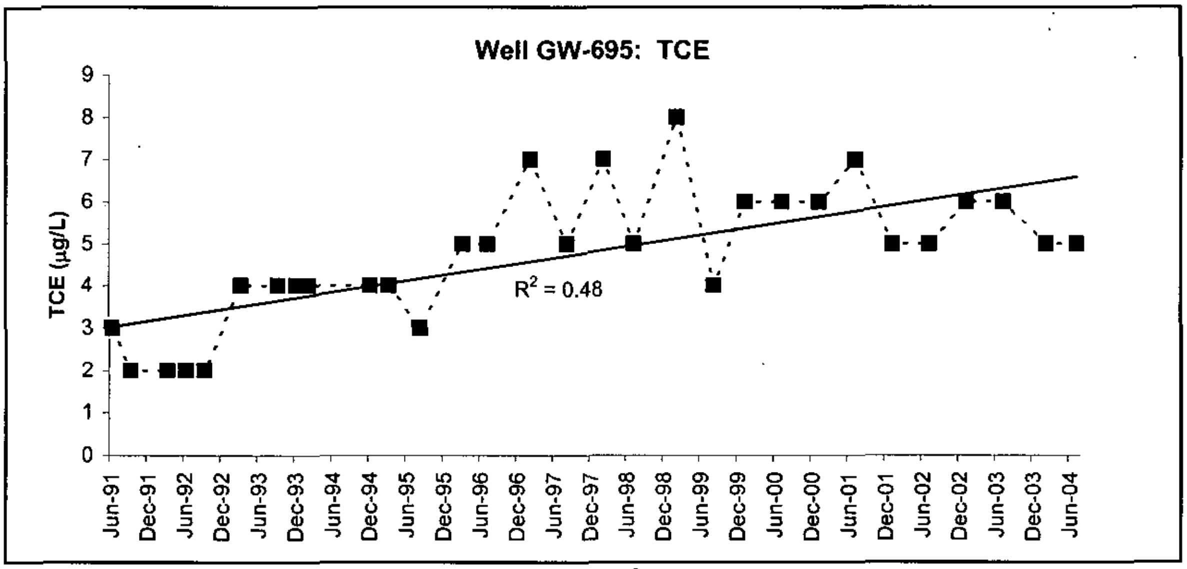


Figure 3

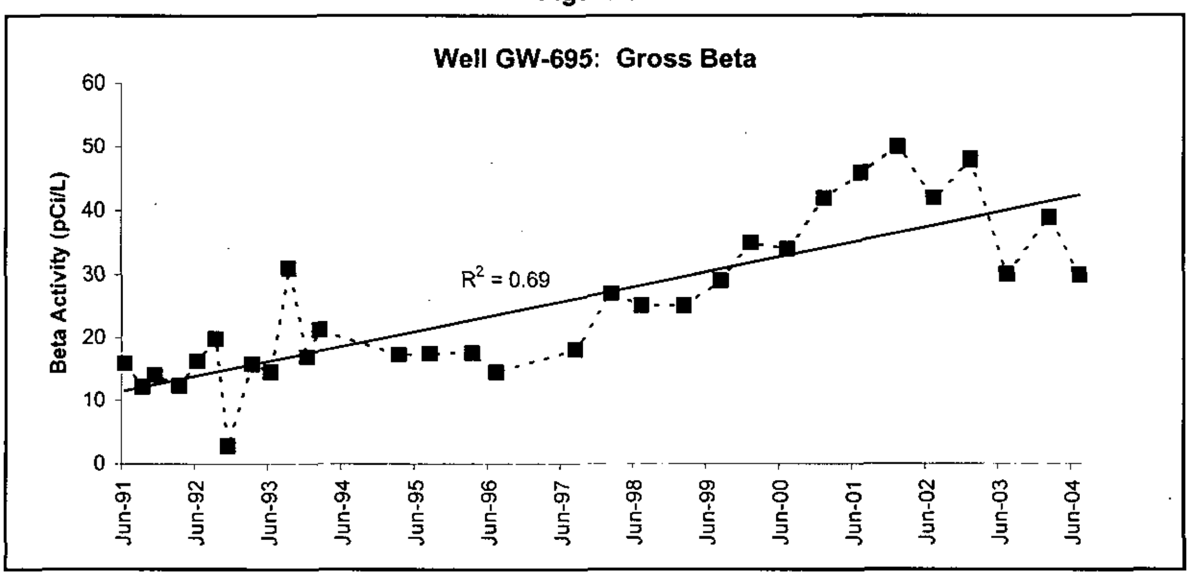


Figure 4

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-696

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 81-10
Y-12 GRID EAST COORDINATE: 56,810.35
Y-12 GRID NORTH COORDINATE: 29,276.64
SURFACE ELEVATION: 969.78 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/18/90   PAIRED/CLUSTERED WITH: GW-697 GW-698
TAG DEPTH (measured): 31.70 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 969.78 ft above msl   MEASURING POINT: TOC
WELL BORE DIAMETER: 12 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard   Sampling Port No.: .   Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	18.5	951.28
BOTTOM (filter pack or open hole):	32.5	937.28
MIDPOINT (filter pack or open hole):	25.5	944.28
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	14.13	955.65

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	1 samples	03/11/97	03/11/97
LOW-FLOW SAMPLING METHOD:	1 samples	05/20/03	05/20/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/20/03	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X   TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: .   LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: .   OTHER: .
WATER LEVEL FLUCTUATION: 0 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	10.1 μg/L	03/11/97	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-696

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1990, completed with a screened monitored interval from 18.5 to 32.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-698 located in Bear Creek Valley within the south central section of Y-12, near the southeast corner of Bldg. 81-10.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from this well in March 1997 and May 2003.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements show the average static groundwater level in the well is 14 ft below ground surface.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the two samples collected in from the well indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6.6;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except iron and manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Neither groundwater sample had nitrate above the applicable analytical reporting limit.

5.2 URANIUM

Neither groundwater sample had uranium above the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Low levels of PCE (0.5 μg/L), TCE (2 μg/L), c12DCE (7 μg/L) and VC (0.6 μg/L) were detected in the groundwater sample collected in March 1997. These compounds are confirmed components of dissolved VOC plumes in the groundwater hydraulically upgradient to the west and northwest of the well. None of these compounds (or other VOCs) was detected in the groundwater sample collected in May 2003.

5.4 GROSS ALPHA ACTIVITY

Neither groundwater sample had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

Neither groundwater sample had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

100 - 1,000	<0.015	500 - 5,000	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-698

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 81-10
Y-12 GRID EAST COORDINATE: 56,803.74
Y-12 GRID NORTH COORDINATE: 29,277.15
SURFACE ELEVATION: 970.09 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/02/90 PAIRED/CLUSTERED WITH: GW-696 GW-697
TAG DEPTH (measured): 74.88 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 970.09 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	63.0	907.09
BOTTOM (filter pack or open hole):	75.0	895.09
MIDPOINT (filter pack or open hole):	69.0	901.09
PUMP INTAKE:	71.00	899.09
WATER LEVEL (average):	32.08	938.01

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	3 samples	06/09/96	11/03/04
LOW-FLOW SAMPLING METHOD:	10 samples	06/23/98	11/02/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/18/04	.	11/02/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 25.52 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	12	221 mg/L	11/13/01	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	13	762 μg/L	05/23/01	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-698

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1990, completed with a screened monitored interval from 63 to 75 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-696 and GW-697 and is located in Bear Creek Valley (BCV) at the former location of Bldg. 81-10 (only the concrete foundation remains in place), which is in the south-central section of Y-12 at the intersection of Third Street and G Road. Building 81-10 began use as a tin shop in 1943. A roasting furnace was installed in the building in 1957 and used until 1962 to recover mercury from contaminated equipment, soils, sludge, and other solid wastes. An estimated 3,000 lb of mercury was spilled and lost to the subsurface soils through cracks in the concrete floor during operation of the furnace. An initial clean up of the site in 1971 recovered about 130,000 lb of mercury from contaminated materials, including 2,700 lb from a sump located at the northeast corner of the concrete foundation building. Also, contaminated soils and sludge that were placed in steel drums and stored on site reportedly leaked before they were removed in 1993 (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain three samples between March 1996 and November 2004, and the low-flow sampling method used to obtain ten samples between June 1998 and November 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method appeared to have substantially lower summed VOC concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during May and November 2004, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias (Table 1). Summed concentrations of VOCs detected in the samples obtained with the low-flow method are about 30% higher than the corresponding summed VOC concentrations for the samples obtained with the conventional sampling method the next day. Also, the conventional sampling method appears to yield less mineralized groundwater samples with nitrate concentrations that are at least 50% lower than detected in the samples obtained the previous day with the low flow method.

Inherent differences in the manner in which each sampling method induces flow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for nitrate and VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce flow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. Conventional sampling also appears to disturb fine-grained particles in the bottom of the well or in the fractures intercepted by the monitored interval, as illustrated by the total suspended solids (TSS) reported for the (unfiltered) samples collected in May 2003 (47 mg/L). In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method appears to induce greater relative inflow of uncontaminated (or less nitrate- and VOC-contaminated) groundwater from water-producing features that are not proximal to the monitored interval, whereas low-flow sampling appears to primarily induce inflow of contaminated groundwater from the water producing feature(s) close to the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static groundwater level in the well occurs at an average depth of about 32 ft bgs and exhibits wide temporal fluctuations (Figure 1). The groundwater elevations generally decreased by 15 ft from June 1996 (942.41 ft above msl) to November 2001 (927.35 ft above msl), then steadily increased by about 25 ft through May 2003 (952.87 ft above msl), sharply dropped approximately 15 ft from May to November 2003 (937.39 ft above msl) and has remained fairly steady since that time. It is not clear from the available data what may have caused the steady increase and sudden decrease in groundwater elevations in the well.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-698 indicate flow primarily to the east, parallel with geologic strike in the Maynardville Limestone. Additionally, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 364 – 1,610 mg/L;
- pH (field measurements) of 6.7 – 7.4;
- nitrate concentrations above 100 mg/L;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- total concentrations of other trace metals that are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date that were analyzed for nitrate (as N) had concentrations above the analytical reporting limit (Table 1), and all but one of these results exceed the MCL for nitrate (10 mg/L). There are two primary sources of nitrate located hydraulically upgradient (west) of the well: the former S-3 Ponds and the S-2 Site. Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways in the Maynardville Limestone that are followed by other similarly mobile contaminants originating from the contaminant plumes emplaced during operation of these sites. Based on the relatively limited existing network of monitoring wells within the heavily industrialized areas of Y-12, the extent of nitrate contamination in the Maynardville Limestone, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>50 ft bgs) in the bedrock that extends from the former S-2 Site eastward along geologic strike (i.e., bedding plan fractures) for at least as far as well GW-698 and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with the UEFPC surface water drainage system (DOE 1998).

Groundwater samples obtained with the low-flow sampling method exhibit a fairly wide range of nitrate concentrations, with the highest levels reported for samples collected in May and November 2001 (177 mg/L and 221 mg/L, respectively) and the lowest levels reported for samples collected in November 2002 (48 mg/L) and May 2003 (8.74 mg/L). Also, the nitrate results for these samples show wide temporal concentration fluctuations that do not consistently correlate with seasonal groundwater flow conditions, as illustrated by the order-of-magnitude difference between the nitrate concentrations reported for samples collected during seasonally high flow conditions in May 2001 and May 2003.

A time-series plot of the nitrate concentrations reported for the groundwater samples obtained with the low-flow sampling procedure (Figure 2), which spans a nearly three-year gap (July 1998 – May 2001) in the sampling history, suggests a generally indeterminate long-term concentration trend. In general, nitrate levels appear to have increased between June 1996 (25.3 mg/L) and November 2001 (221 mg/L), steadily decreased through May 2003 (8.74 mg/L), and sharply returned above 100 mg/L through November 2004 (118 mg/L). Interestingly, the nitrate concentration trend exhibits a directly inverse relationship with the presampling groundwater elevations in the well (see Section 2.0), with the increased groundwater elevations accompanied by decreased nitrate levels and the subsequent drop in groundwater elevations accompanied by a sharp increase in nitrate concentrations. This relationship suggests a temporal increase in the relative recharge of uncontaminated (or less nitrate-contaminated) groundwater via the flowpaths intercepted by the monitored interval in the well.

5.2 URANIUM

Uranium concentrations above the analytical reporting limit were reported for eleven of the groundwater samples collected to date, with the historical maximum concentration (0.0.0021 mg/L) obtained from conventional sampling in June 1996 being an order-of-magnitude below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 1): CTET, chloroform, freon-113 (F113), PCE, TCE, and 12DCE (c12DCE). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999).

The primary VOCs in the groundwater samples are PCE and TCE, both of which were detected at concentrations above 100 µg/L in all but two of the samples (Table 1). Also, the most recent sampling results (May and November 2004) show that PCE and TCE concentrations remain substantially above the respective MCLs (5 µg/L). Secondary compounds are CTET, chloroform (CLF), and 12DCE (c12DCE), which were all detected in all but two of the samples, with the highest concentrations (>40 µg/L) reported for c12DCE, and the most recent sampling results showing CTET concentrations above the MCL (5 µg/L). Based on analytical results for the samples collected in May and November 2004, F113 is another secondary compound in the groundwater (previous samples were not analyzed for this compound), with concentrations near 10 in samples obtained with the low-flow sampling method. Also, temporal fluctuations in the concentrations of primary and secondary VOCs do not exhibit a clear and consistent relationship with seasonal groundwater flow conditions, as illustrated by the substantial difference between the summed VOC concentrations reported for samples collected during seasonally high flow in March 2001 (762 µg/L) and March 2003 (55 µg/L).

As noted in Section 2.0, the low-flow sampling method appears to yield groundwater samples with higher summed VOC concentrations than samples collected with the conventional sampling method. However, as illustrated by the following data summary, the concentrations of some compounds (e.g., TCE) are highest in samples collected with the low flow method and the concentrations of some compounds (e.g., F113) are highest in samples collected with the conventional sampling method.

VOC	Concentration (µg/L)			
	Low-Flow Sampling May 18, 2004	**Conventional Sampling May 19, 2004**	**Low-Flow Sampling November 2, 2004**	**Conventional Sampling November 3, 2004**
PCE	120	120	120	150
TCE	300	130	440	200
c12DCE	14	33	38	64
CTET	7	.	6	.
Chloroform	13	3 J	14	5
F113	7	40	12	29
Summed VOCs	461	326	630	448
Notes: "." = Not detected; J = Estimated concentration below analytical reporting limit				

Assuming that the groundwater in the well contains a heterogeneous mixture of dissolved VOCs, it is not clear from the available data why each sampling method appears to influence the concentrations of some compounds and not others. Perhaps the conventional sampling method induces inflow of groundwater that contains higher relative concentrations of some compounds (c12DCE, F113, and possibly PCE) than does the groundwater inflow induced by the low-flow sampling method. Regardless, there is uncertainty as to which groundwater sampling method provides the more representative monitoring results for VOCs. The conservative approach is to assume that representative results are obtained with the low-flow sampling method because this method appears to yield groundwater samples with the highest VOC concentrations.

A time-series plot of the summed concentrations of VOCs detected in groundwater samples obtained with the low-flow sampling method shows a long-term concentration trend which generally mirrors that of nitrate (Figure 3): it spans the three-year gap in the sampling history for the well and shows an increase in VOC concentrations between June 1996 (20 μg/L) and November 2001 (762 μg/L), followed by a steadily decreasing concentrations through May 2003 (55 μg/L), and a sharp rebound in November 2003 (649 mg/L). Also, as with the nitrate concentrations, the summed VOC concentrations show an inverse relationship with the presampling groundwater elevations in the well (Figure 1). This relationship suggests what appears to be a temporal increase in the relative recharge of uncontaminated (or less VOC-contaminated) groundwater via the flowpaths intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (5.89 pCi/L in July 1998) being less than the drinking water MCL for gross alpha activity (15 pCi/L). Low levels of gross alpha activity are supported by the analytical results for uranium isotopes (U-234 and U-238), which were detected (i.e., >MDA and CE) at very low levels (<1.5 pCi/L) in the samples collected in June 1996, May 2002, and November 2002.

5.5 GROSS BETA ACTIVITY

Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE was reported for each groundwater sample (Table 1), with the highest value (23.21 pCi/L in July 1998) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity). Low levels of gross beta activity are consistent with the analytical results showing very low (background) levels of uranium isotopes (see Section 5.4). Technetium-99 (Tc-99), a beta-emitting radionuclide that is a "signature" of the contaminant plume emplaced during operation of the former S-3 Ponds and is chemically and mobile in groundwater, was not detected in the samples collected in June 1996, May 2001, and November 2001 (the only samples that have been analyzed for Tc-99). The lack of Tc-99 in samples from this well suggests that the S-2 Site, and not the S-3 Site, is the source of elevated nitrate concentrations at this well (see Section 5.1).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-698: Consecutive daily sampling results for summed VOCs and other selected analytes, May and November 2004

Analyte	Units	May 18-19, 2004		November 2-3, 2004	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	Std. units	6.89	6.96	6.91	6.94
Dissolved Solids	mg/L	1,070	617	1,010	649
Suspended Solids	mg/L	<1	47	3	3
Calcium	mg/L	214	129	193	153
Nitrate	mg/L	131	35	118	55.9
Barium	mg/L	0.199	0.153	0.183	0.131
Iron	mg/L	0.0732	3.69	0.182	0.355
Summed VOCs	µg/L	461	326	630	448
Gross Alpha Activity	pCi/L	<MDA	5.5	<MDA	<MDA
Gross Beta Activity	pCi/L	<MDA	<MDA	<MDA	5.7

Table 2. Well GW-698: summary of nitrate and VOC results

Sampling Date	Sampling Method		Nitrate (mg/L)	VOC (µg/L)					
	LF	CONV		PCE	TCE	12DCE	F113	CTET	CLF
06/09/96	.	●	25.3	6	11	3	NR	.	.
06/23/98	●	.	108	120	250	14	NR	9	12
07/27/98	●	.	158	130	310	19	NR	9	11
05/23/01	●	.	177	160	540	27	NR	16	19
11/13/01	●	.	221	210	450	15	NR	18	20
05/02/02	●	.	145	150	340	21	NR	11	16
11/07/02	●	.	48	130	180	43	NR	3	5
05/20/03	●	.	8.74	18	34	3	NR	.	.
11/10/03	●	.	160	160	440	23	NR	10	16
05/18/04	●	.	131	120	300	14	7	7	13
05/19/04	.	●	35	120	130	33	40	.	3
11/02/04	●	.	118	120	440	38	12	6	14
11/03/04	.	●	55.9	150	200	64	29	.	5
MCL	**NA**		**10**	**5**	**5**	**70***	**NA**	**5**	**80****

Note: "." = Not detected; NA = Not applicable; NR = Not reported; * MCL for c12DCE; ** MCL for total trihalomethanes (chloroform + bromoform + bromodichloromethane + dibromochloromethane)

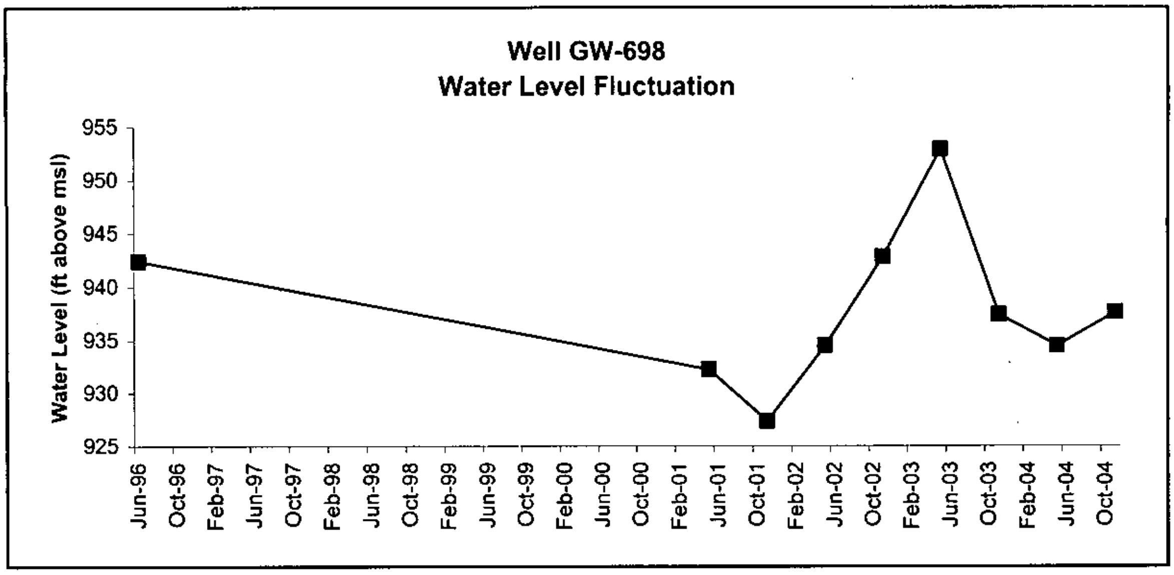


Figure 1

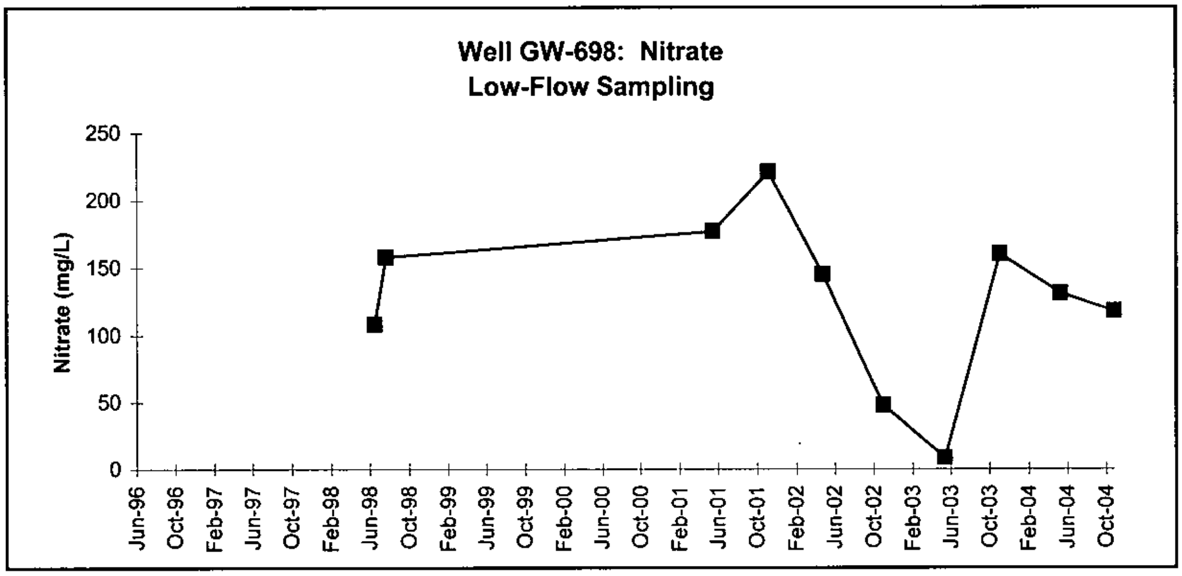


Figure 2

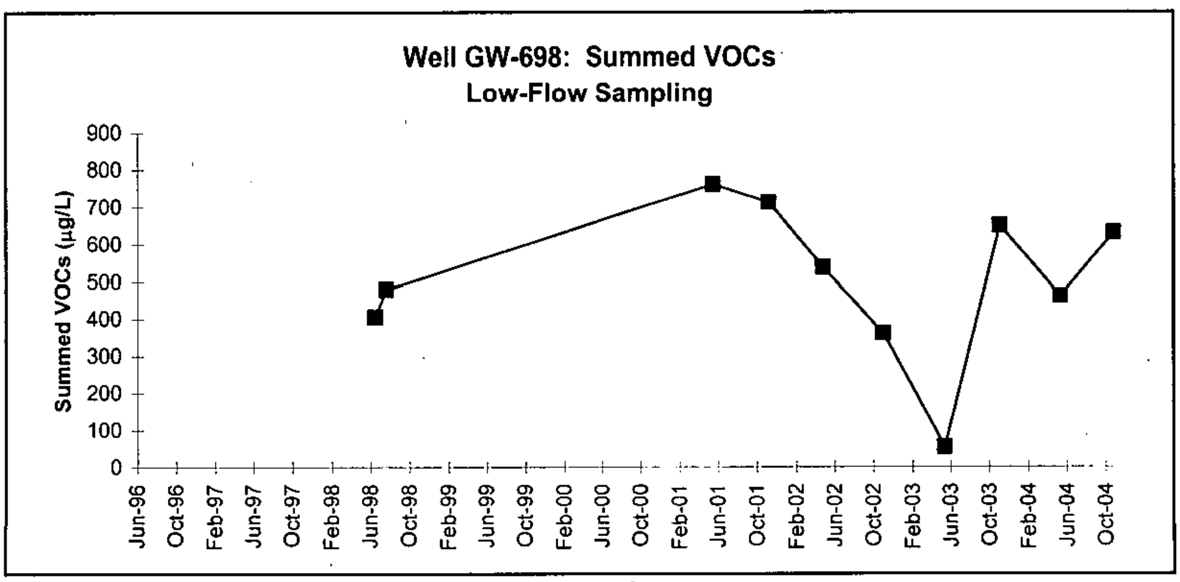


Figure 3

Y/TS-1983/R1/V4

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

MONITORING WELLS GW-700 THROUGH GW-959

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

Index of monitoring wells included in Volume 4

Well	Regime	Revision Year	Well	Regime	Revision Year
GW-700	EF	2003	GW-761	EF	2003
GW-703	BC	2004	GW-762	EF	2004
GW-704	BC	2004	GW-763	EF	2004
GW-706	BC	2004	GW-764	EF	2003
GW-709	CR	2004	GW-765	EF	2004
GW-710	BC	2003	GW-769	EF	2004
GW-711	BC	2003	GW-770	EF	2004
GW-712	BC	2004	GW-775	EF	2004
GW-713	BC	2004	GW-782	EF	2004
GW-714	BC	2004	GW-783	EF	2004
GW-715	BC	2004	GW-786	EF	2003
GW-722-06	EF	2004	GW-787	EF	2003
GW-722-10	EF	2004	GW-791	EF	2004
GW-722-14	EF	2004	GW-795	BC	2004
GW-722-17	EF	2004	GW-796	CR	2004
GW-722-20	EF	2004	GW-797	CR	2004
GW-722-22	EF	2004	GW-798	CR	2004
GW-722-26	EF	2004	GW-799	CR	2004
GW-722-30	EF	2004	GW-801	CR	2004
GW-722-32	EF	2004	GW-802	EF	2004
GW-722-33	EF	2004	GW-816	EF	2004
GW-723	BC	2005	GW-818	EF	2004
GW-724	BC	2004	GW-820	EF	2003
GW-725	BC	2004	GW-827	CR	2004
GW-731	CR	2004	GW-831	CR	2004
GW-732	CR	2004	GW-832	EF	2004
GW-733	EF	2004	GW-835	BC	2003
GW-735	EF	2004	GW-916	BC	2004
GW-736	BC	2005	GW-917	BC	2004
GW-737	BC	2005	GW-918	BC	2004
GW-738	BC	2004	GW-919	BC	2003
GW-739	BC	2005	GW-920	BC	2004
GW-740	BC	2004	GW-921	BC	2004
GW-742	CR	2004	GW-922	BC	2004
GW-743	CR	2004	GW-923	BC	2004
GW-744	EF	2004	GW-924	BC	2004
GW-747	EF	2004	GW-925	BC	2004
GW-750	EF	2004	GW-926	BC	2004
GW-757	CR	2004	GW-927	BC	2004
GW-760	EF	2004	GW-959	EF	2005

Notes:

BC = Bear Creek Hydrogeologic Regime
CR = Chestnut Ridge Hydrogeologic Regime
EF = Upper East Fork Poplar Creek Hydrogeologic Regime

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	50 - 500	ND	ND

GW-700

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 81-10
Y-12 GRID EAST COORDINATE: 56,827.67
Y-12 GRID NORTH COORDINATE: 29,452.50
SURFACE ELEVATION: 957.78 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/03/90 PAIRED/CLUSTERED WITH: 56-7A
TAG DEPTH (measured): 33.19 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 960.18 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 12 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.0	938.78
BOTTOM (filter pack or open hole):	31.0	926.78
MIDPOINT (filter pack or open hole):	25.0	932.78
PUMP INTAKE:	26.10	931.68
WATER LEVEL (average):	16.90	940.88

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	5		
CONVENTIONAL SAMPLING METHOD:	1 samples	06/08/96	06/08/96
LOW-FLOW SAMPLING METHOD:	4 samples	06/19/00	11/10/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	.	05/20/03	.	11/10/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.22 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	5	425 µg/L	06/08/96	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-700

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1990 in association with the Bldg 81-10 characterization, completed with a screened monitored interval from 19 to 31 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well 56-7A and is located in the south-central Y-12 area, about 750 ft directly west of the North/South Pipe, which is at the upstream (west) end of an exposed section of Upper East Fork Poplar Creek (UEFPC). Several thousand feet of the main channel of UEFPC, including all its northern tributaries in the western and central Y-12 areas, have been filled and replaced with an extensive network of underground storm drains. The storm drains direct surface runoff into the exposed portion of the UEFPC channel at several locations, including the North/South Pipe.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Five groundwater samples have been collected to date, with the conventional sampling method used to obtain one sample in June 1996, and the low-flow sampling method used to obtain four samples between October June 2000 and November 2003. The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits seasonal fluctuations of about 4 ft.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- relatively high TDS (350 - 425 mg/L);
- neutral pH (field measurements) of 6.3 – 7.1;
- very high sulfate concentrations (>90 mg/L);
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Although elevated sulfate levels in groundwater from the Maynardville Limestone may reflect the geochemical influence of secondary minerals in the bedrock (e.g., pyrite), the very high sulfate concentrations in the groundwater at this well most likely indicate contamination. There are numerous potential non-specific sources within Y-12, such as leaking industrial process lines, sanitary sewers, or storm drains, but sulfur leached from the coal stockpile for the Y-12 Steam Plant, which is about 1,100 ft directly west (hydraulically upgradient) of the well, is the most likely source of the sulfate.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Five groundwater samples had nitrate concentrations at or above the applicable analytical reporting limit, all less than 1 mg/L and substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00119 mg/L in October 2000) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, each of the following VOCs were detected in each groundwater sample: PCE, TCE, and 12DCE (Table 1). The source of the VOCs in the groundwater at this well has not been determined, but each compound is a known component of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998).

The highest concentrations have been reported for PCE (360 μg/L) and 12DCE (66 μg/L), with the most recent sampling results showing that PCE and TCE concentrations remain above respective MCLs (Table 1). Although there are significant gaps in the sampling history for this well, the available monitoring results show clearly decreasing summed VOC concentrations (Figure 1). The decreasing concentration trend is primarily attributable to PCE levels, which dropped by almost 65% between June 1996 (360 μg/L) and November 2003 (130 μg/L). However, a similar proportional concentration decrease is less evident for 12DCE (c12DCE), which exhibits a much more indeterminate concentration trend (Table 1). The significance of these divergent concentrations trends with respect to the relative flux of dissolved VOCs via the groundwater flow/transport pathways is not apparent from the available data.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE.

5.5 GROSS BETA ACTIVITY

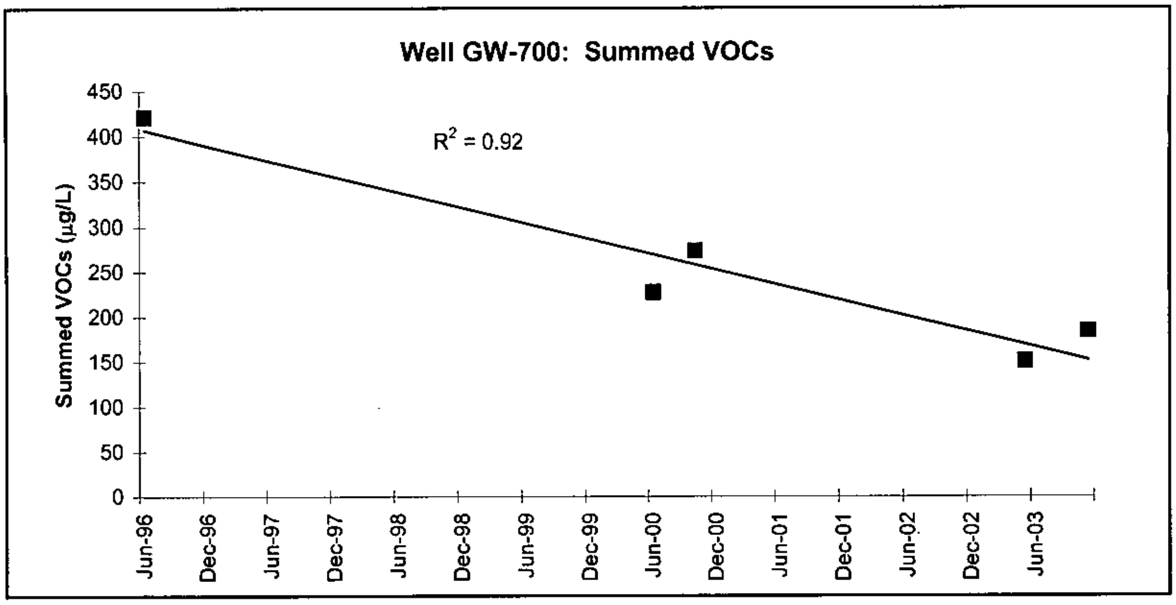
Gross beta activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in June 1996 (15.9 pCi/L), and this result is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Table 1. Well GW-700: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	PCE	**TCE**	**Total 12DCE**	**c12DCE**
06/08/96	360	15	46	NR
06/19/00	150	11	66	66
10/25/00	190	20	63	63
05/20/03	95	9	46	46
11/10/03	130	10	44	44
MCL	**5**	**5**	**NA**	**70**
Notes: NR = Not reported; NA = Not applicable				



Well GW-700: Summed VOCs
$R^2 = 0.92$
Summed VOCs (µg/L)
450
400
350
300
250
200
150
100
50
0
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	<0.015	5 - 50	<7.5	50 - 500

GW-703

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket B
Y-12 GRID EAST COORDINATE: 44,930.51
Y-12 GRID NORTH COORDINATE: 28,806.34
SURFACE ELEVATION: 951.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/07/90 PAIRED/CLUSTERED WITH: GW-704
TAG DEPTH (measured): 185.29 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 955.29 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	133.8	818.00
BOTTOM (filter pack or open hole):	182.0	769.80
MIDPOINT (filter pack or open hole):	157.9	793.90
PUMP INTAKE:	158.51	793.29
WATER LEVEL (average):	39.55	912.25

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	33		
CONVENTIONAL SAMPLING METHOD:	19 samples	06/18/91	08/27/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/16/98	07/21/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/03/04	.	07/21/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.49 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	24	23.8 mg/L	11/16/92	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	33	39.3 µg/L	12/21/93	Decreasing
GROSS ALPHA (15 pCi/L):	2	24 pCi/L	01/24/00	Outliers
GROSS BETA (50 pCi/L):	5	62 pCi/L	01/15/02	Increasing

WELL GW-703

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1990, completed with an open-hole monitored interval from 133.8 to 182 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket B, which consists of a series of wells (GW-694, GW-695, GW-703, GW-704, GW-705, and GW-706) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between June 1991 and August 1997, and the low-flow sampling method used to obtain 14 samples between February 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 40 ft bgs and exhibits seasonal fluctuations up to about 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket B indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 225 – 450 mg/L;
- pH of 6.5 – 8.4 (field measurements);
- elevated concentrations of chloride (>30 mg/L) and sulfate (>25 mg/L) relative to other wells completed at similar depths in the Maynardville Limestone;
- low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated chloride and sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, such as dissolution of locally disseminated sulfide minerals, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate, VOCs, and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for all the groundwater samples collected to date (Table 1), with 24 samples having concentrations that exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 7,200 ft east-northeast (hydraulically upgradient) of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Nitrate concentrations detected in the groundwater samples range from less than 1 mg/L to just under 25 mg/L (Table 1). However, the historical minimum concentration (0.98 mg/L in February 1999) appears to be an outlier compared to the remaining nitrate values, all of which exceed 5 mg/L. As noted previously, more than half of the samples had nitrate concentrations above the MCL, and half of these samples had concentrations near 20 mg/L, including the samples collected most recently (February and July 2004). The nitrate concentrations do not exhibit significant temporal variations or reflect any consistent relationship with seasonal groundwater flow conditions.

A time-series plot of nitrate concentrations in the groundwater samples shows an indeterminate trend with a sharp concentration increase between March and November 1992, followed by generally decreasing concentrations through December 1999, and subsequent concentration increase through January 2002 and fairly steady concentrations thereafter (Figure 2). The initial rise and fall in the concentration of nitrate suggests a temporal "pulse" or "slug" in the relative flux of nitrate via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Increasing concentrations of nitrate evident since December 1999 may represent another such temporal change in nitrate flux.

5.2 URANIUM

All but two of the groundwater samples collected to date (one sample was not analyzed for uranium) had uranium concentrations at or above the applicable analytical reporting limit, with the highest values (0.00765 mg/L and 0.00763 mg/L in February and July 2004, respectively) being almost an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L). Nevertheless, the most recent uranium results reflect an order-of-magnitude increase from the uranium concentrations evident during the early 1990s (e.g., 0.001 mg/L in November 1991).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): benzene, CTET, chloroform, PCE, TCE, 11DCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 2,200 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket B. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are TCE and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample, with the historical maximum concentration of 28 µg/L in March 1993. The most recent sampling results show that the TCE concentrations remain above the drinking water MCL (5 µg/L). Low concentrations of 12DCE were detected in all but five of the samples, with all but one of the results being less than 10 µg/L and the most recent data showing c12DCE concentrations substantially below the MCL (70 µg/L). The remaining VOCs were detected in only eight of the groundwater samples, all collected between September 1992 and August 1998, and all of the reported concentrations are estimated values below 5 µg/L (Table 2).

A time-series plot of TCE concentrations in the groundwater samples shows a generally decreasing long-term concentration trend (Figure 3), with the most recent TCE concentration (12 µg/L in July 2004) being about 45% lower than evident during the early 1990s. The overall decrease in TCE levels probably results from corrective actions at the primary sources of VOCs in BCV west of Y-12, including the closure of the Oil Landfarm WMA and the installation of low-permeability caps at the site, and the CERCLA remedial actions at the BYBY/HCDA, which involved the excavation and removal of contaminated soils above and below the saturated zone (BJC 2003). Additionally, the TCE results show significant temporal variation, with cyclical "peak" concentrations typically reported for samples obtained during seasonally high groundwater flow conditions (winter and spring). These fluctuations potentially correspond with changes in the relative flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

Unlike TCE, the concentrations of the other VOCs detected in the groundwater samples do not exhibit any discernable long-term trend or significant temporal concentration fluctuations (Table 2), as illustrated by the 12DCE (total) concentrations reported for the samples collected in March 1992 (5 μg/L), July 1996 (4 μg/L), January 2000 (5 μg/L), and July 2004 (4 μg/L). Assuming the groundwater contaminant plume in the Maynardville Limestone contains a heterogeneous mixture of dissolved VOCs, it is not clear from the available data why the concentrations of individual compounds exhibit divergent long-term trends and temporal variations, or if such variations are significant with respect to the relative flux of dissolved VOCs in the groundwater.

5.4 GROSS ALPHA ACTIVITY

Twenty-two of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the two highest values (18.4 pCi/L in June 1992 and 24 pCi/L in January 2000) exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, these results appear to be outliers compared to the other results for gross alpha activity, which are all less than 10 pCi/L, including the results reported for the samples collected most recently (February and July 2004).

5.5 GROSS BETA ACTIVITY

All but two of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), including four samples with gross beta activity above the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is Tc-99, which was detected (i.e., >MDA and CE) in the samples collected in January 2001 (54 pCi/L), July 2001 (65 pCi/L), January 2002 (66 pCi/L), and July 2002 (62 pCi/L). Note that all the Tc-99 results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. This beta-emitting radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

A time-series plot of gross beta activity reported for the groundwater samples shows a generally increasing long-term trend dominated by wide temporal fluctuations, some of which may be attributable to inherent analytical variability (Figure 4). Nevertheless, the overall increase in gross beta activity suggests a corresponding increase in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. The temporal changes in gross beta activity do not exhibit any consistent relationship with seasonal groundwater flow conditions, as illustrated by the comparable "peak" concentrations reported for samples collected during low flow conditions in June (48.2 mg/L) and September 1992 (47.8 mg/L) and during high flow conditions in December 1993 (42.7 mg/L) February 1994 (44.5 mg/L).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-703: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
06/18/91	6	4.37
09/11/91	5.73	5.06
11/18/91	6.2	10.5
03/24/92	5.67	16.1
06/20/92	17	48.5
09/20/92	21.8	47.8
11/16/92	23.8	20.3
03/20/93	22.36	6.39
06/03/93	9.6	< CE
09/20/93	21.8	28.6
12/21/93	22.6	42.7
02/23/94	21	44.5
12/12/94	9.1	19.4
03/29/95	22	18.7
08/30/95	19	18.7
03/16/96	19.3	33.4
07/31/96	17.5	32.9
02/19/97	16.5	<MDA
08/27/97	15.6	40
02/15/98	12.7	23
08/10/98	8.56	27
02/16/99	0.98	18
08/02/99	9.399	34
01/24/00	10.4	46
07/24/00	15.2	46
01/23/01	16.1	53
07/17/01	17.9	47
01/16/02	20.8	62
07/16/02	20.7	62
01/16/03	21.5	61
07/15/03	20.2	49
02/03/04	20.2	54
07/21/04	19.1	49
MCL	**10**	**50***

Note: * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

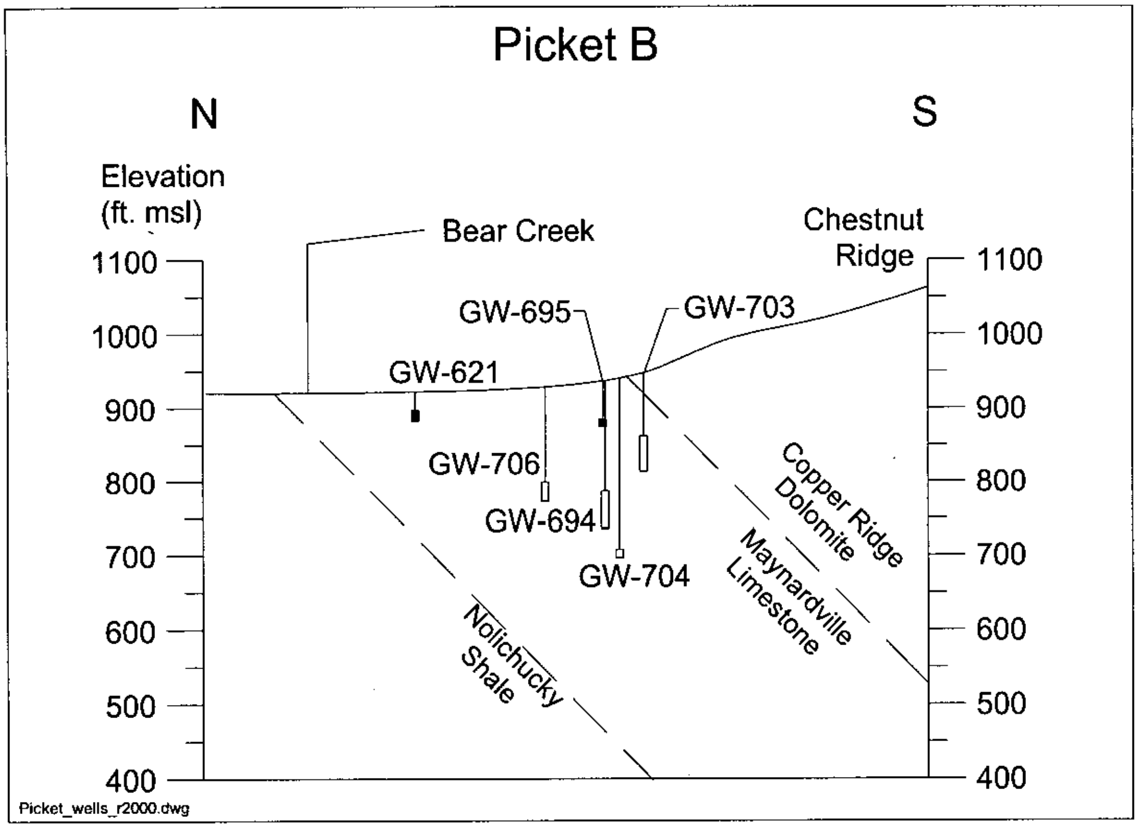
Table 2. Well GW-703: summary of VOC results

Date Sampled	Concentration (µg/L)		
	TCE	12DCE (Total)	c12DCE
06/18/91	25	.	NR
09/11/91	23	.	NR
11/18/91	23	.	NR
03/24/92	25	5	NR
06/20/92	15	5	NR
09/20/92	23	10	NR
11/16/92	15	9	NR
03/20/93	28	8	NR
06/03/93	23	7	NR
09/20/93	21	6	NR
12/21/93	22	13	NR
02/23/94	26	8	NR
12/12/94	19	7	NR
03/29/95	21	.	NR
08/30/95	17	.	NR
03/16/96	13	9	NR
07/31/96	9	4 J	NR
02/19/97	FP	5	5
08/27/97	14	3 J	3 J
02/16/98	21	4 J	4 J
08/10/98	18	3 J	3 J
02/16/99	20	3 J	3 J
08/03/99	16	5	5
01/24/00	19	5	5
07/24/00	21	5	5
01/22/01	16	6	6
07/16/01	16	6	6
01/15/02	15	6	6
07/15/02	16	6	6
01/16/03	15	6	6
07/15/03	15	6	6
02/03/04	14	5	5
07/21/04	12	4 J	4 J
MCL	**5**	**NA**	**70**

Table 2. (continued)

Date Sampled	Concentration (µg/L)	
	11DCE	OTHER
		.
06/18/91	.	.
09/11/91	.	.
11/18/91	.	.
03/24/92	.	.
06/20/92	.	.
09/20/92	1 J	.
11/16/92	.	.
03/20/93	2 J	.
06/03/93	1 J	111TCA (0.5 J), Chloroform (0.5 J)
09/20/93	.	111TCA (0.9 J), 11DCA (0.5 J), CTET(0.4 J), Chloroform (0.5 J)
12/21/93	2 J	
02/23/94	.	.
12/12/94	.	.
03/29/95	.	.
08/30/95	.	.
03/16/96	.	.
07/31/96	.	.
02/19/97	3 J	.
08/27/97	.	.
02/16/98	2 J	Benzene (1 J)
08/10/98	1 J	.
02/16/99	.	.
08/03/99	.	.
01/24/00	.	.
07/24/00	.	.
01/22/01	.	.
07/16/01	.	.
01/15/02	.	.
07/15/02	.	.
01/16/03	.	.
07/15/03	.	.
02/03/04	.	.
07/21/04	.	.
MCL	**7**	.

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported



Screened Well Construction

Open-Hole Well Construction

Figure 1

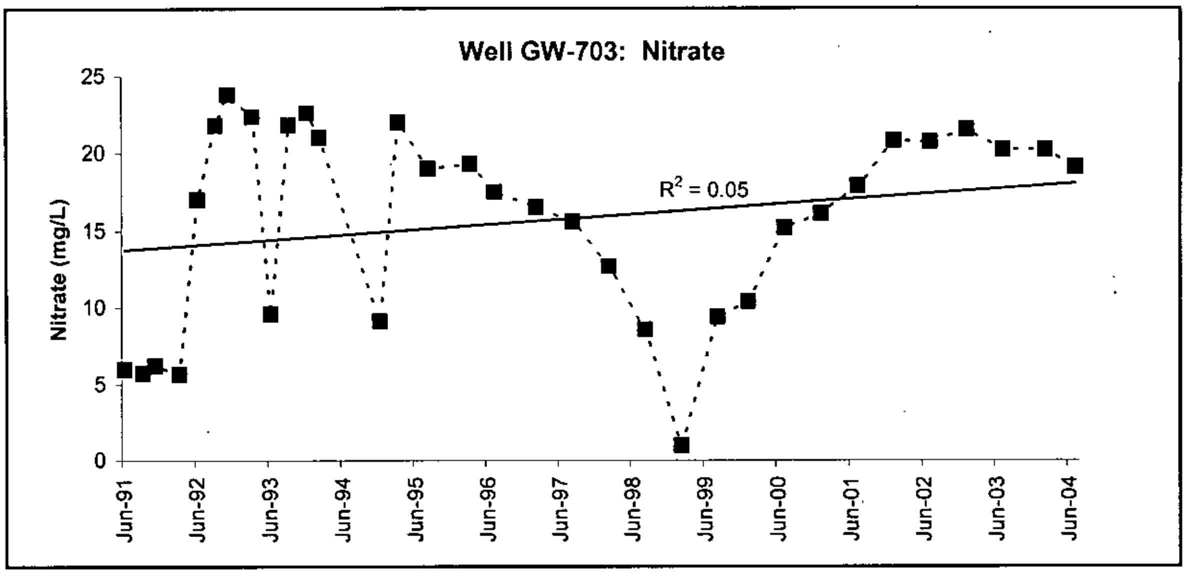


Figure 2

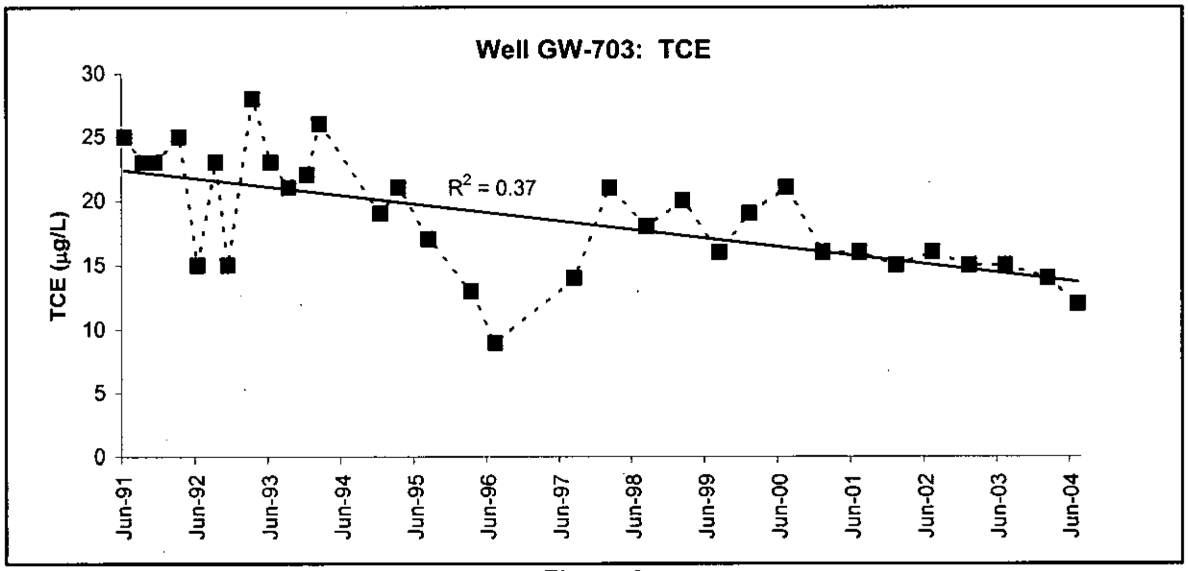


Figure 3

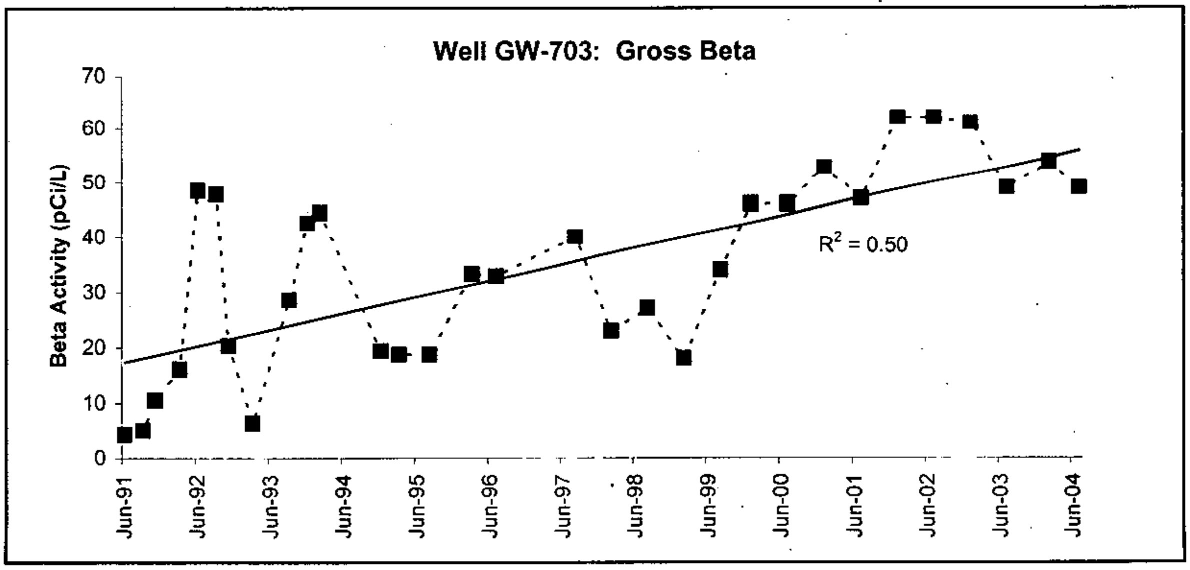


Figure 4

MAXIMUM CONCENTRATION: 2004

10 - 100	0.015 - 0.03	5 - 50	7.5 - 15	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-704

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket B
Y-12 GRID EAST COORDINATE: 44,934.98
Y-12 GRID NORTH COORDINATE: 28,844.67
SURFACE ELEVATION: 941.99 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/20/90 PAIRED/CLUSTERED WITH: GW-703
TAG DEPTH (measured): 258.65 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 945.33 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.63 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	244.5	697.49
BOTTOM (filter pack or open hole):	256.0	685.99
MIDPOINT (filter pack or open hole):	250.3	691.74
PUMP INTAKE:	250.16	691.83
WATER LEVEL (average):	30.61	911.38

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 35

		First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	19 samples	06/20/91	08/28/97
LOW-FLOW SAMPLING METHOD:	16 samples	01/05/98	07/22/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/04/04	.	07/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 16.94 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	24	20.8 mg/L	02/25/94	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	33	134 µg/L	03/22/93	Decreasing
GROSS ALPHA (15 pCi/L):	1	31.3 pCi/L	08/01/96	Outlier
GROSS BETA (50 pCi/L):	1	52 pCi/L	02/04/04	

WELL GW-704

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1990, completed with an open-hole monitored interval from 244.5 to 256 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket B, which consists of a series of wells (GW-694, GW-695, GW-703, GW-704, GW-705, and GW-706) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between June 1991 and August 1997, and the low-flow sampling method used to obtain 16 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 31 ft bgs and exhibits seasonal fluctuations up to about 17 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket B indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 180 – 440 mg/L;
- pH of 7.2 – 8.4 (field measurements);
- elevated concentrations of chloride (>25 mg/L) and sulfate (>30 mg/L) relative to other wells completed at similar depths in the Maynardville Limestone;
- low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated chloride and sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, such as dissolution of locally disseminated sulfide minerals, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate, VOCs, and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for all but one of the groundwater samples collected to date (Table 1), with 24 samples having concentrations that exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 7,200 ft east-northeast (hydraulically upgradient) of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, most of the groundwater samples had nitrate concentrations above the MCL (Table 1), with the highest concentrations reported for samples collected in November 1992 (19 mg/L), February 1994 (20.8 mg/L), and December 1994 (18 mg/L). Also, the unusually low nitrate concentrations reported for samples collected in December 1993 (0.23 mg/L) and July 2004 (0.0429 mg/L) are substantially less than the other nitrate results and may be analytical artifacts. Additionally, the nitrate concentrations exhibit apparently seasonal fluctuations, with the highest concentrations typically reported for samples collected during seasonally high groundwater flow conditions (winter and spring). This relationship suggests increased flux of nitrate from seasonal (and episodic) recharge of nitrate-contaminated groundwater via the flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of nitrate concentrations in the groundwater samples shows a generally decreasing long-term trend dominated by wide temporal fluctuations (Figure 2). The overall decrease in nitrate concentrations probably reflect the substantially reduced flux of nitrate following closure of the former S-3 Ponds and installation of the low-permeability cap at the site. Also, the nitrate results reported for the samples obtained with the low-flow sampling method exhibit significantly more temporal variation than indicated by the nitrate results reported for the samples obtained with the conventional sampling method. This may be at least partially attributable to inherent differences in the manner in which each sampling method induces flow of groundwater into the well. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features (e.g., conduits or fractures) that may not be proximal to the well. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features more proximal to the well.

5.2 URANIUM

Twenty-eight groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0194 mg/L in February 2004) being less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): benzene, bromoform, CTET, chloroform, PCE, TCE, 11DCA, 11DCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 2,200 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket B. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are TCE, 11DCE, and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample, with the historical maximum concentration of 120 µg/L (March 1993). The more recent sampling results show lower concentrations of TCE that nonetheless remain substantially above the drinking water MCL (5 µg/L). Concentrations of 11DCE and 12DCE are much lower than those of TCE, with most of the results for these compounds being estimated values below 5 µg/L. Although the historical maximum concentration of 11DCE (8 µg/L in December 1994 and February 1998) slightly exceeds the MCL (7 µg/L), the most recent sampling results show 11DCE concentrations below the MCL. Results for c12DCE reported for all the samples collected since 1997 show concentrations at least an order-of-magnitude below the MCL (70µg/L). Secondary compounds in the groundwater samples are CTET, 11DCA, and 111TCA (Table 2). None of these VOCs have been detected in groundwater samples collected since January 2000 and all of the results for each compound are estimated concentrations of 2 µg/L or less. Benzene, bromoform, chloroform, and methylene chloride were each detected at trace concentrations (1 µg/L or less) in no more than two of the samples, and each of these results may be a sampling or analytical artifact.

A time-series plot of TCE concentrations in the groundwater samples shows a generally decreasing long-term concentration trend (Figure 3), with the most recent TCE concentration (37 µg/L in July 2004) being about 66% lower than the historical maximum concentration (120 µg/L in March 1993). The overall decrease in TCE levels probably results from corrective actions at the primary sources of VOCs in BCV west of Y-12, including the closure of the Oil Landfarm WMA and the installation of low-permeability caps at the site, and the CERCLA remedial actions at the BYBY/HCDA, which involved the excavation and removal of contaminated soils above and below the saturated zone (BJC 2003). Additionally, the TCE results show significant temporal variation, with cyclical "peak" concentrations typically reported for samples obtained during seasonally low groundwater flow conditions (summer and fall), and the lowest TCE levels detected in samples obtained during seasonally high flow conditions (winter and fall). This relationship suggests that the lower TCE concentrations reflect "dilution" from seasonal (or episodic) recharge of uncontaminated (or less TCE-contaminated) groundwater via the flow/transport pathways intercepted by the monitored interval in the well.

Unlike TCE, the concentrations of the other VOCs detected in the groundwater samples do not exhibit any discernable long-term trend or significant temporal concentration fluctuations (Table 2), as illustrated by the 12DCE concentrations reported for the samples collected in June 1992 (3 µg/L), August 1997 (3 µg/L), and January 2004 (2 µg/L). Assuming the groundwater contaminant plume in the Maynardville Limestone contains a heterogeneous mixture of dissolved VOCs, it is not clear from the available data why the concentrations of individual compounds exhibit divergent long-term trends and temporal variations, or if such variations are significant with respect to the relative flux of dissolved VOCs.

5.4 GROSS ALPHA ACTIVITY

Nineteen groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (31.3 pCi/L in August 1996) exceeding the MCL for gross alpha activity (15 pCi/L). However, the historical maximum appears to be an outlier compared to the other results for gross alpha activity, which are all near 10 pCi/L (e.g., 11 pCi/L in February 2004).

5.5 GROSS BETA ACTIVITY

Twenty-two groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1). Although all of the results are less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the MCL for gross beta activity), most exceed background levels of gross beta activity in groundwater. The source of the beta activity has not been conclusively determined. Some of the beta activity may be from uranium isotopes and related beta-emitting decay products based on the relatively low levels of U-234 (1.31 – 3.07 pCi/L) and U-238 (1.03 – 5.34 pCi/L) detected in the ten groundwater samples that were analyzed for these isotopes. None of the samples were analyzed for Tc-99, which is the primary beta-emitting isotope in groundwater samples from other Exit Pathway Picket B wells (e.g., GW-703). Technetium-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

A time-series plot of gross beta activity reported for the groundwater samples shows a generally increasing long-term trend dominated by wide temporal fluctuations, some of which may be attributable to inherent analytical variability (Figure 4). The results for gross beta activity do not exhibit any clear or consistent relationship with seasonal groundwater flow conditions, as illustrated by the results for samples collected during low-flow conditions in July 2001 (16 pCi/L), July 2002 (41 pCi/L), July 2003 (13 pCi/L), and July 2004 (<MDA). Moreover, the gross beta results reported for the samples obtained with the low-flow sampling method exhibit significantly more temporal variation than indicated by the nitrate results reported for the samples obtained with the conventional sampling method. As noted previously regarding the nitrate concentrations in the samples, this may be at least partially attributable to inherent differences in the manner in which each sampling method induces inflow of groundwater into the well (see Section 5.1).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-704: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
06/20/91	11	< CE
09/12/91	9.19	5.28
11/19/91	9.55	3.33
03/23/92	11.5	< CE
06/19/92	12.12	5.58
09/18/92	17	< CE
11/11/92	19	< CE
03/22/93	14.28	< CE
06/04/93	15	9.93
09/22/93	17	13.9
12/22/93	0.23	3.64
02/25/94	20.8	14.6
12/13/94	18	9.62
03/30/95	16	11.2
08/31/95	15	7.65
03/17/96	17.5	<MDA
08/01/96	16.5	16.9
02/19/97	17.2	<MDA
08/28/97	16.5	<MDA
01/05/98	16.1	30
08/13/98	<0.028	<MDA
02/16/99	14.7	22
08/24/99	7.197	<MDA
01/25/00	17.2	34
07/24/00	1.14	13
01/23/01	16	36
07/17/01	0.387	16
01/16/02	14.5	26
07/16/02	12	41
01/21/03	12	27
07/16/03	7.61	13
02/04/04	17.4	52
07/22/04	0.0429	<MDA
MCL	**10**	**50***

Note: * SDWA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 2. Well GW-704: summary of VOC results

Date Sampled	Concentration (µg/L)			
	TCE	12DCE (Total)	c12DCE	11DCE
06/20/91	79	.	NR	5
09/12/91	65	2 J	NR	4 J
11/19/91	65	.	NR	5
03/23/92	64	2 J	NR	4 J
06/19/92	84	3 J	NR	6
09/18/92	79	3 J	NR	5
11/11/92	95	3 J	NR	5
03/22/93	120	3 J	NR	6
06/04/93	92	3 J	NR	6
09/22/93	86	4 J	NR	6
12/22/93	55	2 J	NR	4 J
02/25/94	84	3 J	NR	6
12/13/94	100	3 J	NR	8
03/30/95	96	.	NR	6
08/31/95	85	.	NR	.
03/17/96	97	6	NR	7
08/01/96	70	3 J	NR	5
02/19/97	FP	3 J	3 J	8
08/28/97	100	3 J	3 J	7
01/05/98	35	4 J	4 J	3 J
08/13/98	78	3 J	3 J	8
02/16/99	52	5	5	4 J
08/24/99	79	2 J	2 J	6
01/25/00	50	4 J	4 J	.
07/24/00	69	.	.	5
01/23/01	62	5	5	6
07/17/01	55	2 J	2 J	4 J
01/16/02	45	4 J	4 J	4 J
07/16/02	41	4 J	4 J	3 J
01/21/03	57	3 J	3 J	6
07/16/03	39	4 J	4 J	3 J
02/04/04	18	2 J	2 J	.
07/22/04	37	2 J	2 J	4 J
MCL	**5**	**NA**	**70**	**7**

Table 2. (continued)

Date Sampled	Concentration (µg/L)			
	CTET	**111TCA**	**11DCA**	**OTHER**
06/20/91	2 J	2 J	.	.
09/12/91	0.7 J	1 J	.	Chloroform (0.4 J)
11/19/91	1 J	2 J	1 J	Bromoform (1 J)
03/23/92	.	.	.	.
06/19/92	1 J	2 J	1 J	.
09/18/92	.	.	1 J	.
11/11/92	2 J	2 J	.	.
03/22/93	2 J	2 J	1 J	.
06/04/93	1 J	2 J	.	Benzene (0.5 J), Chloroform (0.4 J)
09/22/93	.	2 J	.	.
12/22/93	.	.	.	.
02/25/94	1 J	2 J	.	.
12/13/94	2 J	2 J	1 J	.
03/30/95	.	.	.	.
08/31/95	.	.	.	.
03/17/96	2 J	2 J	.	.
08/01/96	.	.	.	.
02/19/97	2 J	2 J	1 J	.
08/28/97	2 J	2 J	1 J	.
01/05/98	.	.	.	.
08/13/98	.	.	2 J	Methylene chloride (1 J)
02/16/99	.	.	.	.
08/24/99	.	.	2 J	.
01/25/00	.	.	.	.
07/24/00	.	.	.	.
01/23/01	.	.	.	.
07/17/01	.	.	.	.
01/16/02	.	.	.	.
07/16/02	.	.	.	.
01/21/03	.	.	.	.
07/16/03	.	.	.	.
02/04/04	.	.	.	.
07/22/04	.	.	.	.
MCL	**7**	**200**	**NA**	**.**

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

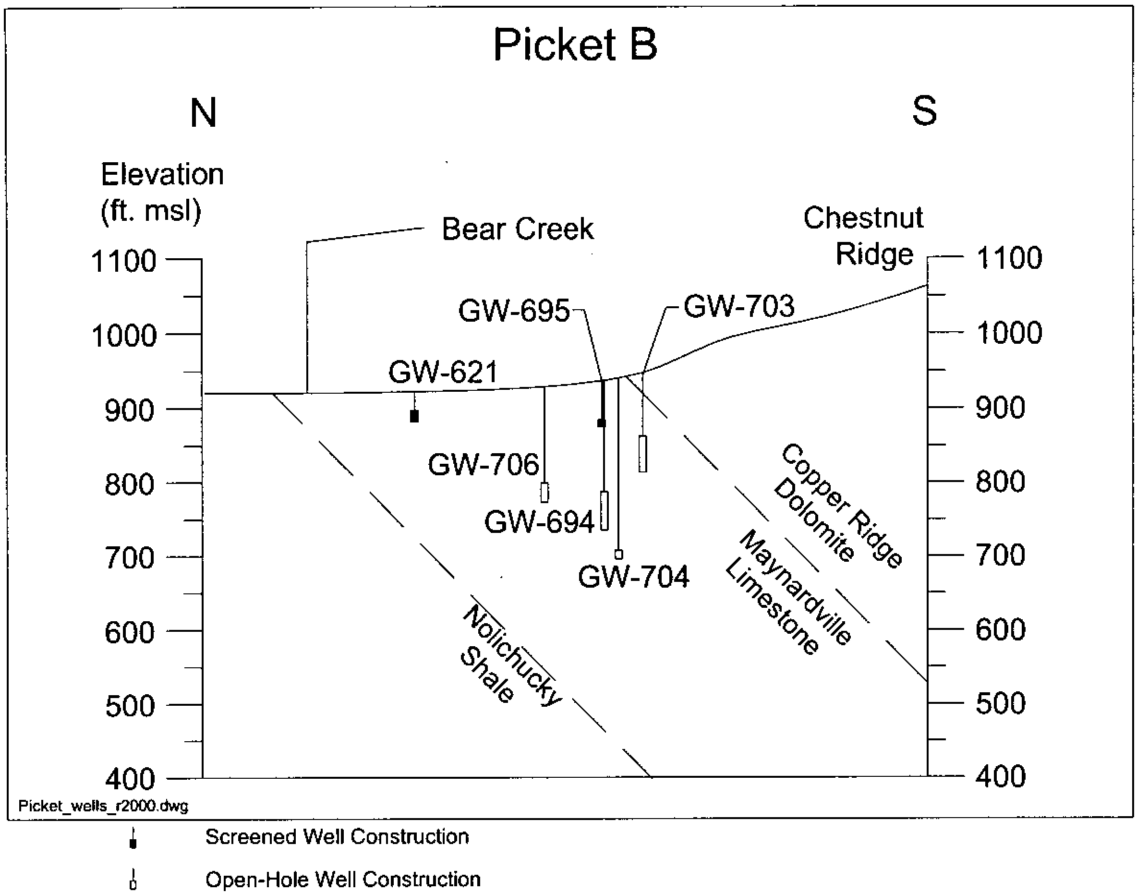

Picket B
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-695
GW-703
GW-621
GW-706
GW-694
GW-704
Copper Ridge
Dolomite
Maynardville
Limestone
Nolichucky
Shale
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

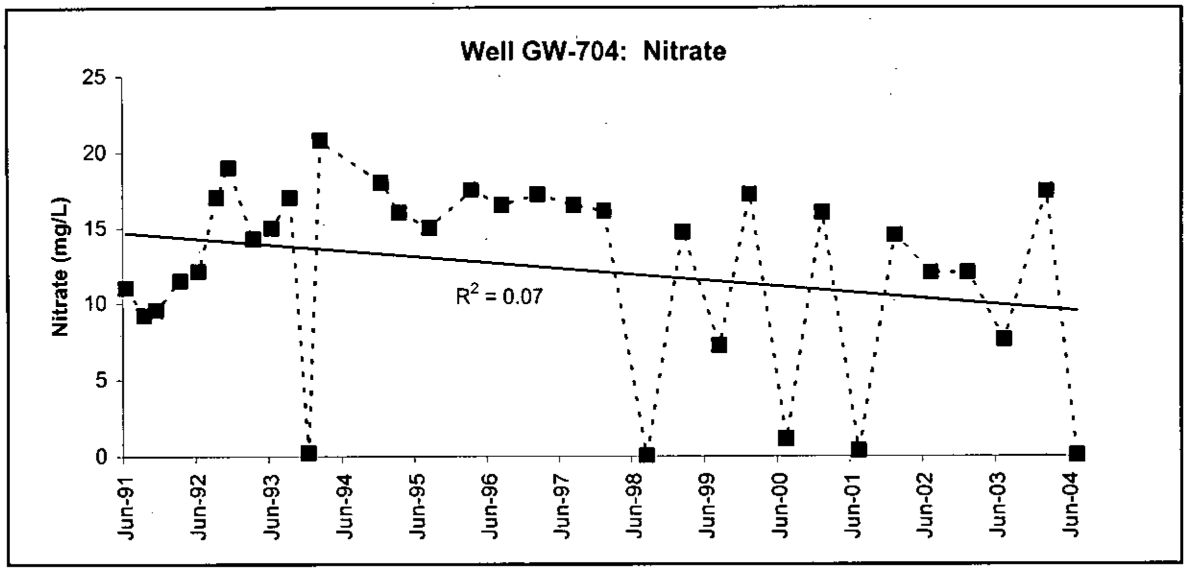


Figure 2

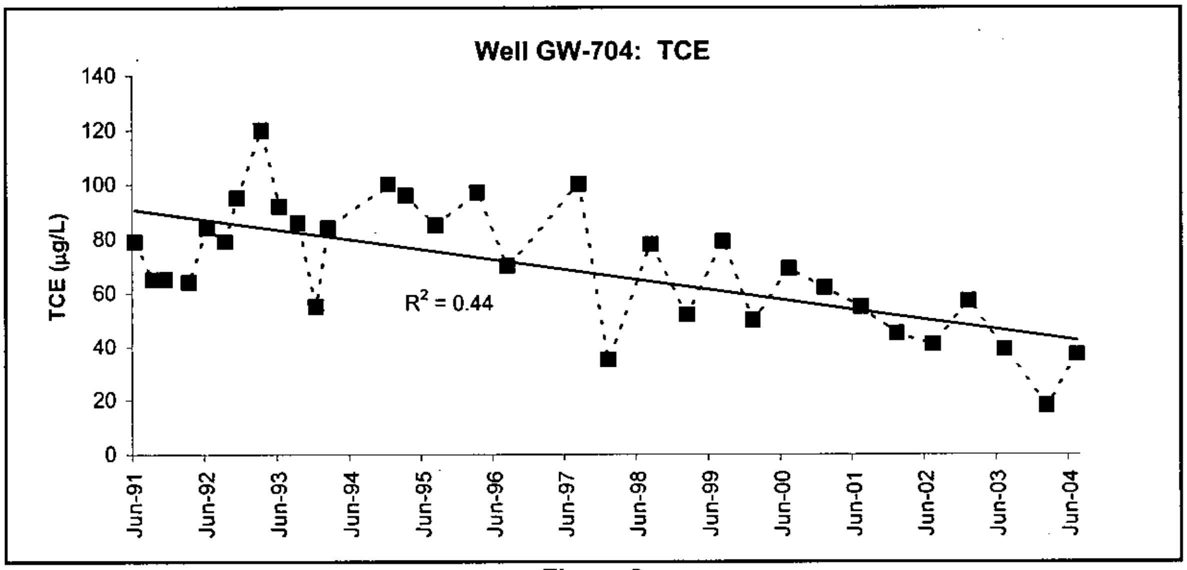
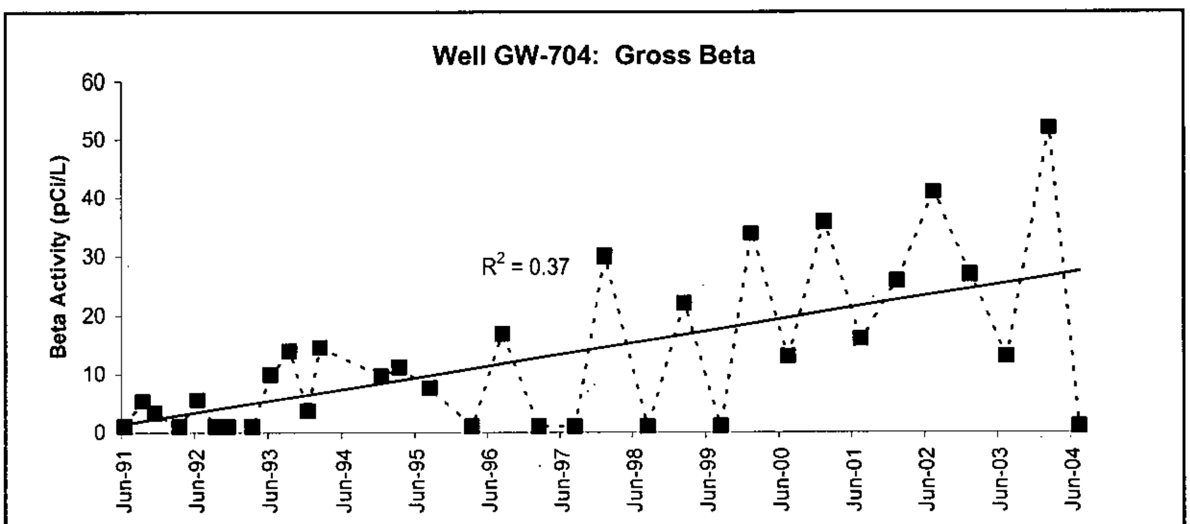


Figure 3



Note: Results that are <MDA or <CE are shown as 1 pCi/L.

Figure 4

MAXIMUM CONCENTRATION: 2004

10 - 100	0.03 - 0.3	5 - 50	15 - 150	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-706

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket B
Y-12 GRID EAST COORDINATE: 44,943.63
Y-12 GRID NORTH COORDINATE: 28,946.41
SURFACE ELEVATION: 925.78 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/27/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 185.79 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 929.47 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	156.1	769.68
BOTTOM (filter pack or open hole):	182.5	743.28
MIDPOINT (filter pack or open hole):	169.3	756.48
PUMP INTAKE:	174.81	750.97
WATER LEVEL (average):	12.3	913.48

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	39		
CONVENTIONAL SAMPLING METHOD:	21 samples	06/20/91	07/26/00
LOW-FLOW SAMPLING METHOD:	18 samples	01/05/98	07/22/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/04/04	.	07/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 9.58 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	32	99.1 mg/L	01/23/01	Decreasing
URANIUM (0.03 mg/L):	32	0.277 mg/L	02/01/00	Indeterminate
SUMMED VOCs (5 µg/L):	29	69 µg/L	03/23/92	Indeterminate
GROSS ALPHA (15 pCi/L):	33	120 pCi/L	02/01/00	Indeterminate
GROSS BETA (50 pCi/L):	30	310 pCi/L	01/23/01	Indeterminate

WELL GW-706

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1991, completed with an open-hole monitored interval from about 156.1 to 182.5 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) approximately 7,000 ft west of Y-12, near the base of the steep northern flank of Chestnut Ridge, about 200 ft directly south of the main channel of Bear Creek. The well is a component of Exit Pathway Picket B, which consists of a series of wells (GW-621, GW-694, GW-695, GW-703, GW-704, GW-705, and GW-706) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek throughout BCV.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between June 1991 and July 2000, and the low-flow sampling method used to obtain 18 samples between January 1998 and July 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method had substantially lower nitrate concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during January/February and July 2000, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias (Table 1); nitrate concentrations in the samples obtained with the low-flow method are about 50% higher than the corresponding nitrate concentrations in the samples obtained with the conventional sampling method. Also, the conventional sampling method appears to promote the inflow of less mineralized groundwater into the well, as illustrated by the lower TDS (and sharply lower calcium levels) evident with the conventional sampling event in February 2000 (Table 1). Unfiltered samples obtained with the conventional sampling method also typically have higher total suspended solids (TSS), which show a direct correlation with total iron concentrations (see Section 4.0).

Inherent differences in the manner in which each sampling method induces flow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for nitrate. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce flow from water-producing features that may not be near the monitored interval of the well. Conventional sampling also appears to disturb fine-grained particles in the bottom of the well or in the fractures intercepted by the open-hole interval, which frequently results in the collection of unfiltered samples with significant levels of TSS, including the samples collected in September 1991 (13 mg/L), November 1992 (10 mg/L), September 1993 (27 mg/L), and February 2000 (15 mg/L). In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow from the water-producing feature(s) near the well. Thus, the conventional sampling method appears to induce inflow of less mineralized groundwater (with lower nitrate levels) from water-producing features that are not proximal to the well. If so, it seems unusual that the inflow does not seem to influence the concentrations of other analytes in the samples, including groundwater contaminants (e.g., VOCs).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 12 ft bgs and exhibits seasonal fluctuations up to about 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket B indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 165 – 820 mg/L;
- pH of 5.2 – 8 (field measurements);
- iron (total) concentrations that sporadically exceed 10 mg/L;
- elevated concentrations of chloride (>40 mg/L) and sulfate (>30 mg/L) relative to other wells completed at shallower depths in the Maynardville Limestone
- low molar proportions of potassium and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the chloride and sodium concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well. Also, the unusually high total iron concentrations in the samples show a direct correlation with the TSS in the samples and are clearly artifacts of the preservation of the unfiltered samples (i.e., acidification below a pH of 2).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, these contaminants are all present at elevated levels in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations above the analytical reporting limit were reported for all but two of the groundwater samples collected to date that were analyzed for nitrate (Table 2), and all of these results equal or exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about

7,200 ft east-northeast of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As shown on Table 1, nitrate concentrations above the analytical reporting limit range between the historical minimum and maximum values of 10 mg/L (June 1991) and 99 mg/L (January 2001), with the highest concentrations (including the historical maximum value) reported for samples obtained using the low-flow sampling method (see Section 2.0). Compared to the other low-flow sampling results, which are all less than 50 mg/L, the historical maximum value appears to be an outlier. Nevertheless, the low-flow sampling results show wide seasonal fluctuations in nitrate concentrations, and the historical maximum value may be an unusually high temporal peak, which often correlate with samples obtained during seasonally high groundwater flow conditions (winter and spring). Although the highest nitrate concentration reported for samples obtained with the conventional sampling method (84 mg/L in November 1991) is comparable to the historical maximum nitrate value, most of the conventional sampling results for nitrate are below 40 mg/L, including three non-detect results (Table 1). Also, unlike the low-flow sampling data, the temporal peak nitrate concentrations indicated by the conventional sampling results often correlate with samples obtained during seasonally low groundwater flow conditions (summer and fall).

Respective time-series plots of nitrate concentrations in the groundwater samples obtained with the low-flow sampling method (Figure 2) and conventional sampling method (Figure 3) show generally decreasing long-term concentrations trends punctuated by wide temporal (seasonal) fluctuations. The low-flow sampling results, for instance, show an overall decrease of about 45% between January 1998 (45.7 mg/L and July 2004 (24.2 mg/L). The long-term decrease in nitrate concentrations is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap (DOE 1997).

5.2 URANIUM

All of the groundwater samples collected to date that were analyzed for uranium had concentrations at or above the applicable analytical reporting limit (Table 2), and the results for most of these samples exceed the drinking water MCL for uranium (0.03 mg/L). There are several sources of uranium in BCV hydraulically upgradient of Exit Pathway Picket B, including the contaminant plume originating from the former S-3 Ponds and inflow of uranium-contaminated surface water in Bear Creek. The CERCLA remedial investigation identified the former Boneyard/Burnyard (BYBY) as the primary source of uranium in groundwater from the Maynardville Limestone hydraulically downgradient (west) of the site (DOE 1997), which is about 2,500 ft east of Exit Pathway Picket B. Uranium-bearing wastes disposed at the BYBY were below the seasonally high water table and the limestone bedrock provided a ready source of dissolved carbonate, which combined with uranyl cations leached from the wastes and greatly increased what would otherwise be relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997). As a major source area, the BYBY was prioritized for CERCLA remedial action, which was completed in May 2003 and involved: (1) the excavation and on-site consolidation/off-site disposal of about 81,000 yd^3 of waste materials; (2) construction of a multi-layer low-permeability cap over waste materials consolidated on site; and (3) reconstruction of a northern tributary of Bear Creek (NT-3) that drains the site (BJC 2004).

As noted previously, total uranium concentrations reported for most of the groundwater samples, including the samples collected most recently (February and July 2004), exceed the MCL (0.03 mg/L). The three results that are below the MCL (June 1991, March 1993, and September 1993) appear to be outliers (too low) and may be analytical artifacts (Table 2). Also, the results of paired low-flow and conventional sampling (see Section 2.0) are inconclusive with respect to uranium concentrations (Table 1), with sample obtained with the low-flow sampling method in February 2000 having a substantially lower uranium concentration (0.0808 mg/L) then the sample obtained with the conventional sampling method (0.277 mg/L) the next day, but nearly equal uranium concentrations reported for the samples obtained with the from low-flow and conventional methods in July 2000. Also, the uranium concentrations do not exhibit any consistent correlation with seasonal flow conditions, as illustrated by the temporal peak concentrations reported for samples collected during both seasonally low (e.g., 0.139 mg/L in July 1998) and seasonally high (e.g., 0.23 mg/L in December 1993) groundwater flow conditions.

A time-series plot of uranium concentrations in the groundwater samples shows an indeterminate long-term trend (Figure 3). Also, the uranium concentrations reported for groundwater samples collected since January 2002 suggest a decreasing trend, with the concentration reported for the sample collected in July 2003 (0.0662 mg/L) being the lowest value reported for the well since March 1995 (0.078 mg/L). The recent decrease in uranium concentrations may be attributable to the CERCLA remedial action at the BYBY.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in all but four of the groundwater samples collected to date (Table 3): PCE, TCE, 11DCE, and 12DCE (isomers). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 μg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 2,500 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket B. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are TCE and 12DCE (c12DCE), at least one of which was detected in all but four of the samples (Table 3), with respective historical maximum concentrations of 30 μg/L and 34 μg/L in March 1992. The most recent sampling results (February and July 2004) show TCE concentrations slightly above the drinking water MCL (5 μg/L) and c12DCE concentrations substantially below the MCL (70 μg/L). Other VOCs (PCE and 11DCE) were detected only in the four samples collected between March and November 1992, and all of these results are estimated values below 5 μg/L. Additionally, as noted in Section 2.0 and illustrated by the data summarized below, there are not any significant differences between concentrations of VOCs detected in the groundwater samples obtained with the conventional and low-flow sampling methods.

VOC	Concentration (μg/L)			
	Low-Flow Sampling January 31, 2000	**Conventional Sampling February 1, 2000**	**Low-Flow Sampling July 25, 2000**	**Conventional Sampling July 26, 2000**
TCE	9	11	13	12
c12DCE	3 J	6	7	8

These findings suggest that the VOC concentrations are not strongly influenced by the apparent tendency for the conventional sampling method to induce inflow of less mineralized (and less nitrate-contaminated) groundwater from the water-producing features intercepted by the monitored interval in the well.

A time-series plot of the summed VOC concentrations reported for the groundwater samples shows an indeterminate long-term trend dominated by wide temporal concentration fluctuations (Figure 5). Relatively unchanged concentrations of the VOCs in the groundwater at this well, as illustrated by the 12DCE results reported for the samples collected in November 1991 (11 μg/L) and January 2003 (12 μg/L), suggest minimal overall change in the relative flux of VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

All but one of the groundwater samples collected to date that were analyzed for gross alpha activity had results above the applicable MDA and corresponding CE, and all but two of these results exceed the drinking water MCL for gross alpha activity (Table 4). Uranium isotopes (and alpha-emitting daughters) are the source elevated gross alpha activity in the groundwater at this well, with the most recent (February and July 2004) sampling results showing U-234 and U-238 levels near 15 pCi/L and 25 pCi/L, respectively (Table 4). The contaminant plumes originating from the former S-3 Ponds and the BYBY are primary sources of uranium isotopes in groundwater and surface water in BCV west of Y-12, with the latter site being the closest and most likely source of the uranium isotopes in the groundwater at the Exit Pathway Picket B wells (DOE 1997). As with total uranium (see Section 5.2), U-234 and U-238 ions leached from wastes disposed at the BYBY probably combined with carbonate dissolved from the (limestone) bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

Thirty-five groundwater samples had gross alpha activity above the MDA and corresponding CE (Table 4). The widest range of gross alpha activities, including the historical minimum (4.58 pCi/L in June 1991) and historical maximum values (120 pCi/L in February 2000), were reported for the samples obtained with the conventional sampling method. A smaller range of values for gross alpha activity is evident from the low-flow sampling results, with activities for all but three of the samples ranging between 20 and 60 pCi/L. Nevertheless, the "paired" sampling results for gross alpha activity do not suggest a clear and consistent bias from either sampling method (Table 1). Additionally, the gross alpha results reported for samples obtained with either method do not exhibit any clear and consistent relationship with seasonal groundwater flow conditions, as illustrated by temporal high levels reported for samples collected during seasonally high (e.g., 60 pCi/L in January 2003) and seasonally low (e.g., 88.5 pCi/L in November 1992) flow.

A time-series plot of the gross alpha activity reported for each groundwater sample shows an indeterminate long-term trend (Figure 6). This suggests minimal overall changes in the relative flux of alpha-emitting radionuclides along the groundwater flow/transport pathways intercepted by the well. However, the long-term trend is dominated by a series of temporal "peaks" evident in November 1991 (58.4 pCi/L), November 1992 (88.5 pCi/L), December 1993 (99.2 pCi/L), and February 2000 (120 pCi/L). It is not clear if these peak gross alpha activities are outliers (i.e., analytical artifacts) or if they are significant with respect to the relative flux of alpha-emitting radionuclides via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, results for samples collected after February 2000 define a decreasing trend, with the gross alpha activity evident in July 2004 (20 pCi/L) being the lowest value reported for any sample collected since September 1997 (29 pCi/L). As with the recent decrease in total uranium concentrations (see Section 5.2), the apparent decrease in the levels of gross alpha activity in the groundwater at this well may be attributable to reduced flux of uranium isotopes as a result of the CERCLA remedial actions at the BYBY.

5.5 GROSS BETA ACTIVITY

All but three of the groundwater samples analyzed for gross beta activity had results above the applicable MDA and corresponding CE (Table 4), and all but four of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Although uranium isotopes and related daughter products contribute to the gross beta activity in the groundwater at this well, Tc-99 is the primary source of the beta activity. Ten groundwater samples collected between March 1993 and August 1996 were analyzed for this beta-emitting radionuclide, and results that exceed the MDA and CE range from 25.3 pCi/L (August 1995) to 686 pCi/L (September 1993) and are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent (Table 4). Technetium-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

As noted previously, most of the groundwater samples had gross beta activity above the SDWA screening level (Table 4), including the samples collected most recently (February and July 2004). The lowest gross beta activities, including the historical minimum value (7.42 pCi/L in March 1993), were reported for samples obtained with the conventional sampling method, whereas the highest gross beta activities, including the historical maximum value (310 pCi/L in

January 2001), were reported for samples obtained with the low-flow sampling method. Nevertheless, as shown on Table 1, the results for gross beta activity obtained from "paired" sampling do not suggest consistent bias from either sampling method. Additionally, the gross beta activity reported for samples obtained with each method show wide temporal fluctuations, with the highest levels typically evident in samples obtained during seasonally high groundwater flow conditions (winter and spring). This potentially reflects seasonal (and episodic) inflow of Tc-99 contaminated recharge via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of the gross beta activity reported for each groundwater sample shows an indeterminate or slightly increasing long-term trend dominated by prominent "spikes" evident in January 1991 (197 pCi/L), December 1993 (150 pCi/L), and January 2001 (310 pCi/L). The indeterminate long-term trend suggests minimal overall changes in the relative flux of beta-emitting radionuclides along the groundwater flow/transport pathways intercepted by the well. However, as illustrated by the data summarized in Table 4, the available results for Tc-99 show a clearly decreasing trend, with the Tc-99 activity reported for the sample collected in August 1996 (65.5 pCi/L) being an order-of-magnitude lower than the Tc-99 activity reported for the sample collected in December 1993 (686 pCi/L). This trend suggests a substantial reduction in the relative flux of Tc-99 as a direct consequence of the closure of the former S-3 Ponds and the installation of the low-permeability cap at the site.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-706: Consecutive daily sampling results for summed VOCs and other selected analytes, January/February and July 2000

Analyte	Units	January 31 – February 1, 2000		July 25-26, 2000	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.43	7.59	7.6	7.17
Dissolved Solids	mg/L	583	426	446	430
Suspended Solids	mg/L	4	15	<1	<1
Calcium	mg/L	137	101	98.4	99.1
Nitrate	mg/L	41.6	23.4	22.9	14.9
Barium	mg/L	0.187	0.135	0.141	0.143
Iron	mg/L	1.87	4.85	0.281	0.283
Uranium	mg/L	0.0808	0.277	0.139	0.125
Summed VOCs	µg/L	31	0	12	20
Gross Alpha Activity	pCi/L	33	120	72	54
Gross Beta Activity	pCi/L	88	83	110	57

Table 2. Well GW-706: summary of results for nitrate and uranium

Sampling Method and Date	Concentration (mg/L)	
	Nitrate as N	Total Uranium
Conventional Sampling		
06/20/91	10	0.009
09/13/91	36.26	0.11
11/20/91	84.15	0.13
03/23/92	23.5	0.087
06/19/92	41.3	0.14
09/21/92	49	0.168
11/13/92	37	0.168
03/23/93	<0.2	0.002
06/11/93	32	0.137
09/23/93	<0.2	0.008
12/28/93	28.9	0.23
03/04/94	13.8	0.039
12/15/94	35	0.117
03/31/95	16	0.078
08/30/95	18	0.11
03/19/96	15.2	0.12
08/06/96	16.8	0.13
02/21/97	18.1	0.13
09/03/97	33.1	0.11
02/01/00	23.4	0.277
07/26/00	14.9	0.125
Low-Flow Sampling		
01/05/98	45.7	0.13
08/10/98	48.1	0.111
02/17/99	44.6	0.113
08/04/99	25.95	0.0942
01/31/00	41.6	0.0808
07/25/00	22.9	0.139
01/23/01	99.1	0.117
07/17/01	28.5	0.12
01/16/02	36.8	0.132
07/16/02	15.7	0.106
01/21/03	25.9	0.12
07/16/03	25.2	0.0662
02/04/04	27.4	0.0724
07/22/04	24.2	0.0773
MCL	**10**	**0.03**

Table 3. Well GW-706: summary of VOC results

Date Sampled	Concentration (μg/L)			
	TCE	12DCE	c12DCE	OTHER
Conventional Sampling				
06/20/91	3 J	.	NR	.
09/13/91	.	.	NR	.
11/20/91	4 J	11	NR	.
03/23/92	30	34	NR	PCE (1 J), 11DCE (4 J)
06/19/92	9	10	NR	11DCE (1 J)
09/21/92	15	16	NR	11DCE (2 J)
11/13/92	13	14	NR	11DCE (2 J)
03/23/93	9	7	NR	.
06/11/93	6	5	NR	.
09/23/93	5	5	NR	.
12/28/93	.	.	NR	.
03/04/94	5	5	NR	.
12/15/94	16	13	NR	.
03/31/95	8	.	NR	.
08/30/95	.	.	NR	.
03/19/96	8	6	NR	.
08/06/96	7	8	NR	.
02/21/97	FP1	2 J	2 J	.
09/03/97	11	5	5	.
02/01/00	11	6	6	.
07/26/00	12	8	8	.
Low-Flow Sampling				
01/05/98	20	12	12	.
08/10/98	13	6	6	.
02/17/99	19	12	12	.
08/04/99	.	.	.	.
08/24/99	13	6	6	.
01/31/00	9	3 J	3 J	.
07/25/00	13	7	7	.
01/23/01	20	14	14	.
07/17/01	14	9	9	.
01/16/02	17	14	14	.
07/16/02	16	13	13	.
01/21/03	16	12	12	.
07/16/03	6	2 J	2 J	.
02/04/04	10	7	7	.
07/22/04	6	3 J	3 J	.
MCL	**5**	**NA**	**70**	

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

Table 4. Well GW-706: summary of results for gross alpha activity, uranium isotopes, gross beta activity, and Tc-99

Sampling Method and Date	Concentration (pCi/L)				
	Gross Alpha Activity	U-234	U-238	Gross Beta Activity	Tc-99
Conventional Sampling					
06/20/91	4.58	.	.	21.84	.
09/13/91	24.84	.	.	67.36	.
11/20/91	58.4	.	.	197	.
03/23/92	41.5	.	.	78.3	.
06/19/92	41.7	.	.	140	.
09/21/92	63	.	.	141	.
11/13/92	88.5	.	.	136	.
03/23/93	< CE	.	.	7.42	<CE
06/11/93	54.4	.	.	97.9	<CE
09/23/93	11.7	.	.	< CE	686
12/28/93	99.2			150	288
03/04/94	24.6	.	.	24.3	142
12/15/94	38.1	.	.	78	101
03/31/95	37.6	.	.	48.6	109
08/30/95	29.9	.	.	56.1	25.3
03/19/96	53.7	.	.	52.8	56
08/06/96	62.8	.	.	< CE	65.5
02/21/97	45	.	.	73	.
09/03/97	29	.	.	67	.
02/01/00	120	.	.	83	.
07/26/00	54	.	.	57	.
Low-Flow Sampling					
01/05/98	42	.	.	130	.
06/24/98	49.95	20.5	43.54	105.79	.
07/14/98	.	26.92	46.76	.	.
08/10/98	42	.	.	140	.
02/02/99	.	18.07	33.46	.	.
02/17/99	43	.	.	120	.
08/04/99	38	9.51	18.99	86	.
08/24/99	.	.	.	.	.
01/31/00	33	16.44	31.4	88	.
07/25/00	72	29.51	50.08	110	.
01/23/01	69	24.22	40.85	310	.
07/17/01	56	22.06	39.97	140	.
01/16/02	58	21.89	45.9	140	.
07/16/02	45	19.78	32.99	72	.
01/21/03	60	21.26	35.66	110	.
07/16/03	30	12.76	27.25	89	.
02/04/04	37	14.02	25.25	98	.
07/22/04	20	16.47	27.57	81	.
MCL	**15**	**NA**		**50***	**3,790***

Note: "." = Not analyzed; NA = Not applicable; * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

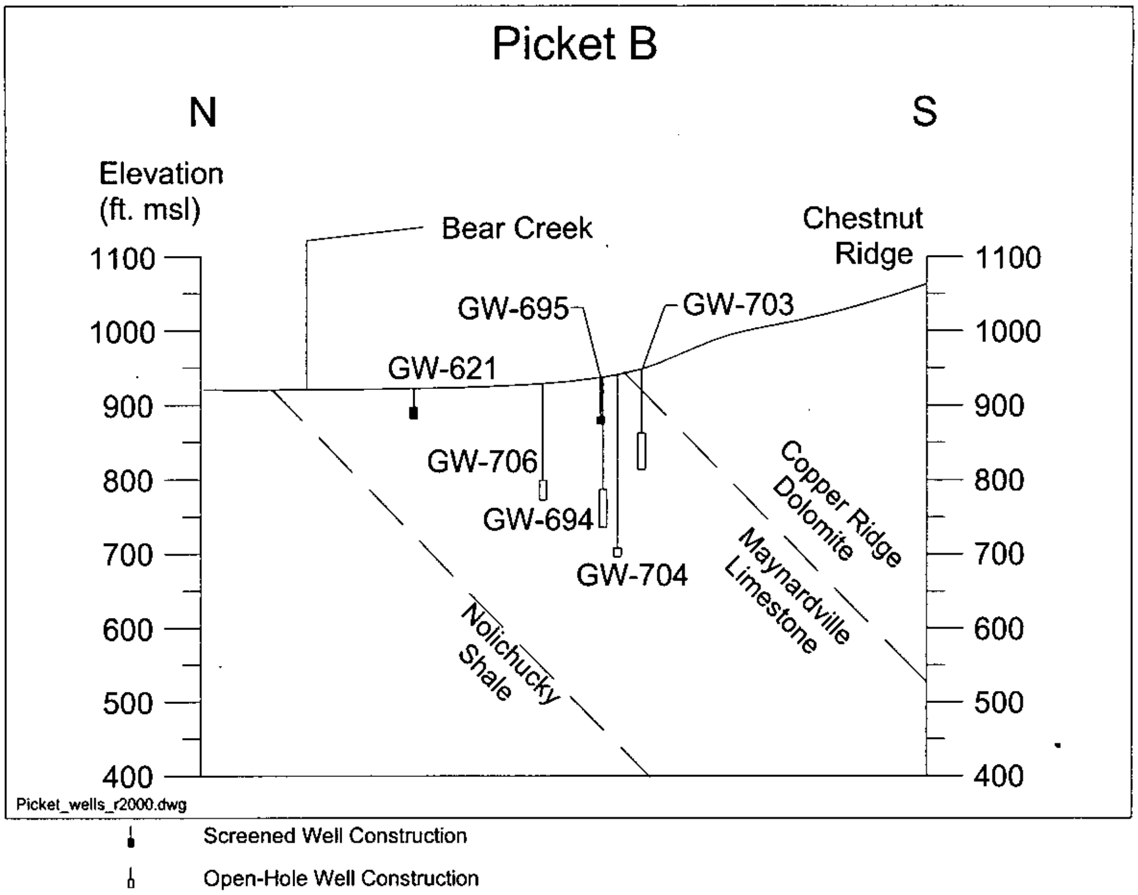

Picket B
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-695
GW-703
GW-621
GW-706
GW-694
GW-704
Copper Ridge
Dolomite
Maynardville
Limestone
Nolichucky
Shale
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

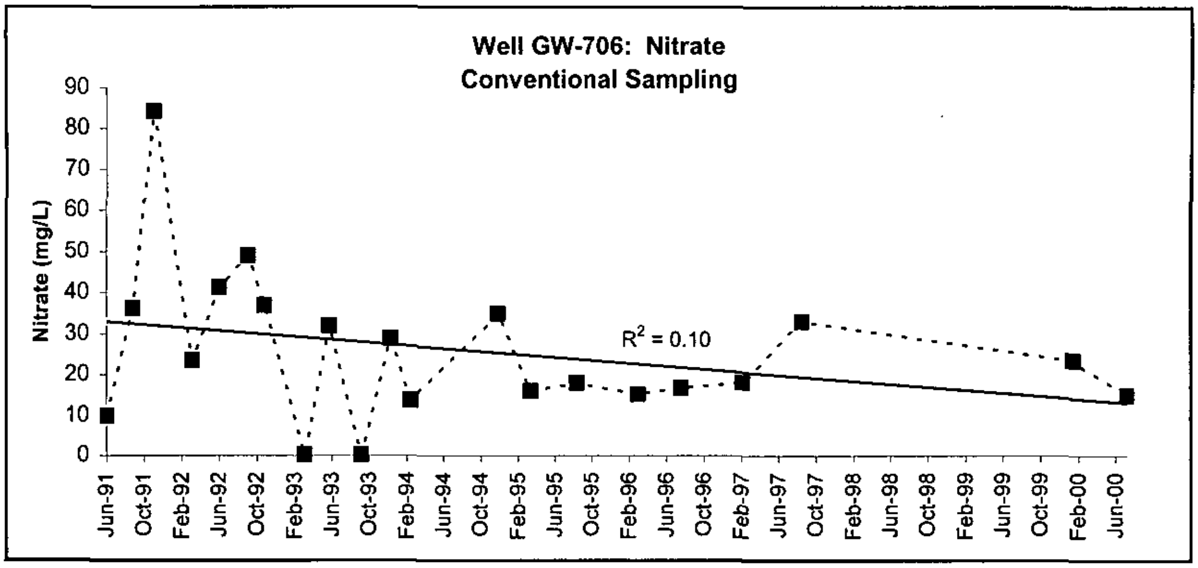


Figure 2

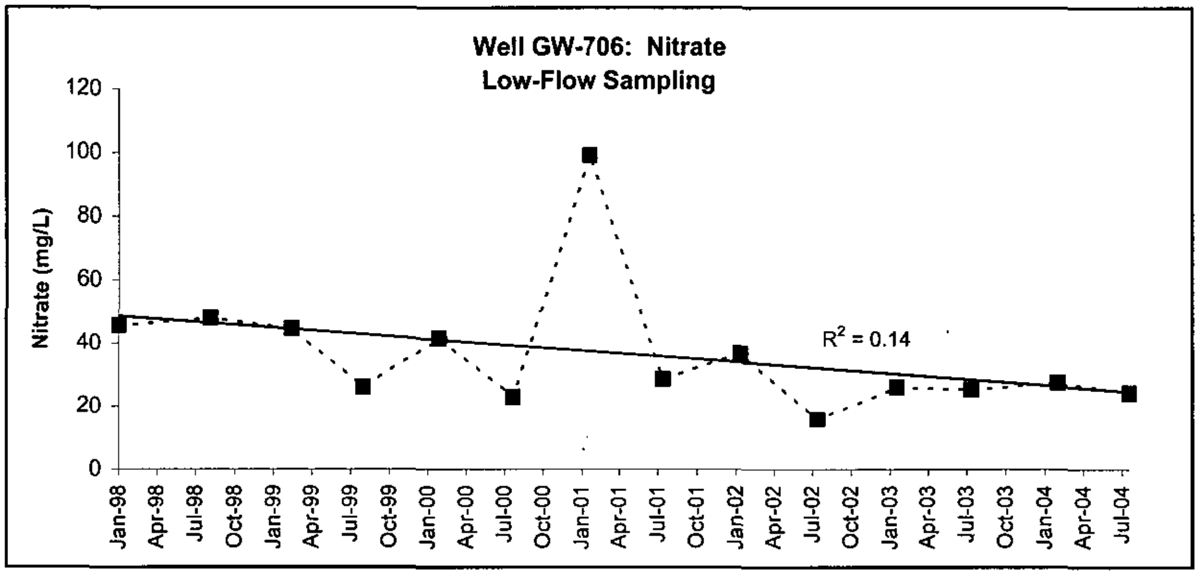


Figure 3

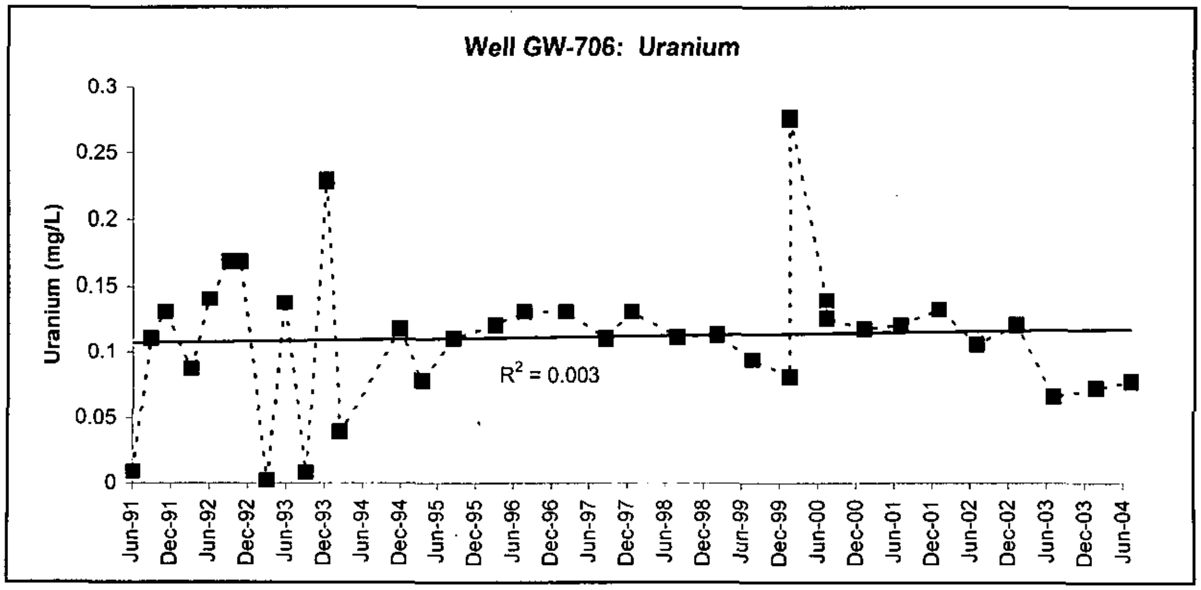


Figure 4

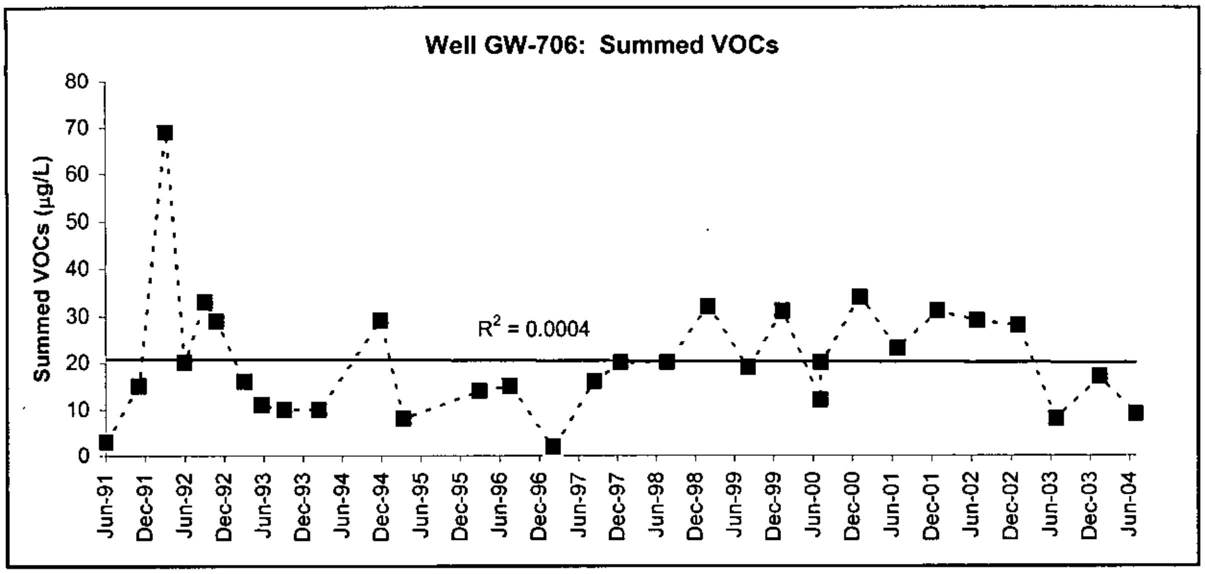


Figure 5

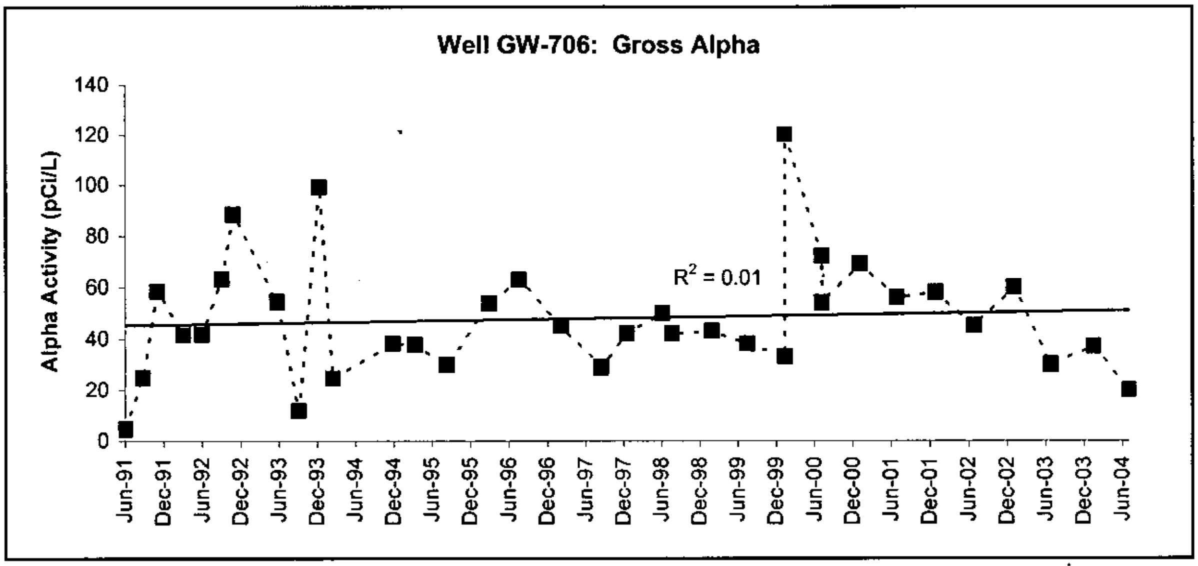


Figure 6

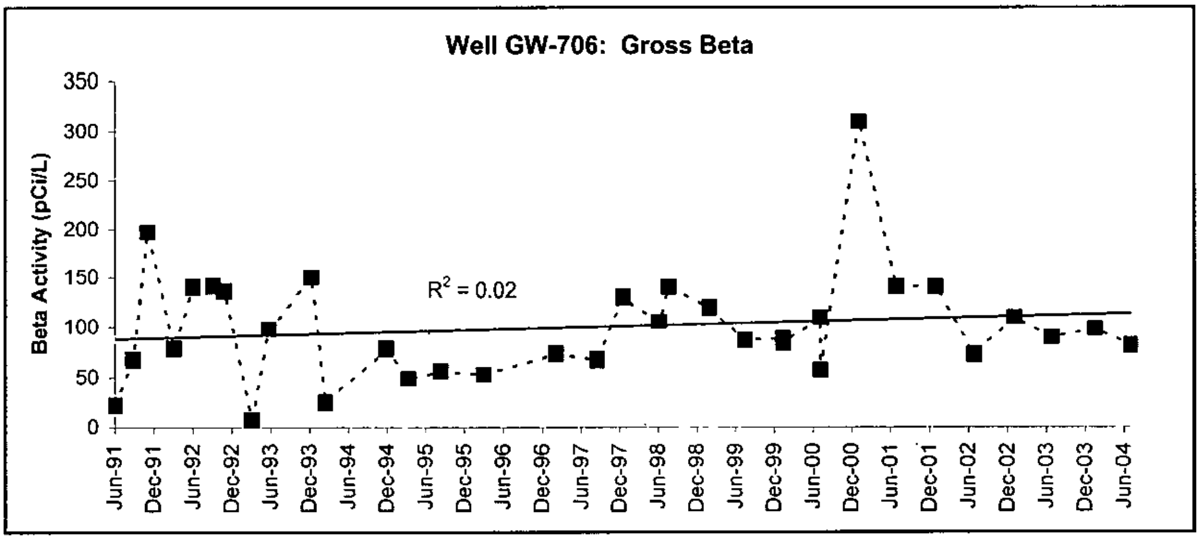


Figure 7

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-709

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill II
Y-12 GRID EAST COORDINATE: 52,371.88
Y-12 GRID NORTH COORDINATE: 25,344.08
SURFACE ELEVATION: 903.84 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/05/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 83.52 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 906.81 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.25 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	68.7	835.14
BOTTOM (filter pack or open hole):	80.6	823.24
MIDPOINT (filter pack or open hole):	74.7	829.19
PUMP INTAKE:	75.53	828.31
WATER LEVEL (average):	25.81	878.03

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	37		
CONVENTIONAL SAMPLING METHOD:	21 samples	06/19/91	04/02/97
LOW-FLOW SAMPLING METHOD:	16 samples	10/16/97	07/22/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/20/04	.	07/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 31.46 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	76 µg/L	10/16/97	Indeterminate
GROSS ALPHA (15 pCi/L):	1	25.6 pCi/L	11/21/91	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-709

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1991, completed with a screened monitored interval from 68.7 to 80.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 500 ft south (hydraulically downgradient) of Industrial Landfill II. This closed landfill operated from 1983 to 1996 and received combustible and decomposable nonhazardous solid waste, including construction spoil material (scrap metal, glass, paper, plastics, wood, asphalt roofing material) and special wastes (such as asbestos and beryllium oxide) generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between June 1991 and April 1997, and the low-flow sampling method used to obtain 16 samples between October 1997 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group. The average static groundwater level in the well is 26 ft bgs. Although presampling depth-to-water measurements for the well suggest substantial (>30 ft) water-level fluctuations (Figure 1), excluding the unusually low water level in July 1994 and the unusually high water levels in April 1998 and January 2001, the groundwater elevations in the well typically fluctuate by less than 5 ft. The average result of several falling head permeability tests performed in well GW-709 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.26×10^{-5} cm/s (0.036 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 251 mg/L;
- pH (field measurements) of 7.6 – 9.7;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Fourteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.58 mg/L in January 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Thirteen groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.002 mg/L in June 1991) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Chestnut Ridge Regime. Acetone was detected in groundwater samples collected in April 1999 (4 μg/L), October 1997 (76 μg/L), April 1999 (6 μg/L), and February 2000 (11 μg/L). Trace levels of toluene were reported for samples collected in July 1994 (0.3 μg/L) and July 2004 (0.27 μg/L). These results may be sampling or analytical artifacts because acetone and toluene are common laboratory reagents.

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (25.6 pCi/L in November 1991) exceeding the MCL for gross alpha activity (15 pCi/L). However, this result is probably an outlier because none of the other gross alpha results exceed 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (20.4 pCi/L in November 1991) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

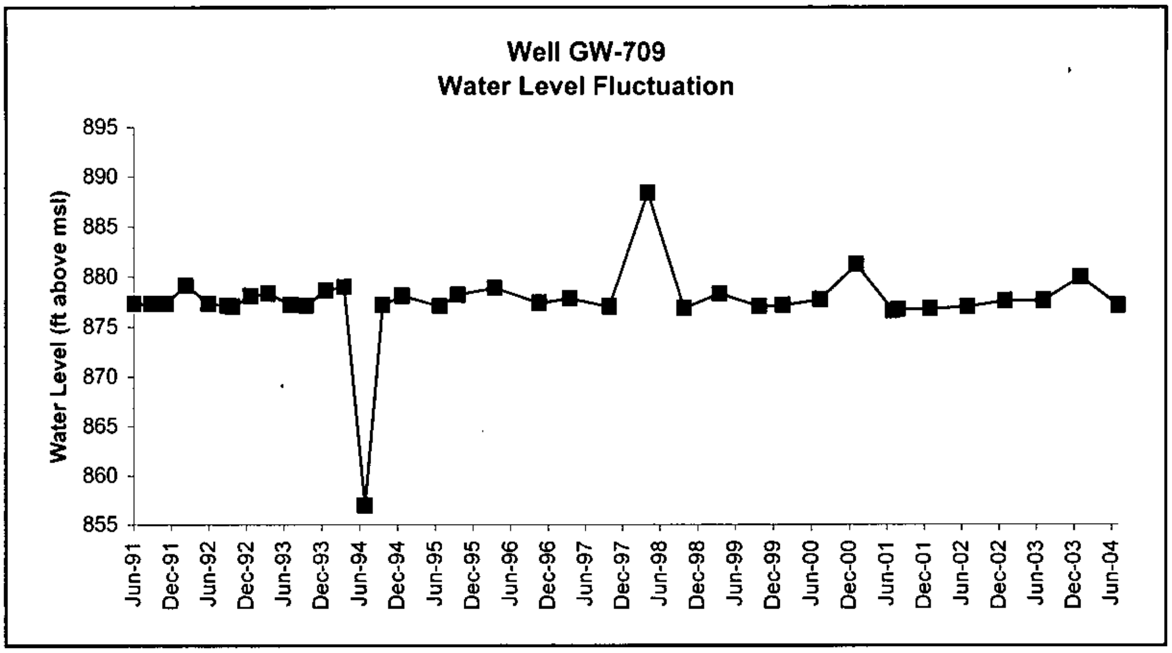

Well GW-709
Water Level Fluctuation
Water Level (ft above msl)
895
890
885
880
875
870
865
860
855
Jun-91
Dec-91
Jun-92
Dec-92
Jun-93
Dec-93
Jun-94
Dec-94
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04

Figure 1

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	5 - 50	ND	ND

GW-710

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket W
Y-12 GRID EAST COORDINATE: 36,470.67
Y-12 GRID NORTH COORDINATE: 27,644.95
SURFACE ELEVATION: 906.83 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/02/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 750.73 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 906.42 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	539.7	367.13
BOTTOM (filter pack or open hole):	744.5	162.33
MIDPOINT (filter pack or open hole):	642.1	264.73
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	66.17	840.66

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	17 samples	12/05/91	08/28/97
LOW-FLOW SAMPLING METHOD:	2 samples	01/15/03	07/14/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	01/15/03	.	07/14/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.52 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	74.9 mg/L	04/30/93	Anomalous Result
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	11 µg/L	07/14/03	Indeterminate
GROSS ALPHA (15 pCi/L):	1	32.3 pCi/L	12/05/91	Anomalous Result
GROSS BETA (50 pCi/L):	1	63 pCi/L	08/28/97	Anomalous Result

WELL GW-710

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1991, completed with an open-hole monitored interval from 539.7 to 744.5 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), which underlies Bear Creek throughout the Bear Creek Regime. The interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathways for groundwater and surface water contaminants originating from source areas in Bear Creek Valley west of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between December 1991 and August 1997, and the low-flow sampling method used to obtain samples in January and July 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (>400 ft bgs) in the Maynardville Limestone. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 65 ft bgs and exhibit moderate fluctuations (<10 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields highly mineralized, sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- very high TDS (>1,000 mg/L);
- pH (field measurements) of 5.9 – 7.8; and
- total (unfiltered sample) concentrations of trace metals [except unusually high concentrations of several trace metals, notably boron (>1 mg/L) and strontium (>5 mg/L)] that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

A combination of several natural processes may account for the high boron and strontium concentrations in the groundwater at this well, including: mixing of the sulfate-enriched groundwater with brines in the deeper bedrock, which may cause precipitation of barite and celestite ($SrSO_4$); upward diffusion of the solutes from the deeper bedrock; and matrix diffusion from the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Excluding a suspected outlier (74.9 mg/L) reported for a sample collected from the well in April 1993, none of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are principal groundwater contaminants in the Bear Creek Regime. However, benzene was detected in both samples collected in CY 2003 (10 μg/L in each sample) which may reflect naturally occurring concentrations at this depth (>700 ft bgs) in the Maynardville Limestone (known to be petroliferous). Very low (estimated values) single detections of acetone (1 μg/L in February 1997) and chloromethane (1 μg/L in July 2003) are considered outliers.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with one result (32.3 pCi/L in December 1991) above and two results (5.2 pCi/L in September 1992, and 8.08 pCi/L in November 1992) below the MCL for gross alpha activity (15 pCi/L). The inconsistent detection and widely variable results for gross alpha activity may be related to analytical interference associated with the very high TDS of the (unfiltered) groundwater samples (see Section 4.0).

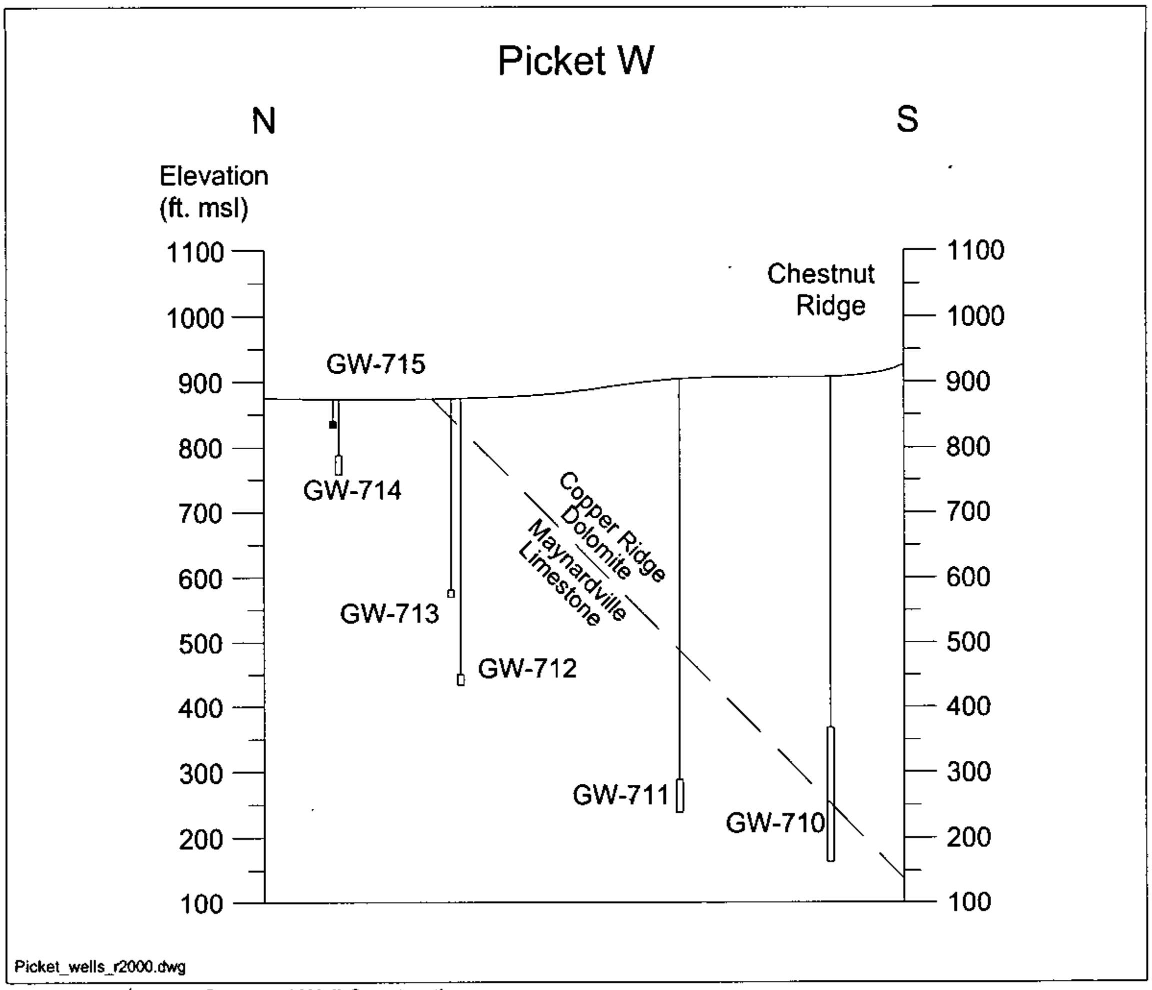
5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (63 pCi/L in August 1997) exceeding the SDWA screening level for gross beta activity (50 pCi/L). As described for gross alpha activity, the inconsistent detection and widely variable results (6.8 pCi/L to 63 pCi/L) for gross beta activity may be related to analytical interference associated with the very high TDS of the groundwater samples (see Section 4.0).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Saunders, J.A. and L.E. Toran. 1992. *Evolution of Ca-Mg-SO_4 Type and Na-Ca-SO_4 Type Water in Fractured Sedimentary Rock Near Oak Ridge, Tennessee*, Y/TS-875/R2, Oak Ridge National Laboratory, Oak Ridge, TN.



– Screened Well Construction

– Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-711

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket W
Y-12 GRID EAST COORDINATE: 36,535.38
Y-12 GRID NORTH COORDINATE: 27,872.80
SURFACE ELEVATION: 901.96 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/10/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 668.57 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 905.20 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	616.0	285.96
BOTTOM (filter pack or open hole):	666.2	235.76
MIDPOINT (filter pack or open hole):	641.1	260.86
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	58.98	842.99

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	19		
CONVENTIONAL SAMPLING METHOD:	17 samples	12/10/91	08/26/97
LOW-FLOW SAMPLING METHOD:	2 samples	01/15/03	07/14/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	01/15/03	.	07/14/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: H (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 15.44 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	23.8 pCi/L	12/10/91	Anomalous Result
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-711

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1991, completed with an open-hole monitored interval from 616 to 666.2 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), which underlies Bear Creek throughout the Bear Creek Regime. The interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathway for groundwater and surface water contaminants originating from source areas in Bear Creek Valley west of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Nineteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between December 1991 and August 1997, and the low-flow sampling method used to obtain samples in January and July 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (<400 ft bgs) in the Maynardville Limestone. The average static groundwater level in the well is 59 ft bgs. Presampling depth-to-water measurements for the well indicate moderate (<10 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields highly mineralized, sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- very high TDS (>1,000 mg/L);
- pH (field measurements) of 6.6 – 9.7; and
- total (unfiltered sample) concentrations of trace metals [except unusually high concentrations of several trace metals, notably boron (>1 mg/L) and strontium (>5 mg/L)] that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

A combination of several natural processes may account for the high boron and strontium concentrations in the groundwater at this well, including: mixing of the sulfate-enriched groundwater with brines in the deeper bedrock, which may cause precipitation of barite and celestite ($SrSO_4$); upward diffusion of the solutes from the deeper bedrock; and matrix diffusion from the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime.

5.4 GROSS ALPHA ACTIVITY

Two groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with one result (23.8 pCi/L in December 1991) above and one result (3.31 pCi/L in March 1992) below the MCL for gross alpha activity (15 pCi/L). Both results are probably sampling or analytical artifacts.

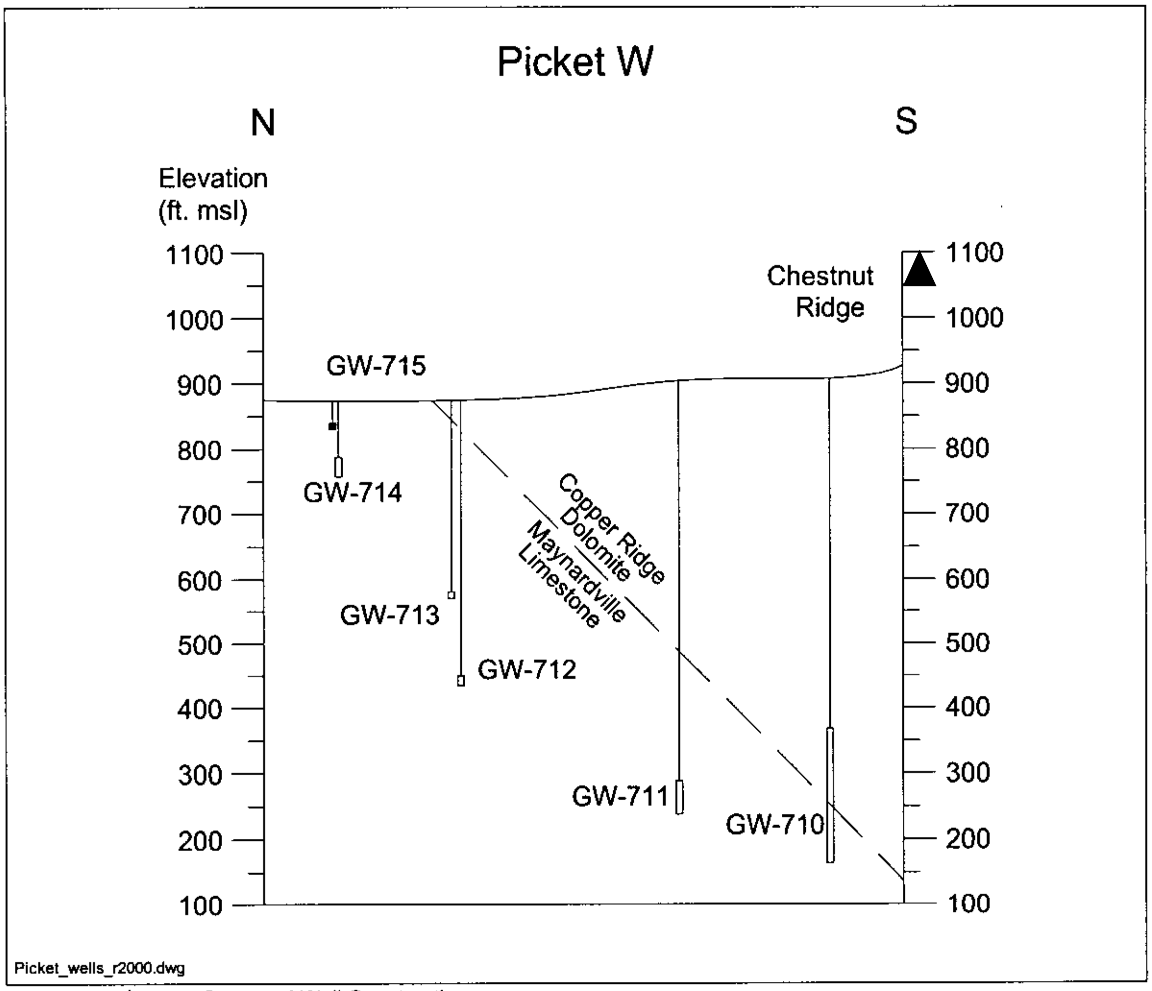
5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (22.3 pCi/L in March 1992) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Saunders, J.A. and L.E. Toran. 1992. *Evolution of $Ca\text{-}Mg\text{-}SO_4$ Type and $Na\text{-}Ca\text{-}SO_4$ Type Water in Fractured Sedimentary Rock Near Oak Ridge, Tennessee*, Y/TS-875/R2, Oak Ridge National Laboratory, Oak Ridge, TN.



– Screened Well Construction

– Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-712

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket W
Y-12 GRID EAST COORDINATE: 36,506.87
Y-12 GRID NORTH COORDINATE: 28,232.52
SURFACE ELEVATION: 873.61 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/20/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 460.53 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 877.89 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	441.5	432.11
BOTTOM (filter pack or open hole):	457.5	416.11
MIDPOINT (filter pack or open hole):	449.5	424.11
PUMP INTAKE:	446.22	427.39
WATER LEVEL (average):	29.37	844.24

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	17 samples	12/09/91	08/26/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/20/98	07/07/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/06/04	.	07/07/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.03 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	6 µg/L	07/14/98	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-712

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1991, completed with an open-hole monitored interval from 441.5 to 457.5 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), which underlies Bear Creek throughout the Bear Creek Regime. The interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathway for groundwater and surface water contaminants originating from source areas in Bear Creek Valley west of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between December 1991 and August 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the deep bedrock interval (<400 ft bgs) in the Maynardville Limestone. Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 30 ft bgs and exhibit substantial (11 ft) fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

This well yields sulfate-enriched (>50% of total anions) calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 250 – 898 mg/L;
- pH (field measurements) of 7.3 – 8.5;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Eighteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (1.4 mg/L in July 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Seven groundwater samples had uranium concentrations above the analytical reporting limit, with the highest concentration (0.001 mg/L) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime. The single detections of acetone (6 µg/L in July 1998), chlorobenzene (2 µg/L in January 2000), and bromomethane (2 µg/L in January 2001) are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE. The highest activity (12.31 pCi/L in January 2003) is below the MCL for gross alpha activity (15 pCi/L) and is considered to be an outlier because the other results are below 6 pCi/L.

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest activity (20.78 pCi/L in January 1999) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

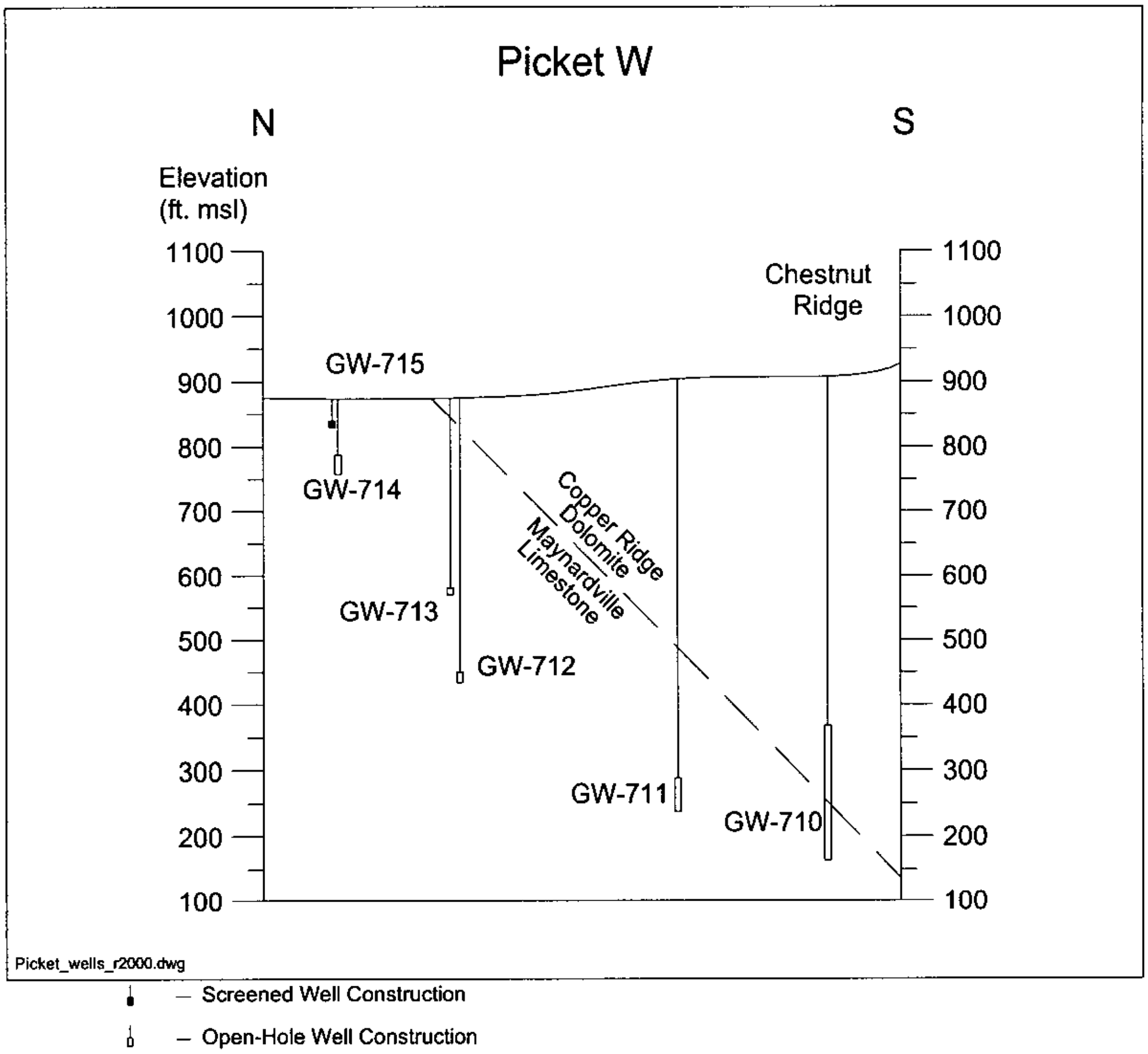

Picket W
N
S
Elevation
(ft. msl)
1100
1000
900
800
700
600
500
400
300
200
100
Chestnut
Ridge
GW-715
GW-714
GW-713
GW-712
GW-711
GW-710
Copper Ridge
Dolomite
Maynardville
Limestone
Picket_wells_r2000.dwg
— Screened Well Construction
– Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	<7.5	<25

GW-713

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket W
Y-12 GRID EAST COORDINATE: 36,434.40
Y-12 GRID NORTH COORDINATE: 28,235.95
SURFACE ELEVATION: 877.83 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/13/92 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 318.39 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 881.43 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	305.0	572.83
BOTTOM (filter pack or open hole):	315.2	562.63
MIDPOINT (filter pack or open hole):	310.1	567.73
PUMP INTAKE:	307.40	570.43
WATER LEVEL (average):	33.99	843.84

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	15 samples	06/13/92	08/27/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/20/98	07/07/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/05/04	.	07/07/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.8 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	16 µg/L	12/03/92	Outlier
GROSS ALPHA (15 pCi/L):	2	19.45 pCi/L	07/10/01	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-713

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1992, completed with an open-hole monitored interval from 305 to 315.2 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), which underlies Bear Creek throughout the Bear Creek Regime. The interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathway for groundwater and surface water contaminants originating from source areas in Bear Creek Valley west of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between June 1992 and August 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the intermediate bedrock interval in the Maynardville Limestone. The average static groundwater level in the well is 34 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

This well yields sulfate-enriched (>50% of total anions) calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 319 – 564 mg/L;
- pH (field measurements) of 6.7 – 8.4;
- fluoride concentrations near 0.5 mg/L; and
- total (unfiltered sample) concentrations of trace metals (except unusually high concentrations [>1 mg/L] of total strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

A combination of several natural processes may account for the high strontium concentrations in the groundwater at this well, including: mixing of the sulfate-enriched groundwater with brines in the deeper bedrock, which may cause precipitation of barite and celestite ($SrSO_4$); upward diffusion of the solutes from the deeper bedrock; and matrix diffusion from the bedrock (Saunders and Toran 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion

5.1 NITRATE

Fourteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (1.4 mg/L in April 1993) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Six groundwater samples had uranium concentrations above the analytical reporting limit, with the highest concentration (0.0052 mg/L on February 1997) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime. A single detection of 2-butanone (16 µg/L in December 1992) is considered a sampling or analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest activities reported for the samples collected in July 2001 (19.45 pCi/L) and July 2002 (15.75 pCi/L). Both results exceed the MCL for gross alpha activity (15 pCi/L). Much lower levels of gross alpha activity are evident before and after these "peak" concentrations. Also, the frequency of detection of gross alpha activity above the MDA appears to have increased. Only three of 15 samples collected between June 1992 and August 1997 had gross alpha above the MDA (and CE), whereas seven of 14 samples collected between January 1998 and July 2004 had gross alpha above the MDA.

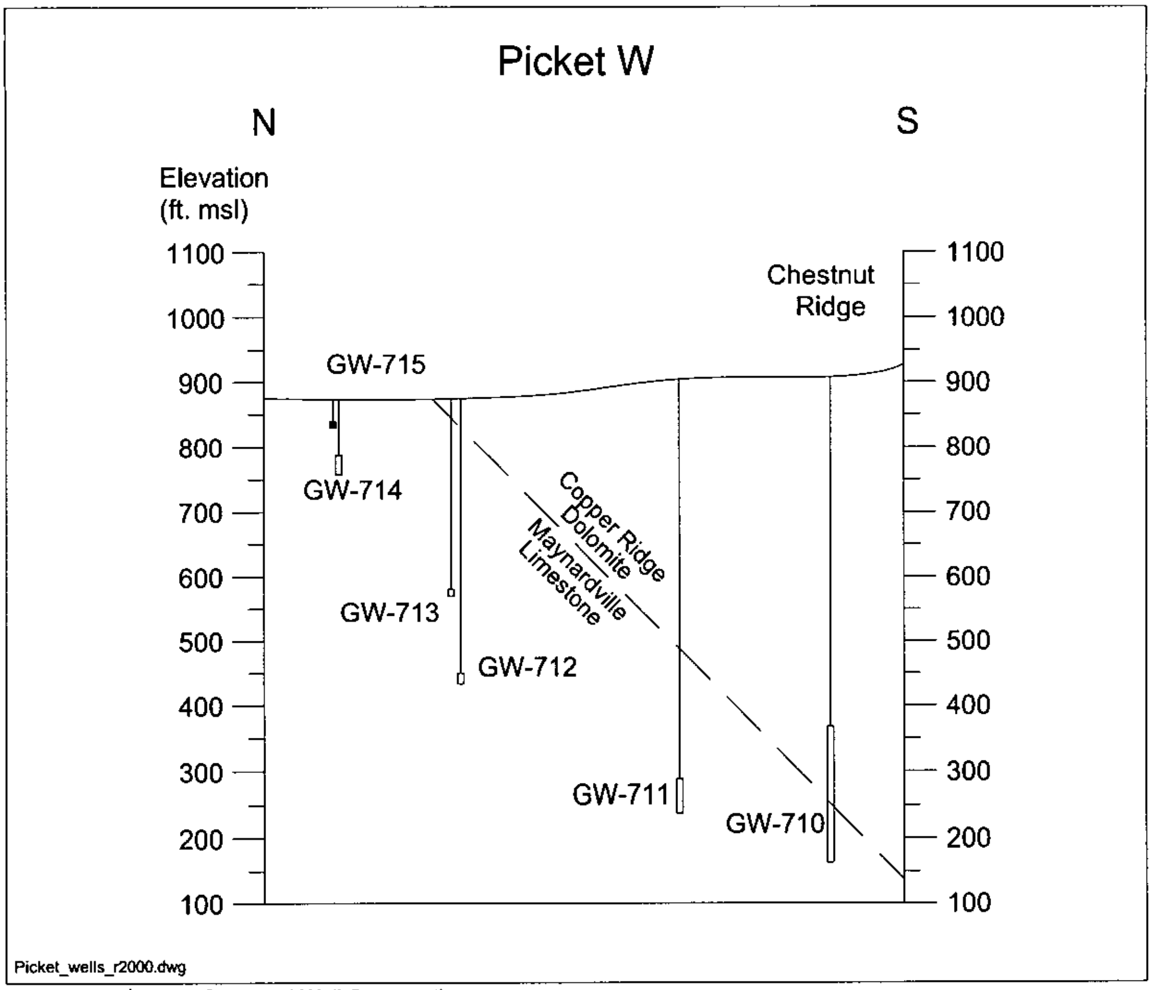
5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest activities reported for the samples collected in January 2000 (17.92 pCi/L), July 2001 (28.57 pCi/L), and July 2002 (39.75 pCi/L). These results exceed background levels evident in uncontaminated groundwater from shallower depths in the Maynardville Limestone, but are less than the SDWA screening level for gross beta activity (50 pCi/L). Much lower levels of gross beta activity are evident before and after these "peak" concentrations. Also, the frequency of detection of gross beta activity above the MDA appears to have increased. Only one of 15 samples collected between June 1992 and August 1997 had gross beta above the MDA (and CE), whereas nine of 14 samples collected between January 1998 and July 2004 had gross beta above the MDA.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Saunders, J.A. and L.E. Toran. 1992. *Evolution of Ca-Mg-SO_4 Type and Na-Ca-SO_4 Type Water in Fractured Sedimentary Rock Near Oak Ridge, Tennessee*, Y/TS-875/R2, Oak Ridge National Laboratory, Oak Ridge, TN.



– Screened Well Construction

– Open-Hole Well Construction

Figure 1

GW-713

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-714

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Exit Pathway Picket W
Y-12 GRID EAST COORDINATE:	36,435.09
Y-12 GRID NORTH COORDINATE:	28,421.56
SURFACE ELEVATION:	872.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	RCRA
HYDROLOGIC MONITORING:	.
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	01/24/92	PAIRED/CLUSTERED WITH:	GW-715
TAG DEPTH (measured):	146.90 ft below top of casing (TOC)		
MEASURING POINT ELEVATION:	875.88 ft above msl	MEASURING POINT:	TOWW
WELL BORE DIAMETER:	10.6 inches		
WELL CASING MATERIAL:	SF25		
WELL CASING DIAMETER:	7 inches (outside diameter)		
WELL SCREEN TYPE:	.		
DEDICATED SAMPLING EQUIPMENT:	Well Wizard	Sampling Port No.: .	Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	115.1	757.20
BOTTOM (filter pack or open hole):	145.0	727.30
MIDPOINT (filter pack or open hole):	130.1	742.25
PUMP INTAKE:	138.42	733.88
WATER LEVEL (average):	25.35	846.95
GEOLOGIC FORMATION:	Maynardville Limestone	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	14 samples	09/03/92	08/27/97
LOW-FLOW SAMPLING METHOD:	16 samples	01/21/98	07/07/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/05/04	.	07/07/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	.	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	.	
WATER LEVEL FLUCTUATION:	12.33 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	36 µg/L	07/14/98	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-714

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1992, completed with an open-hole monitored interval from 115 to 145 ft bgs, and constructed with 7-inch diameter steel (SF25) riser casing. The well forms a cluster with well GW-715 and is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), the principal groundwater exit pathway for contaminants originating from source areas in the Bear Creek Regime.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between September 1992 and August 1997, and the low-flow sampling method used to obtain 16 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the intermediate bedrock interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 25 ft bgs. Presampling depth-to-water measurements for the well indicate moderate (12 ft) water-level fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically lower in well GW-714 than in well GW-715, which is completed at a shallower depth (44 ft bgs) in the Maynardville Limestone. Based on the distance (91.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (average 0.01) from well GW-715 to GW-714 during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 228 – 324 mg/L, excluding an outlier (160 mg/L) in July 2000;
- pH of 6.6 – 8.1 (field measurements);
- sulfate concentrations above 40 mg/L;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-six groundwater samples had nitrate concentrations above the applicable analytical reporting limit. Although all the nitrate results are below the MCL (10 mg/L), most of the concentrations exceed background levels in the Bear Creek Regime, with the historical maximum concentration just under 5 mg/L (4.8 mg/L in November 1992 and April 1993). The source of the nitrate is the contaminant plume emplaced during operation of the former S-3 Ponds, which are located near the headwaters of Bear Creek about 2.5 miles east of Exit Pathway Picket W. Nitrate is a principal component of the plume and is highly mobile in groundwater. Elevated nitrate concentrations essentially delineate the maximum extent of contaminant transport from the former S-3 Ponds and effectively trace the principal migration pathways in the Maynardville Limestone. In the deeper bedrock flowpaths (>100 ft bgs), the existing network of wells in the Maynardville Limestone defines a more or less continuous plume extending from directly south (down geologic dip) of the former S-3 Ponds for about 10,000 ft along strike to the west, whereas attenuation from more active recharge and groundwater flux has reduced nitrate levels and produced a more discontinuous nitrate plume in the shallow karst network (DOE 1997). However, the presence of nitrate more than 100 ft bgs in the groundwater at well GW-714 probably does not indicate the contiguous downgradient extension of the plume. Instead, two observations suggest that localized inflow of contaminated surface water in Bear Creek is the likely source of nitrate in the well (Bechtel Jacobs Company LLC [BJC] 2003). First, presampling groundwater elevations in wells GW-714 and GW-715 show vertically downward hydraulic gradients (see Section 3.0), which suggests that the main channel of Bear Creek may locally lose flow to the Maynardville Limestone. Second, the monitoring results for Bear Creek sampling station BCK-07.87, which is located in a sharp meander of the main channel of the creek directly northeast (upstream) of Exit Pathway Picket W, show nitrate concentrations above the MCL.

5.2 URANIUM

Uranium concentrations above the applicable analytical reporting limit were reported for the 14 groundwater samples collected between September 1992 and August 1997, with the highest concentration (0.0032 mg/L in August 1997) being substantially below the MCL for uranium (0.03 mg/L). Uranium concentrations have been below the reporting limit (0.004 mg/L) in all samples collected since January 1998.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in two groundwater samples: acetone in July 1998 (36 μg/L) and a trace of 12DCA in July 1999 (3 μg/L). These results may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.78 pCi/L in November 1992) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

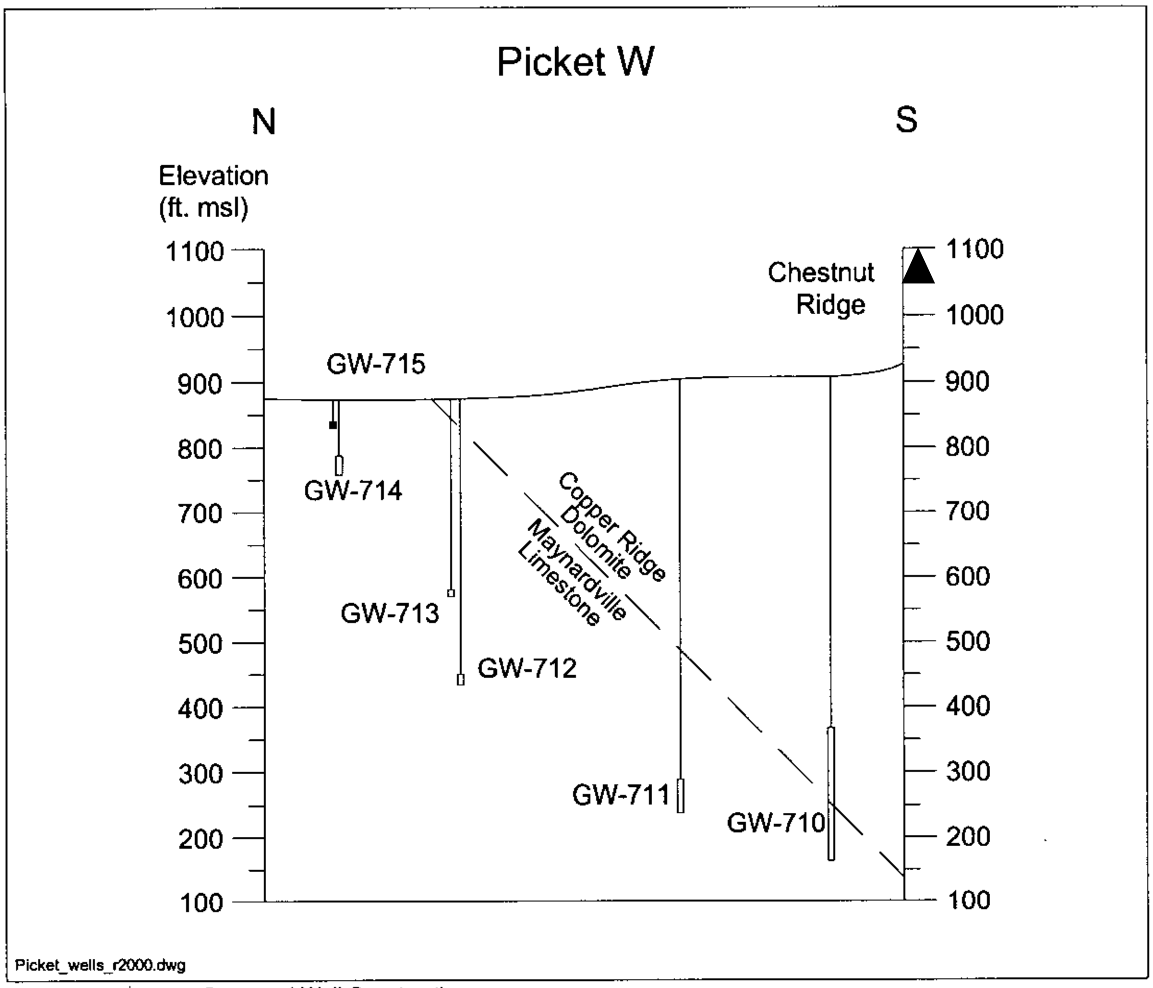
Sixteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (24.8 pCi/L in November 1992) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

Bechtel Jacobs Company LLC [BJC] 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the Y-12 National Security Complex, Oak Ridge, Tennessee*, BJC/OR-1730, Bechtel Jacobs Company LLC, Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.



– Screened Well Construction

– Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-715

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket W
Y-12 GRID EAST COORDINATE: 36,453.11
Y-12 GRID NORTH COORDINATE: 28,424.58
SURFACE ELEVATION: 872.17 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/29/92 PAIRED/CLUSTERED WITH: GW-714
TAG DEPTH (measured): 45.96 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 874.92 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.25 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	32.0	840.17
BOTTOM (filter pack or open hole):	44.0	828.17
MIDPOINT (filter pack or open hole):	38.0	834.17
PUMP INTAKE:	37.25	834.92
WATER LEVEL (average):	24.52	847.65

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	15 samples	09/04/92	07/08/03
LOW-FLOW SAMPLING METHOD:	15 samples	01/21/98	01/05/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/05/04	.	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 11.83 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	1	0.043 mg/L	07/01/02	Outlier
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	17.96 pCi/L	07/01/02	Outlier
GROSS BETA (50 pCi/L):	1	158.44 pCi/L	02/04/99	Outlier

WELL GW-715

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1992, completed with a screened monitored interval from 32 to 44 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and continuous wire-wound stainless steel screen (0.01 slot). The well forms a cluster with well GW-714 and is located in Bear Creek Valley about three miles west of Y-12. It is a component of Exit Pathway Picket W, which consists of a series of wells (GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1), the principal groundwater exit pathway for contaminants originating from source areas in the Bear Creek Regime.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well, with the conventional sampling method used to obtain 15 samples between September 1992 and July 2003, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004. To evaluate suspected sampling method bias (higher contaminant concentrations in low-flow samples than in conventional samples), "paired sampling" was performed during July 2003 when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day. The results of the paired sampling did not confirm the suspected bias, because contaminant concentrations (except for chromium, iron, manganese, and nickel) were similar in both samples (Elvado Environmental LLC 2004).

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium and nickel that are most likely attributable to corrosion of the Type 304 stainless steel riser casing and screen used in construction of the well (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Maynardville Limestone. The average static groundwater level in the well is 25 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (12 ft) water-level fluctuations. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically higher in well GW-715 than in well GW-714, which is completed at a greater depth (145 ft bgs) in the Maynardville Limestone. Based on the distance (91.9 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (average 0.01) from well GW-715 to GW-714 during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 249 – 567 mg/L;
- pH of 5.2 – 7.4 (field measurements);
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are less than 0.5 mg/L.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-seven groundwater samples had nitrate concentrations above the applicable analytical reporting limit. Although all the nitrate results are below the MCL (10 mg/L), most of the concentrations exceed background levels in the Bear Creek Regime, with the historical maximum concentration less than 5 mg/L (4.2 mg/L in July 2002). The source of the nitrate is the contaminant plume emplace during operation of the former S-3 Ponds, which are located near the headwaters of Bear Creek about 2.5 miles east of Exit Pathway Picket W. Nitrate is a principal component of the plume and is highly mobile in groundwater. Elevated nitrate concentrations essentially delineate the maximum extent of contaminant transport from the former S-3 Ponds and effectively trace the principal migration pathways in the Maynardville Limestone. In the deeper bedrock flowpaths (>100 ft bgs), the existing network of wells in the Maynardville Limestone defines a more or less continuous plume extending from directly south (down geologic dip) of the former S-3 Ponds for about 10,000 ft along strike to the west, whereas attenuation from more active recharge and groundwater flux has reduced nitrate levels and produced a more discontinuous nitrate plume in the shallow karst network (DOE 1997). Therefore, the presence of nitrate in the groundwater at well GW-715 probably does not indicate the contiguous downgradient extension of the plume. Instead, two observations suggest that localized inflow of contaminated surface water in Bear Creek is the likely source of nitrate in the well (Bechtel Jacobs Company LLC [BJC] 2003). First, presampling groundwater elevations in wells GW-714 and GW-715 show vertically downward hydraulic gradients (see Section 3.0), which suggests that the main channel of Bear Creek may locally lose flow to the Maynardville Limestone. Second, the monitoring results for Bear Creek sampling station BCK-07.87, which is located in a sharp meander of the main channel of the creek directly northeast (upstream) of Exit Pathway Picket W, show nitrate concentrations above the MCL.

5.2 URANIUM

Total uranium concentrations above the applicable analytical reporting were detected in 21 groundwater samples, with the concentration evident in July 2002 (0.043 mg/L) exceeding the previous high for the well (0.0194 mg/L in January 2000) and the MCL (0.03 mg/L). As with nitrate in the shallow groundwater at this well, the elevated uranium concentrations in the well probably reflect localized recharge of contaminated surface water in Bear Creek; monitoring results for Bear Creek sampling station BCK-07.87 show total uranium concentrations almost an order-of-magnitude above the MCL (0.03 mg/L). Additionally, a very large washed-out area at the top of bedrock (about 35 ft bgs) noted during well installation may have enhanced flowpaths for surface water infiltration; construction of the filter pack required 60 sacks of sand.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the groundwater samples from this well except for a trace of 12DCA (2 μg/L) in the sample collected in July 1999. This result is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, including each of the samples collected from the well since January 2001. Only one of these results, the historical maximum (17.96 pCi/L in July 2002), exceed the MCL for gross alpha activity (15 pCi/L), with the remaining results all less than 10 pCi/L. Available monitoring results confirm that U-234 and U-238 are the source of the alpha radioactivity, with the historical maximum value for each isotope (4.77 pCi/L and 10.15 pCi/L, respectively) corresponding with the historical maximum gross alpha activity (July 2002). As with total uranium, localized recharge of contaminated surface water in Bear Creek probably explains the presence of U-234 and U-238 in the shallow groundwater at this well; monitoring results for Bear Creek sampling station BCK-07.87 show gross alpha activity substantially above 15 pCi/L, U-234 activity above 25 pCi/L, and U-238 activity above 50 pCi/L.

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (158 pCi/L in February 1999) being substantially above the SDWA screening level for gross beta activity (50 pCi/L). However, this result appears to be an outlier because only one of the remaining results (39 pCi/L in July 2002) exceeds 20 pCi/L. Nevertheless, the confirmed presence of uranium isotopes (and presumed presence of daughter products) in the groundwater at this well may account for the elevated gross beta activity. Additionally, low levels (<25 pCi/L) of Tc-99 were detected in three samples collected from the well between July 2001 and July 2002. The contaminant plume emplaced during operation of the former S-3 Ponds is the only source of Tc-99 in the Bear Creek Regime (only the S-3 Ponds received wastes containing Tc-99) and Tc-99 is the principal beta-emitting isotope in the intermingled contaminant plume in the Maynardville Limestone upgradient of the well. As with the other primary contaminants in the well, the presence of Tc-99 in the shallow groundwater probably reflects localized recharge of contaminated surface water in Bear Creek; monitoring results for Bear Creek sampling station BCK-07.87 show gross beta activity ranging above and below the SDWA screening level (50 pCi/L) and corresponding Tc-99 values ranging between 15 and 90 pCi/L.

5.6 OTHER

A total of 25 groundwater samples had concentrations of chromium and/or nickel above the respective analytical reporting limit, including four results for chromium and eight results for nickel that exceed the respective MCLs. As shown in Table 2, the samples obtained with the conventional sampling method in July 2003 had substantially higher concentrations than samples obtained with the low-flow sampling method (see Section 2.0).

Table 2. Chromium and nickel results for well GW-715

Sampling Method and Date	Total Concentration (mg/L)	
	Chromium UTL = 0.029 MCL = 0.10	Nickel UTL = 0.06 MCL = 0.10
Conventional Sampling		
09/04/92	<0.01	<0.01
12/01/92	0.01	0.011
03/21/93	<0.01	<0.01
04/29/93	<0.01	0.033
08/01/93	0.064	0.033
11/11/93	0.019	0.038
02/26/94	<0.01	<0.01
08/20/94	<0.01	<0.01
01/14/95	<0.01	<0.01
07/29/95	<0.01	0.015
01/29/96	0.099	0.047
07/18/96	0.076	**0.12**
02/03/97	**1.4**	**0.4**
08/27/97	<0.01	**0.12**
07/08/03	**3.26**	**0.13**
Low-Flow Sampling		
01/21/98	0.013	0.089
07/16/98	0.0674	**0.109**
02/04/99	0.0249	0.0865
07/15/99	0.0489	**0.152**
01/05/00	0.0467	0.0458
07/11/00	0.0858	0.0955
01/02/01	**0.121**	**0.233**
07/09/01	0.018	0.0429
01/02/02	0.0576	**0.134**
07/01/02	0.019	0.0281
01/07/03	**0.17**	0.0296
07/07/03	0.0083	0.0145

Note: Bold typeface denotes results that exceed the MCL.

Based on the following considerations, the elevated concentrations of chromium and nickel in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel well casing and screen: (1) mobile species of each metal are not typically present in groundwater with the neutral pH conditions evident in the well; (2) there are not any known sources of either metal near the well; (3) neither metal is a primary component of the commingled groundwater contaminant plume in the Maynardville Limestone hydraulically upgradient (east) of the well; (4) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); (5) groundwater in the well exhibits geochemical conditions that could be corrosive to Type 304 stainless steel (e.g., dissolved oxygen > 2 mg/L; Driscoll 1986); and (6) results of biological sampling performed in February 2000 indicate that the biomass observed in the well during a downhole video inspection in August 1999 is composed of slime-forming bacteria (Energy Systems 2000) and slime-forming bacteria have been associated with microbiologically induced corrosion of Type 304 stainless steel (Sarouhan et al. 1998).

6.0 REFERENCES

AJA Technical Services, Inc. 2000. *Groundwater Protection Program Calendar Year 1999 Evaluation of Groundwater and Surface Water Quality Data for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/SUB/00-MVM64V/4, prepared for Lockheed Martin Energy Systems, Inc. Oak Ridge, TN.

BWXT Y-12 L.L.C. (BWXT) 2003. *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation,* Y/TS-881/R5, BWXT Y-12 L.L.C., Oak Ridge, TN.

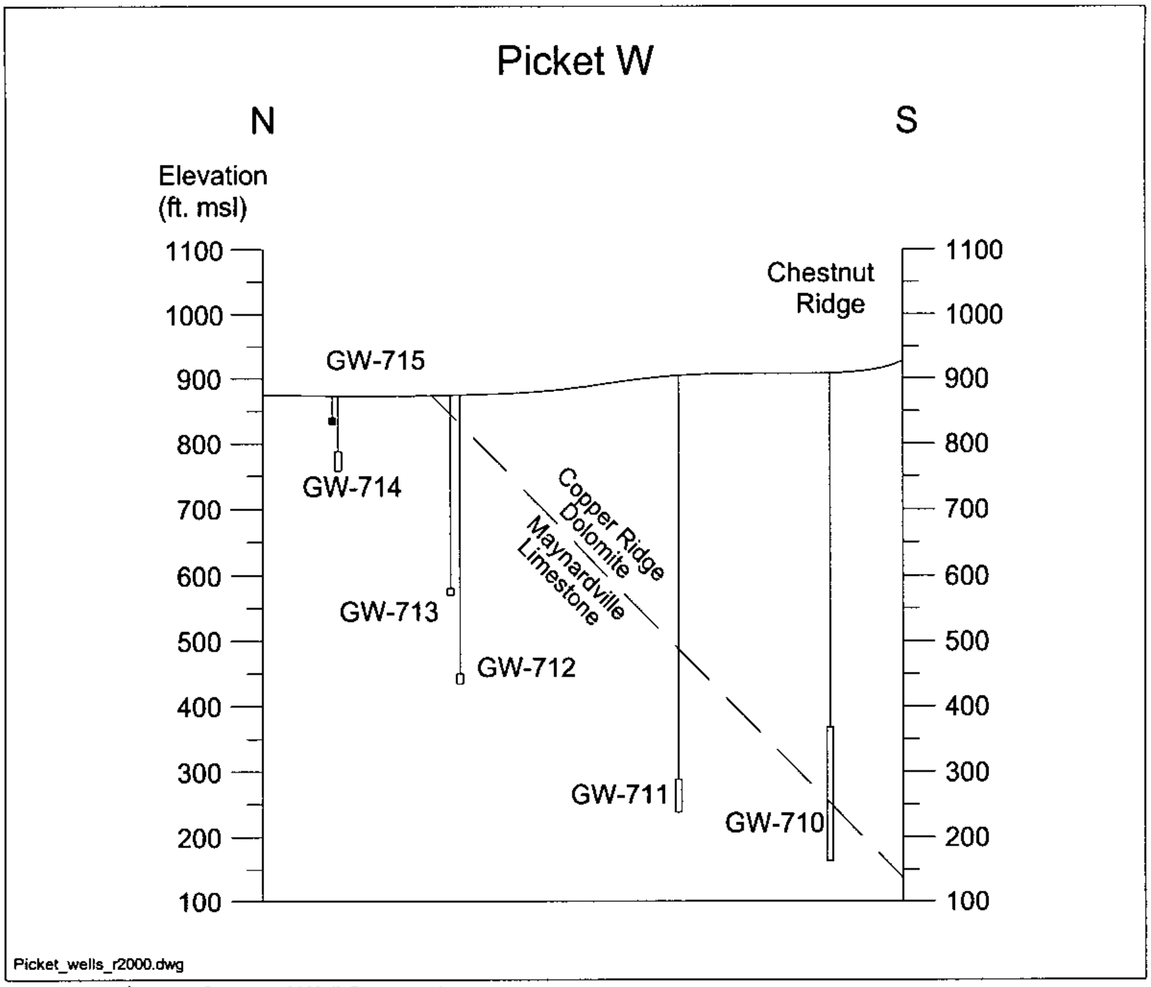
Elvado Environmental LLC. 2004. *Calendar Year 2004 Groundwater Monitoring Report, U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Y/SUB/04-030332/1, prepared for BWXT Y-12, L.L.C.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.



– Screened Well Construction

– Open-Hole Well Construction

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	<5	<7.5	50 - 500

GW-722-06

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 6 Port Depth : 560 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	. samples	07/28/97	10/25/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/14/04	08/07/04	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	7	532 µg/L	11/30/00	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	2	342.64 pCi/L	05/09/03	Outlier

WELL GW-722
Sampling Port 06

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables the collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 06 being 560 ft bgs (Figure 1). A total of 27 samples were collected from the sampling port between July 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 06 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 06 yields sulfate- and chloride-enriched sodium-bicarbonate groundwater generally characterized by:

- TDS of 510 – 633 mg/L, excluding an outlier (15 mg/L) in July 1998;
- pH (field measurements) of 6.2 – 8.3;
- chloride concentrations above 100 mg/L and sulfate levels above 50 mg/L;
- low molar proportions of calcium, magnesium, and potassium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.36 mg/L in November 2002) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.0014 mg/L in July 1999 and 0.004 mg/L in November 2000) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Several VOCs have been detected in one or more of the groundwater samples, including acetone, acrylonitrile, and compounds that are confirmed groundwater contaminants in the East Fork Regime (PCE and petroleum hydrocarbons). The results for acetone, including the clear outlier result (530 μg/L) reported for the sample collected in November 2000, are analytical artifacts. Low concentrations (5 – 15 μg/L) of acrylonitrile were detected in five samples. The Westbay™ system contains several components made with acrylonitrile and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999). Trace levels (<2 μg/L) of benzene, ethylbenzene, toluene, and an associated degradation product (styrene) were detected in seven samples.

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this well/sampling port: (1) downgradient transport from a groundwater contaminant plume originating from one or more potential sources within Y-12, including leaks and spills during historical operation of former petroleum fuel underground storage tanks (USTs); (2) residual contamination from installation of the well; (3) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (4) contamination of the samples during sampling or handling; and (5) traces of natural hydrocarbons in the low-permeability bedrock.

Migration from an upgradient source area(s) in Y-12 seems an unlikely source of the hydrocarbons considering the depth of the sampling port (>500 ft bgs), the extremely low hydraulic conductivity of the groundwater flowpaths intercepted by the monitored interval, the substantial distance (>5,000 ft) to the nearest potential source area (Tank 2331-U near Building 9201-1), and the various natural attenuation processes (including biologically mediated degradation) operative during transport to the well.

Residual contamination from installation/construction of the well also seems an unlikely source of the hydrocarbons in light of the age of the well (>12 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/ construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple if not all sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from other ports in the well.

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (11.13 pCi/L in May 2003) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Nine groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the two highest values being slightly below (43 pCi/L in May 2001) and substantially above (342 pCi/L in May 2003) the SDWA screening level for gross beta activity (50 pCi/L). Both of these results, however, appear to be outliers (none of the other gross beta results exceed 20 pCi/L) and are probably analytical artifacts.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Westbay Instruments, Inc. 1999. Personal communication with Mr. Dave Mercer on June 14, 1999.

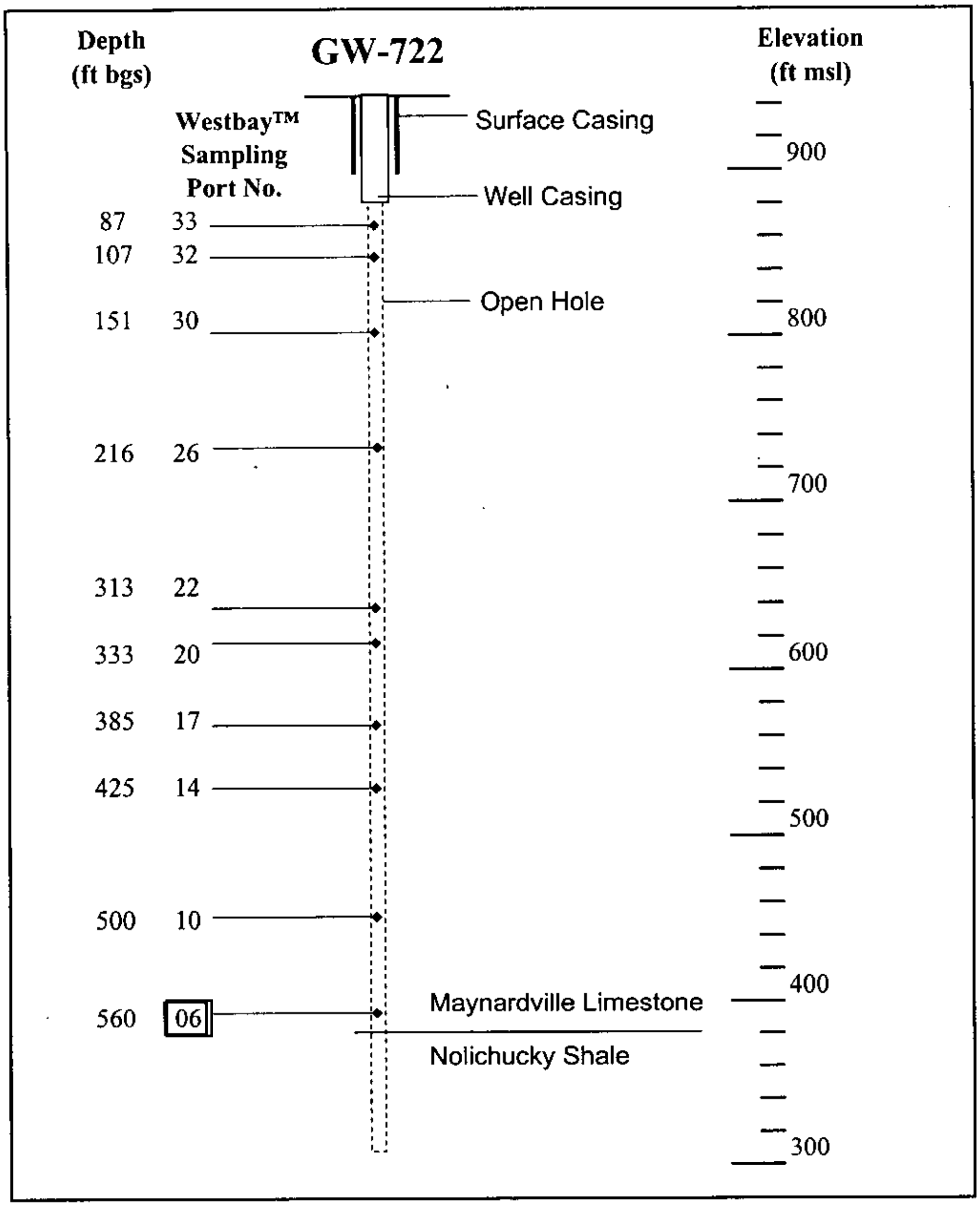


Figure 1

GW-722-06

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-10

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 10 Port Depth : 500 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	. samples	07/29/97	10/27/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/17/04	08/07/04	10/27/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	11	128 µg/L	02/18/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 10

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 10 being 500 ft bgs (Figure 1). A total of 28 samples were collected from the sampling port between July 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 10 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 10 yields chloride-, sodium-, and sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 322 – 630 mg/L, excluding a suspected outlier (41 mg/L) in July 1997;
- pH (field measurements) of 6.5 – 8.4;
- chloride and sodium concentrations near 100 mg/L and sulfate levels above 50 mg/L;
- low molar proportions of potassium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Thirteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.45 mg/L in February 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest value (0.004 mg/L in November 2000) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in each groundwater sample collected between July 1997 and July 2000: PCE, TCE, c12DCE, 11DCE, CTET, chloroform, methylene chloride, and TCFM. The highest concentrations were reported for CTET (>50 μg/L), chloroform (>25 μg/L), and PCE (>10 μg/L). This sampling port yields groundwater from migration pathways for the CTET-dominated plume of dissolved VOCs in the Maynardville Limestone that originates from multiple sources in Y-12 and extends eastward (along strike) beneath New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road (DOE 1998); sampling ports 14, 17, 20, and 22 are believed to monitor the center of mass of the plume (DOE 2002). Available data for port 10 show that summed VOC concentrations exceeded 100 μg/L between July 1997 and August 1998, decreased below 75 μg/L through July 2000, sharply dropped to zero in September 2000, and subsequently has remained below 10 μg/L (Figure 2). This sharp decrease in VOC concentrations follows the hydrologic testing and subsequent operation of a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE and this result (3.1 pCi/L in July 2000) is less than the MCL for gross alpha activity (15 pCi/L) and is probably an analytical artifact.

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (43.5 pCi/L in May 2001) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). This result, however, appears to be an outlier (all the other gross beta results are less than 12 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee,* DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

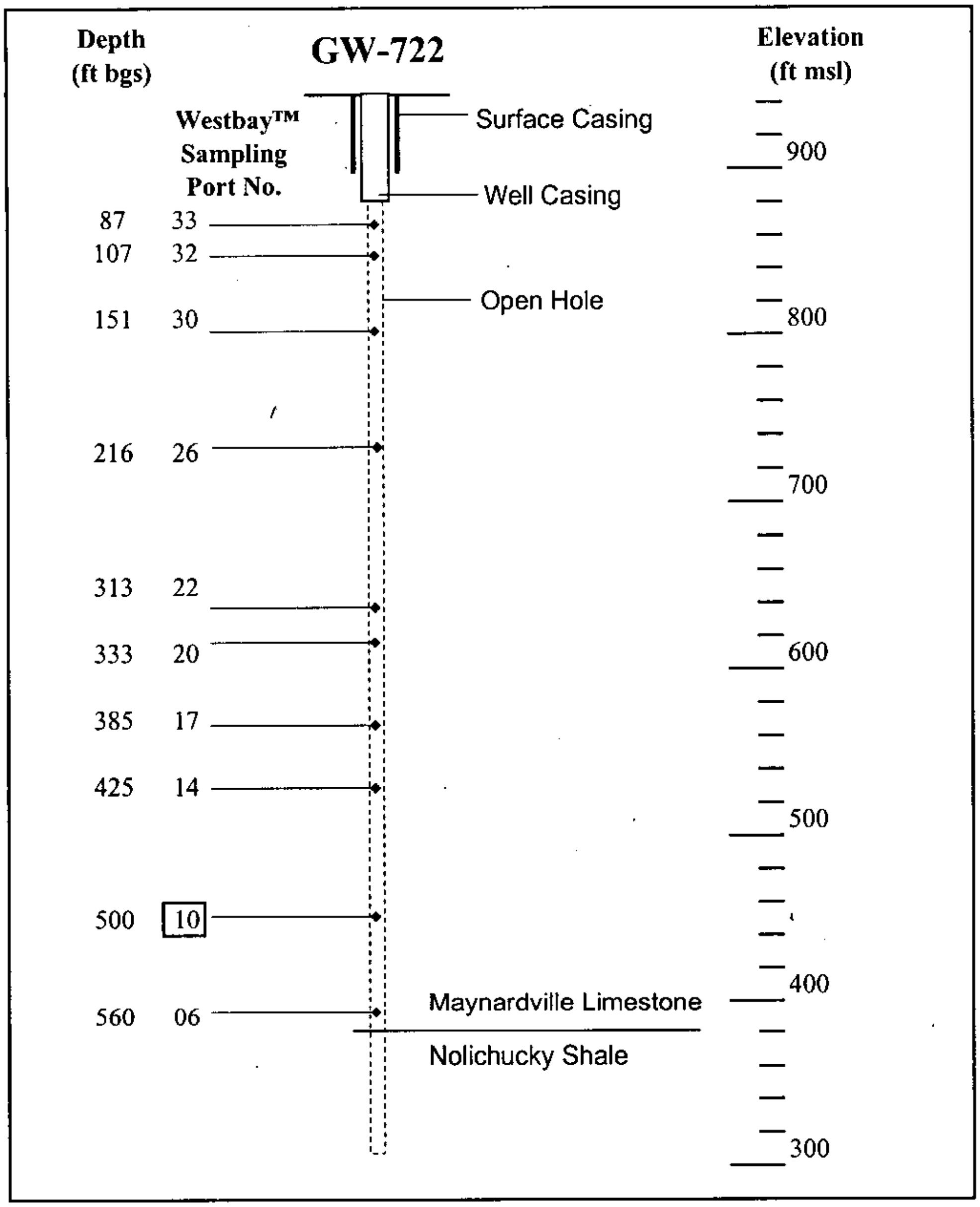


Figure 1

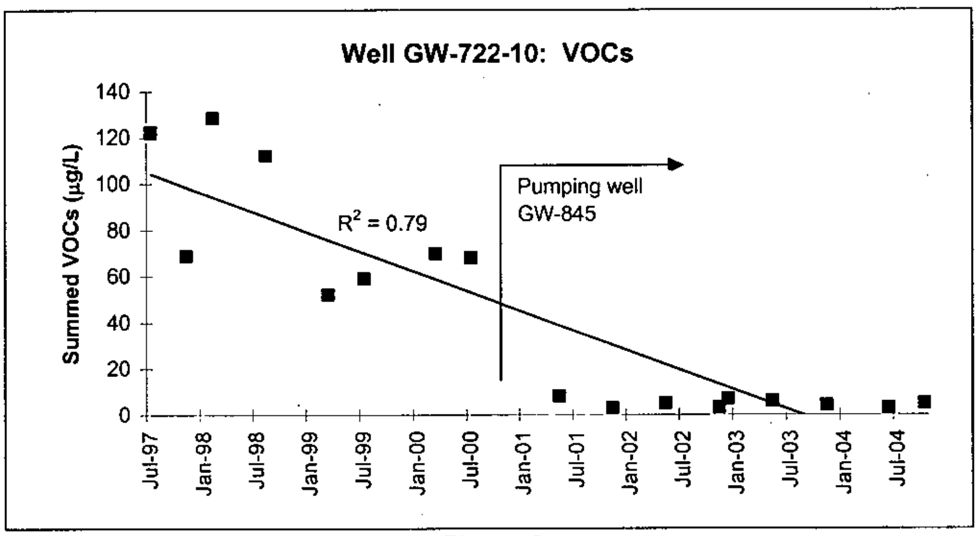


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-14

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 14 Port Depth : 425 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone .
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	. samples	07/29/97	10/28/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	06/24/04	08/07/04	10/28/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	25	1,113 µg/L	02/19/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 14

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 14 being 425 ft bgs (Figure 1). A total of 26 samples were collected from the sampling port between July 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 14 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 14 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 185 – 590 mg/L;
- pH (field measurements) of 6.6 – 8.6;
- chloride and sodium concentrations near 100 mg/L and sulfate levels above 50 mg/L;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-five groundwater samples contained nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (3.09 mg/L in February 1998) being substantially below the MCL for nitrate (10 mg/L). Although below the MCL, these nitrate results exceed the range of background levels in the Maynardville Limestone (<1 mg/L). The source of the nitrate in the groundwater from this sampling port has not been confirmed, but may be the contaminant plume emplaced in the western part of Y-12 during operation of the former S-3 Ponds and the S-2 Site (DOE 1998). Nitrate leached from a stockpile of urea that was located in the eastern part of Y-12 also may be a potential source of nitrate in the groundwater.

In any case, the nitrate results reflect a decreasing concentration trend, with the lowest concentrations evident after the hydrologic testing and subsequent operation a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.004 mg/L in November 2000 and 0.000536 mg/L in July 2002) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in all but one of the groundwater samples: PCE, TCE, c12DCE, 11 DCE, 111TCA, 11DCA, CTET, chloroform, acetone, and TCFM. The highest concentrations were reported for CTET (>500 μg/L), chloroform (>50 μg/L), PCE (>50 μg/L), and TCFM (>10 μg/L). This sampling port yields groundwater from migration pathways for the CTET-dominated plume of dissolved VOCs in the Maynardville Limestone that originates from multiple sources in Y-12 and extends eastward (along strike) beneath New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road (DOE 1998); sampling ports 14, 17, 20, and 22 are believed to monitor the center of mass of the plume (DOE 2002). Available data for port 14 show clearly decreasing VOC concentration trends, with the lowest concentrations evident following the hydrologic testing and subsequent full-time operation of groundwater extraction well GW-845 (Figure 2).

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8 pCi/L in September 2000) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (23 pCi/L in March 1999) being less than the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

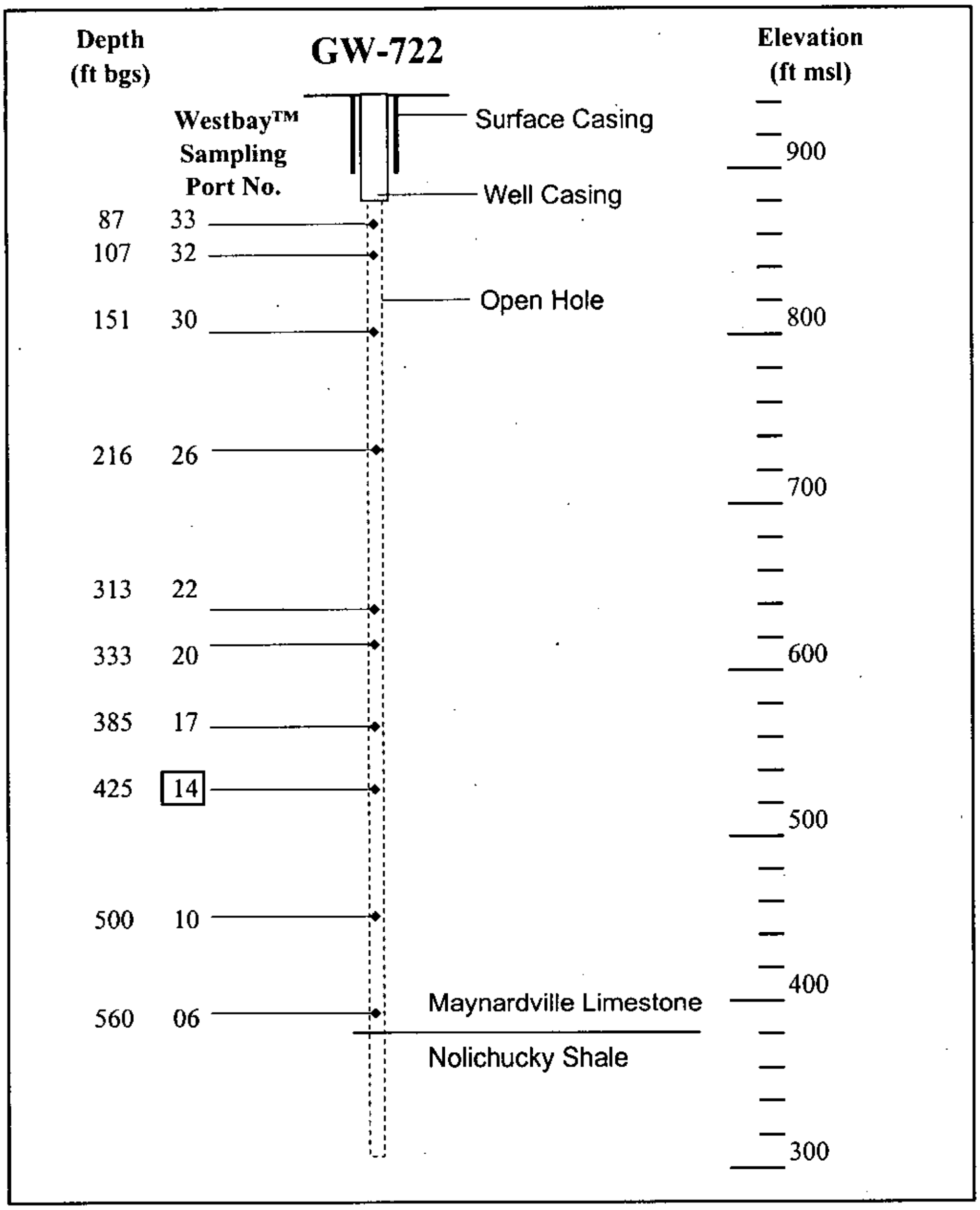


Figure 1

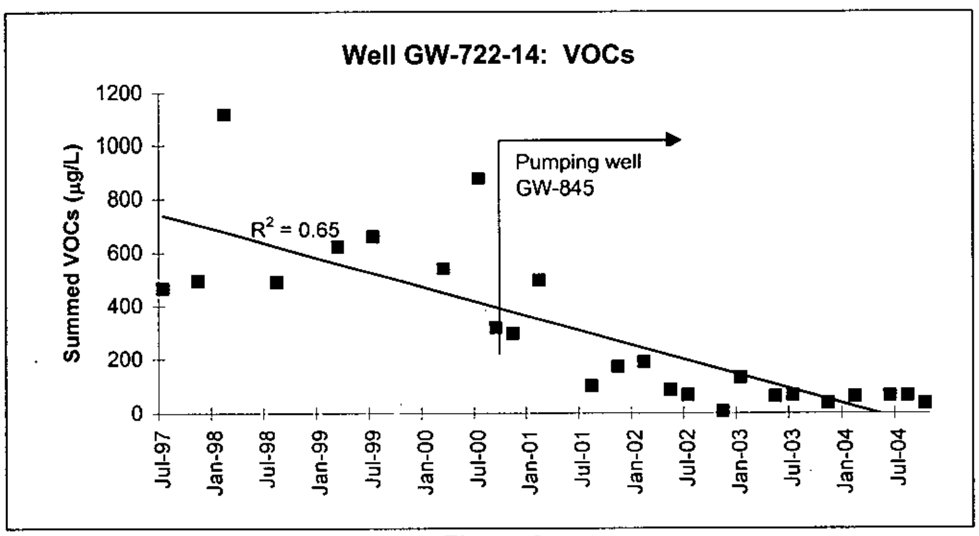


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	50 - 500	<7.5	<25

GW-722-17

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 17 Port Depth : 385 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	27		
CONVENTIONAL SAMPLING METHOD:	. samples	02/27/96	10/28/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	06/28/04	08/07/04	10/28/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	25	1,274 µg/L	02/25/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		.

WELL GW-722
Sampling Port 17

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 17 being 385 ft bgs (Figure 1). A total of 27 samples were collected from the sampling port between February 1996 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 17 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 17 yields chloride-, sodium-, and sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 251 – 354 mg/L, excluding an outlier (34 mg/L) in September 2000;
- pH (field measurements) of 6.9 – 8.3;
- chloride, sodium, and sulfate concentrations above 30 mg/L;
- low molar proportions potassium (<10% of total anions); and
- *total (unfiltered sample) concentrations of trace metals that are either below respective* analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Each groundwater sample contained nitrate above the applicable analytical reporting limit, with the highest concentration (3.67 mg/L in July 1997) being substantially below the MCL for nitrate (10 mg/L). Although below the MCL, these nitrate results exceed the range of background levels in the Maynardville Limestone (<1 mg/L). The source of the nitrate in the groundwater from this sampling port has not been confirmed, but may be the contaminant plume emplaced in the western part of Y-12 during operation of the former S-3 Ponds and the S-2 Site (DOE 1998). Nitrate leached from a stockpile of urea that was located in the eastern part of Y-12 also may be a potential source of nitrate in the groundwater. In any case, these nitrate results reflect a decreasing concentration trend with the lowest concentrations evident after the hydrologic testing and subsequent operation of a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.004 mg/L in November 2000) is substantially below the MCL for uranium (0.03 mg/L) and is probably an analytical artifact.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in all but one of the groundwater samples: PCE, TCE, c12DCE, 11 DCE, 111TCA, 11DCA, CTET, chloroform, acetone, and TCFM. The highest concentrations were reported for CTET (>500 μg/L), chloroform (>50 μg/L), PCE (>50 μg/L), and TCFM (>10 μg/L). This sampling port yields groundwater from migration pathways for the CTET-dominated plume of dissolved VOCs in the Maynardville Limestone that originates from multiple sources in Y-12 and extends eastward (along strike) beneath New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road (DOE 1998); sampling ports 14, 17, 20, and 22 are believed to monitor the center of mass of the plume (DOE 2002). Available data for port 17 show widely variable but clearly decreasing VOC concentration trends (Figure 2), with the lowest concentrations evident following the hydrologic testing and subsequent full-time operation of groundwater extraction well GW-845.

5.4 GROSS ALPHA ACTIVITY

Two groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, and this result (2.6 pCi/L in September 2000) is less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.9 pCi/L in February 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

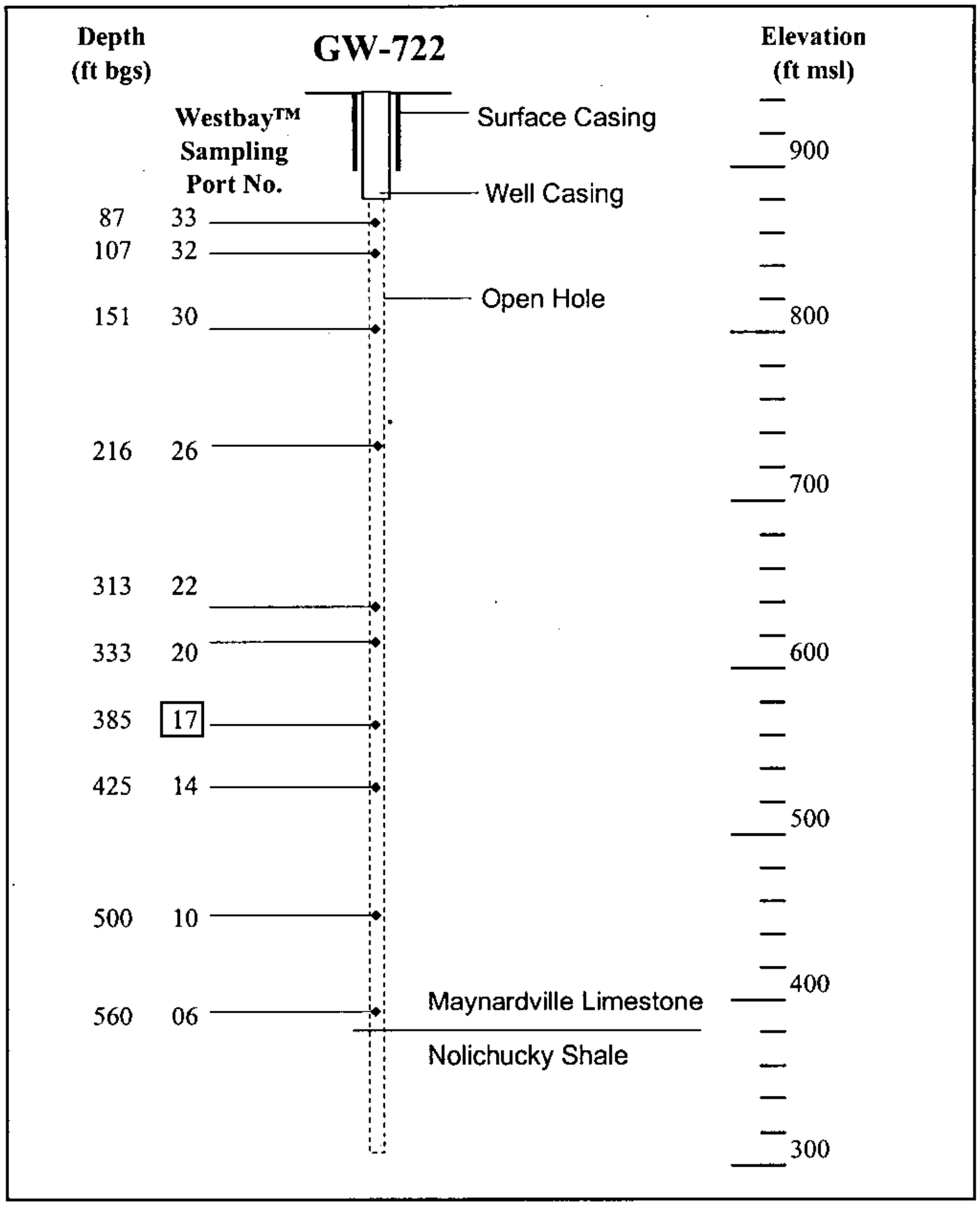


Figure 1

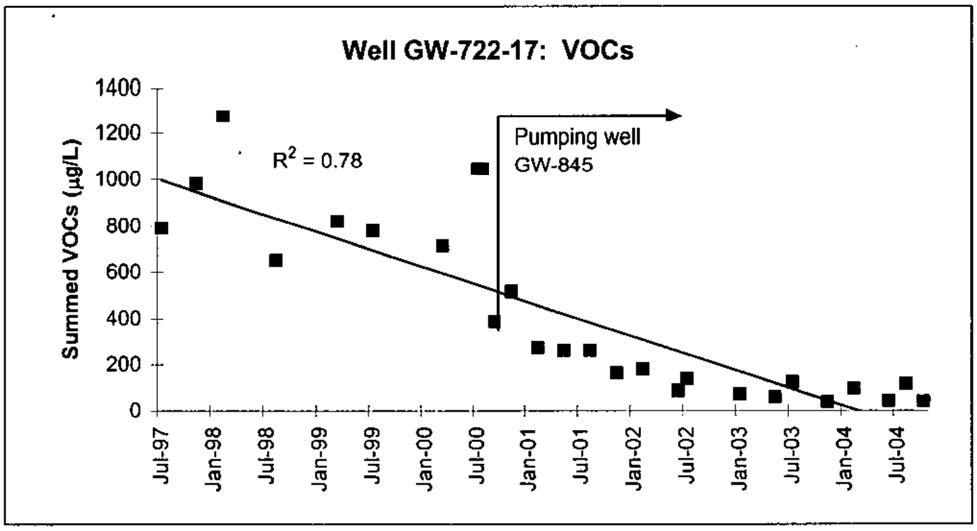


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-20

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 20 Port Depth : 333 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	. samples	07/30/97	10/27/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	06/24/04	08/07/04	10/27/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	26	1,350 µg/L	12/02/97	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 20

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 20 being 333 ft bgs (Figure 1). A total of 26 samples were collected from the sampling port between July 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 20 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 20 yields sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 253 – 940 mg/L;
- pH (field measurements) of 6.6 – 800;
- sulfate concentrations near 30 mg/L;
- low molar proportions chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Each groundwater sample contained nitrate above the applicable analytical reporting limit, with the highest concentration (2.73 mg/L in December 1997) being substantially below the MCL for nitrate (10 mg/L). Although below the MCL, these nitrate results exceed the range of background levels in the Maynardville Limestone (<1 mg/L). The source of the nitrate in the groundwater from this sampling port has not been confirmed, but may be the contaminant plume emplaced in the western part of Y-12 during operation of the former S-3 Ponds and the S-2 Site (DOE 1998). Nitrate leached from a stockpile of urea that was located in the eastern part of Y-12 also may be a potential source of nitrate in the groundwater. In any case, these nitrate results reflect a decreasing concentration trend with the lowest concentrations evident after the hydrologic testing and subsequent operation of a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.00087 mg/L in July 1997) is substantially below the MCL for uranium (0.03 mg/L) and is probably an analytical artifact.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in all of the groundwater samples: PCE, TCE, c12DCE, 11 DCE, 111TCA, 11DCA, CTET, chloroform, methylene chloride, chloromethane, acetone, and TCFM. The highest concentrations were reported for CTET (>500 μg/L), chloroform (>50 μg/L), PCE (>50 μg/L), and TCFM (>10 μg/L). This sampling port yields groundwater from migration pathways for the CTET-dominated plume of dissolved VOCs in the Maynardville Limestone that originates from multiple sources in Y-12 and extends eastward (along strike) beneath New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road (DOE 1998); sampling ports 14, 17, 20, and 22 are believed to monitor the center of mass of the plume (DOE 2002). Available data for port 22 show widely variable but clearly decreasing VOC concentration trends (Figure 2), with the lowest concentrations evident following the hydrologic testing and subsequent full-time operation of groundwater extraction well GW-845.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.6 pCi/L in September 2000) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Four groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.16 pCi/L in May 2003) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

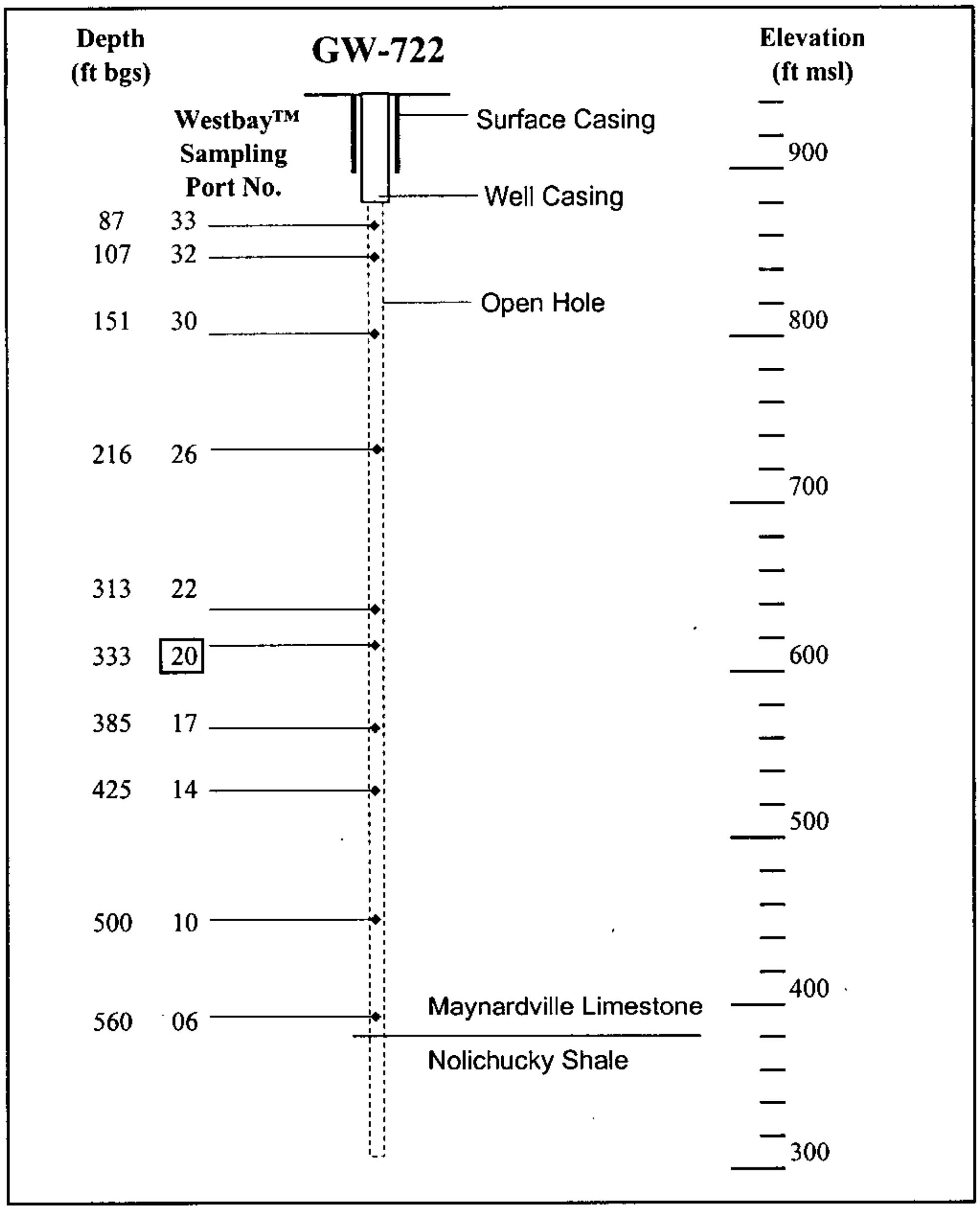


Figure 1

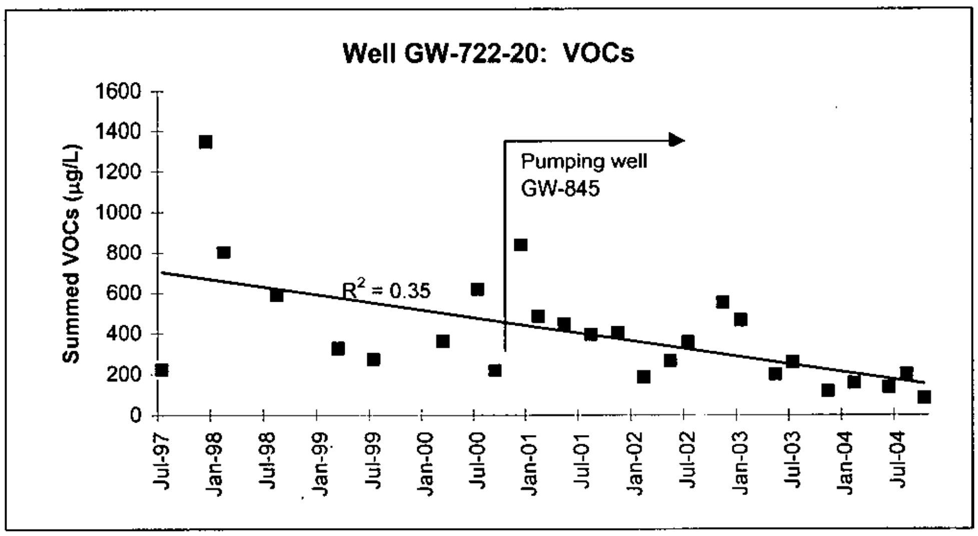


Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-22

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 22 Port Depth : 313 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	. samples	07/31/97	10/27/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/23/04	06/24/04	08/07/04	10/27/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	26	953 µg/L	07/31/97	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 22

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 22 being 313 ft bgs (Figure 1). A total of 26 samples were collected from the sampling port between July 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 22 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 22 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 222 – 360 mg/L, excluding an outlier (35 mg/L) in December 1997;
- pH (field measurements) of 6.6 – 8.2;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Each groundwater sample contained nitrate above the applicable analytical reporting limit, with the highest concentration (3.26 mg/L in July 1997) being substantially below the MCL for nitrate (10 mg/L). Although below the MCL, these nitrate results exceed the range of background levels in the Maynardville Limestone (<1 mg/L). The source of the nitrate in the groundwater from this sampling port has not been confirmed, but may be the contaminant plume emplaced in the western part of Y-12 during operation of the former S-3 Ponds and the S-2 Site (DOE 1998). Nitrate leached from a stockpile of urea that was located in the eastern part of Y-12 also may be a potential source of nitrate in the groundwater. In any case, these nitrate results reflect a decreasing concentration trend with the lowest concentrations evident after the hydrologic testing and subsequent operation of a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest value (0.00069 mg/L in July 1997) being substantially below the MCL for uranium (0.03 mg/L). These results are probably analytical artifacts.

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in 26 of the groundwater samples: PCE, TCE, c12DCE, 11DCE, 111TCA, 11DCA, CTET, chloroform, and TCFM. The highest concentrations were reported for CTET (>500 μg/L), chloroform (>50 μg/L), and PCE (>40 μg/L). This sampling port yields groundwater from migration pathways for the CTET-dominated plume of dissolved VOCs in the Maynardville Limestone that originates from multiple sources in Y-12 and extends eastward (along strike) beneath New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road (DOE 1998); sampling ports 14, 17, 20, and 22 are believed to monitor the center of mass of the plume (DOE 2002). Available data for port 22 show widely variable but clearly decreasing VOC concentration trends (Figure 2), with the lowest concentrations evident following the hydrologic testing and subsequent full-time operation of groundwater extraction well GW-845.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE and both results (4.8 pCi/L in August 1998 and 2.62 pCi/L in May 2002) are substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.7 pCi/L in August 1998) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

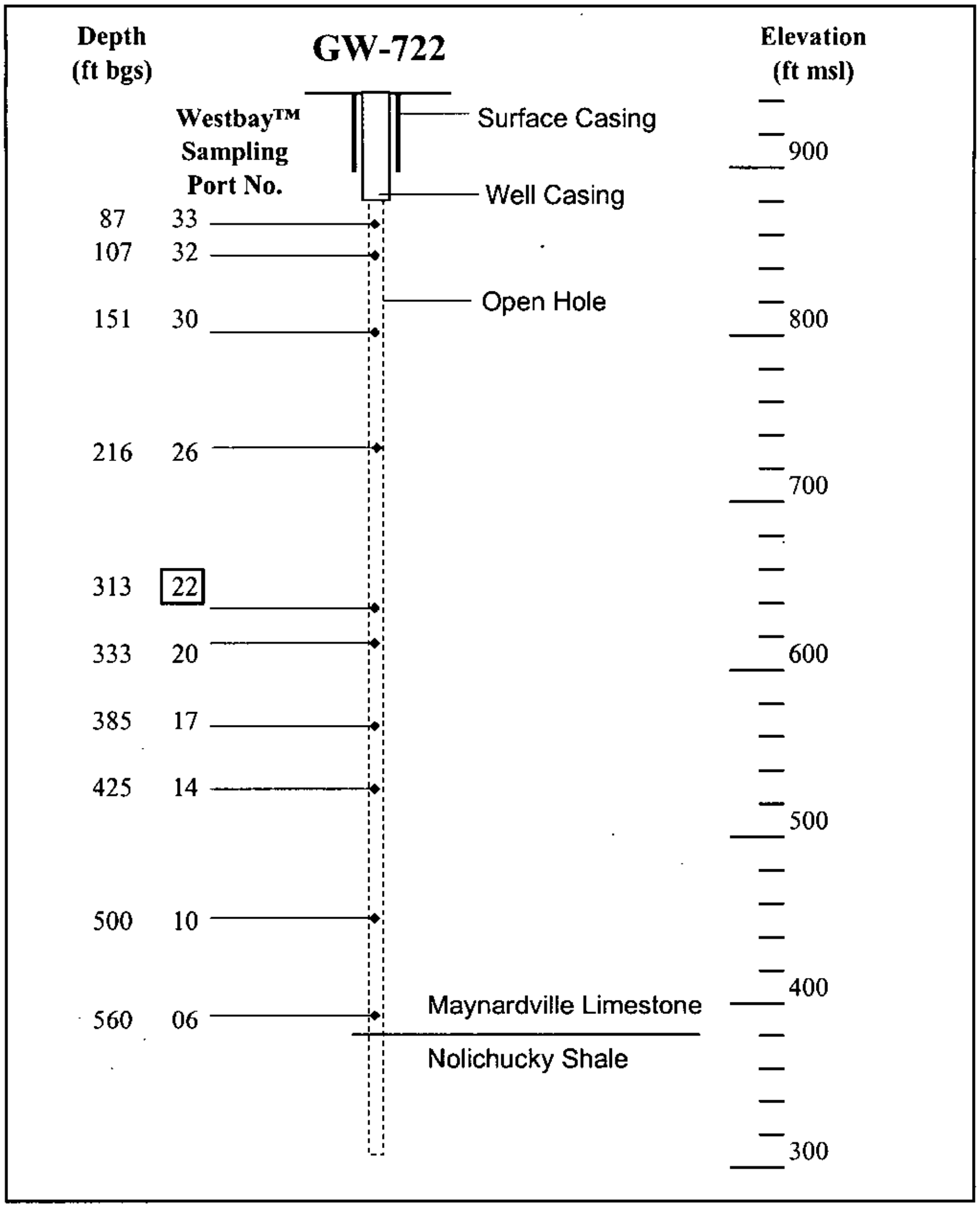


Figure 1

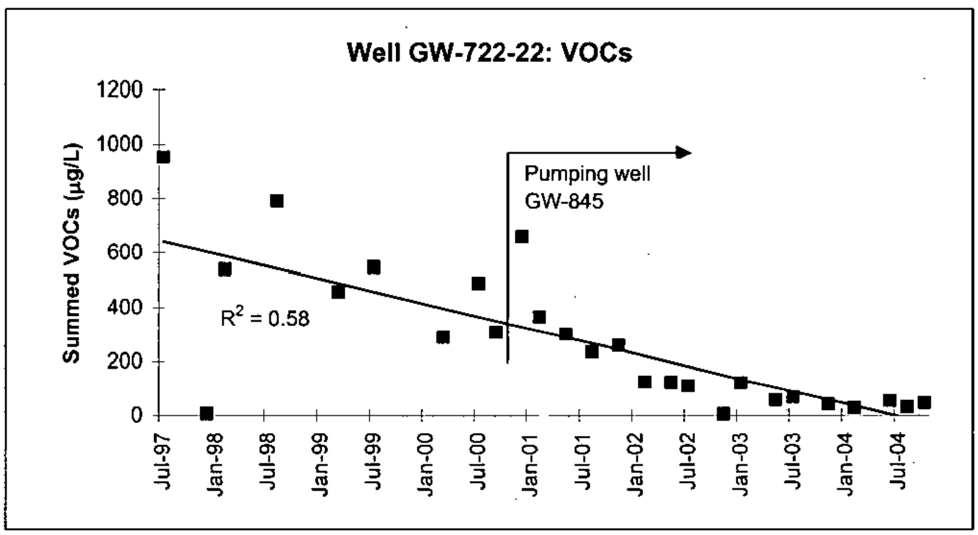


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	5 - 50	<7.5	<25

GW-722-26

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 26 Port Depth : 216 (ft bgs)

MONITORED INTERVAL

TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	. samples	08/04/97	10/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/16/04	08/07/04	10/26/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	26	83 µg/L	08/25/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 26

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 26 being 216 ft bgs (Figure 1). A total of 28 samples were collected from the sampling port between August 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 26 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 26 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 154 – 280 mg/L;
- pH (field measurements) of 6.7 – 8.1;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals (except strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four groundwater samples contained nitrate above the applicable analytical reporting limit, with the highest concentration (0.17 mg/L in November 2002) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Significant concentrations (15 – 32 μg/L) of acrylonitrile were detected in each groundwater sample collected between August 1997 and March 2000. The Westbay™ monitoring system contains several components made with acrylonitrile and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999).

In contrast to the deeper sampling ports in well GW-722, only a few groundwater samples from port 26 contained the primary components of the dissolved VOC plume in the Maynardville Limestone (CTET, chloroform, and PCE) that originates from multiple sources in Y-12 and extends eastward (along geologic strike) under New Hope Pond into Union Valley east of the ORR boundary along Scarboro Road; PCE was detected in one sample (1 μg/L in December 1997), chloroform was detected in one sample (1 μg/L in September 2000), and CTET was detected in three samples (1 μg/L in December 1997, 5 μg/L in September 2000, and 2 μg/L in December 2000).

One or more petroleum hydrocarbons (benzene, ethylbenzene, toluene, and xylene [BTEX]) and a related degradation compound (styrene) were detected at low concentrations (<10 μg/L) in all but two of the groundwater samples (one of the samples was not analyzed for VOCs). The concentrations of these compounds exhibit an indeterminate long-term trend, as illustrated by the ethylbenzene results reported for the groundwater samples collected in August 1997 (3 μg/L), July 1999 (3 μg/L), August 2001 (3 μg/L), and July 2003 (2 μg/L). Moreover, the indeterminate concentration trends do not show any clear response to the hydrologic testing and subsequent operation of a groundwater extraction well (GW-845) installed about 600 ft east of well GW-722 as part of the contaminant plume capture system required under a CERCLA Action Memorandum (DOE 1999). Based on results of a long-term aquifer pumping test (and dye trace study) performed in July 1998, full-time operation of the system began in October 2000 and has involved pumping groundwater from the extraction well at a rate of 25 gpm (the pump intake is about 300 ft bgs) and treating the groundwater to remove VOCs, particulates, iron, and manganese. Operation of the system has produced 15 to 17 ft of drawdown in the immediate vicinity of the extraction well and an elongated zone of influence, oriented parallel with geologic strike, extending least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the extraction well, which closely approximates the hydrologic influence observed during the long-term aquifer pumping test (DOE 2002).

There are several potential sources of the petroleum hydrocarbons in the groundwater samples from this well/sampling port: (1) downgradient transport from a groundwater contaminant plume originating from one or more potential sources within Y-12, including leaks and spills during historical operation of former petroleum fuel underground storage tanks (USTs); (2) residual contamination from installation of the well; (3) contamination from components of the Westbay sampling equipment that are made of or contain petroleum-based materials; (4) contamination of the samples during sampling or handling; and (5) traces of natural hydrocarbons in the low-permeability bedrock.

Migration from an upgradient source area(s) in Y-12 seems an unlikely source of the hydrocarbons considering the depth of the sampling port (>200 ft bgs), the extremely low hydraulic conductivity of the groundwater flowpaths intercepted by the monitored interval, the substantial distance (>5,000 ft) to the nearest potential source area (Tank 2331-U near Building 9201-1), and the various natural attenuation processes (including biologically mediated degradation) operative during transport to the well.

Residual contamination from installation/construction of the well also seems an unlikely source of the hydrocarbons in light of the age of the well (>12 years). Moreover, well installation and construction was closely supervised and controlled to exclude usage of petroleum-based drilling equipment lubricants. Additionally, well installation/ construction records do not note any accidental spills/leaks of petroleum-based fluids from the drilling rig or support equipment during installation of the well.

Contamination from components of the Westbay sampling equipment in the well is possible, as several components of the sampling apparatus contain petroleum hydrocarbons. However, it is not known if the hydrocarbons are leachable from these components and repeated sampling since installation of the equipment would be expected to "flush" any leached constituents from the sampling port. Also, such systemic contamination from components of the Westbay sampling equipment would be expected to result in consistent contamination of samples from multiple if not all sampling ports. However, only some of the other ports repeatedly yield samples that contain petroleum hydrocarbons. Indeed, these compounds have not been detected consistently in any of the samples collected to date from eight of the sampling ports in the well. In addition, these hydrocarbons have been observed in groundwater samples from some deeper wells that are not instrumented with Westbay sampling equipment.

Contamination of the samples during collection or handling also may be possible, but is not indicated by results for associated quality assurance samples (i.e., petroleum hydrocarbons are not detected in the field or trip blanks). Similarly, data for laboratory blank samples do not support contamination during storage and/or analysis in the laboratory. Also, contamination of the samples during collection at the well head seems very unlikely again because such systemic contamination would result in the detection of petroleum hydrocarbons in the samples collected from other ports in the well.

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.2 pCi/L in August 1997) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (14.9 pCi/L in May 2003) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U.S. Department of Energy. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1941&D2/R1), U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

Westbay Instruments, Inc. 1999. Personal communication with Mr. Dave Mercer on June 14, 1999.

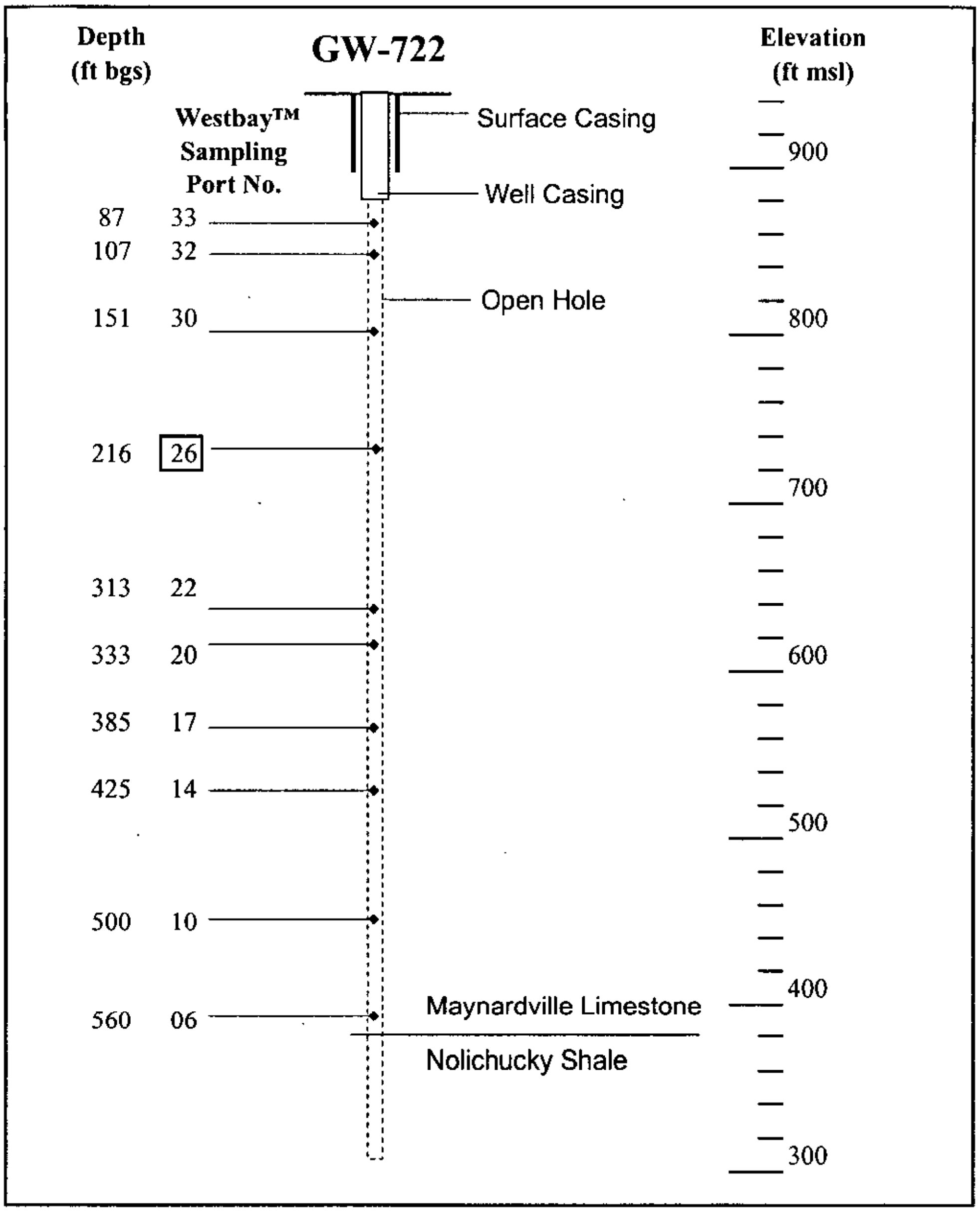

Depth (ft bgs)
GW-722
Elevation (ft msl)
Westbay™ Sampling Port No.
Surface Casing
Well Casing
Open Hole
87 33
107 32
151 30
216 26
313 22
333 20
385 17
425 14
500 10
560 06
Maynardville Limestone
Nolichucky Shale
900
800
700
600
500
400
300

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	ND	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-30

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 30 Port Depth : 151 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	. samples	03/07/96	10/25/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/14/04	08/07/04	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	2	159 pCi/L	10/25/04	Outlier

WELL GW-722
Sampling Port 30

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 30 being 151 ft bgs (Figure 1). A total of 29 samples were collected from the sampling port between March 1996 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 30 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 30 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 150 – 201 mg/L, excluding an outlier (82 mg/L) in November 2002;
- pH (field measurements) of 6.6 – 9.1;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Fifteen groundwater samples contained nitrate above the applicable analytical reporting limit, with the highest concentration (0.65 mg/L in February 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Six groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest value (0.000603 mg/L in July 2001) being substantially below the MCL for uranium (0.03 mg/L). These results are probably analytical artifacts.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, very low levels (<5 μg/L) of VOCs were detected in only five groundwater samples from the well: acrylonitrile was detected in three samples (August 1997, February 1999, and March 2000); ethylbenzene was detected in one sample (December 2002); and acetone was detected in one sample (October 2004).

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (1.96 pCi/L in May 2002) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (59 pCi/L in May 2003) being slightly above the SDWA screening level for gross beta activity (50 pCi/L). However, this result appears to be an outlier (only two other results exceed 10 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

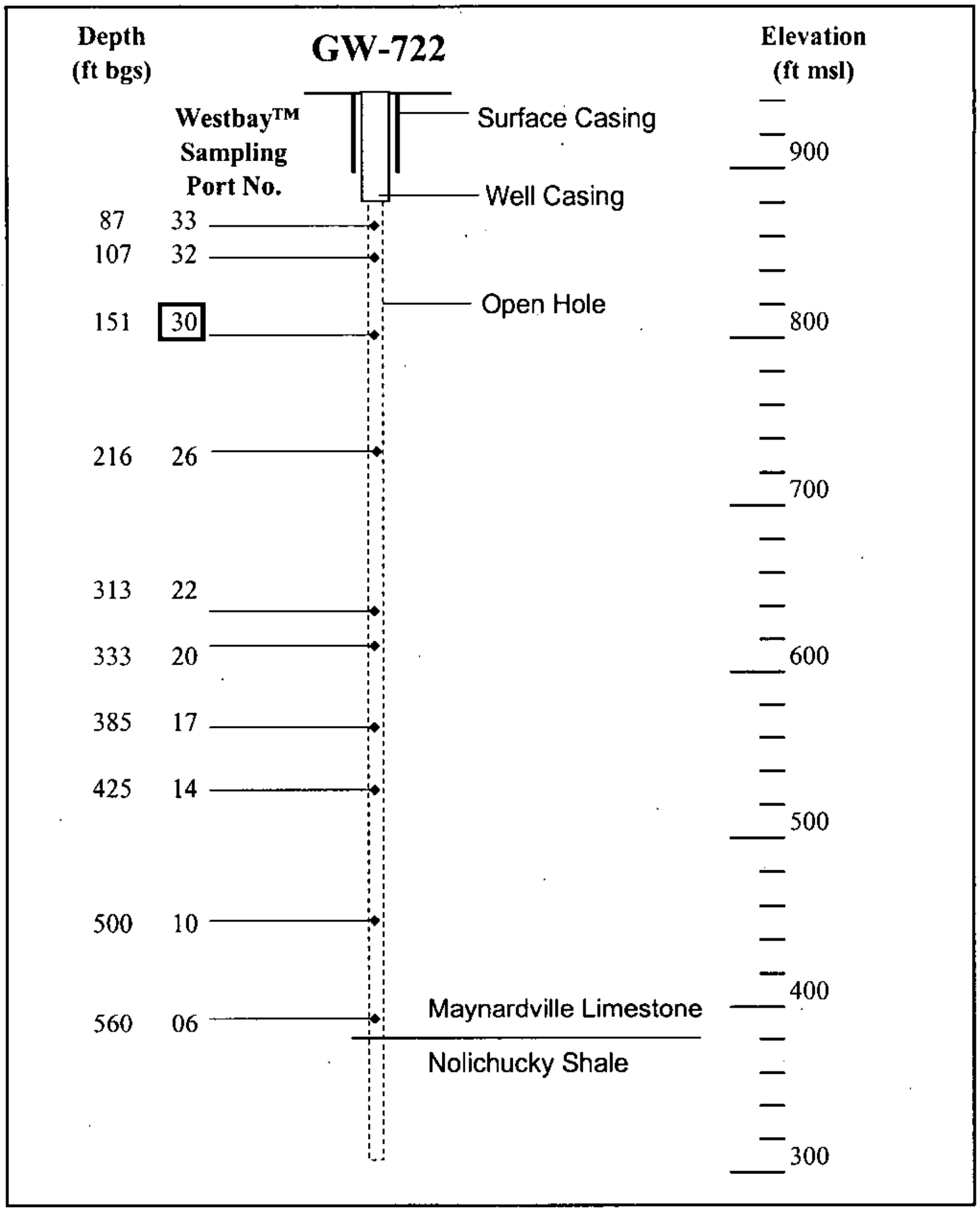

Depth
(ft bgs)
GW-722
Elevation
(ft msl)
Westbay™
Sampling
Port No.
Surface Casing
Well Casing
Open Hole
87 33
107 32
151 30
216 26
313 22
333 20
385 17
425 14
500 10
560 06
Maynardville Limestone
Nolichucky Shale
900
800
700
600
500
400
300

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-722-32

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 32 Port Depth : 107 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	. samples	08/05/97	10/26/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/16/04	08/07/04	10/26/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	44.16 pCi/L	11/12/02	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 32

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 32 being 107 ft bgs (Figure 1). A total of 28 samples were collected from the sampling port between August 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 32 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 32 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 150 – 324 mg/L;
- pH (field measurements) of 5.4 – 8.4;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

All but two groundwater samples contained nitrate above the applicable analytical reporting limit, with the highest concentration (1 mg/L in October 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit, and both results (0.0006 mg/L in September 1998 and 0.0212 mg/L in January 2003) are below the MCL for uranium (0.03 mg/L). Both results are considered to be outliers.

5.3 VOLATILE ORGANIC COMPOUNDS

Aside from trace levels of chloroform (<3 µg/L) detected in ten groundwater samples, non-detect values or false positive results were reported for VOCs that are confirmed groundwater contaminants in the East Fork Regime.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (44.16 pCi/L in November 2002) being substantially above the MCL for gross alpha activity (15 pCi/L). However, this result appears to be an outlier (none of the other gross alpha results exceed 10 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (39.82 pCi/L in May 2003) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). However, this result appears to be an outlier (only one other result exceeds 10 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

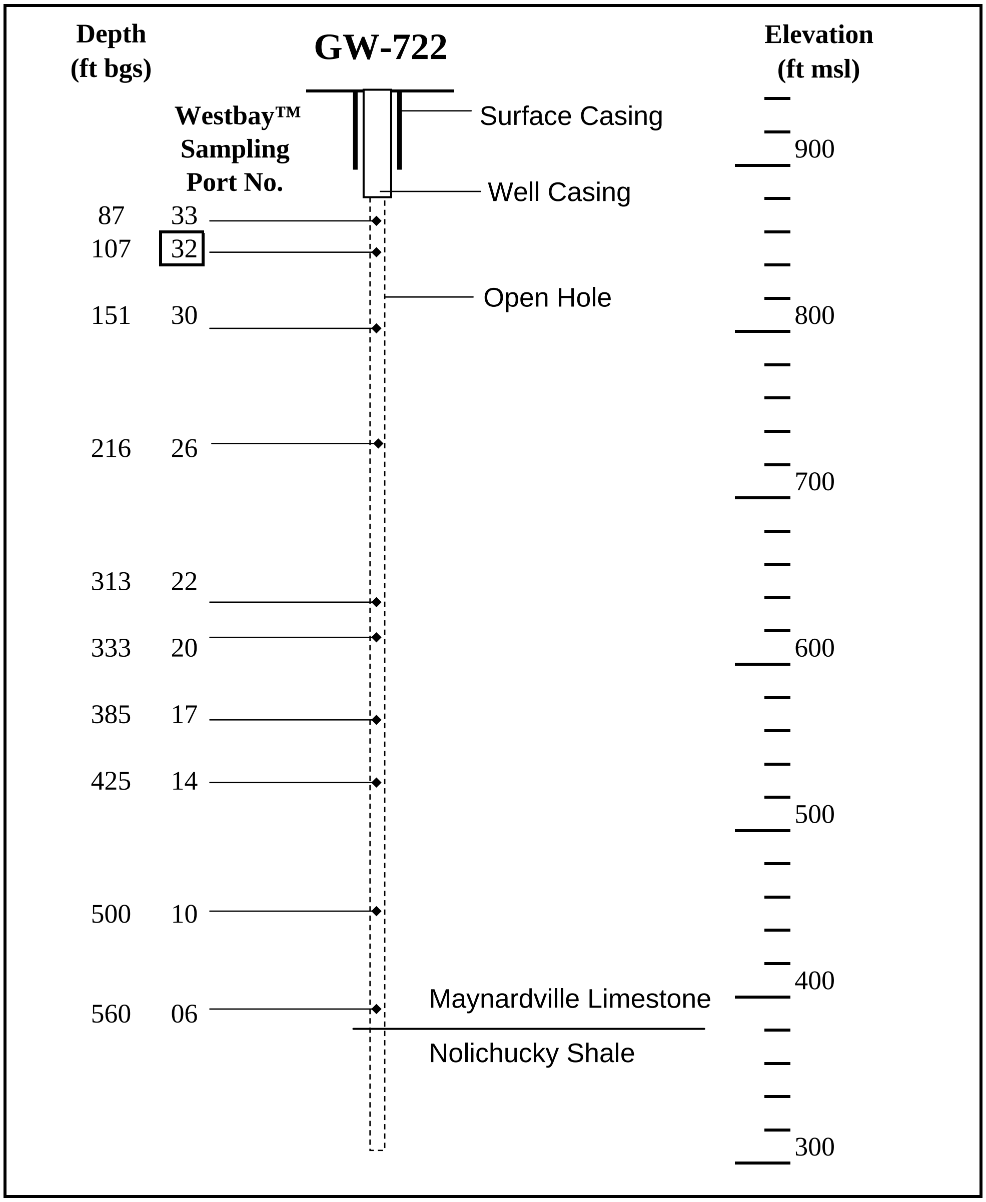

Depth
(ft bgs)
GW-722
Elevation
(ft msl)
Westbay™
Sampling
Port No.
Surface Casing
Well Casing
Open Hole
87 33
107 32
151 30
216 26
313 22
333 20
385 17
425 14
500 10
560 06
Maynardville Limestone
Nolichucky Shale
900
800
700
600
500
400
300

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	<7.5	<25

GW-722-33

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,925.78
Y-12 GRID NORTH COORDINATE: 28,532.41
SURFACE ELEVATION: 951.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order, CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/09/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): . ft below top of casing (TOC)
MEASURING POINT ELEVATION: 953.71 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 6 inches
WELL CASING MATERIAL: SJ55
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Westbay Sampling Port No.: 33 Port Depth : 87 (ft bgs)

MONITORED INTERVAL TYPE: Westbay

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	.	.
BOTTOM (filter pack or open hole):	.	.
MIDPOINT (filter pack or open hole):	.	.
PUMP INTAKE:	.	.
WATER LEVEL (average):	.	.

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	. samples	08/05/97	10/27/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/22/04	06/17/04	08/07/04	10/27/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: . pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	7 µg/L	03/05/98	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-722
Sampling Port 33

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole interval from 74 to 644 ft bgs, constructed with nominal 4.5-inch diameter steel (SF25) riser casing, and equipped with a multiport monitoring system (Westbay™) that enables collection of groundwater samples from multiple discreet depth intervals within the open-hole interval. The well is located in Bear Creek Valley near the east end of Y-12, about 350 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

The Westbay™ multiport monitoring system in the well has been used to obtain groundwater samples from ten sampling ports, with port 33 being 87 ft bgs (Figure 1). A total of 28 samples were collected from the sampling port between August 1997 and October 2004. Each sample was obtained by lowering a 250 milliliter non-vented stainless steel sample collection bottle to the sampling port, opening the port valve, allowing the bottle to fill, retrieving the filled bottle to the surface, and decanting the contents into the appropriate laboratory sample bottle(s). The sample collection bottle was lowered, filled, and retrieved as many times as necessary to fill the laboratory sample bottle(s). Groundwater in the first sample collection bottle retrieved from the sampling port was used as a "formation rinse" to obtain field measurements and to condition the sample collection bottle.

3.0 HYDROLOGIC CHARACTERISTICS

Sampling port 33 yields groundwater from the Conasauga Group (Maynardville Limestone).

4.0 GEOCHEMICAL CHARACTERISTICS

Sampling port 33 yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 196 – 350 mg/L;
- pH (field measurements) of 4.6 – 8.3;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

All but two groundwater samples contained nitrate above the applicable analytical reporting limit, with the highest concentration (0.98 mg/L in November 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest value (0.00136 mg/L in March 2000) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Trace levels of chloroform (<3 µg/L) were detected in 12 groundwater samples, with CTET and benzene detected in the sample collected in November 2002; all other VOC results show non-detect values or false positive results were reported for VOCs that are confirmed groundwater contaminants in the East Fork Regime.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.24 pCi/L in November 2002) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (20.14 pCi/L in October 2003) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

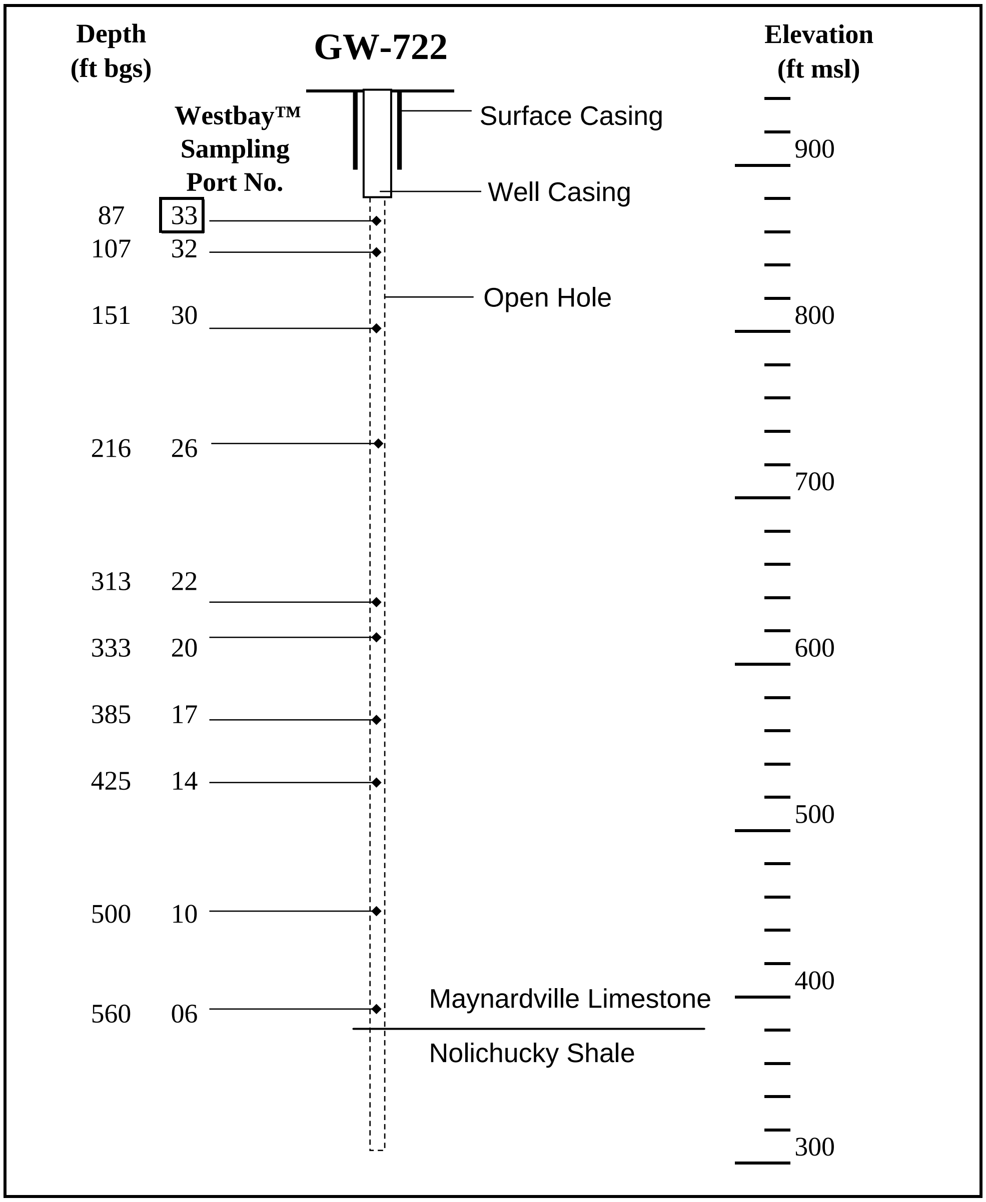

Depth
(ft bgs)
GW-722
Elevation
(ft msl)
Westbay™
Sampling
Port No.
Surface Casing
Well Casing
Open Hole
87 33
107 32
151 30
216 26
313 22
333 20
385 17
425 14
500 10
560 06
900
800
700
600
500
400
300
Maynardville Limestone
Nolichucky Shale

Figure 1

MAXIMUM CONCENTRATION: 2005

ND	ND	5 - 50	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-723

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 49,088.55
Y-12 GRID NORTH COORDINATE: 29,006.44
SURFACE ELEVATION: 1,019.31 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/15/91 PAIRED/CLUSTERED WITH: GW-739 GW-740
TAG DEPTH (measured): 447.24 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,022.23 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	340.6	678.71
BOTTOM (filter pack or open hole):	444.5	574.81
MIDPOINT (filter pack or open hole):	392.6	626.76
PUMP INTAKE:	434.1	585.23
WATER LEVEL (average):	68.50	950.81

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	13 samples	05/27/92	08/09/96
LOW-FLOW SAMPLING METHOD:	4 samples	03/05/02	07/27/05

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2005	03/03/05	.	07/27/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.1 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	6	20 mg/L	08/30/92	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	10	24 µg/L	02/12/93	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-723

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole monitored interval from 340.6 to 444.5 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone underlies Bear Creek throughout BCV and the hydrologic interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathways for groundwater and surface water contaminants.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between May 1992 and August 1996, and the low-flow sampling method used to obtain four samples between March 2002 and July 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the deep (>300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 69 ft bgs and exhibits seasonal fluctuation of about 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the unfiltered groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 155 – 376 mg/L (low for a deep well, suggests lower residence time and higher permeability);
- pH (field measurements) of 6.7 – 9;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations);
- low calcium concentration (<15 mg/L) compared to other wells at Exit Pathway Picket C; and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All but four of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), including six samples with concentrations that exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located about 7,200 ft east-northeast (hydraulically upgradient) of the Exit Pathway Picket B, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, six groundwater samples had nitrate concentrations above the MCL, with a historical maximum concentration of 20 mg/L (August 1992 and February 1993). All samples collected since February 1995 had nitrate concentrations below the MCL (10 mg/L), and none of the samples collected after August 1996 had concentrations above the analytical reporting limit (0.028 mg/L). The decrease in nitrate concentrations probably reflects the substantially reduced flux of nitrate following closure of the former S-3 Ponds and installation of the low-permeability cap. Note, however, that all of the groundwater samples with nitrate concentrations below the analytical reporting limit were obtained using the low-flow sampling method; all previous samples were collected using the conventional sampling method. Thus, the nitrate concentrations may be at least partially attributable to the manner in which each sampling method induces flow of groundwater into the well. Low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features more proximal to the well. In contrast, conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features (e.g., conduits or fractures) that may not be proximal to the well.

5.2 URANIUM

Twelve of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0033 mg/L in December 1994) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date: TCE, 12DCE, CTET, and 2-butanone. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 1,500 ft west-southwest (hydraulically downgradient) of Exit Pathway Picket C. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOC in the groundwater samples is TCE (Table 1), which is the only VOC detected in every sample collected to date, including ten samples with TCE concentrations that exceed the drinking water MCL (5 µg/L). The highest TCE concentrations were detected in samples collected in May 1992 (22 µg/L), February 1993 (21 µg/L), and August 1992 (15 µg/L), with the most recent results showing TCE concentrations at the MCL in March 2005 (5 µg/L) and slightly below the MCL in July 2005 (4 µg/L). Low concentrations of CTET (1 µg/L) and 12DCE (2 µg/L) were detected in the sample collected in February 1993 and 2-butanone (4 µg/L) was detected in the sample collected in December 1994.

As indicated by the data in Table 1 and illustrated by the corresponding time-series plot (Figure 1), TCE concentrations detected in the groundwater samples shows an indeterminate long-term concentration trend dominated by apparent “peak” concentrations in May 1992 (22 µg/L) and February 1993 (21 µg/L). Aside from these results, however, there is little overall difference in the relative concentration of TCE over time, as illustrated by the equal concentrations reported for the groundwater samples collected in October 1992 (5 µg/L) and March 2005 (5 µg/L), although the concentrations evident in August 1996 (8 µg/L) and July 2005 (4 µg/L) suggest a slightly decreasing tend. In any case, the long-term concentration trend suggests minimal overall changes in the relative flux of TCE via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Five groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.3 pCi/L in July 2002) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (37.5 pCi/L in December 1994) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

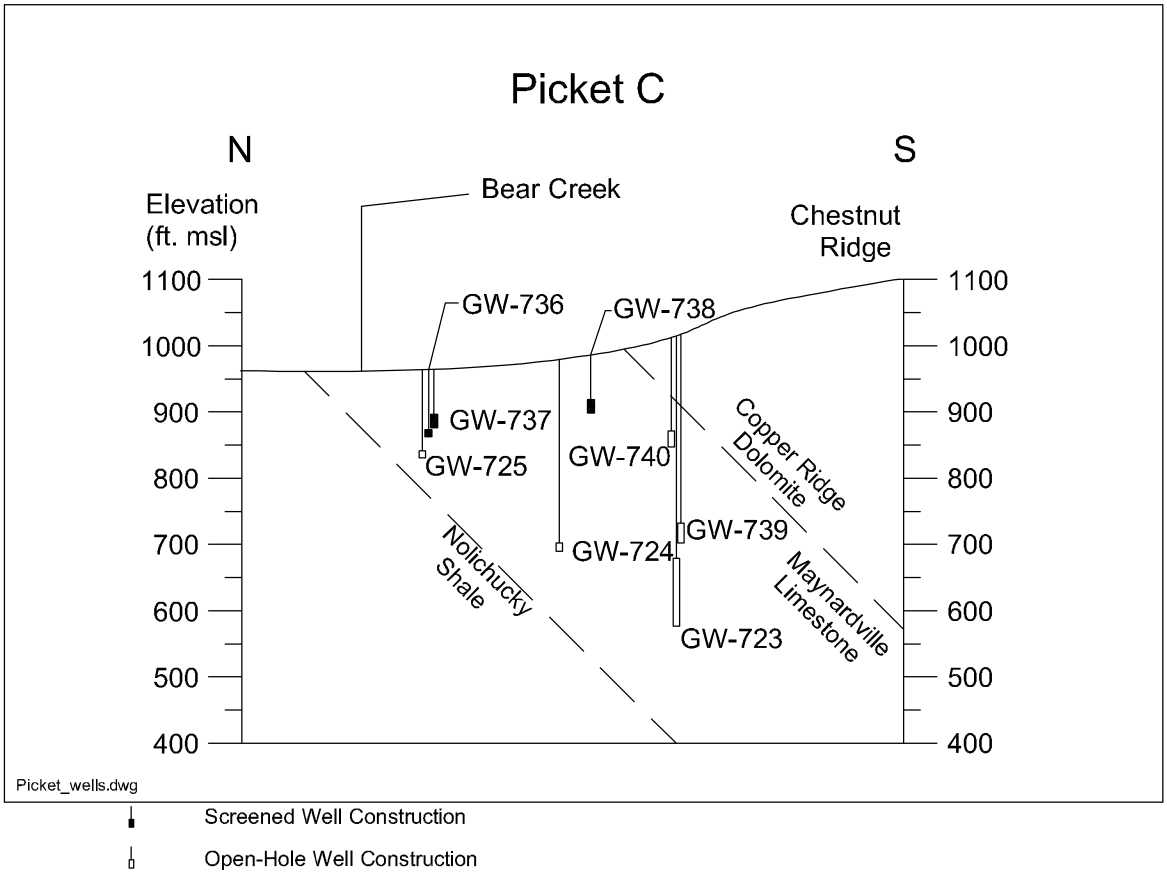
HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-723: summary of nitrate and VOC results

Sampling Date	Nitrate (mg/L)	TCE (µg/L)
05/27/92	10	22
08/30/92	20	15
10/29/92	11	5
02/12/93	20	21
05/18/93	6.39	3 J
09/27/93	9.6	4 J
12/14/93	10.6	5
03/17/94	7.6	8
12/20/94	15	6
02/20/95	16	6
09/13/95	6.7	6
03/21/96	3.36	5
08/09/96	5.61	8
03/05/02	.	6
07/23/02	.	6
03/03/05	.	5 J
07/27/05	.	4 J
MCL	**10**	**5**
Note: "." = not detected; J = Estimated value		



Picket C
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-736
GW-738
GW-737
GW-725
GW-740
GW-739
GW-724
GW-723
Copper Ridge
Dolomite
Nolichucky
Shale
Maynardville
Limestone
Picket_wells.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

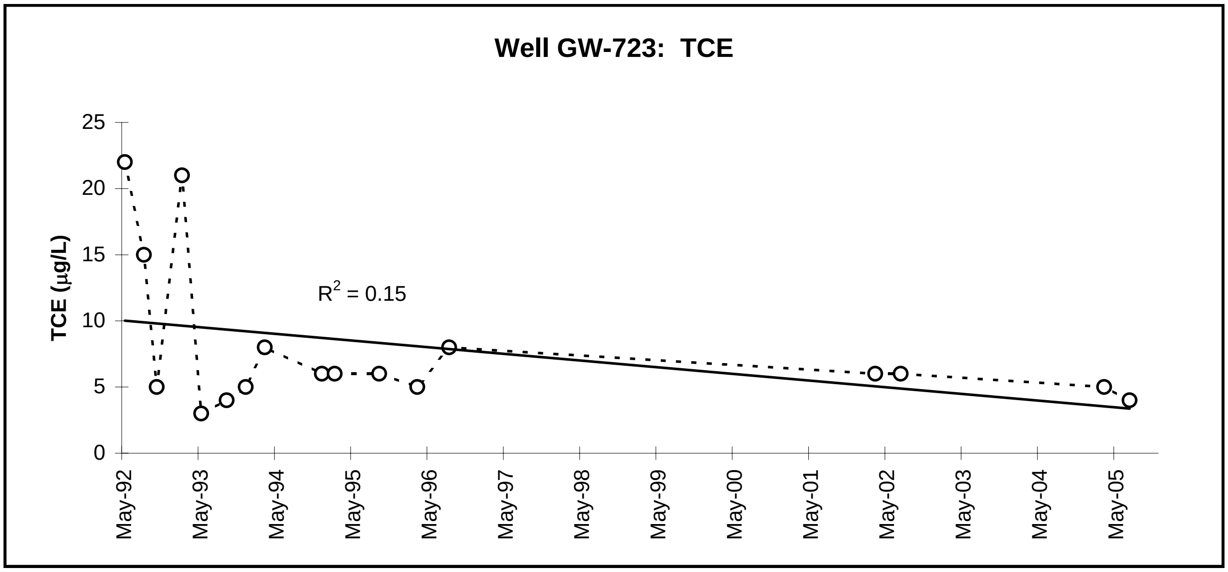

Well GW-723: TCE
TCE (µg/L)
25
20
15
10
5
0
$R^2 = 0.15$
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05

Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	<0.015	50 - 500	ND	25 - 50

GW-724

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 48,995.17
Y-12 GRID NORTH COORDINATE: 29,198.24
SURFACE ELEVATION: 976.62 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/12/91 PAIRED/CLUSTERED WITH: GW-738
TAG DEPTH (measured): 293.60 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 979.75 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	289.6	687.02
BOTTOM (filter pack or open hole):	301.6	675.02
MIDPOINT (filter pack or open hole):	295.6	681.02
PUMP INTAKE:	294.37	682.25
WATER LEVEL (average):	27.58	949.04

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	15 samples	05/20/92	09/05/97
LOW-FLOW SAMPLING METHOD:	14 samples	03/05/98	07/27/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/10/04	.	07/27/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.79 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	28	62 mg/L	02/10/93	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	171 µg/L	03/21/96	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	1	60 pCi/L	02/03/00	Indeterminate

WELL GW-724

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole monitored interval from about 289.6 to 301.6 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between May 1992 and September 1997, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the deep bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 28 ft bgs and exhibits seasonal fluctuations up to about 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 330 – 660 mg/L;
- pH of 6.3 – 8 (field measurements);
- elevated concentrations of chloride (>70 mg/L), total iron (>2 mg/L), sodium (>25 mg/L), and strontium (>1 mg/L) relative to other wells completed at shallower depths in the Maynardville Limestone;
- low molar proportions of potassium and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals (except iron and strontium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated chloride and sodium concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), and all but one of these results exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 3,500 ft east-northeast of the Exit Pathway Picket C, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, all but one of the groundwater samples had nitrate concentrations above the MCL, with all but four of these results being 25 mg/L or higher (Table 1). The nitrate concentrations exhibit apparently seasonal fluctuations, with the highest concentrations, including the historical maximum (62 mg/L in February 1993), typically evident in samples obtained during seasonally high flow conditions (winter and spring), and the lowest concentrations, including the historical minimum (7.73 mg/L in September 1998), typically reported for samples obtained during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (and episodic) fluctuations in the relative flux of nitrate via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

A time-series plot of nitrate concentrations in the groundwater samples shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 2). The overall decrease in nitrate concentrations, with the most recent sampling result (19.5 mg/L in July 2004) being 60 - 70% lower than evident in the early 1990s (e.g., 54 mg/L in August 1992), is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap.

5.2 URANIUM

Fifteen groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.00128 mg/L in August 1999) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): CTET, chloroform, PCE, TCE, toluene, and 12DCE (isomers). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 1,500 ft west-southwest (hydraulically downgradient) of Exit Pathway Picket C. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOC in the groundwater samples is TCE (Table 2), which was detected in every sample, with the historical maximum concentration of 160 µg/L in March 1996 and the most recent sampling results (February and July 2004) showing concentrations remain above 75 µg/L and substantially exceed the drinking water MCL (5 µg/L). Secondary compounds in the samples are PCE and 12DCE, which were detected in all but three of the samples, although all of the results for both compounds are estimated values below 5 µg/L. Also, the most recent sampling results also show that PCE and c12DCE concentrations remain below the respective MCLs (5 µg/L and 70 µg/L). Similarly low concentrations (estimated values below 5 µg/L) of CTET, chloroform, and toluene were detected in a total of nine samples, most of which were collected between January 1991 and March 1996 (Table 2).

A time-series plot of TCE concentrations in the groundwater samples shows an indeterminate long-term concentration trend (Figure 3) characterized by three distinct segments: (1) a generally increasing trend between May 1992 (54 µg/L) and March 1996 (160 µg/L), (2) a series of unusually low concentrations in August 1996 (40 µg/L), February 1997 (35 µg/L), and

September 1997 (45 µg/L), and (3) a slightly decreasing trend between March 1998 (130 µg/L) and July 2004 (77 µg/L). Additionally, the temporal "peak" concentrations of TCE are most frequently indicated by results for samples obtained during seasonally high groundwater flow conditions (winter and spring). These temporal fluctuations potentially correspond with changes in the relative flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

Unlike TCE, the concentrations of the other VOCs detected in the groundwater samples do not exhibit any discernable long-term trend or significant temporal concentration fluctuations (Table 1), as illustrated by the PCE concentrations reported for the samples collected in December 1993 (3 µg/L), September 1998 (3 µg/L), and July 2004 (4 µg/L). Assuming the groundwater contaminant plume in the Maynardville Limestone contains a heterogeneous mixture of dissolved VOCs, it is not clear from the available data why the concentrations of individual compounds exhibit divergent long-term trends and temporal variations, or if such variations are significant with respect to the relative flux of VOCs in the groundwater.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.97 pCi/L in February 1993) being less than the drinking water MCL for gross alpha activity (15 pCi/L). Also, the groundwater samples collected in January and July 2001 were analyzed for U-234 and U-238, which are the alpha-emitting radionuclides that are most likely to be present in the groundwater, and the respective results for each isotope that exceed the applicable MDA are less than 0.5 pCi/L.

5.5 GROSS BETA ACTIVITY

Twenty-five groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), but only the result for one sample (60 pCi/L in February 2000) exceeds the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is believed to be Tc-99 based on the detection (i.e., >MDA and CE) of this beta-emitting radionuclide in the samples collected in January (48 pCi/L) and July 2001 (43 pCi/L). Note that both results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. This radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

A time-series plot of gross beta activity reported for the groundwater samples shows an indeterminate long-term trend dominated by wide temporal fluctuations (Figure 4). The indeterminate trend suggests minimal overall change in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, unlike the nitrate concentrations, temporal "peak" levels of gross beta activity do not exhibit a clear and consistent correlation with seasonal groundwater flow conditions, although five of the seven highest gross beta values were reported for samples obtained during seasonally high flow conditions (winter and spring).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-724: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
05/20/92	41.7	22.1
08/25/92	54	37.9
10/29/92	25	5.06
02/10/93	62	11.1
05/18/93	37	40.4
09/29/93	50.1	41.8
12/14/93	46.4	32
03/18/94	48.4	41.8
12/18/94	42	39.4
02/19/95	41	39.8
09/24/95	38	44
03/21/96	38.8	36.9
08/14/96	35.1	29.5
02/27/97	35.7	47
09/05/97	36.3	30
03/05/98	20.6	<MDA
09/01/98	7.73	<MDA
02/22/99	30.6	27
08/09/99	24.96	33
02/03/00	26.4	60
07/31/00	17.6	25
01/25/01	23.9	41
07/19/01	25.9	38
01/30/02	25.8	38
07/23/02	12	<MDA
01/28/03	22.9	23
07/21/03	11.5	<MDA
02/10/04	22.7	35
07/27/04	19.5	19
MCL	**10**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 1. Well GW-724: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	**TCE**	**12DCE (Total)**	**c12DCE**	**OTHER**
05/20/92	2 J	54	.	NR	Toluene (1 J)
08/25/92	1 J	51	2 J	NR	.
10/29/92	2 J	95	2 J	NR	.
02/10/93	2 J	95	2 J	NR	.
05/18/93	.	46	.	NR	.
09/29/93	.	3 J	.	NR	Chloroform (7)
12/14/93	3 J	140	3 J	NR	CTET (2 J)
03/18/94	1 J	70	2 J	NR	.
12/18/94	2 J	98	2 J	NR	.
02/19/95	4 J	150	4 J	NR	CTET (2 J), Chloroform (1 J)
09/24/95	4 J	140	4 J	NR	CTET (2 J), Chloroform (1 J)
03/21/96	4 J	160	4 J	NR	CTET (3 J)
08/14/96	1 J	40	1 J	NR	.
02/27/97	.	35	1 J	1 J	.
09/05/97	.	45	.	.	.
03/05/98	3 J	130	4 J	4 J	.
09/01/98	3 J	120	3 J	3 J	Chloroform (1 J)
02/22/99	4 J	120	3 J	3 J	.
08/09/99	.	110	4 J	4 J	.
02/03/00	.	130	3 J	3 J	.
07/31/00	.	120	3 J	3 J	.
01/25/01	.	120	3 J	3 J	.
07/19/01	3 J	100	3 J	3 J	.
01/30/02	3 J	98	3 J	3 J	CTET (2 J)
07/23/02	3 J	110	3 J	3 J	.
01/28/03	3 J	100	3 J	3 J	.
07/21/03	3 J	100	3 J	3 J	.
02/10/04	4 J	96	3 J	3 J	CTET (2 J)
07/27/04	4 J	77	2 J	2 J	.
MCL	**5**	**5**	**NA**	**70**	**.**

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

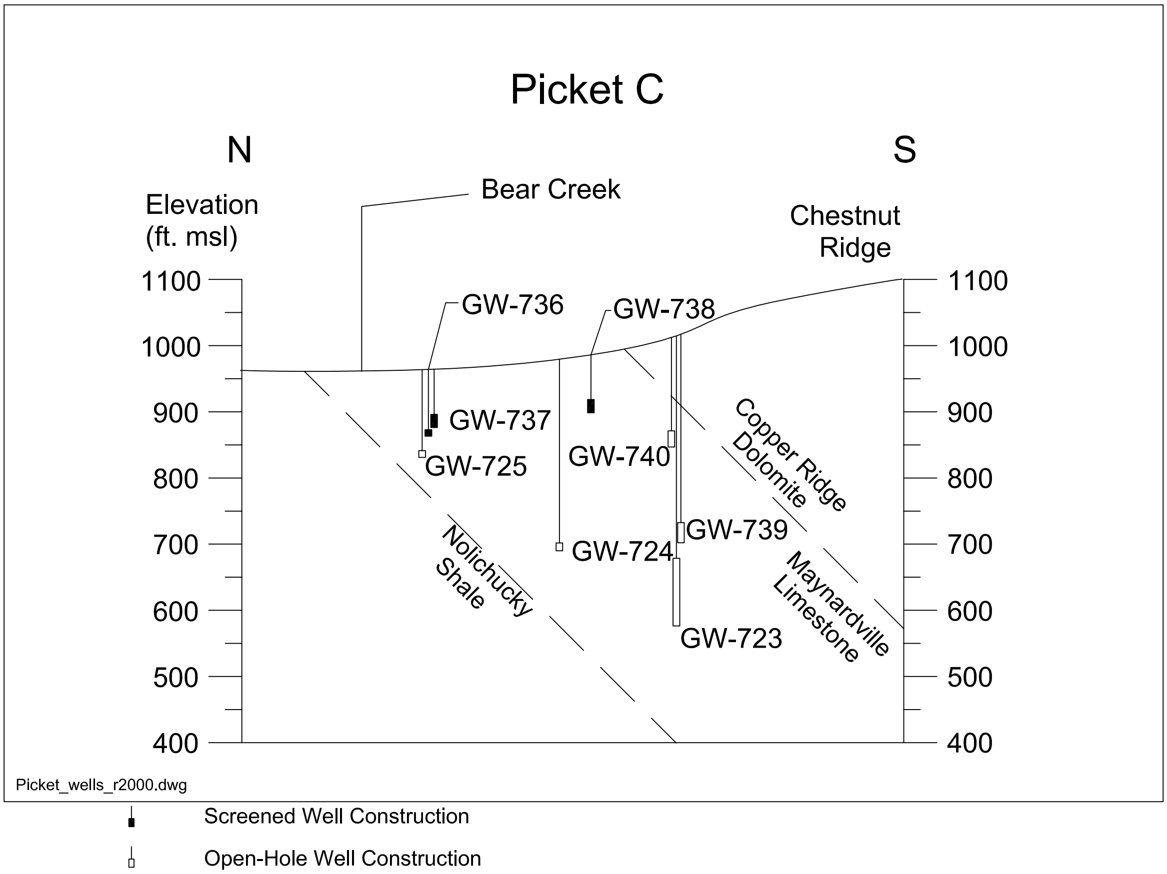

Picket C
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-736
GW-738
GW-737
GW-725
GW-740
GW-739
GW-724
GW-723
Copper Ridge
Dolomite
Nolichucky
Shale
Maynardville
Limestone
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

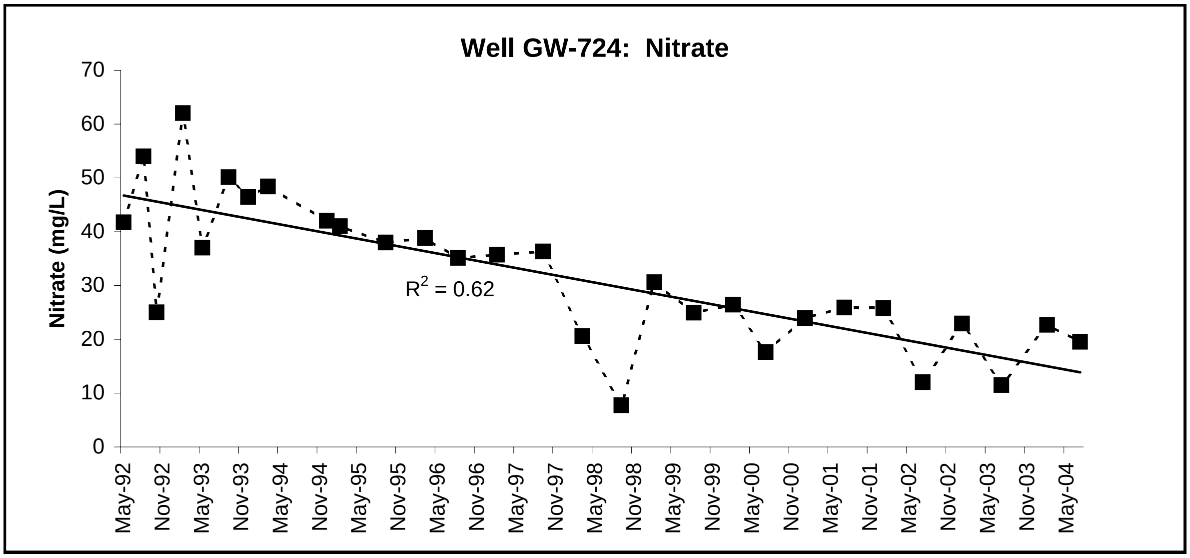


Figure 2

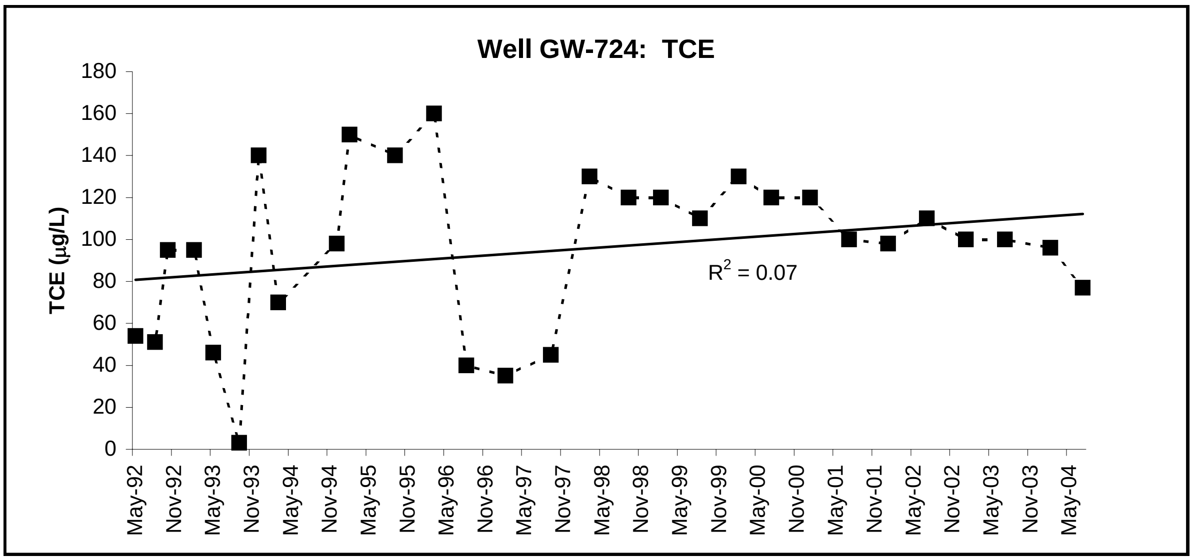


Figure 3

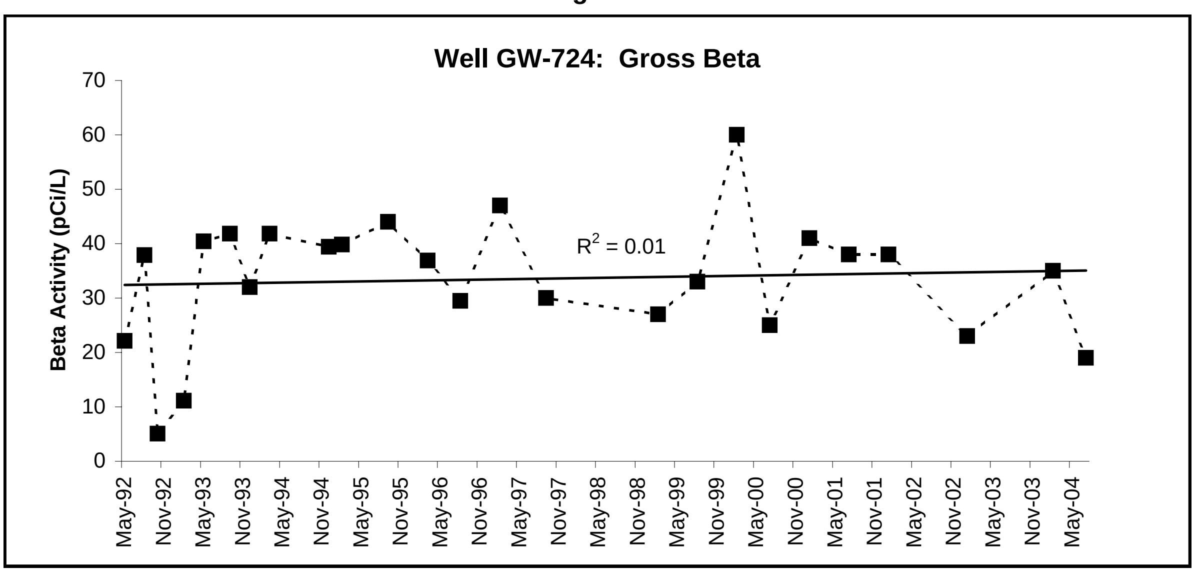


Figure 4

MAXIMUM CONCENTRATION: 2004

10 - 100	<0.015	50 - 500	<7.5	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-725

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 48,989.13
Y-12 GRID NORTH COORDINATE: 29,405.44
SURFACE ELEVATION: 958.26 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/27/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 145.42 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 961.63 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	132.5	825.76
BOTTOM (filter pack or open hole):	142.5	815.76
MIDPOINT (filter pack or open hole):	137.5	820.76
PUMP INTAKE:	137.13	821.13
WATER LEVEL (average):	8.81	949.45

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	17 samples	05/21/92	08/09/00
LOW-FLOW SAMPLING METHOD:	14 samples	03/10/98	07/27/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/11/04	.	07/27/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 9.36 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	31	106 mg/L	03/18/94	Indeterminate
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	31	342 μg/L	02/11/04	Indeterminate
GROSS ALPHA (15 pCi/L):	1	21.2 pCi/L	08/26/92	Outlier
GROSS BETA (50 pCi/L):	1	53.7 pCi/L	12/15/93	Indeterminate

WELL GW-725

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1991, completed with an open-hole monitored interval from about 132.5 to 142.5 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 17 samples between May 1992 and August 2000, and the low-flow sampling method used to obtain 14 samples between March 1998 and July 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method had substantially higher contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired sampling" performed during February and August 2000, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias. As shown by the data summarized in Table 1, groundwater samples obtained with the low-flow method had at least 50% lower summed VOC concentrations than the samples obtained with the conventional sampling method. Interestingly, some of the inorganic analytes, notably nitrate and iron (total), also exhibit substantial difference between the low-flow and conventional sampling results, whereas other inorganic analytes (e.g., calcium and barium) do not.

Inherent differences in the manner in which each sampling method induces flow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features that may not be near the well. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features near the well. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of contaminated groundwater into the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits seasonal fluctuations up to about 10 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sodium-enriched, nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 500 – 1,125 mg/L;
- pH of 6.33 – 7.2 (field measurements);
- elevated concentrations of chloride (>80 mg/L) and sodium (>30 mg/L) relative to other wells completed at shallower depths in the Maynardville Limestone;
- low molar proportions of potassium and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the chloride and sodium concentrations typical of the groundwater samples reflect localized geochemical characteristics, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), and all of these results exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 3,500 ft east-northeast of the Exit Pathway Picket C, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

As noted previously, all of the groundwater samples had nitrate concentrations above the MCL, with higher concentrations, including the historical maximum value (106 mg/L in March 1994), reported for samples obtained using the conventional sampling method, and the lower concentrations, including the historical minimum value (13.8 mg/L in July 2004), reported for samples obtained the low-flow sampling method (Table 1). Also, the conventional sampling results exhibit greater concentrations fluctuations, with peak concentrations evident in February 1993 (61 mg/L), March 1994 (106 mg/L), March 1996 (67.9 mg/L), and February 1997 (76 mg/L). These results suggest seasonally increased flux of nitrate via the groundwater flow/transport pathways intercepted by the monitored interval in the well. In contrast, the low-flow sampling results show much less temporal variability, with the highest concentrations (48.2 mg/L in January 2002 and 56 mg/L in February 2004) appearing to be outliers compared to the other low-flow sampling results, most of which are all less than 25 mg/L.

A combined time-series plot of nitrate concentrations in the groundwater samples obtained with the conventional and low-flow sampling methods shows a generally indeterminate long-term trend (Figure 2). Although the results of "paired" conventional and low-flow sampling in May and August 2000 show significant differences between respective nitrate concentrations, the conventional sampling results also suggest a significant (30 – 50%) decrease from the concentrations evident in the early and mid-1990s. The long-term decrease in nitrate concentrations is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap (DOE 1997).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.012 mg/L in July 2004) being less than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 3): benzene, CTET, chloroform (CLF), methylene chloride, PCE, TCE, toluene, 11DCE, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 μg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 1,500 ft west-southwest (hydraulically downgradient) of Exit Pathway Picket C. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOC in the groundwater samples is TCE (Table 3), which was detected in every sample at concentrations ranging between 7 (February 1997 and July 2004) and 310 μg/L (February 2004), all of which exceed the drinking water MCL (5 μg/L). Secondary compounds in the samples are PCE and 12DCE (isomers), one or both of which were detected in all but six of the samples, although all of the results for both compounds are estimated values below 5 μg/L. The most recent sampling results also show that PCE and c12DCE concentrations remain below the respective MCLs (5 μg/L and 70 μg/L). Similarly low concentrations (most being estimated values below 5 μg/L) of benzene, CTET, chloroform, toluene, 11DCE, and 111TCA were detected in a total of nine samples, most of which were collected between December 1993 and February 1997 (Table 3).

As noted in Section 2.0, summed concentrations of VOCs detected in the groundwater samples obtained with the conventional sampling method are much higher than evident for samples obtained with the low-flow sampling method. As illustrated by the data summarized below, this is attributable to significantly higher TCE concentrations in samples obtained with the conventional sampling method.

VOC	Concentration (μg/L)			
	February 7-8, 2000		August 8-9, 2000	
	Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
PCE	3 J	.	.	.
TCE	12	55	13	90
c12DCE	.	.	.	3 J

This suggests that the conventional sampling method induces greater inflow of TCE-contaminated groundwater into the well, possibly because this method promotes inflow from flowpaths that are not proximal to the well, whereas the low-flow sampling method induces inflow (of TCE-contaminated groundwater) from the flowpaths located near the well (see Section 2.0).

Combined time-series plots of respective TCE concentrations reported for the groundwater samples collected with the conventional and low-flow sampling methods shows an indeterminate long-term concentration trend (Figure 3), dominated by temporal "peak" concentrations evident in February 1995 (130 μg/L), January 2002 (200 μg/L), and February 2004 (310 μg/L). Aside from these results, however, there is little overall difference in the relative concentration of TCE over time, as illustrated by the similar concentrations reported for the groundwater samples collected in March 1992 (82 μg/L) and July 2004 (77 μg/L). This suggests minimal changes in the overall flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Fifteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, including six of the samples obtained with the conventional sampling method and nine samples obtained with the low-flow sampling method. The historical maximum gross alpha value (21.2 pCi/L in August 1992) exceeds the MCL for gross alpha activity (15 pCi/L), but this result appears to be an outlier (all but two of the remaining results are less than

10 pCi/L). Also, the groundwater samples collected in January and July 2001 were analyzed for U-234 and U-238, which are the alpha-emitting radionuclides that are most likely to be present in the groundwater, and the respective results for each isotope are 3 pCi/L or less.

5.5 GROSS BETA ACTIVITY

All of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 2), but only the result for one sample (53.7 pCi/L in December 2000) exceeds the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the MCL for gross beta activity). The source of the gross beta activity in the groundwater at this well is believed to be Tc-99 based on the detection (i.e., >MDA and CE) of this beta-emitting radionuclide in the samples collected in January (22 pCi/L) and July 2001 (36 pCi/L). Note that both results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99. This radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, the only site at Y-12 which received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the groundwater transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

Gross beta activity levels reported for the groundwater samples typically range between 25 and 50 pCi/L (Table 2), with the highest levels, including the historical maximum value (53.7 pCi/L in December 1993) reported for samples obtained using the conventional sampling method. Conversely, lower levels of gross beta activity, including the historical minimum value (11 pCi/L in July 2004), were reported for samples obtained using the low-flow sampling method. Interestingly, the gross beta results obtained with either sampling method show the highest values for samples collected during seasonally high flow conditions. Also, a combined time-series plot of gross beta results reported for samples obtained with conventional and low-flow sampling methods shows an indeterminate long-term trend (Figure 4), as illustrated by the close similarity between the gross beta results reported for samples collected in August 1992 (28.6 pCi/L), March 1998 (29 pCi/L), and July 2004 (34 pCi/L). This indeterminate long-term trend indicated by the sampling results for gross beta activity suggest minimal change in the relative flux of Tc-99 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-725: Consecutive daily sampling results for summed VOCs and other selected analytes, February and August 2000

Analyte	Units	February 2000		August 2000	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7	6.96	6.99	7.12
Dissolved Solids	mg/L	650	679	509	822
Suspended Solids	mg/L	1	11	Not detected.	3
Calcium	mg/L	156	156	151	159
Nitrate	mg/L	22.4	27.3	18.6	30.5
Barium	mg/L	0.223	0.257	0.22	0.256
Iron	mg/L	0.153	6.78	0.166	1.77
Summed VOCs	µg/L	15	55	13	93

Table 2. Well GW-725: summary of results for nitrate and gross beta activity

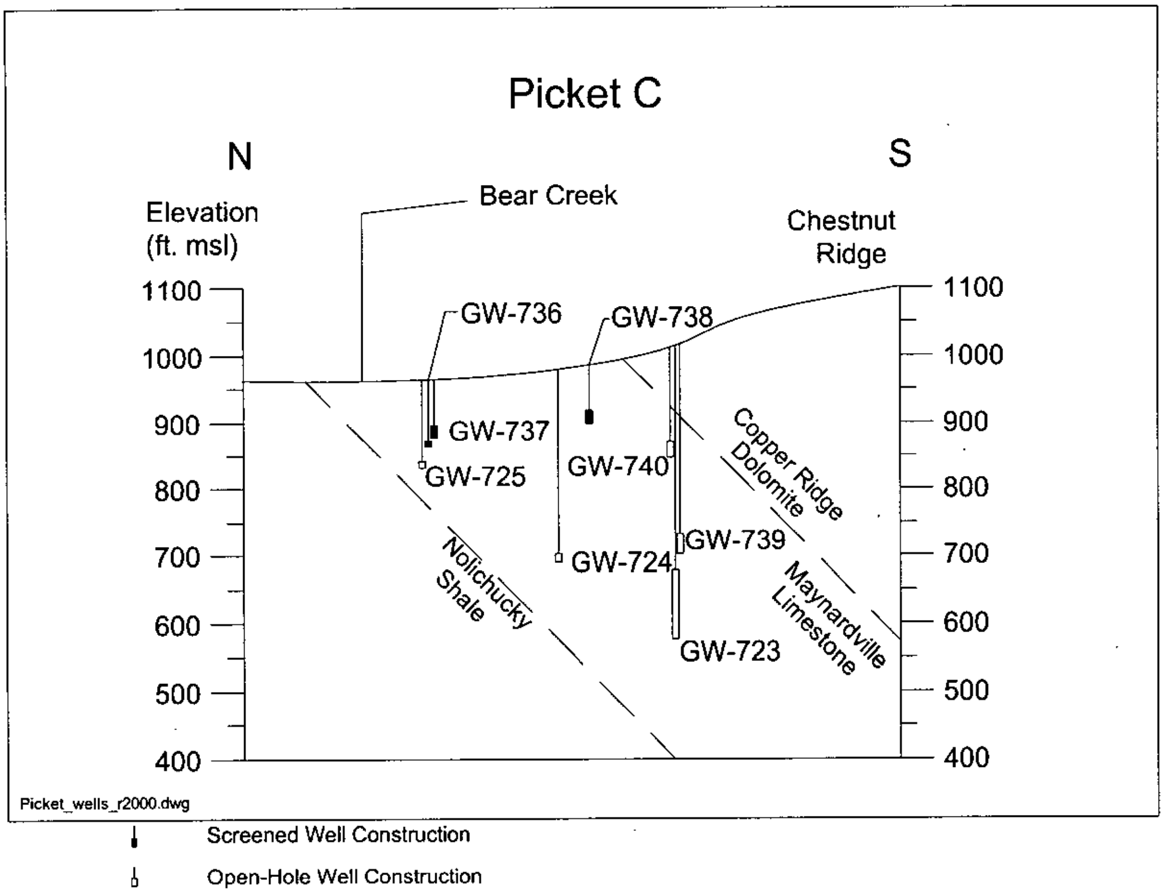
Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
Conventional Sampling		
05/21/92	34	40.9
08/26/92	52	28.6
10/29/92	55	24.5
02/12/93	61	24.2
05/19/93	55	41.6
09/28/93	49.9	46.5
12/15/93	46.2	53.7
03/18/94	106	33
12/18/94	52	36
02/28/95	49	34
09/25/95	35	37.7
03/22/96	67.9	34.3
08/13/96	51	25.4
02/28/97	76.1	27
09/05/97	47.5	28
02/08/00	27.3	29
08/09/00	30.5	35
Low-Flow Sampling		
03/10/98	24.4	29
09/02/98	26.1	30
02/22/99	22.8	34
08/09/99	22.09	36
02/07/00	22.4	40
08/08/00	18.6	32
01/22/01	18.1	22
07/19/01	18.9	36
01/31/02	48.2	32
07/18/02	18.5	29
01/28/03	17.4	34
07/21/03	20.6	29
02/11/04	56	34
07/27/04	13.8	11
MCL	**10**	**50***

Note: * SWDA screening level for a 4 millirem per year dose equivalent (the MCL for gross beta activity)

Table 3. Well GW-725: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	OTHER
Conventional Sampling					
05/21/92	.	82	4 J	NR	.
08/26/92	.	34	3 J	NR	.
10/29/92	2 J	32	4 J	NR	CTET (0.9 J), CLF (1 J), 111TCA (0.8 J)
02/12/93	.	19	2 J	NR	
05/19/93	.	53	3 J	NR	.
09/28/93	0.8	47	2 J	NR	.
12/15/93	1 J	53	3 J	NR	.
03/18/94	2 J	30	3 J	NR	Benzene (1 J), Toluene (2 J)
12/18/94	.	70	1 J	NR	Benzene (1 J)
02/28/95	3 J	130	4 J	NR	11DCE (1 J)
09/25/95	1 J	48	2 J	NR	CTET (4 J), CLF (1 J), 111TCA (2 J)
03/22/96	.	17	.		CLF (1 J), 11DCE (1 J)
08/13/96	.	12	.	.	.
02/28/97	.	7	.	.	.
09/05/97	.	16	.	.	Methylene chloride (2 J)
02/08/00	.	55	.	.	.
08/09/00	.	90	3 J	3 J	.
Low-Flow Sampling					.
03/10/98	3 J	42	4 J	4 J	
09/02/98	2 J	20	3 J	3 J	CTET (1 J)
02/22/99	3 J	19	3 J	3 J	.
08/09/99	.	29	3 J	3 J	.
02/07/00	3 J	12	.	.	.
08/08/00	.	13	.	.	.
01/22/01	.	9	2 J	2 J	.
07/19/01	2 J	10	2 J	2 J	.
01/31/02	.	200	4 J	4 J	.
07/18/02	2 J	15	2 J	2 J	.
01/28/03	2 J	19	2 J	2 J	.
07/21/03	3 J	70	2 J	2 J	.
02/11/04	1 J	310	4 J	4 J	.
07/27/04	.	7	.	.	CTET (12), CLF (3 J), 11DCE (8)
					.
MCL	**5**	**5**	**NA**	**70**	.

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported



Picket C
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-736
GW-738
GW-737
GW-725
GW-740
GW-739
GW-724
GW-723
Copper Ridge
Dolomite
Nolichucky
Shale
Maynardville
Limestone
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

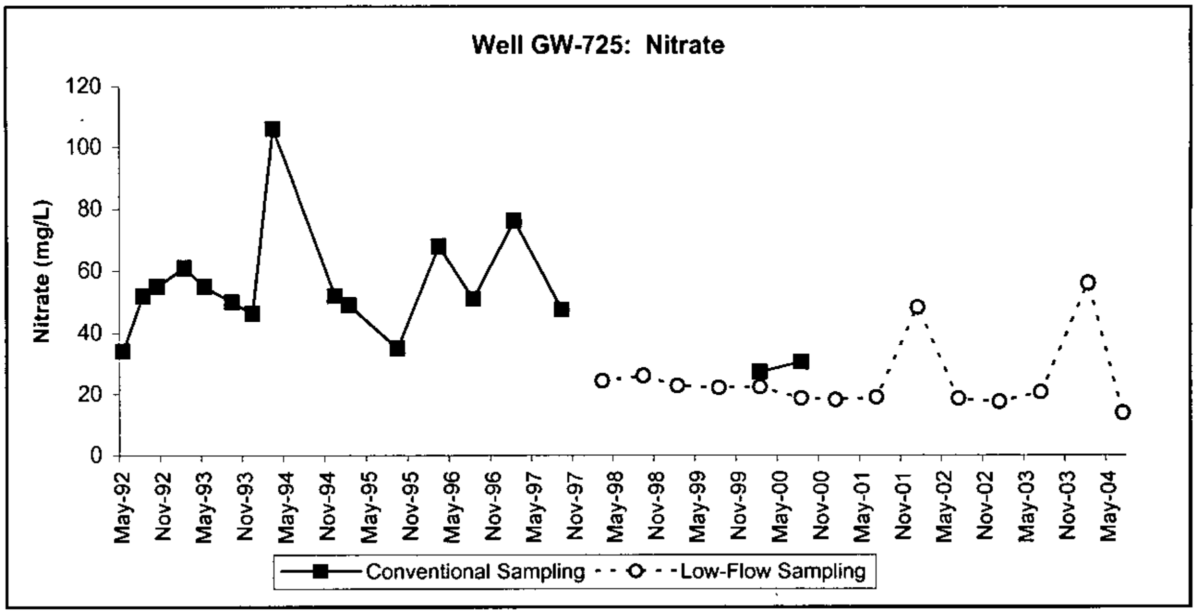


Figure 2

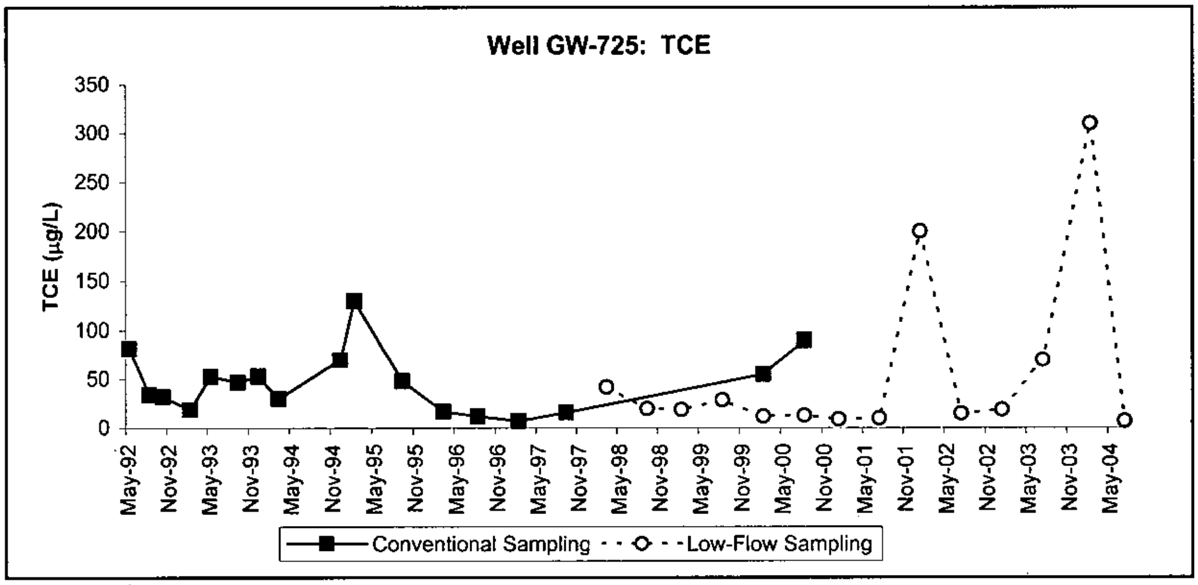


Figure 3

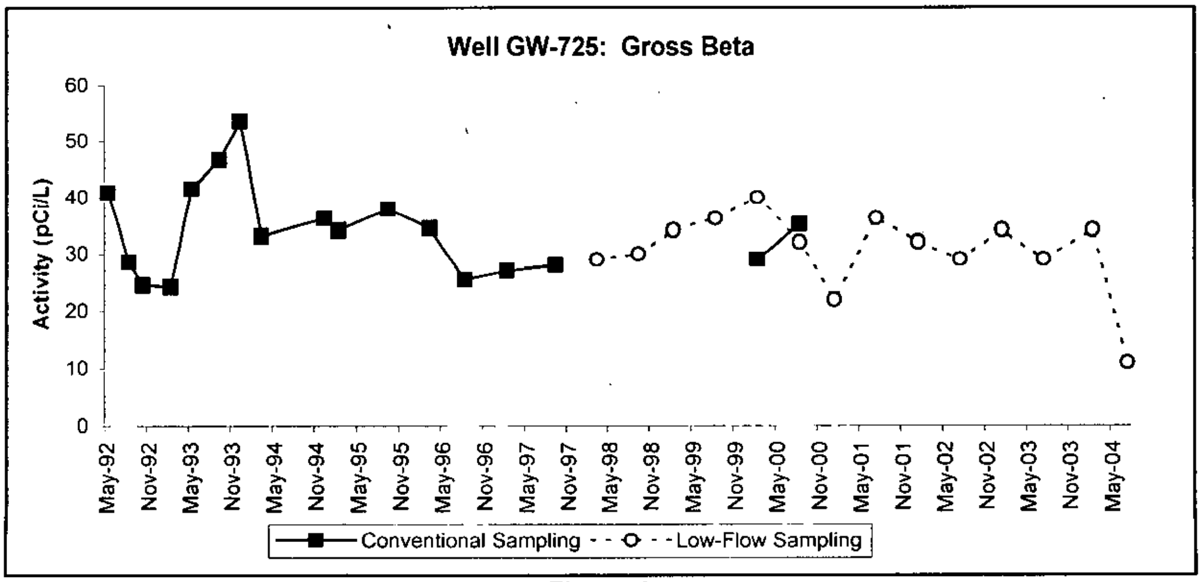


Figure 4

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-731

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Sediment Disposal Basin
Y-12 GRID EAST COORDINATE: 63,863.14
Y-12 GRID NORTH COORDINATE: 27,463.65
SURFACE ELEVATION: 1,045.75 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/12/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 178.53 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,049.38 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	164.0	881.75
BOTTOM (filter pack or open hole):	178.7	867.05
MIDPOINT (filter pack or open hole):	171.4	874.40
PUMP INTAKE:	169.87	875.88
WATER LEVEL (average):	120.88	924.87

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	70		
CONVENTIONAL SAMPLING METHOD:	31 samples	09/27/91	04/24/97
LOW-FLOW SAMPLING METHOD:	39 samples	10/20/97	10/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/14/04	.	10/13/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 4.28 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	77 µg/L	09/27/91	Outlier
GROSS ALPHA (15 pCi/L):	2	18.8 pCi/L	02/23/93	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-731

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1991, completed with a screened monitored interval from 164 to 178.7 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge southeast of Y-12, about 50 ft southeast (hydraulically downgradient) of the Chestnut Ridge Sediment Disposal Basin (CRSDB). The CRSDB is a former sinkhole filled with contaminated sediments generated from remedial actions at Y-12 and covered with a low-permeability, multilayer cap during RCRA closure of the site in 1989. Semiannual statistical evaluations performed for RCRA detection monitoring purposes has not indicated a contaminant release to groundwater at the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventy groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 31 samples between September 1991 and April 1997, and the low-flow sampling method used to obtain 39 samples between October 1997 and October 2004. Many of these samples were collected in accordance with the replicate sampling protocol associated with RCRA post-closure detection monitoring performed between October 1995 and April 2001, when four samples were collected over consecutive days during each semiannual sampling event.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is 121 ft below ground surface. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<5 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 98 – 238 mg/L;
- pH (field measurements) of 7.3 – 10.1;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Thirty-three groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.67 mg/L in January 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Ten groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.01 mg/L in February 1995) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Seventeen groundwater samples collected between September 1991 and July 1995 were analyzed for VOCs and the analytical results for each sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Chestnut Ridge Regime. Acetone (77 µg/L in September 1991) and 4-methyl-2-pentanone (6 µg/L in May 1992) were each detected in only one sample from the well, and both results are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the results that exceed the MCL for gross alpha activity (15 pCi/L) reported for the samples collected in May 1992 (17.3 pCi/L) and February 1993 (18.8 pCi/L). Both results are suspected outliers because the other gross alpha results are all less than 5 pCi/L.

5.5 GROSS BETA ACTIVITY

Fifteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (27.3 pCi/L) being below the SDWA for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-732

LOCATION

HYDROGEOLOGIC REGIME:	Chestnut Ridge Regime
FUNCTIONAL AREA:	Chestnut Ridge Sediment Disposal Basin
Y-12 GRID EAST COORDINATE:	64,267.74
Y-12 GRID NORTH COORDINATE:	27,716.72
SURFACE ELEVATION:	1,060.65 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	RCRA
HYDROLOGIC MONITORING:	X
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	09/11/91
PAIRED/CLUSTERED WITH:	
TAG DEPTH (measured):	192.84 ft below top of casing (TOC)
MEASURING POINT ELEVATION:	1,064.29 ft above msl
MEASURING POINT:	TOWW
WELL BORE DIAMETER:	10.6 inches
WELL CASING MATERIAL:	SS304
WELL CASING DIAMETER:	4.5 inches (outside diameter)
WELL SCREEN TYPE:	SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT:	Well Wizard
Sampling Port No.:	.
Port Depth :	. (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	178.3	882.35
BOTTOM (filter pack or open hole):	190.0	870.65
MIDPOINT (filter pack or open hole):	184.2	876.50
PUMP INTAKE:	184.36	876.29
WATER LEVEL (average):	153.08	907.57
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	71		
CONVENTIONAL SAMPLING METHOD:	32 samples	09/27/91	04/24/97
LOW-FLOW SAMPLING METHOD:	39 samples	10/20/97	10/14/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/08/04	.	10/14/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.
GROUT CONTAMINATION:	.
SAMPLING METHOD SENSITIVITY:	.
WATER LEVEL FLUCTUATION:	26.7 pre-sampling measurements (ft)
TDS:	. (L <150; H >800 mg/L)
LOW pH:	. (<5.5)
OTHER:	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	3	91 pCi/L	04/07/95	Outlier
GROSS BETA (50 pCi/L):	1	59.8 pCi/L	04/07/95	Outlier

WELL GW-732

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1991, completed with a screened monitored interval from 178.3 to 190 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located on the crest of Chestnut Ridge southeast of Y-12 at the Chestnut Ridge Sediment Disposal Basin (CRSDB). The CRSDB is a former sinkhole filled with contaminated sediments generated from remedial actions at Y-12 and covered with a low-permeability, multilayer cap during RCRA closure of the site in 1989. Semiannual statistical evaluations performed for RCRA detection monitoring purposes has not indicated a contaminant release to groundwater at the site.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventy-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 32 samples between September 1991 and April 1997, and the low-flow sampling method used to obtain 39 samples between October 1997 and October 2004. Many of these samples were collected in accordance with the replicate sampling protocol associated with RCRA post-closure detection monitoring performed between October 1995 and April 2001, when four samples were collected over consecutive days during each semiannual sampling event.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group. The average static groundwater level in the well is 153 ft below ground surface. Presampling depth-to-water measurements for the well indicate substantial (> 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 100 – 526 mg/L;
- pH (field measurements) of 7.1 – 11.2;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Thirty-five groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1 mg/L in August 1995) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.016 mg/L in April 1995) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Seventeen groundwater samples collected between September 1991 and July 1995 were analyzed for VOCs and the analytical results for each sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Chestnut Ridge Regime.

5.4 GROSS ALPHA ACTIVITY

Fifteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE. All but three of these results are less than the MCL for gross alpha activity (15 pCi/L); 19.3 pCi/L in November 1993, 34.1 pCi/L in January 1995, and 91 pCi/L in April 1995.

5.5 GROSS BETA ACTIVITY

Seventeen groundwater samples had gross beta activity above the applicable MDA and corresponding CE. Five of these results exceed 15 pCi/L: 27.4 pCi/L in January 1995; 59.8 pCi/L in January 1995, which exceeds the SDWA screening level for gross beta activity (50 pCi/L); and 17.5 pCi/L, 25.1 pCi/L, and 28.4 pCi/L for samples collected on successive days in October 1995.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-733

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket J
Y-12 GRID EAST COORDINATE: 65,067.17
Y-12 GRID NORTH COORDINATE: 28,447.10
SURFACE ELEVATION: 955.69 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/02/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 259.93 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 959.84 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	240.1	715.59
BOTTOM (filter pack or open hole):	256.5	699.19
MIDPOINT (filter pack or open hole):	248.3	707.39
PUMP INTAKE:	248.85	706.84
WATER LEVEL (average):	53.14	902.55

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	21 samples	04/28/92	07/30/97
LOW-FLOW SAMPLING METHOD:	17 samples	03/12/98	07/08/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/08/04	.	07/08/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.18 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	34	98 µg/L	08/11/92	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-733

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1991, completed with an open-hole monitored interval from 240.1 to 256.5 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley near the east end of Y-12, about 300 ft east (hydraulically downgradient) of New Hope Pond (NHP)/Lake Reality. Closed in 1988 and covered with a multi-layer low-permeability cap in 1989, NHP was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12 via UEFPC. Lake Reality is a lined surface impoundment that was built in 1988 to replace NHP. During normal operations, flow in of the Upper East Fork Poplar Creek (UEFPC) bypasses Lake Reality and is directed through the concrete-lined distribution channel, which borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between April 1992 and July 1997, and the low-flow sampling method used to obtain 17 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 53 ft bgs and exhibits seasonal fluctuations of about 9 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-733 indicate components of flow to the north toward the UEFPC drainage system and to the east parallel with geologic strike in the Maynardville Limestone. Additionally, local groundwater flow patterns near NHP are influenced by the full-time operation of a groundwater extraction and treatment system intended to intercept and contain the VOC-contaminated groundwater in the Maynardville Limestone near the east end of Y-12, as required by the CERCLA Action Memorandum (DOE 1999). Beginning in October 2001, groundwater has been pumped from a well (GW-845) located about 700 ft west-northwest (hydraulically upgradient) of well GW-733 and is treated on-site to remove VOCs, particulates, iron, and manganese. Long-term operation of the system has generally maintained 15 to 17 ft of drawdown in the immediate vicinity of well GW-845 and has established an elongated zone of influence that extends parallel with geologic strike for at least 900 ft to the east (downgradient) and 600 ft to the west (upgradient) of the pumping well (DOE 2002).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 156 – 260 mg/L;
- pH (field measurements) of 7.1 – 8.8;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-seven groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest value (2.5 mg/L in July 2000) being less than the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Thirteen groundwater samples had uranium concentrations at the applicable analytical reporting limit, with the highest value (0.001 mg/L in February 1993, August 1993, and January 1994) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 1): acetone, benzene, CTET, chloroform, PCE, and TCE. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and UEFPC watersheds. In the UEFPC watershed east of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near the Fire Training Facility in the southwestern section of Y-12, extends eastward (parallel with geologic strike) and mixes with VOCs released from several sources in the central and eastern Y-12 areas, and enters Union Valley east of the ORR boundary along Scarboro Road (DOE 1998). In October 2000, full-time operation of a groundwater remediation system began to help intercept and contain the (CTET-dominated) portion of the VOC plume in the eastern Y-12 area, as required by the CERCLA Action Memorandum (DOE 1999). Operation of the system involves pumping groundwater from an extraction well (GW-845) completed in the Maynardville Limestone about 700 ft west-northwest (across geologic strike) of well GW-733; treating the groundwater on-site to remove particulates, iron, manganese, and VOCs; and discharging the effluent into UEFPC.

The primary VOCs in the groundwater samples are CTET and chloroform (Table 1), which were detected in each groundwater sample, with respective historical maximum concentrations evident in November 1993 (87 μg/L) and April 1992 (27 μg/L). Acetone, benzene, PCE, and TCE have been detected much less frequently and at substantially lower concentrations, with the bulk of the results for each compound being estimated values below 5 μg/L.

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample (Figure 1) shows a steadily decreasing trend between November 1993 (98 µg/L) and July 1998 (5 µg/L), followed by an indeterminate trend through July 2004 (8 µg/L). Note that the decreasing concentration trend predates the full-time operation of groundwater extraction well GW-845, and the indeterminate trend generally corresponds with the change from conventional sampling to low-flow sampling. Also, the VOC results obtained from conventional sampling before March 1998 show cyclic temporal concentration fluctuations, with the highest concentrations typically detected in samples collected during seasonally low groundwater flow conditions (summer and fall). However, proportionally similar temporal concentration fluctuations are less evident from the VOC low-flow sampling results obtained since March 1998. Moreover, the VOC concentrations in the well do not yet reflect any discernable response to operation of groundwater extraction well GW-845 (DOE 2002).

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.5 pCi/L in February 1999) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seventeen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.9 pCi/L in February 1999) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

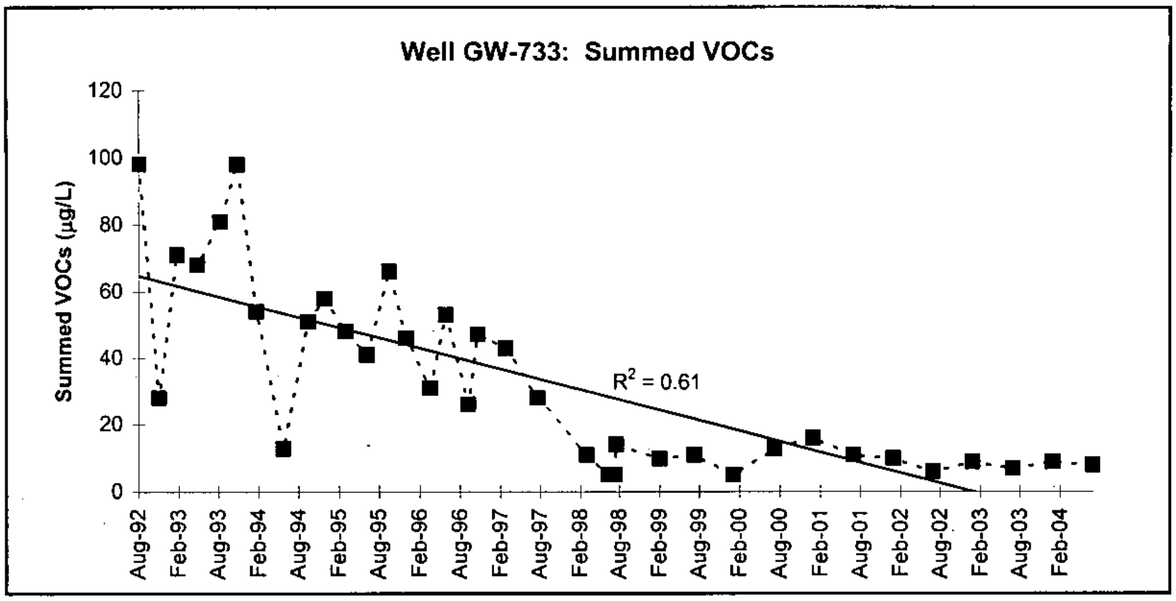
DOE. 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2002. *2001 Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee.* Prepared for the U.S. Department of Energy (DOE/OR/01-1941&D2/R1).

Table 1. Well GW-733: summary of VOC results

Date Sampled	VOC Concentration (µg/L)					
	CTET	Chloroform	PCE	TCE	Acetone	Benzene
04/28/92	.	27	4 J	.	.	.
08/11/92	67	12	3 J	1 J	15	.
11/11/92	.	26	2 J	.	.	.
02/02/93	60	8	2 J	0.9 J	.	.
05/06/93	61	5	2 J	.	.	.
08/18/93	72	6	2 J	1 J	.	.
11/04/93	87	7	3 J	1 J	.	.
01/30/94	50	4 J	.	.	.	.
06/02/94	10	3 J	.	.	.	.
09/24/94	46	4 J	1 J	.	.	.
12/06/94	52	4 J	2 J	.	.	.
03/12/95	44	3 J	1 J	.	.	.
06/17/95	38	3 J	.	.	.	.
09/27/95	53	4 J	2 J	1 J	6	.
12/11/95	40	4 J	1 J	1 J	.	.
03/28/96	27	3 J	1 J	.	.	.
06/07/96	51	FP	2 J	.	.	.
09/17/96	26	FP	.	.	.	.
10/30/96	46	FP	1 J	.	FP	.
03/05/97	31	2 J	1 J	.	9	.
07/30/97	26	2 J	.	.	FP	.
03/12/98	11	FP	.	.	FP	.
06/18/98	3 J	2 J	.	.	.	.
07/21/98	3 J	2 J	.	.	.	.
07/27/98	11	2 J	1 J	.	FP	.
02/11/99	3 J	6	.	.	.	1 J
07/20/99	8	3 J	.	.	.	.
01/13/00	3 J	2 J	.	.	.	.
07/17/00	11	2 J	.	.	.	.
01/08/01	14	2 J	.	.	.	.
07/11/01	10	1 J	.	.	.	.
01/08/02	10	.	.	.	.	.
07/09/02	5	1 J	.	.	.	.
01/07/03	8	1 J	.	.	.	.
07/10/03	5	1 J	.	.	.	1 J
01/08/04	8	1 J	.	.	.	.
07/08/04	7	1 J	.	.	.	.
MCL	**5**	**80***	**5**	**5**	**NA**	**5**

Notes: "." = Not detected; J = Estimated concentration; FP = False positive; NA = Not applicable;
* MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane



Well GW-733: Summed VOCs
Summed VOCs (µg/L)
120
100
80
60
40
20
0
R^2 = 0.61
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-735

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket J
Y-12 GRID EAST COORDINATE: 64,872.27
Y-12 GRID NORTH COORDINATE: 28,866.50
SURFACE ELEVATION: 921.34 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/30/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 81.81 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 924.46 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	67.5	853.84
BOTTOM (filter pack or open hole):	79.2	842.14
MIDPOINT (filter pack or open hole):	73.4	847.99
PUMP INTAKE:	73.58	847.76
WATER LEVEL (average):	19.46	901.88

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	37		
CONVENTIONAL SAMPLING METHOD:	20 samples	04/28/92	04/15/97
LOW-FLOW SAMPLING METHOD:	17 samples	12/03/97	11/15/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/27/04	.	11/15/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.06 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-735

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1991, completed with a screened monitored interval from 67.5 to 79.2 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley east of Y-12, about 400 ft west of the ORR boundary along Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 20 samples between April 1992 and April 1997, and the low-flow sampling method used to obtain 17 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Maynardville Limestone. The average static groundwater level in the well is 19.5 ft bgs. Excluding the unusually low groundwater elevation evident in December 1997 (Figure 1), presampling depth-to-water measurements for the well indicate moderate (<10 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 283 – 486 mg/L;
- pH (field measurements) of 5.7 – 7.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nineteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2.9 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the groundwater sample collected in March 1996 (0.0054 mg/L) exceeds the analytical reporting limit. This result is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at very low levels in two groundwater samples: methylene chloride (0.8 μg/L) in May 1993 and chloroform (2 μg/L) in April 1997. These results are probably sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

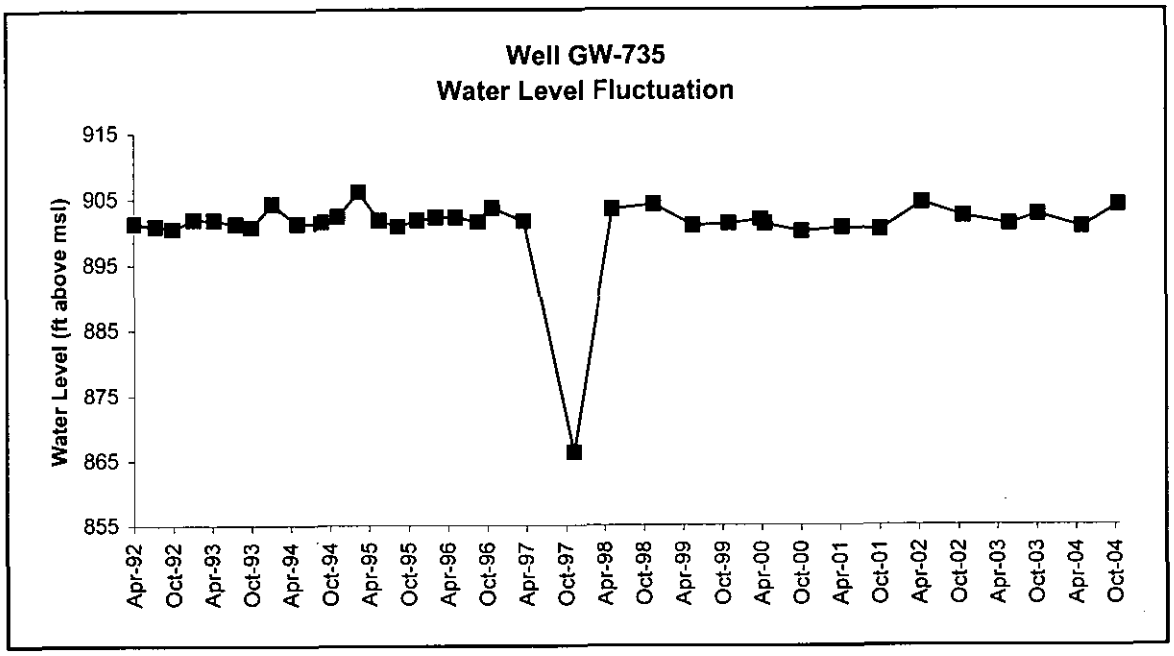
Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (9.2 pCi/L in June 1999) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Thirteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (14.7 pCi/L in December 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.



Well GW-735
Water Level Fluctuation
Water Level (ft above msl)
915
905
895
885
875
865
855
Apr-92
Oct-92
Apr-93
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04
Oct-04

Figure 1

MAXIMUM CONCENTRATION: 2005

10 - 100	0.03 - 0.3	5 - 50	7.5 - 15	25 - 50
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-736

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 48,935.90
Y-12 GRID NORTH COORDINATE: 29,381.05
SURFACE ELEVATION: 957.55 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/25/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 104.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 960.37 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	92.0	865.55
BOTTOM (filter pack or open hole):	105.0	852.55
MIDPOINT (filter pack or open hole):	98.5	859.05
PUMP INTAKE:	96.2	861.37
WATER LEVEL (average):	8.56	949.02

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	11 samples	05/22/92	09/26/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/06/02	08/02/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/03/05	.	08/02/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.02 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	15	61 mg/L	02/11/93	Decreasing
URANIUM (0.03 mg/L):	2	0.0309 mg/L	03/03/05	Increasing
SUMMED VOCs (5 µg/L):	15	44 µg/L	02/11/93	Decreasing
GROSS ALPHA (15 pCi/L):	1	24 pCi/L	03/06/02	Outlier
GROSS BETA (50 pCi/L):	3	68 pCi/L	03/06/02	Indeterminate

WELL GW-736

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1991, completed with a screened monitored interval from 92 to 105 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire wound). The well is located in Bear Creek Valley (BCV) west of Y-12, on the north side of Bear Creek Road and directly south of the main channel of Bear Creek, approximately 300 ft downstream of the confluence between the main channel and a northern tributary (NT-2) of the creek. The well is a component of Exit Pathway Picket C, which consists of a series of wells (GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a north-south transect approximately 3,300 ft (Figure 1).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between May 1992 and September 1995, and the low-flow sampling method used to obtain four samples between March 2002 and August 2005. The sampling history includes quarterly sampling between May 1992 and December 1993, with semiannual sampling in 1994 and 1995, a nearly seven-year period (September 1995 – March 2002) when no samples were collected from the well, and semiannual sampling in 2002 and 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 9 ft bgs and exhibits seasonal fluctuations of about 6 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 598 – 956 mg/L;
- pH of 6.72 – 7.12 (field measurements);

- nitrate concentrations above 10 mg/L;
- elevated concentrations of sodium (>25 mg/L), chloride (>50 mg/L), and sulfate (>40 mg/L) relative to other wells completed at similar depth in the Maynardville Limestone; and
- unusually high concentrations of some trace metals that indicate a correlation with the levels of suspended solids in the samples (see Section 5.6), total concentrations of other trace metals being either below respective analytical reporting limits or within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of locally disseminated sulfides in the Maynardville Limestone may account for the elevated levels of sulfate in the groundwater at this well, and the elevated concentrations of sodium and chloride (and high TDS) potentially indicate that the well does not intercept highly permeable groundwater flowpaths. Instead, the well may be completed in a relatively low-yield interval where the groundwater geochemistry resembles that of the sodium-bicarbonate groundwater typically encountered at a depth of approximately 100 ft bgs in the Nolichucky Shale (and other low-permeability formations of the Conasauga Group). The sodium-bicarbonate geochemistry of the groundwater, which is accompanied by a general increase in chloride levels and TDS, is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Thus, the elevated levels of sodium and chloride (and TDS) may indicate that the well yields groundwater with higher residence time than typical of the more permeable intervals at shallow depths in the Maynardville Limestone. Also, considering that the monitored interval intercepts groundwater flowpaths within the lower part of the Maynardville Limestone (Figure 1), the atypical sodium and chloride levels the groundwater in the well potentially indicates hydraulic connection with the sodium-bicarbonate groundwater from the Nolichucky Shale.

As illustrated by the selected data summarized below, sodium and chloride concentrations appear to have increased (nearly doubled) during the prolonged gap in the sampling history for the well. Although the higher sodium and chloride levels appear to coincide with the change from conventional sampling to low-flow sampling, the concentrations of other major ions (e.g., potassium and sulfate) exhibit no apparent change coincident with the sampling method. Thus, the elevated sodium and chloride concentration do not appear to be artifacts related to the sampling method, but instead seem to define the passing of a temporal "slug" of sodium- and chloride-enriched groundwater via the flowpaths intercepted by the monitored interval in the well.

Sampling Method and Date		**Concentration (mg/L)**		
		Sodium	**Chloride**	**Sulfate**
Conventional Sampling	05/22/92	19	41	45
	09/28/93	20	65	40
	03/21/94	22	48	42.6
	09/26/95	21	49	43
Low-Flow Sampling	03/06/02	35.3	95.7	43.5
	07/18/02	35.1	87.8	40.9
	03/03/05	29.7	64.7	43.6
	08/02/05	29.4	59.5	44.5

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12, all of which are present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (Table 1), and all of these results exceed the drinking water MCL for nitrate (10 mg/L). Elevated nitrate concentrations in the samples indicate that the monitored interval for the well intercepts groundwater flow/transport pathways for nitrate (and other contaminants) released from the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located approximately 3,500 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket C, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984, which emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants in the groundwater. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale, which underlies the former S-3 Ponds, and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Because nitrate is chemically stable and highly mobile in groundwater, the elevated concentrations of nitrate (>10 mg/L) effectively trace the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of elevated nitrate concentrations in the Maynardville Limestone west of Y-12 reflects: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for approximately 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic communication with surface water in Bear Creek.

As noted previously, all of the nitrate results detected in the groundwater samples collected to date exceed 10 mg/L drinking water MCL (Table 1), although nitrate concentrations reported for the samples collected most recently (March and August 2005) are just slightly above the MCL and are the lowest levels reported for the well. Unlike the nitrate concentrations evident in the groundwater at other Maynardville Limestone wells west of Y-12, including several Exit Pathway Picket C wells, the nitrate results for this well do not indicate wide temporal (seasonal) concentration fluctuations, as illustrated by the most recent sampling results noted above. This also supports the possibility, as noted in Section 4.0 regarding the unusual geochemistry of the groundwater samples, that the monitored interval in the well may not intercept the more permeable flowpaths at shallow depths in the Maynardville Limestone, where nitrate concentrations typically exhibit pronounced fluctuations in response to seasonal (and episodic) recharge/discharge cycles.

As shown on Figure 2, a time-series plot of the nitrate concentrations detected in the groundwater samples collected to date shows a short-term increase between May 1992 (37.8 mg/L) and February 1993 (61 mg/L), with subsequent sampling results defining a long-term deceasing trend (spanning the gap in the sampling history for the well) though August 2005 (10.5 mg/L). The overall decrease in nitrate concentrations primarily reflects the substantially reduced flux of nitrate in the Maynardville Limestone following the closure/capping of the former S-3 Ponds, and indicates that the most highly contaminated groundwater has been flushed form the shallow karst network.

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with values slightly above the drinking water MCL (0.03 mg/L) reported for the samples collected in March and August 2005 (Table 1). Note, however, that none of the other Exit Pathway Picket C wells yield groundwater samples with uranium concentrations that exceed the MCL. Nevertheless, the elevated concentrations of uranium indicate that the monitored interval in the well intercepts groundwater flow/transport pathways for uranium from the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only confirmed source of uranium located hydraulically upgradient of Exit Pathway Picket C. Additionally, a time-series plot of the uranium results shows a clearly increasing long-term concentration trend (Figure 3), as illustrated by the uranium concentrations reported for the samples collected in May 1992 (0.006 mg/L), December 1994 (0.0088 mg/L), March 2002 (0.0298 mg/L), and March 2005 (0.0309 mg/L). As with nitrate, the long-term uranium concentration trend spans a significant gap in the sampling history and the change in the groundwater sampling procedure. Nevertheless, this increasing concentration trend potentially reflects a corresponding increase in the relative flux of uranium via the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, increase flux of uranium seems conspicuous considering that the disposal of wastewater at the former S-3 Ponds ceased more than 20 years ago and that similarly increasing flux of other contaminants from the site, particularly nitrate, is not indicated by the data for the well.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in the groundwater samples collected to date (Table 2): benzene, ethylbenzene, carbon disulfide, CTET, chloroform, styrene, PCE, TCE, xylenes, 11DCA, 11DCE, and 112DCA. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient of the Exit Pathway Picket C wells, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE. Hydraulically downgradient (west) of Exit Pathway Picket C, additional influx of VOCs (primarily PCE) occurs from several sources within the Oil Landfarm waste management area (WMA) and the Bear Creek Burial Grounds WMA. Individual and summed VOC concentrations are highest (>300 µg/L) in the deeper groundwater flow/transport pathways (>200 ft bgs) in the Maynardville Limestone directly south (down dip) of the Oil Landfarm WMA, where the main channel of Bear Creek loses substantial flow to the groundwater (karst) system and where groundwater elevations in clustered monitoring wells indicate strongly downward vertical hydraulic gradients in the Maynardville Limestone (DOE 1997).

Based on frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples collected to date are PCE, TCE, and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample, with the historical maximum concentration of 21 µg/L in May 1992. Also, the most recent sampling results (March and August 2005) show that the TCE concentrations remain slightly above the drinking water MCL (5 µg/L). All but one of the samples also contained 12DCE (c12DCE), although all of these results are less than 10 µg/L, with most being estimated concentrations below 5 µg/L. Similarly low concentrations of PCE have been detected in all but four of the samples collected to date, with the historical maximum concentration (7 µg/L in February 2003) being the only result above the MCL (5 µg/L). The remaining compounds were detected at concentrations of 5 µg/L or less and only in samples collected in May 1992, August 1992, and February 1993.

A time-series plot of TCE concentrations detected in the groundwater samples collected to date shows a steadily decreasing long-term concentration trend that is dominated by the nearly seven-year gap in the sampling history (Figure 4). Also, as illustrated by the TCE results for the samples collected in September 1995 (10 µg/L), July 2002 (9 µg/L) and August 2005 (7 µg/L), the rate of concentration decrease appears to have slowed considerably. The overall decrease in TCE levels probably reflects the reduced flux of VOCs following the closure/capping of the former S-3 Ponds and long-term natural attenuation of the VOC sources at Spoil Area I and the Rust Spoil Area, both of which were closed without further remedial action (e.g., waste removal or installation of low-permeability cap). Note also that the concentrations of other VOCs do not exhibit similarly decreasing long-term trends (Table 2), as illustrated by the PCE results reported for the samples collected in October 1992 (2 µg/L) September 1993 (1 µg/L), July 2002 (2 µg/L), and August 2005 (1 µg/L). Assuming a heterogeneous mixture of dissolved VOCs in the karst network at shallow depths in the Maynardville Limestone, it is unclear why the TCE and PCE concentrations exhibit such divergent trends or if such differences are significant with respect to the relative flux of dissolved VOCs. Perhaps the TCE and PCE (and other VOCs) are not well mixed in the groundwater system, but instead occur within separate, discreet transport pathways that are intercepted by the monitored interval in the well. The divergent concentration trends also may reflect differential transport from separate source areas, with decreased flux from the source of TCE (Rust Spoil Area) and comparably more consistent flux of PCE from another upgradient source (e.g., Spoil Area I).

5.4 GROSS ALPHA ACTIVITY

Ten groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 1), although only the historical maximum value (24 pCi/L in March 2002) exceeds the drinking water MCL for gross alpha activity (15 pCi/L). However, this result may be an outlier because all other results for gross alpha activity are less than 15 pCi/L. Note also that the highest levels of gross alpha activity have all been reported for the samples collected after the transition to the low-flow groundwater sampling method in 1998 and the nearly seven-year gap in the groundwater sampling history for the well. Nevertheless, uranium isotopes (and alpha-emitting daughters) in the groundwater are the likely source of the gross alpha activity, as indicated by the low levels of U-234 and U-238 detected in the groundwater samples collected in March and August 2005 (Table 1). Upgradient sources of the uranium isotopes are the same as noted for total uranium in Section 5.2 and, as with total uranium, U-234 and U-238 ions leached from the source area(s) probably combined with carbonate dissolved from the (limestone) bedrock, which greatly increased their relatively limited mobility in the neutral pH groundwater in the Maynardville Limestone (DOE 1997).

5.5 GROSS BETA ACTIVITY

All but one of the groundwater samples collect to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), and results reported for the samples collected in September 1993 (57.9 pCi/L), December 1993 (52 pCi/L), and March 2002 (68 pCi/L) exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Uranium isotopes (and beta-emitting daughters) in the groundwater (see Section 5.4) may be a source of the gross beta activity. However, the detection of Tc-99 in the samples collected in March (13 pCi/L) and August 2005 (23 pCi/L) indicate that this beta-emitting radionuclide may be the primary source of the gross beta activity in the groundwater from this well. Note that both Tc-99 results are substantially below the SDWA screening level (900 pCi/L) for a 4 mrem/yr dose equivalent. Nevertheless, Tc-99 is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing this radionuclide (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate, which reflects their common source and their similar transport characteristics in the groundwater.

A time-series plot of gross beta activity values reported for the groundwater samples collected to date shows an indeterminate long-term trend dominated by "peak" values in September 1993 (57.9 pCi/L) and March 2002 (68 pCi/L) and the nearly seven-year gap in the sampling history (Figure 5). Aside from these peaks, the results suggest a widely variably but slightly decreasing trend, as indicated by the results reported for the samples collected in May 1994 (49.5 pCi/L), September 1995 (38.7 pCi/L), and August 2005 (30 pCi/L). This potentially reflects a corresponding overall decrease in the relative flux of Tc-99 in response to the closure/capping of the former S-3 Ponds.

5.6 OTHER

As noted in Section 4.0, unusually high aluminum and iron concentrations were detected in (unfiltered) groundwater samples collected using the low-flow method during seasonally high flow directions (March 2002 and March 2005) and appear related to elevated total suspended solids (TSS). This correlation potentially indicates colloidal co-transport of aluminum and iron complexes in the groundwater. Although these samples also had elevated concentrations of several other metals (e.g., beryllium, copper, vanadium, and zinc), these results most likely reflect analytical interferences associated with the high levels of aluminum and iron. As illustrated by the data included in the following summary, the aluminum and iron concentrations appear to fluctuate concurrently with TSS levels, whereas similar correlations are not evident between TSS and the concentrations of other trace metals (barium, strontium, and uranium) detected in the samples (and not influenced by analytical interferences).

Date Sampled	Concentration (mg/L)					
	TSS	Aluminum	Iron	Barium	Strontium	Uranium
Conventional Sampling						
02/28/95	<1	<0.02	0.036	0.2	0.3	0.0086
09/26/95	<1	<0.02	0.0084	0.21	0.32	0.0093
Low-Flow Sampling						
03/06/02	91	30.7	20.7	0.327	0.389	0.0298
07/17/02	8	9.35	5.14	0.229	0.364	0.0256
03/03/05	13	20.1	18.7	0.278	0.327	0.0309
08/02/05	2	1.43	0.883	0.883	0.329	0.0308

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

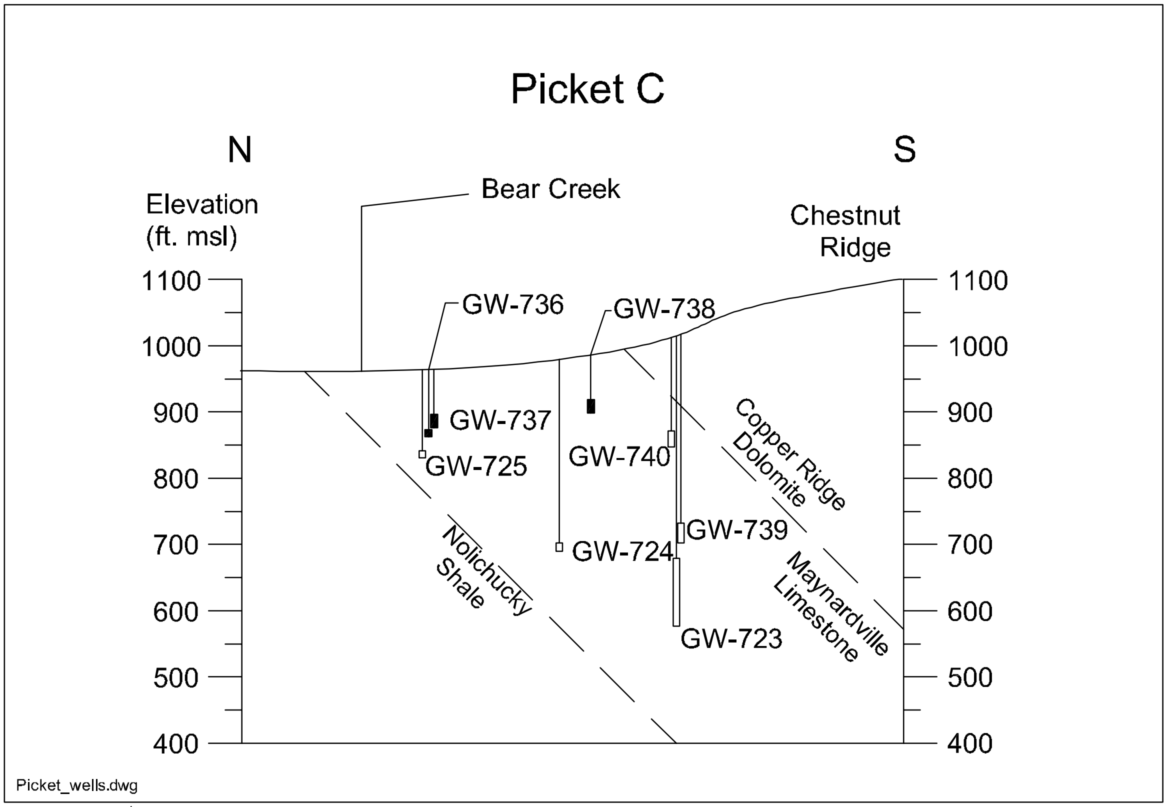
Table 1. Well GW-736: summary of results for nitrate, total uranium, and radioanalytes

Sampling Date	Concentration (mg/L)		Activity (pCi/L)				
	Nitrate	Total Uranium	Gross Alpha	Gross Beta	Tc-99	U-234	U-238
05/22/92	37.8	0.006	6.01	48.9	.	.	.
08/27/92	52	0.007	7.82	18.6	.	.	.
10/30/92	54	0.007	< CE	13.8	.	.	.
02/11/93	61	0.007	7.8	22.9	.	.	.
05/18/93	42	0.003	< CE	45.2	.	.	.
09/28/93	43.8	0.006	< CE	57.9	.	.	.
12/15/93	42.4	0.008	4.12	52	.	.	.
03/21/94	37.79	0.009	< CE	49.5	.	.	.
12/19/94	34	0.0088	1.98	47.9	.	.	.
02/28/95	32	0.0086	3.41	43.7	.	.	.
09/26/95	31	0.0093	2.31	38.7	.	.	.
03/06/02	17.8	0.0298	24	68	.	.	.
07/17/02	15.3	0.0256	<MDA	<MDA	.	.	.
03/03/05	11	0.0309	14	33	13	6.6	8.9
08/02/05	10.5	0.0308	11	30	23	5.6	8.2
MCL	**10**	**0.03**	**15**	**50***	**900***	**NA**	**NA**
Note: "." = Not analyzed; * = MCL is SDWA screening level for 4 mrem/yr dose equivalent							

Table 2. Well GW-736: summary of VOC results

Sampling Date	Concentration (µg/L)			
	PCE	TCE	12DCE	c12DCE
05/22/92	.	21	.	NR
08/27/92	3 J	20	8	NR
10/30/92	2 J	14	5	NR
02/11/93	7	12	7	NR
05/18/93	3 J	12	5	NR
09/28/93	1 J	9	3 J	NR
12/15/93	3 J	13	5	NR
03/21/94	1 J	6	3 J	NR
12/19/94	.	4 J	2 J	NR
02/28/95	.	5	2 J	NR
09/26/95	4 J	10	4 J	NR
03/06/02	.	8	2 J	2 J
07/17/02	2 J	9	3 J	3 J
03/03/05	2 J	8	2 J	2 J
08/02/05	1 J	7	2 J	2 J
MCL	**5**	**5**	**NA**	**70**
Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable NR = Not reported				

One or more of the following compounds also were detected at concentrations of 5 ug/L or less in samples collected May 1992, August 1992, and February 1993: benzene, chloroform, carbon tetrachloride, carbon disulfide, ethylbenzene, styrene, xylenes,. 11DCE, 11DCA, and 112DCA.



Screened Well Construction

Open-Hole Well Construction

Figure 1

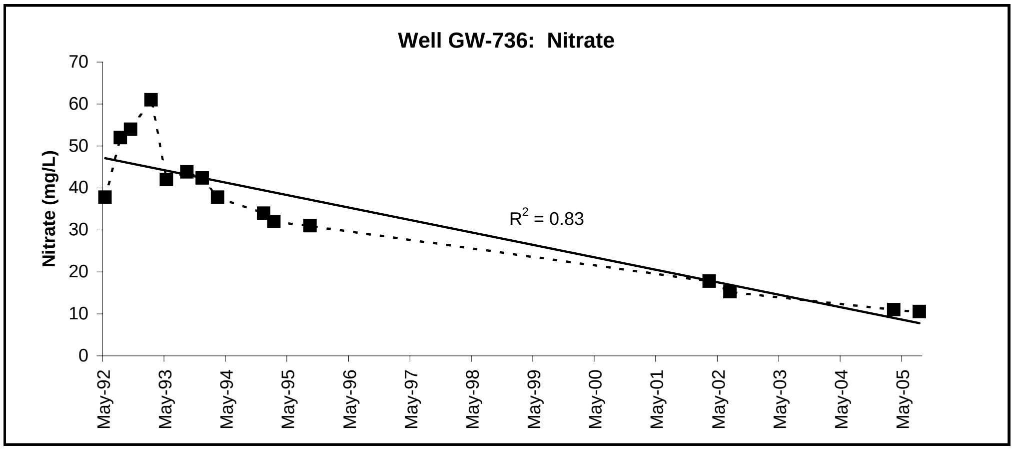


Figure 2

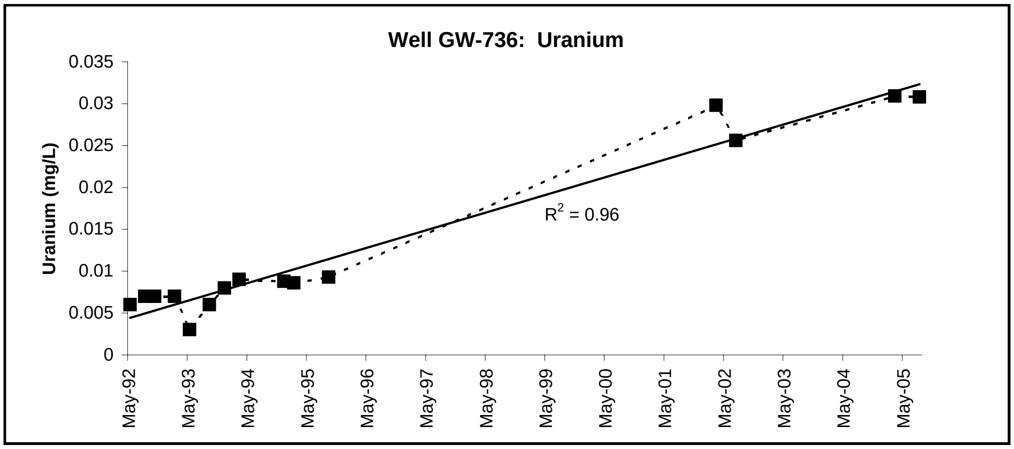


Figure 3

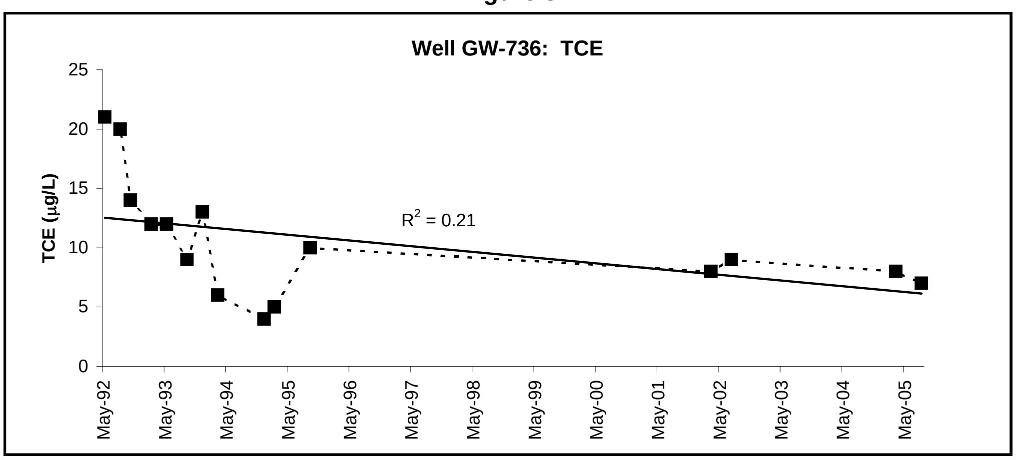


Figure 4

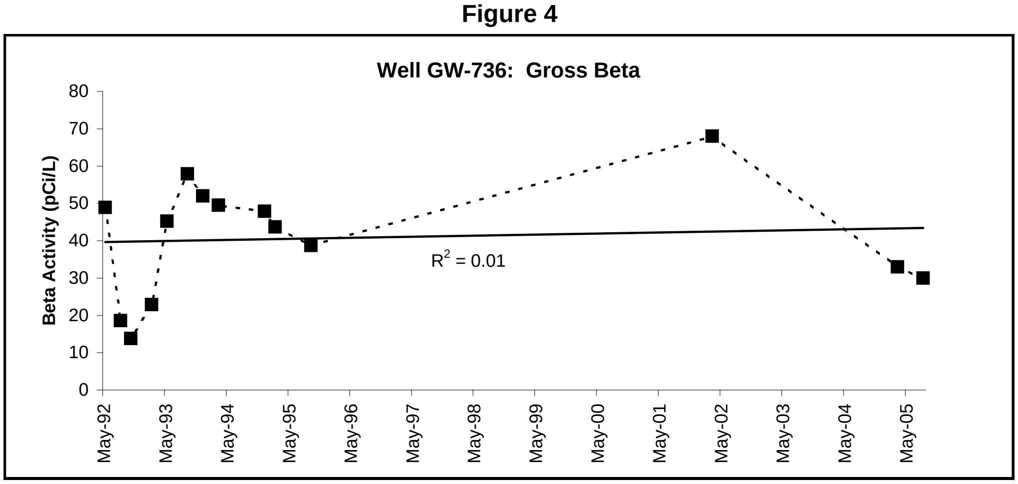


Figure 5

MAXIMUM CONCENTRATION: 2005

5 - 10	0.015 - 0.03	5 - 50	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-737

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 48,890.01
Y-12 GRID NORTH COORDINATE: 29,365.49
SURFACE ELEVATION: 957.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/07/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 92.03 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 960.07 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	79.0	878.50
BOTTOM (filter pack or open hole):	89.5	868.00
MIDPOINT (filter pack or open hole):	84.3	873.25
PUMP INTAKE:	84.4	873.07
WATER LEVEL (average):	9.39	948.11

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	11 samples	05/22/92	09/26/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/06/02	08/02/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/03/05	.	08/02/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.11 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	13	61 mg/L	10/30/92	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	15	37 µg/L	08/27/92	Decreasing
GROSS ALPHA (15 pCi/L):	1	23.8 pCi/L	08/27/92	Outlier
GROSS BETA (50 pCi/L):	2	60.8 pCi/L	12/15/93	Decreasing

WELL GW-737

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1991, completed with a screened monitored interval from 79 to 89.5 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire wound). The well is located in Bear Creek Valley (BCV) west of Y-12, on the north side of Bear Creek Road and directly south of the main channel of Bear Creek, approximately 300 ft downstream of confluence between the main channel and a northern tributary (NT-2) of the creek. This wells is a component of Exit Pathway Picket C, which consists of a series of wells (GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a north-south transect approximately 3,000 ft west of Y-12 (Figure 1).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain eleven samples between May 1992 and September 1995, and the low-flow sampling method used to obtain four samples between March 2002 and August 2005. The sampling history includes quarterly sampling between May 1992 and December 1993, with semiannual sampling in 1994 and 1995, a nearly seven-year period (September 1995 – March 2002) when no samples were collected from the well, and semiannual sampling in 2002 and 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network provides the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of approximately 9 ft bgs and exhibits seasonal fluctuations of approximately 7 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 522 – 876 mg/L;
- pH of 6.5 – 7.29 (field measurements);

- elevated concentrations of sodium (>25 mg/L), chloride (>50 mg/L), and sulfate (>40 mg/L) relative to other wells completed at similar depth in the Maynardville Limestone; and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

Dissolution of locally disseminated sulfides in the Maynardville Limestone may account for the elevated levels of sulfate in the groundwater at this well, and the elevated concentrations of sodium and chloride potentially indicate that the well does not intercept highly permeable groundwater flowpaths. Instead, the well may be completed in a relatively low-yield interval where the groundwater geochemistry resembles that of the sodium-bicarbonate groundwater typically encountered at a depth of approximately 100 ft bgs in the Nolichucky Shale (and other low-permeability formations of the Conasauga Group). The sodium-bicarbonate geochemistry of the groundwater, which is accompanied by a general increase in chloride levels and TDS, is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et al. 1992). Thus, the elevated levels of sodium and chloride (and TDS) may indicate that the well yields groundwater with higher residence time than typical of the more permeable intervals at shallow depths in the Maynardville Limestone. Also, considering that the monitored interval intercepts groundwater flowpaths within the lower part of the Maynardville Limestone (Figure 1), the atypical sodium and chloride levels the groundwater in the well potentially indicates hydraulic connection with the sodium-bicarbonate groundwater from the Nolichucky Shale.

As illustrated by the selected data summarized below, sodium and chloride concentrations appear to have increased (nearly doubled) during the prolonged gap in the sampling history for the well. Although the higher sodium and chloride levels appear to coincide with the change from conventional sampling to low-flow sampling, the concentrations of other major ions (e.g., potassium and sulfate) exhibit no apparent change coincident with the sampling method. Thus, the elevated sodium and chloride concentration do not appear to be artifacts related to the sampling method, but instead seem to define the passing of a temporal "slug" of sodium- and chloride-enriched groundwater via the flowpaths intercepted by the monitored interval in the well.

Sampling Method and Date		**Concentration (mg/L)**			
		Sodium	**Chloride**	**Potassium**	**Sulfate**
Conventional Sampling	05/22/92	22	49	3.9	46
	09/28/93	23	54	3.2	38
	03/21/94	22	52	3.3	40.1
	09/26/95	21	46	3.1	42
Low-Flow Sampling	03/06/02	40.2	96.3	3.33	40.6
	07/18/02	35.9	79.5	3.29	40.3
	03/03/05	33.2	54.2	3.28	39
	08/02/05	28.3	48.2	2.94	39.5

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show nitrate, VOCs, and gross beta activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, and only the results for the samples collected most recently (March and August 2005) are below the 10 mg/L drinking water MCL for nitrate (Table 1). Elevated nitrate concentrations in the samples indicate that the monitored interval for the well intercepts groundwater flow/transport pathways for nitrate (and other contaminants) released from the former S-3 Ponds, which are RCRA-regulated, unlined surface impoundments that were closed in 1988 and covered with a multilayer low-permeability cap in 1989. Located approximately 3,500 ft east-northeast (hydraulically upgradient) of Exit Pathway Picket C, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984, which emplaced a heterogeneous plume of inorganic, organic, and radiological contaminants in the groundwater. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale, which underlies the former S-3 Ponds, and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Because nitrate is chemically stable and highly mobile in groundwater, the elevated concentrations of nitrate (>10 mg/L) effectively trace the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of elevated nitrate concentrations in the Maynardville Limestone west of Y-12 reflects: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for approximately 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic communication with surface water in Bear Creek.

As noted previously and shown by data summarized in Table 1, nitrate concentrations above 10 mg/L were detected in all of the groundwater samples except those collected in March (5.4 mg/L) and August 2005 (6.65 mg/l), with a historical maximum concentration of 61 mg/L in October 1992. Unlike the nitrate concentrations evident in the groundwater at other Maynardville Limestone wells west of Y-12, including several Exit Pathway Picket C wells, the nitrate results for this well do not indicate wide temporal (seasonal) concentration fluctuations, as illustrated by the most recent sampling results noted above. This too supports the possibility, as noted in Section 4.0 regarding the unusual geochemistry of the groundwater samples, that the monitored interval in the well may not intercept the more permeably flowpaths at shallow depths in the Maynardville Limestone, where nitrate concentrations typically exhibit pronounced temporal fluctuations in response to seasonal (and episodic) recharge/discharge cycles.

As shown on Figure 2, a time-series plot of nitrate concentrations detected in the groundwater samples collected to date shows a short-term increase between May 1992 (43.9 mg/L) and October 1992 (61 mg/L), with subsequent sampling results defining a long-term decreasing trend, (spanning the gaps in the sampling history for the well) through the historical minimum value in March 2005 (5.4 mg/L). The overall decrease in nitrate concentrations primarily reflects the substantially reduced flux of nitrate in the Maynardville Limestone following the closure/capping of the former S-3 Ponds, and indicates that the most highly contaminated groundwater has been flushed from the shallow karst network.

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (Table 1), with the highest value (0.017 mg/L in March 2005) being below the drinking water MCL for uranium (0.03 mg/L). Note, however, that the concentrations reported for the samples collected since March 2002 substantially exceed all previous results. These results, although below the MCL, suggest an increasing long-term concentration trend, as illustrated by a time-series plot of the uranium results reported for the samples collected to date (Figure 3).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): CTET, chloroform, PCE, TCE, 12DCE, 111TCA, 11DCA, and vinyl acetate. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient of the Exit Pathway Picket C wells, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), the latter site considered a primary source of TCE. Hydraulically downgradient (west) of Exit Pathway Picket C, additional influx of VOCs (primarily PCE) occurs from several sources within the Oil Landfarm waste management area (WMA) and the Bear Creek Burial Grounds WMA. Individual and summed VOC concentrations are highest (>300 µg/L) in the deeper groundwater flow/transport pathways (>200 ft bgs) in the Maynardville Limestone directly south (down dip) of the Oil Landfarm WMA, where the main channel of Bear Creek loses substantial flow to the groundwater (karst) system and where groundwater elevations in clustered monitoring wells indicate strongly downward vertical hydraulic gradients in the Maynardville Limestone (DOE 1997).

Based on frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples are PCE, TCE, and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample collected to date, with the historical maximum concentration of 21 µg/L in August 1992, and the most recent sampling results (March and August 2005) showing TCE concentrations at or slightly above the drinking water MCL (5 µg/L). Most of the samples also contained PCE and 12DCE (c12DCE), with all the results for PCE and all but three of the results for 12DCE being estimated values below 5 µg/L, and the most recent results showing concentrations below the respective MCL for each compound (Table 2). The remaining compounds were detected infrequently, with chloroform detected most often (six samples), and all these results are estimated values of 1 or 2 µg/L. Additionally, like the nitrate levels, none of the VOCs appear to exhibit wide concentration fluctuations, as illustrated by the TCE concentrations detected in the samples collected in March (6 µg/L) and August 2005 (5 µg/L).

A time-series plot of TCE concentrations detected in the groundwater samples collected to date shows a generally decreasing long-term concentration trend (Figure 4). The overall decrease in TCE levels probably reflects the reduced flux of TCE (and other VOCs) following the closure/capping of the former S-3 Ponds and the long-term natural attenuation of the VOC sources at Spoil Area I and the Rust Spoil Area, both of which were closed without further remedial action (e.g., waste removal or installation of low-permeability cap). Note, however, that the concentrations of other VOCs detected in the samples collected to date do not exhibit similarly decreasing long-term trends, as illustrated by the PCE results for reported for the samples collected in May 1993 (3 µg/L), March 1995 (4 µg/L), March 2002 (3 µg/L), and March 2005 (3 µg/L). Assuming a heterogeneous mixture of dissolved VOCs in the karst network at shallow depths in the Maynardville Limestone, it is unclear why the TCE and PCE concentrations exhibit such divergent temporal trends or if such differences are significant with respect to the relative flux of dissolved VOCs. Perhaps the TCE and PCE (and other VOCs) are not well mixed in the groundwater system, but instead occur within separate, discreet transport pathways that are intercepted by the monitored interval in the well. The divergent concentration trends also may reflect differential transport from separate source areas, with decreased flux from the source of TCE (Rust Spoil Area) and comparably more consistent flux of PCE from another upgradient source (e.g., Spoil Area I).

5.4 GROSS ALPHA ACTIVITY

Nine groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the highest value (23.8 pCi/L in August 1992) exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, this result is a suspected outlier because all other gross alpha results are less than 10 pCi/L.

5.5 GROSS BETA ACTIVITY

All of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE (Table 1), including results for two samples (52.8 pCi/L in September 1993 and 60.8 pCi/L in December 1993) that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Although most of the gross beta results are less than the SWDA screening level, they exceed background levels and are probably attributable to Tc-99, a beta-emitting radionuclide that is considered a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds. Also, the lack of elevated gross alpha activity (and relatively low total uranium concentrations) suggests that uranium isotopes (and beta-emitting decay products) are not present in the groundwater at this well. Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on results of radiological analyses for Tc-99 and the distribution of elevated gross beta activity indicated by the network of wells in BCV west of Y-12, the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate (see Section 5.1), which reflects their common source and their similar transport characteristics in the groundwater.

Excluding the historical minimum value (4.85 pCi/L in October 1992) as a suspected outlier compared to previous and subsequent results, gross beta activity above 40 pCi/L was reported for all the samples collected between May 1992 and September 1995 (Table 1). Also, considering the analytical variability inherent to the laboratory analyses for gross beta activity, the results do not indicate significant temporal fluctuations, as noted in the previous discussions of nitrate and VOC concentrations and illustrated by the gross beta activity reported for the samples collected in March (15 pCi/L) and August 2005 (21 pCi/L). The apparent lack of significant temporal variability in gross beta activity (and nitrate and VOC concentrations) supports the possibility that the monitored interval in the well may not intercept the more permeable flowpaths at shallow depths in the Maynardville Limestone, where gross beta activity (i.e., Tc-99 concentrations) typically exhibit pronounced temporal fluctuations in response to seasonal (and episodic) recharge/discharge cycles.

A time-series plot of gross beta activity (excluding the suspected outlier noted above) reported for the groundwater samples collected to date shows an indeterminate trend between May 1992 (44 pCi/L) and September 1995 (47 pCi/L), with subsequent results showing a decreasing long-term trend, spanning the gaps in the sampling history, through March 2005 (15 pCi/L) (Figure 5).

6.0 REFERENCES

Bechtel Jacobs Company LLC. (BJC). 2004. *Calendar Year 2003 Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* BJC/OR-1730, prepared for Bechtel Jacobs Company LLC, Oak Ridge, TN.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-737: summary of results for nitrate, total uranium, gross alpha activity, and gross beta activity

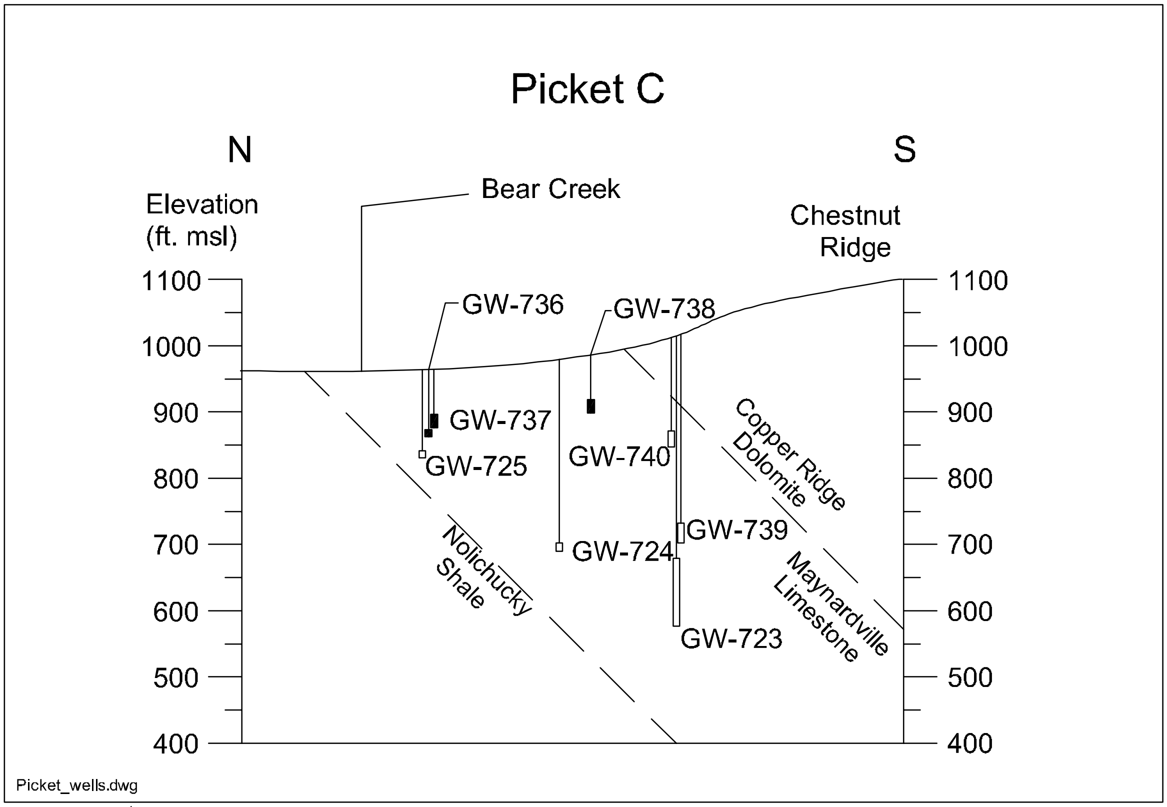
Sampling Date	Concentration (mg/L)		Activity (pCi/L)	
	Nitrate	Total Uranium	Gross Alpha Activity	Gross Beta Activity
05/22/92	43.9	0.005	<CE	44
08/27/92	54	0.007	[23.8]	48.2
10/30/92	61	0.006	<CE	[4.85]
02/11/93	57	0.009	9.66	23.6
05/19/93	37	0.009	<CE	42
09/28/93	49.9	0.005	<CE	52.8
12/15/93	44.3	0.008	5.85	60.8
03/21/94	41.99	0.01	3.15	44.1
12/18/94	34	0.0089	3.2	42.7
03/01/95	33	0.009	3.84	42.8
09/26/95	33	0.0088	<CE	47.4
03/06/02	14.2	0.0162	9.6	32
07/18/02	11.6	0.0141	5.9	29
03/03/05	5.4	0.017	5.1	15
08/02/05	6.65	0.0163	<MDA	21
MCL	**10**	**0.03**	**15**	**50***
Note: * = MCL is SDWA screening level for 4 mrem/yr dose equivalent; [ ] = suspected outlier				

Table 2. Well GW-737: summary of VOC results

Sampling Date	Concentration (μg/L)				
	PCE	**TCE**	**12DCE**	**c12DCE**	**Chloroform**
05/22/92	.	18	.	NR	2 J
08/27/92	4 J	21	9	NR	2 J
10/30/92	3 J	15	5	NR	.
02/11/93	4 J	9	4 J	NR	2 J
05/19/93	3 J	9	4 J	NR	2 J
09/28/93	3 J	9	3 J	NR	1 J
12/15/93	3 J	11	4 J	NR	.
03/21/94	2 J	4 J	2 J	NR	.
12/18/94	3 J	12	4 J	NR	.
03/01/95	4 J	15	6	NR	1 J
09/26/95	4 J	11	4 J	NR	.
03/06/02	3 J	5	2 J	2 J	.
07/18/02	2 J	7	.	.	.
03/03/05	3 J	6	2 J	2 J	.
08/02/05	2 J	5 J	1 J	1 J	.
MCL	**5**	**5**	**NA**	**70**	**80***

Sampling Date	Compound/Concentration (μg/L)
05/22/92	CTET (1 J), 11DCA (1 J),111TCA (1 J)
08/27/92	Vinyl acetate (1 J)
02/11/93	CTET (1 J)

Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported;
* = MCL is for total trihalomethanes



Screened Well Construction

Open-Hole Well Construction

Figure 1

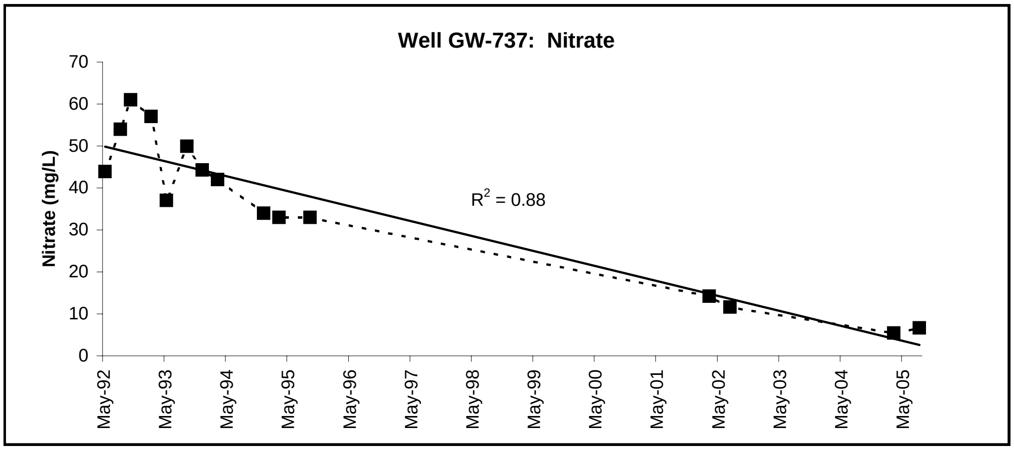


Figure 2

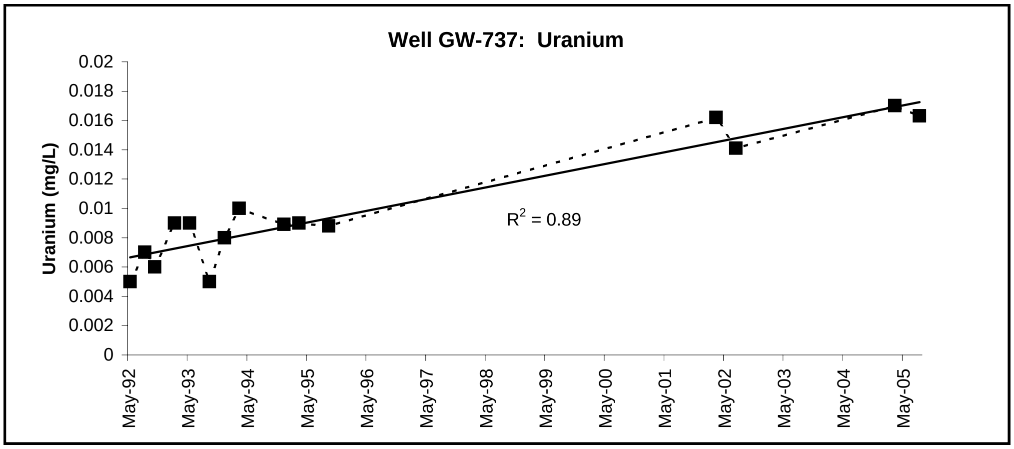


Figure 3

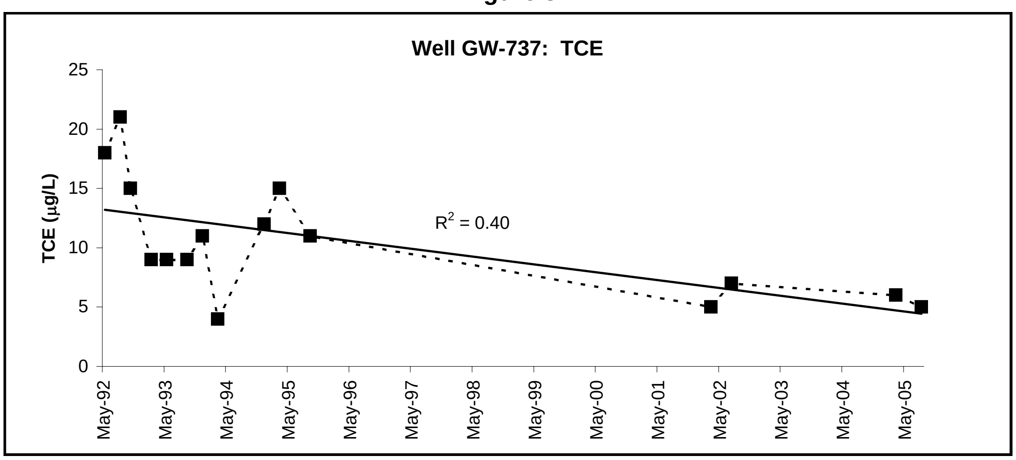


Figure 4

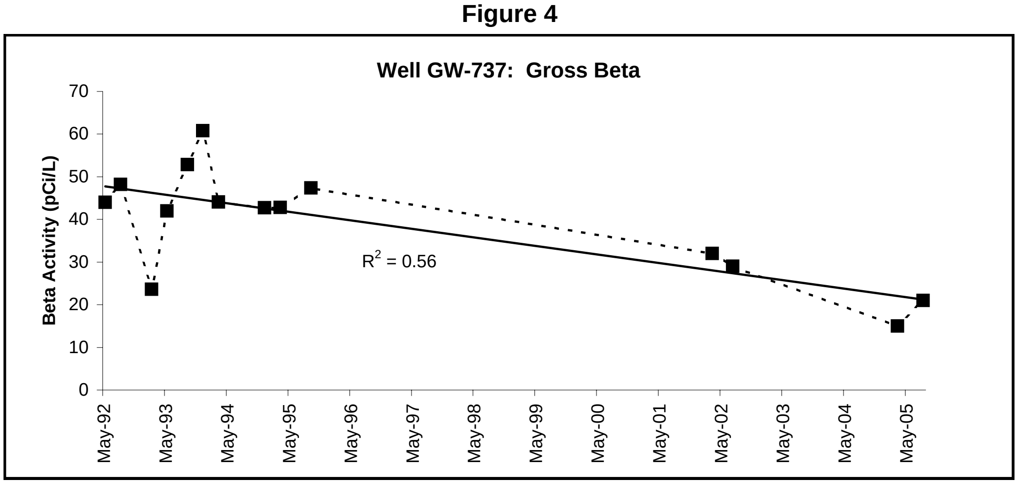


Figure 5

GW-737

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
5 - 10	<0.015	5 - 50	ND	25 - 50

GW-738

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 49,025.75
Y-12 GRID NORTH COORDINATE: 29,149.69
SURFACE ELEVATION: 980.36 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/21/91 PAIRED/CLUSTERED WITH: GW-724
TAG DEPTH (measured): 91.78 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 983.31 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	63.5	916.86
BOTTOM (filter pack or open hole):	88.0	892.36
MIDPOINT (filter pack or open hole):	75.8	904.61
PUMP INTAKE:	78.55	901.81
WATER LEVEL (average):	26.14	954.22

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	15 samples	05/26/92	09/04/97
LOW-FLOW SAMPLING METHOD:	15 samples	03/04/98	07/26/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	.	07/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.78 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	25	40.4 mg/L	09/27/93	Decreasing
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	99 µg/L	05/26/92	Decreasing
GROSS ALPHA (15 pCi/L):	1	33.7 pCi/L	10/29/92	Outlier
GROSS BETA (50 pCi/L):	5	65 pCi/L	01/24/01	Indeterminate

WELL GW-738

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1991, completed with a screened monitored interval from 63.5 to 88 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire wound). The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone subcrops along the axis of BCV and underlies the main channel of Bear Creek.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between May 1992 and September 1997, and the low-flow sampling method used to obtain 15 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Maynardville Limestone (Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 26 ft bgs and exhibits seasonal fluctuations up to about 8 ft. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV and on Chestnut Ridge, groundwater elevation isopleths in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 425 – 650 mg/L;
- pH of 6.2 – 7.8 (field measurements);
- elevated concentrations of sulfate (>30 mg/L) relative to other wells completed at similar depths in the Maynardville Limestone;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

It is not clear if the elevated sulfate concentrations typical of the groundwater samples reflect localized geochemical characteristics, such as dissolution of locally disseminated sulfide minerals, or if the elevated concentrations are the result of contamination from one or more sources upgradient of the well.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, nitrate and VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-nine of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit (one sample was not analyzed for nitrate), and all but two of these results exceed the MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 3,500 ft east-northeast of the Exit Pathway Picket C, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells, the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek.

Aside from the historical maximum nitrate concentration (40.5 mg/L in September 1993) and the historical minimum nitrate concentration (1.5 mg/L in May 1992), the remaining nitrate results generally range between 5 - 25 mg/L (Table 1). Also, the nitrate concentrations clearly exhibit significant temporal (seasonal) fluctuations, with the lowest levels (including the historical minimum) typically reported for samples collected during seasonally high groundwater flow (winter and spring), and the highest concentrations (including the historical maximum) typically reported for samples collected during seasonally low flow conditions (summer and fall). This relationship suggests seasonal (or episodic) "dilution" from recharge of uncontaminated (or less nitrate-contaminated) groundwater via the flow/transport pathways intercepted by the monitored interval in the well. Dilution associated with presampling recharge to the shallow flow system may explain the conspicuously low nitrate concentration reported for the sample collected in May 1992, which appears to be an outlier compared to the other nitrate results (Table 1).

A time-series plot of nitrate concentrations in the groundwater samples (excluding the suspected outlier result noted above) shows a generally decreasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 2). The overall decrease in nitrate concentrations is attributable to the reduced flux of nitrate from the former S-3 Ponds following closure of the site and installation of the low-permeability cap. Also, the nitrate results obtained with the low-flow sampling method seemingly exhibit greater temporal variability than the conventional sampling results. This may be an artifact of the semiannual sampling frequency used for low-flow sampling (the bulk of the conventional sampling events were performed quarterly), but also may be related to inherent differences in the manner in which each sampling method induces inflow of groundwater into the well. Conventional sampling involves aggressively purging the well (1-2 gallons per minute), which may substantially lower the water level in the well and induce inflow from water-producing features that may not be proximal to the monitored interval. In contrast, low-flow sampling involves purging the well at a flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater flow from the water-producing features near the well.

5.2 URANIUM

Twenty-eight groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit (one sample was not analyzed for uranium), with the highest value (0.0031 mg/L in January 2003) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): acetone, CTET, chloroform, PCE, TCE, xylenes, 12DCE (isomers), and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downstream (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Boneyard/Burnyard (BYBY), Hazardous Chemical Disposal Area (HCDA), and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest VOC concentrations within the Maynardville Limestone exceed 300 μg/L and occur in the deeper groundwater south (down dip) of the HCDA, about 1,500 ft west-southwest (hydraulically downgradient) of Exit Pathway Picket C. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek (DOE 1997).

The primary VOCs in the groundwater samples are TCE and 12DCE (Table 2). The dominant compound is TCE, which was detected in every sample, with the historical maximum concentration of 96 μg/L in May 1992. Also, the most recent sampling results (February and July 2004) show that the TCE concentrations remain substantially above the drinking water MCL (5 μg/L). Many of the samples also contained 12DCE (c12DCE), but at substantially lower concentrations than evident for TCE, with all of the results being estimated values (<5 μg/L) substantially below the MCL (70 μg/L). Twelve of the 15 samples collected between May 1992 and July 1997 contained low concentrations (estimated values below 5 μg/L) of chloroform, CTET, PCE, or 111TCA; only chloroform was detected in any of the samples collected since then (3 μg/L in July 2004). Acetone and xylene were detected in one sample each and both results may be analytical artifacts.

A time-series plot of TCE concentrations in the groundwater samples shows a steadily decreasing long-term concentration trend (Figure 3), with the most recent TCE concentration (20 μg/L in July 2004) being more than 50% lower than evident during the early and mid-1990s. The overall decrease in TCE levels probably results from corrective actions at the primary sources of VOCs in BCV west of Y-12, including the closure of the Oil Landfarm and BCBG WMAs and the installation of low-permeability caps at each site and the CERCLA remedial actions at the BYBY/HCDA, which involved the excavation and removal of contaminated soils above and below the saturated zone (BJC 2003). Additionally, the TCE results show significant temporal variation, with cyclical "peak" concentrations typically reported for samples obtained during seasonally high groundwater flow conditions (winter and spring). These temporal fluctuations potentially correspond with changes in the relative flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well. Also, the temporal changes in TCE concentrations show an inverse relationship with the corresponding fluctuations in nitrate concentrations and gross beta activity, whereby the respective levels of these contaminants are typically lowest in samples obtained during seasonally high groundwater flow conditions. This suggests the seasonal (or episodic) inflow/recharge of TCE-contaminated groundwater along the flowpaths intercepted monitored by well GW-738, and that the source(s) of TCE in groundwater at the well differ from that of nitrate (S-3 Site).

The concentrations of other VOCs detected in the groundwater samples do not exhibit the temporal fluctuations evident for TCE (Table 2). For instance, the 12DCE was detected at an estimated concentration of 2 μg/L in each of the six consecutive samples collected between August 1996 and February 1999. Assuming the plume of dissolved VOCs in the Maynardville Limestone contains a heterogeneous mixture of compounds, it is not clear from the available data why the concentrations of individual compounds exhibit such divergent temporal variations or if such variations are significant with respect to the relative flux of dissolved VOCs via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (33.7 pCi/L in October 1992) exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, the historical maximum appears to be an outlier compared to the other results for gross alpha activity, which are all less than 10 pCi/L.

5.5 GROSS BETA ACTIVITY

Twenty-eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, including results for seven samples that exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity), with the historical maximum value reported for the sample collected in October 1991 (159 pCi/L). The source of the gross beta activity in the groundwater at this well is believed to be Tc-99 based on the detection of this radionuclide (i.e., >MDA and CE) in the samples collected in

January (81 pCi/L) and July 2001 (65 pCi/L). Both results are substantially below the SDWA screening level (3,790 pCi/L) for a 4 mrem/yr dose from Tc-99. This beta-emitting radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

A time-series plot of gross beta activity reported for the groundwater samples shows an indeterminate or slightly increasing long-term trend dominated by wide temporal (seasonal) fluctuations (Figure 4). The indeterminate trend suggests minimal overall change in the relative flux of beta-emitting radionuclides via the groundwater flow/transport pathways intercepted by the monitored interval in the well. As with nitrate concentrations, the wide temporal changes in gross beta activity levels show cyclical "peak" values reported for samples obtained during seasonally low groundwater flow conditions (summer and fall), which suggests "dilution" from seasonal (and episodic) recharge of groundwater that does not contain beta-emitting radionuclides. Also, the gross beta activity reported for samples obtained with the low-flow sampling method seemingly exhibit greater temporal variability than the conventional sampling results for gross beta activity, but this may be an artifact of the semiannual sampling frequency (the bulk of the conventional sampling events were performed quarterly).

6.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203- 227).

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-738: summary of results for nitrate and gross beta activity

Sampling Date	Concentration	
	Nitrate (mg/L)	Gross Beta Activity (pCi/L)
05/26/92	[1.5]	24.3
08/25/92	22	43.2
10/29/92	27	48.7
02/10/93	22	41.4
05/18/93	15	30.2
09/27/93	40.4	47.5
12/14/93	24.8	60.1
03/16/94	17.3	48.3
12/17/94	22	50
02/18/95	18	42.3
09/17/95	19	44.5
03/20/96	14	33.2
08/08/96	12.7	22.2
02/25/97	11	<MDA
09/04/97	10.4	22
03/04/98	18	47
09/01/98	11.5	29
02/18/99	19.3	46
08/05/99	10.31	30
02/03/00	17.3	43
07/31/00	9.36	32
01/24/01	19.7	65
07/18/01	13.8	42
01/30/02	17.2	57
07/23/02	15.1	55
01/22/03	16.2	60
07/17/03	11.9	44
02/09/04	7.53	25
07/26/04	9.31	20
MCL	**10**	**50***

Note: [ ] = Result is a suspected outlier; * SDWA screening level for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity)

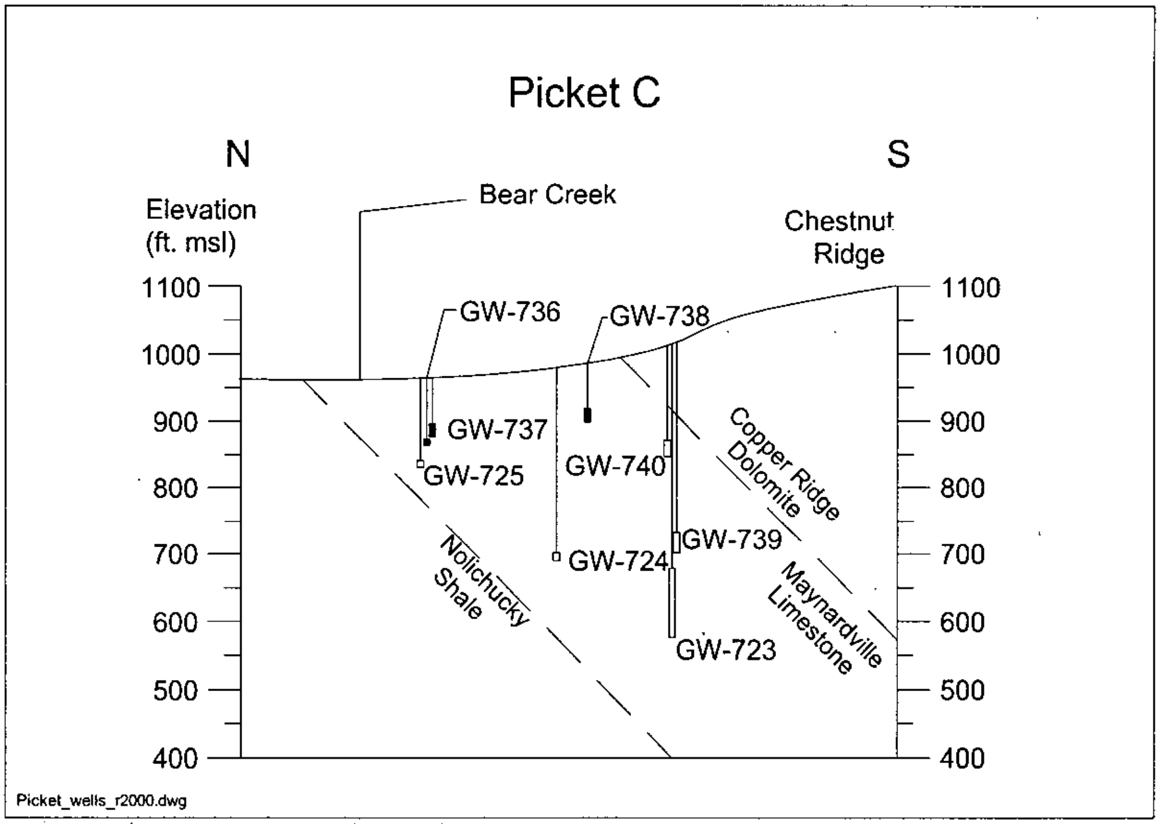
Table 2. Well GW-738: summary of VOC results

Date Sampled	Concentration (μg/L)			
	PCE	TCE	12DCE (Total)	c12DCE
05/26/92	.	96	.	NR
08/25/92	.	60	4 J	NR
10/29/92	.	65	4 J	NR
02/10/93	.	55	4 J	NR
05/18/93	.	51	3 J	NR
09/27/93	.	44	3 J	NR
12/14/93	.	50	3 J	NR
03/16/94	0.8 J	55	4 J	NR
12/17/94	.	20	1 J	NR
02/18/95	1 J	48	3 J	NR
09/17/95	1 J	52	4 J	NR
03/20/96	.	50	3 J	NR
08/08/96	.	40	2 J	NR
02/25/97	.	43	2 J	2 J
09/04/97	.	36	2 J	2 J
03/04/98	.	37	2 J	2 J
09/01/98	.	30	2 J	2 J
02/18/99	.	36	2 J	2 J
08/24/99	.	38	2 J	2 J
02/03/00	.	31	.	.
07/31/00	.	35	.	.
01/24/01	.	33	.	.
07/18/01	.	30	.	.
01/30/02	.	37	2 J	2 J
07/23/02	.	25	.	.
01/22/03	.	28	1 J	1 J
07/17/03	.	25	1 J	1 J
02/09/04	.	25	1 J	.
07/26/04	.	20	.	.
MCL	**5**	**5**	**NA**	**70**

Table 2. (continued)

Date Sampled	Concentration (µg/L)			
	Chloroform	CTET	111TCA	OTHER
05/26/92	FP	2 J	1 J	.
08/25/92	2 J	2 J	0.9	.
10/29/92	2 J	2 J	0.9	.
02/10/93	2 J	1 J	.	.
05/18/93	2 J	.	.	.
09/27/93	1 J	.	.	.
12/14/93	2 J	1 J	.	.
03/16/94	2 J	2 J	0.7 J	.
12/17/94	.	.	.	.
02/18/95	1 J	1 J	.	.
09/17/95	1 J	1 J	.	Xylene (1 J)
03/20/96	1 J	.	1 J	.
08/08/96	1 J	.	.	.
02/25/97	1 J	.	.	.
09/04/97	FP	1 J	.	.
03/04/98	FP	.	.	.
09/01/98	.	.	.	.
02/18/99	.	.	.	.
08/24/99	.	.	.	.
02/03/00	.	.	.	.
07/31/00	.	.	.	.
01/24/01	.	.	.	.
07/18/01	.	.	.	.
01/30/02	.	.	.	.
07/23/02	.	.	.	Acetone (6)
01/22/03	.	.	.	.
07/17/03	.	.	.	.
02/09/04	.	.	.	.
07/26/04	3 J	.	.	.
MCL	**5**	**NA**	**NA**	

Note: "." = Not detected; FP = False positive; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported



Screened Well Construction

Open-Hole Well Construction

Figure 1

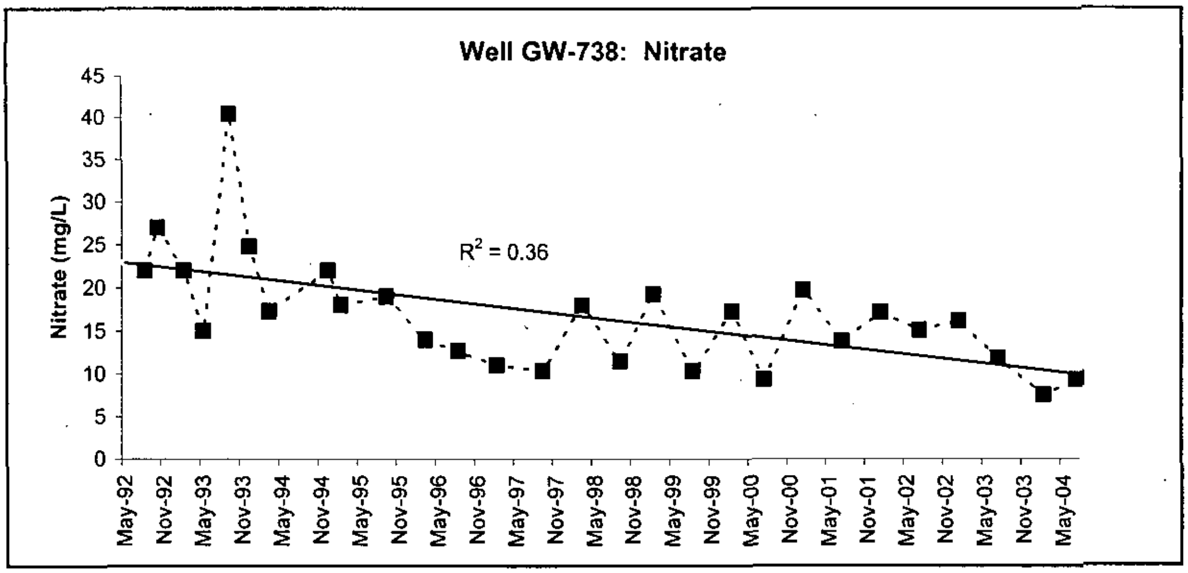


Figure 2

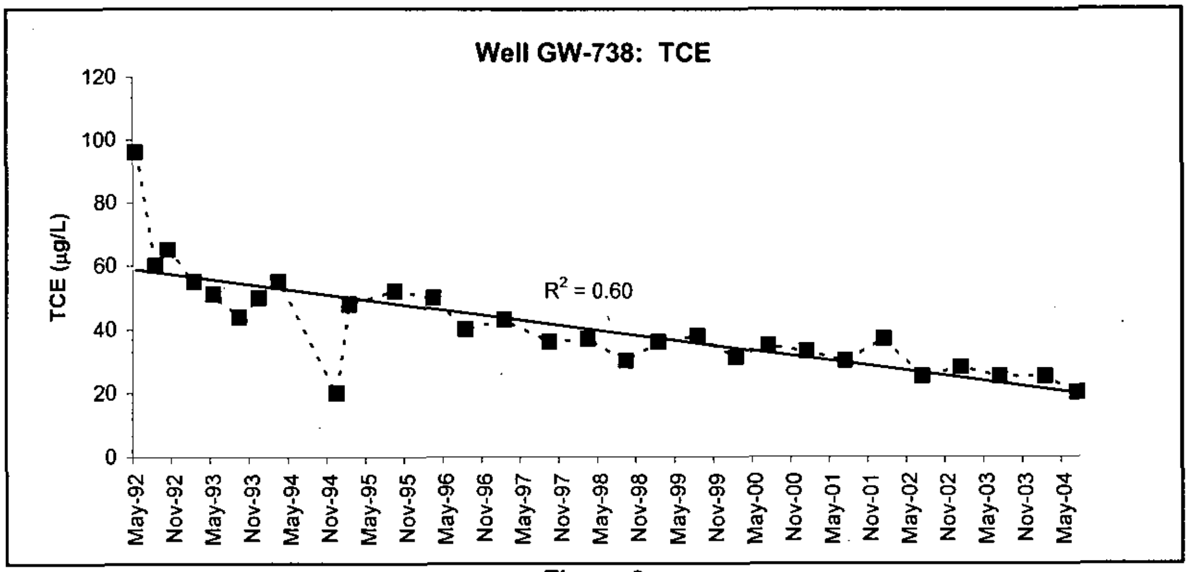


Figure 3

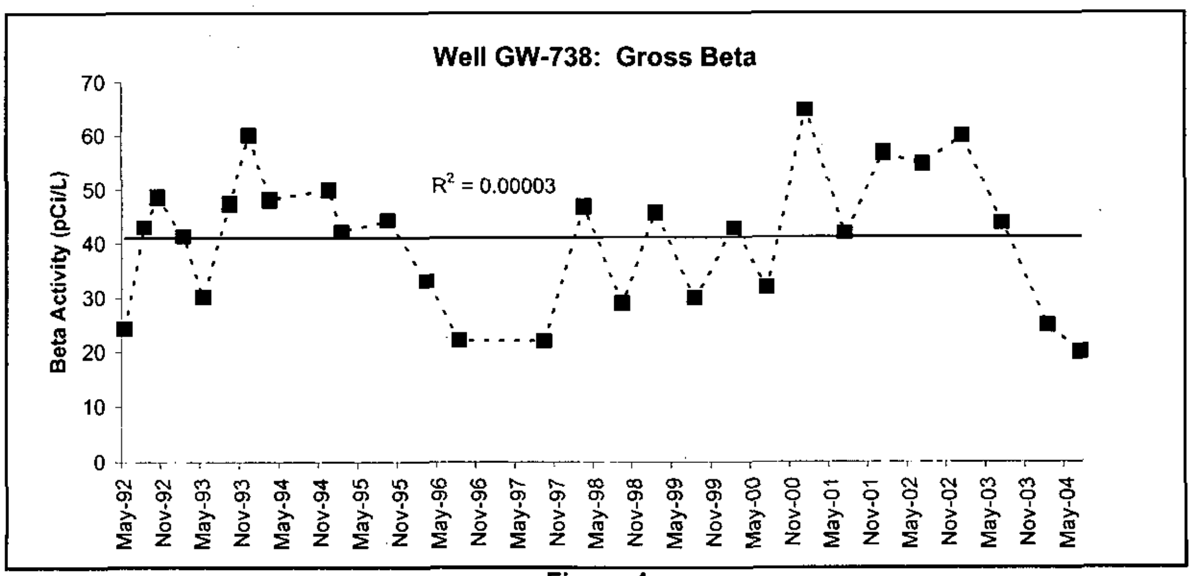


Figure 4

MAXIMUM CONCENTRATION: 2005

<5	<0.015	5 - 50	ND	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-739

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 49,125.60
Y-12 GRID NORTH COORDINATE: 29,010.00
SURFACE ELEVATION: 1,020.66 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 11/26/91 PAIRED/CLUSTERED WITH: GW-723 GW-740
TAG DEPTH (measured): 322.88 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,023.74 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	289.2	731.46
BOTTOM (filter pack or open hole):	320.0	700.66
MIDPOINT (filter pack or open hole):	304.6	716.06
PUMP INTAKE:	313.9	706.74
WATER LEVEL (average):	72.03	948.63

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	11 samples	05/27/92	09/16/95
LOW-FLOW SAMPLING METHOD:	4 samples	03/05/02	07/27/05

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2005	03/07/05	.	07/27/05	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.52 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS — Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	15	60 µg/L	05/27/92	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-739

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in November 1991, completed with an open-hole monitored interval from 289.2 to 320 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a north-south transect approximately 3,000 ft west of Y-12 (Figure 1).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between May 1992 and September 1995, and the low-flow sampling method used to obtain four samples between March 2002 and July 2005. The sampling history includes quarterly sampling between May 1992 and December 1993, with semiannual sampling in 1994 and 1995, a nearly 7-year period (September 1995 – March 2002) when no samples were collected from the well, and semiannual sampling in 2002 and 2005.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the deep (>300 ft bgs) bedrock interval in the Maynardville Limestone (Conasauga Group), which exhibits the hydrologic characteristics typical of karst aquifers. Most groundwater flow in the Maynardville Limestone, which subcrops along the axis of BCV and underlies the main channel of Bear Creek, occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Hydrologic interaction between the creek and the shallow karst network providing the principal exit-pathway for contaminants released from source areas within the Bear Creek watershed west of Y-12. Below the shallow karst network, fractures provide the primary groundwater flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 72 ft bgs and exhibits moderate (<10 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 259 – 358 mg/L;
- pH (field measurements) of 7.2 – 7.8;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, with the highest value (8.76 mg/L in December 1993) being below the drinking water MCL for nitrate (10 mg/L) and the lowest concentrations (<2 mg/L) reported for samples collected since March 2002.

5.2 URANIUM

All but one of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.002 mg/L in October 1992 and September 1993) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 1): CTET, chloroform, TCE, 12DCE (c12DCE), 111TCA, and vinyl acetate. The presence of VOCs in the samples indicates that the monitored interval in the well intercepts groundwater flow/transport pathways for VOCs released from one or more upgradient sources that contribute to an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. Available data for the network of wells completed in the Maynardville Limestone west of the flow divide indicate that VOC-contaminated groundwater, as defined by individual or summed VOC concentrations above 5 µg/L, appears to originate near Spoil Area I and to extend hydraulically downgradient for several thousand feet westward (parallel with geologic strike) down the axis of BCV. The apparent distribution of VOCs within the plume reflects the relative influx from multiple source areas, commingling during downgradient groundwater transport, and hydraulic communication with Bear Creek (DOE 1997). In the upper part of BCV, hydraulically upgradient of the Exit Pathway Picket C wells, the primary VOCs are TCE, c12DCE, and PCE and the confirmed or suspected source areas include Spoil Area I, the contaminant plume emplaced during historical operation of the former S-3 Ponds, and the Rust Spoil Area (or nearby source within the Bear Creek floodplain), which is believed to be a primary source of TCE. Hydraulically downgradient (west) of Exit Pathway Picket C, additional influx of VOCs (primarily PCE) occurs from several sources within the Oil Landfarm waste management area (WMA) and the Bear Creek Burial Grounds WMA. Individual and summed VOC concentrations are highest (>300 µg/L) in the deeper groundwater flow/transport pathways (>200 ft bgs) in the Maynardville Limestone directly south (down dip) of the Oil Landfarm WMA, where the main channel of Bear Creek loses substantial flow to the groundwater (karst) system and where groundwater elevations in clustered monitoring wells indicate strongly downward vertical hydraulic gradients (DOE 1997).

Based on frequency of detection and concentration magnitude, the primary VOC in the groundwater samples is TCE (Table 1), which is the only compound detected in all of the samples and, as noted above, is believed to reflect transport/migration from the Rust Spoil Area or from a nearby source in the Bear Creek floodplain. The first sample collected from the well had the historical maximum TCE concentration (58 µg/L in May 1992) and the most recent TCE results from March (33 µg/L) and July 2005 (31 µg/L) show that concentrations remain substantially above the drinking water MCL for TCE (5 µg/L). Aside from TCE, many of the samples contained trace levels of CTET and/or 12DCE, with all results for both compounds being estimated concentrations of 1 or 2 µg/L. A few samples collected between February 1993 and February 1995 had similarly low levels of chloroform, vinyl acetate, and 111TCA (Table 1); results for these compounds, particularly vinyl acetate, are probably analytical artifacts.

A time-series plot of TCE concentrations detected in the groundwater samples collected to date shows a slightly decreasing long-term concentration trend (Figure 2). The overall decrease in TCE levels probably reflects the somewhat reduced flux of TCE from long-term natural attenuation of the suspected VOC sources at Spoil Area I and the Rust Spoil Area, both of which were closed without further remedial action (e.g., waste removal or installation of low-permeability cap).

5.4 GROSS ALPHA ACTIVITY

Two groundwater samples had gross alpha activity above the MDA and corresponding CE, with the highest value (3.94 pCi/L in August 1992) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (14.2 pCi/L in September 1993) being below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee*, Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

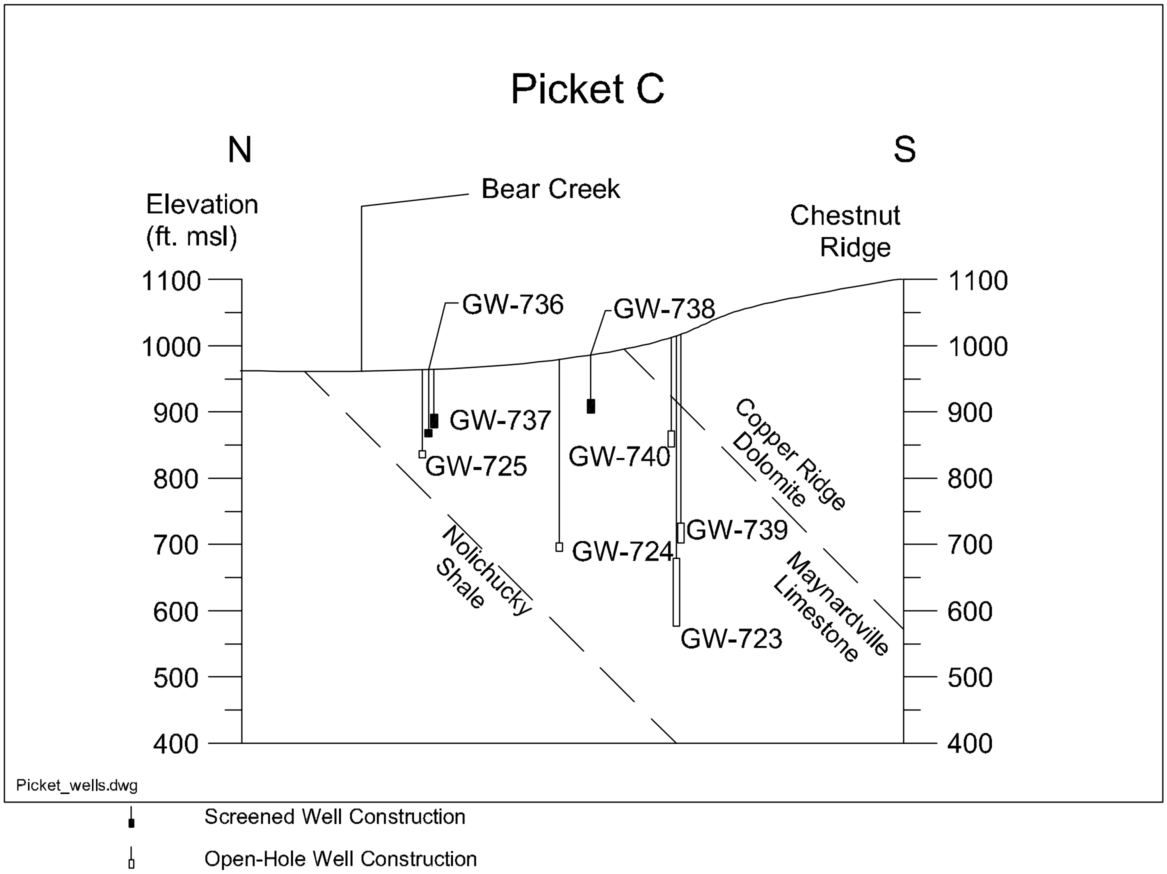
U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-739: summary of VOC results

Sampling Date	Concentration (µg/L)			
	TCE	**12DCE**	**c12DCE**	**CTET**
05/27/92	58	.	NR	2 J
08/29/92	42	2 J	NR	1 J
10/29/92	45	1 J	NR	1 J
02/10/93	32	2 J	NR	.
05/18/93	33	.	NR	.
09/27/93	39	2 J	NR	.
12/13/93	42	2 J	NR	1 J
03/16/94	35	2 J	NR	1 J
12/18/94	35	1 J	NR	.
02/17/95	45	2 J	NR	1 J
09/16/95	47	2 J	NR	1 J
03/05/02	36	.	.	.
07/22/02	37	.	.	.
03/07/05	33	1 J	1 J	.
07/27/05	31	.	.	.
MCL	**5**	**NA**	**70**	**5**

Sampling Date	Compound/Concentration (µg/L)
02/10/93	Vinyl acetate (1 J)
12/13/93	Chloroform (1 J), 111TCA (0.7 J)
02/17/95	Chloroform (1 J)

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable; NR = Not reported



Picket C
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-736
GW-738
GW-737
GW-725
GW-740
GW-739
GW-724
GW-723
Copper Ridge
Dolomite
Nolichucky
Shale
Maynardville
Limestone
Picket_wells.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

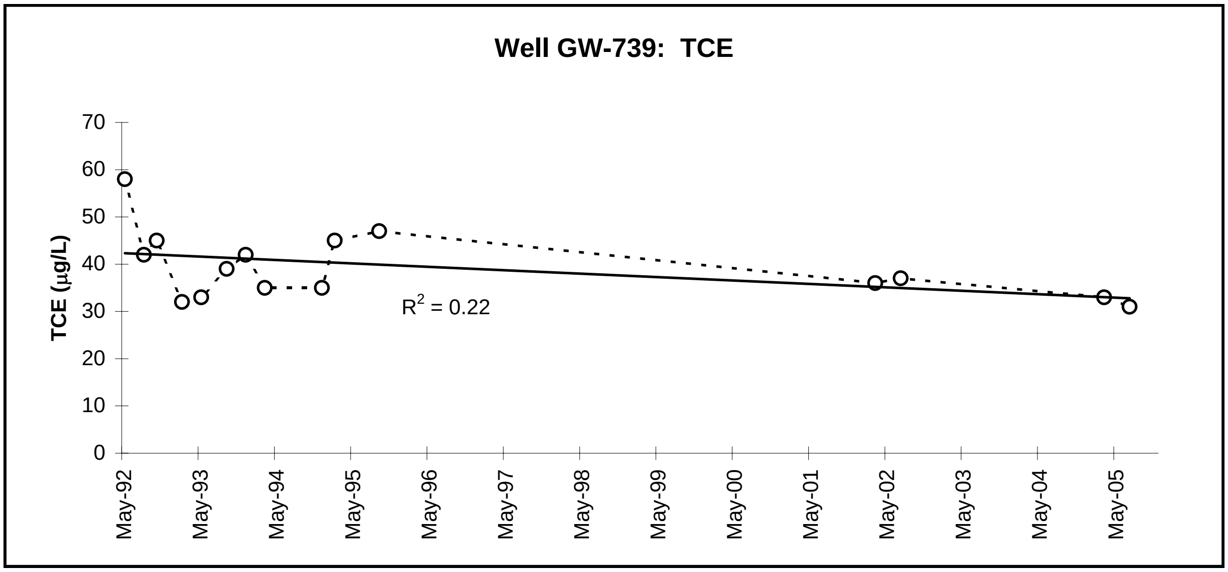

Well GW-739: TCE
TCE (µg/L)
70
60
50
40
30
20
10
0
R^2 = 0.22
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05

Figure 2

MAXIMUM CONCENTRATION: 2004

<5	ND	50 - 500	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-740

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Exit Pathway Picket C
Y-12 GRID EAST COORDINATE: 49,055.41
Y-12 GRID NORTH COORDINATE: 29,027.17
SURFACE ELEVATION: 1,016.95 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/20/91 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 192.67 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,020.25 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: .
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	165.6	851.35
BOTTOM (filter pack or open hole):	190.0	826.95
MIDPOINT (filter pack or open hole):	177.8	839.15
PUMP INTAKE:	183.70	833.25
WATER LEVEL (average):	67.46	949.49

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	30		
CONVENTIONAL SAMPLING METHOD:	15 samples	06/02/92	09/04/97
LOW-FLOW SAMPLING METHOD:	15 samples	03/04/98	07/26/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/09/04	.	07/26/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.84 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	176 µg/L	06/02/92	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-740

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1991, completed with an open-hole monitored interval from 165.6 to 190 ft bgs, and constructed with nominal 7-inch diameter steel (SF25) riser casing. The well is located in Bear Creek Valley (BCV) west of Y-12 and is a component of Exit Pathway Picket C, which consists of a series of wells (GW-736, GW-737, GW-738, GW-739, and GW-740) completed at different depths (and hydrostratigraphic zones) along a strike-normal transect across the Maynardville Limestone (Figure 1). The Maynardville Limestone underlies Bear Creek throughout BCV and the hydrologic interaction between the creek and the shallow karst network in the Maynardville Limestone provide the primary exit-pathways for groundwater and surface water contaminants.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between June 1992 and September 1997, and the low-flow sampling method used to obtain 15 samples between March 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the intermediate bedrock interval in the Conasauga Group (Maynardville Limestone). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 67 ft bgs and exhibits moderate (>10 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of Exit-Pathway Picket C indicate westerly flow directions, parallel with geologic strike (i.e., bedding-plane fractures) in the Maynardville Limestone.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the two samples collected from the well indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 244 – 360 mg/L;
- pH (field measurements) of 5.6 – 7.8;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-nine of the groundwater samples had nitrate concentrations above the analytical reporting limit (one sample was not analyzed for nitrate), with the highest concentration (4.8 mg/L in September 1993) being below the drinking water MCL for nitrate (10 mg/L). Although the nitrate concentrations do not exceed the MCL, they are higher than the applicable UTL (2.7 mg/L) and probably reflect the transport of nitrate from the intermingled contaminant plumes in the Maynardville Limestone hydraulically upgradient (east) of the well. The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Several million gallons of nitric acid wastes from Y-12 were disposed during historical operation of the site (1951–1984), which emplaced a heterogeneous mixture of inorganic, organic, and radiological contaminants in the Nolichucky Shale beneath the site. Nitrate is one of the principal components of the plume and it enters the Maynardville Limestone via several pathways hydraulically downgradient of the former S-3 Ponds, including direct inflow from the Nolichucky Shale and hydraulic communication with nitrate-contaminated surface water in Bear Creek. Contaminated surface water is primarily from the northern tributaries of Bear Creek (NT-1 and NT-2) that are the principal discharge areas for nitrate-contaminated groundwater exiting the shallow flow system in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (notably Tc-99) and elsewhere in BCV.

5.2 URANIUM

Seven groundwater samples had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.001 mg/L in June 1992, August 1992, and December 1993) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in 29 groundwater samples collected from the well: acetone, CTET, chloroform, PCE, TCE, 12DCE (isomers), 11DCE, 11DCA, and 111TCA. These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, which occurs near the west end of Y-12, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and extends several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Plume constituents in the upper part of BCV are TCE, c12DCE, and PCE; source areas include Spoil Area I and the former S-3 Ponds. Farther downgradient (west), major inputs of VOCs occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain; the Oil Landfarm waste management area (WMA), including the former Hazardous Chemical Disposal Area (HCDA) and Sanitary Landfill I; and inflow of VOC-contaminated groundwater and surface water that discharges from a northern tributary of Bear Creek (NT-7) that traverses the Bear Creek Burial Grounds WMA. The highest

VOC concentrations within the plume exceed 300 µg/L and occur in the deeper groundwater south (down dip) of the HCDA. These high concentrations coincide with downward vertical hydraulic gradients in the Maynardville Limestone in this area and a major losing reach of the main channel of Bear Creek south-southwest of Sanitary Landfill I (DOE 1997).

The primary VOC in the groundwater samples is TCE (Table 1); this compound was detected in every sample, with the historical maximum concentration of 77 µg/L in August 1992. Also, the most recent sampling results show that the TCE concentrations remain substantially above the drinking water MCL (5 µg/L). Secondary compounds in the samples are 12DCE (c12DCE), with trace levels (all estimated values below 5 µg/L) detected in all but two of the samples, and CTET, which was detected at similarly low levels (2 µg/L) in about half of the samples. Acetone, chloroform, 11DCE, 11DCA, and 111TCA have been detected much more infrequently and the respective results are all estimated values below analytical reporting limits.

The concentrations of VOCs in the groundwater at this well, as illustrated by the sampling results for TCE (Figure 2), show: (1) a sharply decreasing trend between December 1992 (77 µg/L) and June 1995 (28 µg/L); (2) an abrupt rebound above 70 µg/L through September 1995; and (3) a generally decreasing concentration trend through July 2004 (48 µg/L). These temporal changes in TCE concentrations potentially correspond with long-term changes in the relative flux of TCE along the groundwater flow/transport pathways intercepted by the monitored interval in the well. However, the other VOCs in the well do not exhibit similar concentration fluctuations, as illustrated by the results for 12DCE (Table 1). It is not clear from the available data why the concentrations of individual compounds exhibit such divergent temporal variations or if such variations are significant with respect to the relative flux of dissolved VOCs.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (9.7 pCi/L in July 2003) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Fifteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (16.9 pCi/L in September 1993) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-740: summary of VOC results

Date Sampled	VOC Concentration (µg/L)					
	TCE	12DCE (Total)	c12DCE	CTET	Chloroform	111TCA
06/02/92	75	3 J	NR	2 J	FP	1 J
08/30/92	77	2 J	NR	3 J	FP	1 J
10/28/92	63	2 J	NR	1 J	2 J	1 J
02/09/93	50	4 J	NR	1 J	2 J	.
05/17/93	38	2 J	NR	.	2 J	.
09/27/93	33	2 J	NR	.	1 J	.
12/11/93	35	2 J	NR	.	1 J	.
03/14/94	45	2 J	NR	.	1 J	.
12/17/94	28	2 J	NR	.	1 J	.
02/16/95	76	3 J	NR	2 J	1 J	FP
09/17/95	76	3 J	NR	2 J	1 J	FP
03/19/96	72	3 J	NR	2 J	1 J	1 J
08/07/96	31	2 J	NR	.	.	.
02/24/97	65	3 J	3 J	2 J	FP	.
09/04/97	73	3 J	3 J	2 J	FP	.
03/04/98	72	3 J	3 J	3 J	FP	1 J
08/31/98	59	2 J	2 J	2 J	1 J	1 J
02/18/99	65	3 J	3 J	2 J	.	3 J
08/24/99	64	2 J	2 J	2 J	.	.
02/02/00	63	.	.	.	.	.
07/27/00	62	.	.	.	.	.
01/24/01	57	2 J	2 J	.	.	.
07/18/01	51	2 J	2 J	.	.	.
01/29/02	58	2 J	2 J	.	.	2 J
07/22/02	57	2 J	2 J	.	.	.
01/22/03	54	2 J	2 J	.	.	.
07/17/03	57	2 J	2 J	2 J	.	.
02/09/04	50	3 J	3 J	.	.	.
07/26/04	45	2 J	2 J	.	.	.
MCL	**5**	**NA**	**70**	**5**	**80***	**200**

Notes: "." = Not detected; J = Estimated concentration; FP = False positive; NR = Not reported; NA= Not applicable *MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane

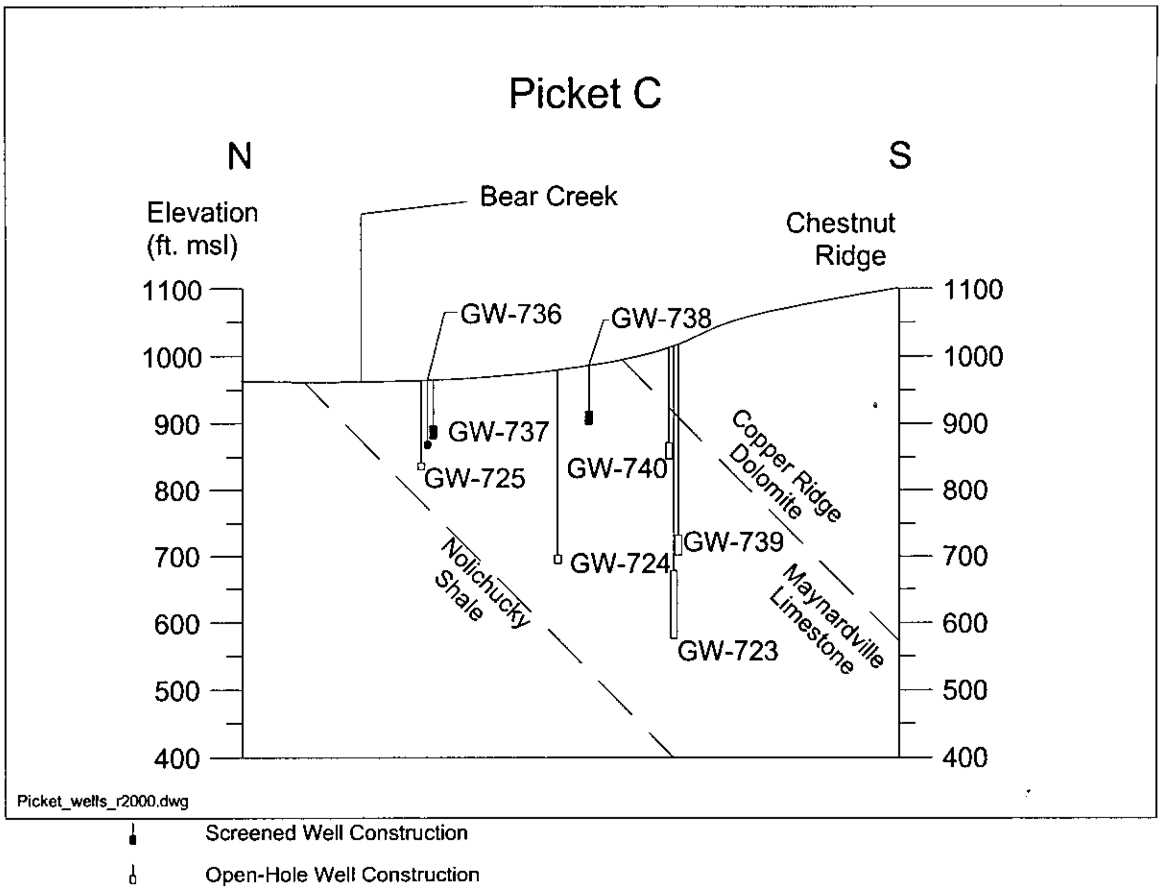

Picket C
N
S
Elevation
(ft. msl)
Bear Creek
Chestnut
Ridge
1100
1000
900
800
700
600
500
400
GW-736
GW-738
GW-737
GW-725
GW-740
GW-724
GW-739
GW-723
Copper Ridge
Dolomite
Nolichucky
Shale
Maynardville
Limestone
Picket_wells_r2000.dwg
Screened Well Construction
Open-Hole Well Construction

Figure 1

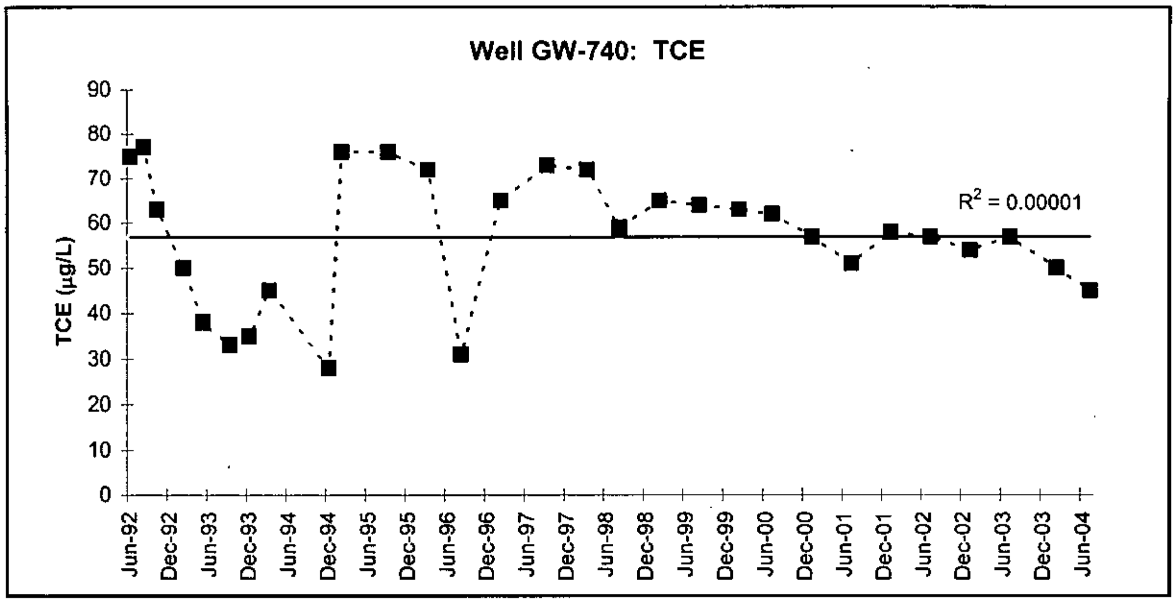

Well GW-740: TCE
TCE (µg/L)
90
80
70
60
50
40
30
20
10
0
R2 = 0.00001
Jun-92
Dec-92
Jun-93
Dec-93
Jun-94
Dec-94
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04

Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	7.5 - 15	ND

GW-742

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,908.05
Y-12 GRID NORTH COORDINATE: 28,037.99
SURFACE ELEVATION: 1,097.83 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/05/91 PAIRED/CLUSTERED WITH: GW-743
TAG DEPTH (measured): 422.03 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,100.97 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SF25
WELL CASING DIAMETER: 7 inches (outside diameter)
WELL SCREEN TYPE: 0
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Open Hole

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	350.0	747.83
BOTTOM (filter pack or open hole):	420.0	677.83
MIDPOINT (filter pack or open hole):	385.0	712.83
PUMP INTAKE:	408.9	688.97
WATER LEVEL (average):	124.96	972.87

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	16 samples	04/10/92	02/01/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/21/04	10/18/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/21/04	.	10/18/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 44.26 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-742

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1991, completed with an open-hole monitored interval from 350 to 420 ft bgs, and constructed nominal 7-inch diameter steel (SF25) riser casing. The well is paired with well GW-743 and is located near the crest of Chestnut Ridge directly south of Y-12, approximately 400 ft south of the eastern part of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between April 1992 and February 1996, and the low-flow sampling method used to obtain samples in April and October 2004.

Presampling depth-to-water measurements show that the static water level in the well exhibits substantial (>40 ft) temporal (seasonal) fluctuations (Figure 1). Similarly distinctive groundwater elevation fluctuations also are evident in other wells completed in the Knox Group on Chestnut Ridge (including well GW-743), particularly wells located at or near the crest of the ridge, which is both a recharge area and a groundwater flow divide (Solomon et al. 1992). Wide temporal fluctuations in the groundwater elevations suggest that the monitored interval for the well intercepts highly permeable flowpaths in the Knox Group. This interpretation is supported by the relatively low TDS of the groundwater samples collected to date (see Section 4.0), which indicates fairly short residence time for groundwater in the well and potentially indicates that the monitored interval intercepts "quickflow" conduits in the bedrock (Shevenell 1994).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Copper Ridge Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 145 ft bgs and exhibits substantial seasonal fluctuations, as noted in Section 2.0. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-742 indicate radial flow directions, with components of flow to the north into BCV, to the east along the axis of the ridge (parallel with geologic strike), and south toward drainage features that traverse the broad southern flank of the ridge. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-742 are typically lower than evident in well GW-743, which is completed at a shallower depth (about 160 ft bgs) in the Knox Group. Based on the distance between the monitored interval midpoint (elevation) in each well (about 230 ft), the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.007 – 0.061) from well GW-743 to GW-742 during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 136 – 208 mg/L;
- pH of 6.9 – 8.1 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- unusually high total (unfiltered sample) iron concentrations (e.g., 2.69 mg/L in April 2004); and
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, none of these contaminants are generally present in the groundwater at this well.

5.1 NITRATE

None of the groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit.

5.2 URANIUM

Six of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest concentration (0.007 mg/L in October 1992) being an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the groundwater samples collected to date.

5.4 GROSS ALPHA ACTIVITY

Twelve groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (9.09 pCi/L in February 1994) being below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.12 pCi/L in November 1994) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

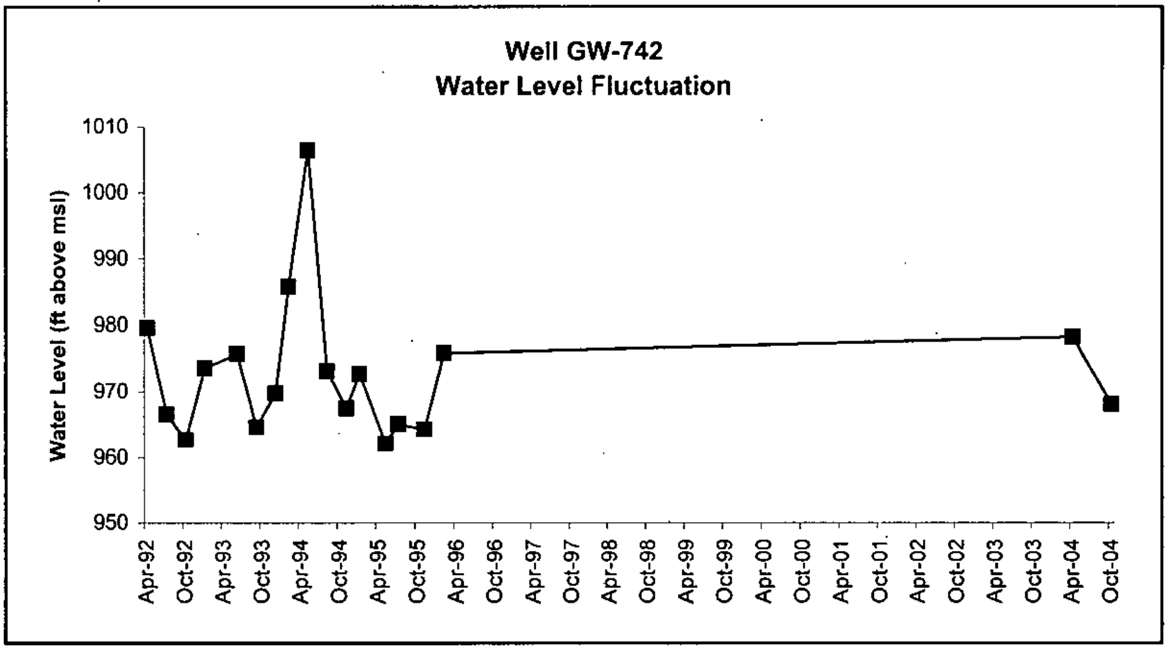

Well GW-742
Water Level Fluctuation
Water Level (ft above msl)
1010
1000
990
980
970
960
950
Apr-92
Oct-92
Apr-93
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04
Oct-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-743

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Chestnut Ridge Security Pits
Y-12 GRID EAST COORDINATE: 58,907.98
Y-12 GRID NORTH COORDINATE: 28,056.00
SURFACE ELEVATION: 1,098.72 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 12/13/91 PAIRED/CLUSTERED WITH: GW-742
TAG DEPTH (measured): 162.56 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,100.36 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	150.1	948.62
BOTTOM (filter pack or open hole):	161.1	937.62
MIDPOINT (filter pack or open hole):	155.6	943.12
PUMP INTAKE:	156.4	942.36
WATER LEVEL (average):	121.26	977.46

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	16 samples	04/07/92	02/23/96
LOW-FLOW SAMPLING METHOD:	2 samples	04/21/04	10/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	04/21/04	.	10/18/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 51.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS — **Results (since 1991) > Screening Level**

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	8 µg/L	11/13/95	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-743

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in December 1991, completed with a screened monitored interval from 150 to 161 ft bgs, and constructed nominal 4-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is paired with well GW-742 and is located near the crest of Chestnut Ridge directly south of Y-12, approximately 400 ft south of the eastern part of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between April 1992 and February 1996, and the low-flow sampling method used to obtain samples in April and October 2004.

Presampling depth-to-water measurements show that the static water level in the well exhibits substantial (>50 ft) temporal (seasonal) fluctuations (Figure 1). Similarly distinctive groundwater elevation fluctuations also are evident in other wells completed in the Knox Group on Chestnut Ridge (including well GW-742), particularly wells located at or near the crest of the ridge, which is both a recharge area and a groundwater flow divide (Solomon et al. 1992). Wide temporal fluctuations in the groundwater elevations suggest that the monitored interval for the well intercepts highly permeable flowpaths in the Knox Group. This interpretation is supported by the relatively low TDS of the groundwater samples collected to date (see Section 4.0), which indicates fairly short residence time for groundwater in the well and potentially indicates that the monitored interval intercepts "quickflow" conduits in the bedrock (Shevenell 1994).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the bedrock interval in the lower Knox Group (Copper Ridge Dolomite), which underlies the steep northern flank of Chestnut Ridge. The Knox Group formations, along with the uppermost formation (Maynardville Limestone) of the underlying Conasauga Group, comprise an aquifer consisting of three vertically gradational subsystems distinguished by groundwater flux, which decreases with depth: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone (Solomon et al. 1992). The stormflow and vadose zones occur at shallow depths within the thick (>100 ft) residuum that has developed on Chestnut Ridge. In the bedrock zone, orthogonal sets of permeable, planar fractures form water-producing zones within an essentially impermeable matrix, and dissolution of carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 121 ft bgs and exhibits substantial seasonal fluctuations, as noted in Section 2.0. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-743 indicate radial flow directions, with components of flow to the north into BCV, to the east along the axis of the ridge (parallel with geologic strike), and south toward drainage features that traverse the broad southern flank of the ridge. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-743 are typically higher than evident in well GW-742, which is completed at a greater depth (420 ft bgs) in the Knox Group. Based on the distance between the monitored interval midpoint (elevation) in each well (about 230 ft), the contemporaneous groundwater elevations indicate downward vertical hydraulic gradients (0.007 – 0.061) from well GW-743 to GW-742 during seasonally high and low flow conditions.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 106 – 186 mg/L;
- pH of 6.7 – 8.7 (field measurements);
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite);
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, none of these contaminants are generally present in the groundwater at this well.

5.1 NITRATE

Twelve of the groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest concentration (1.4 mg/L in February 1994) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Only one of the groundwater samples collected to date had a total uranium concentration at or above the applicable analytical reporting limit, and this result (0.00061 mg/L in February 1996) is orders-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Two of the groundwater samples collected to date contained VOCs: methylene chloride was detected in the sample collected in October 1992, but the result is a false positive, and a low level of acetone (8 µg/L) was detected in the sample collected in November 1995. The latter result also is a likely analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Five of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.84 pCi/L in May 1995) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

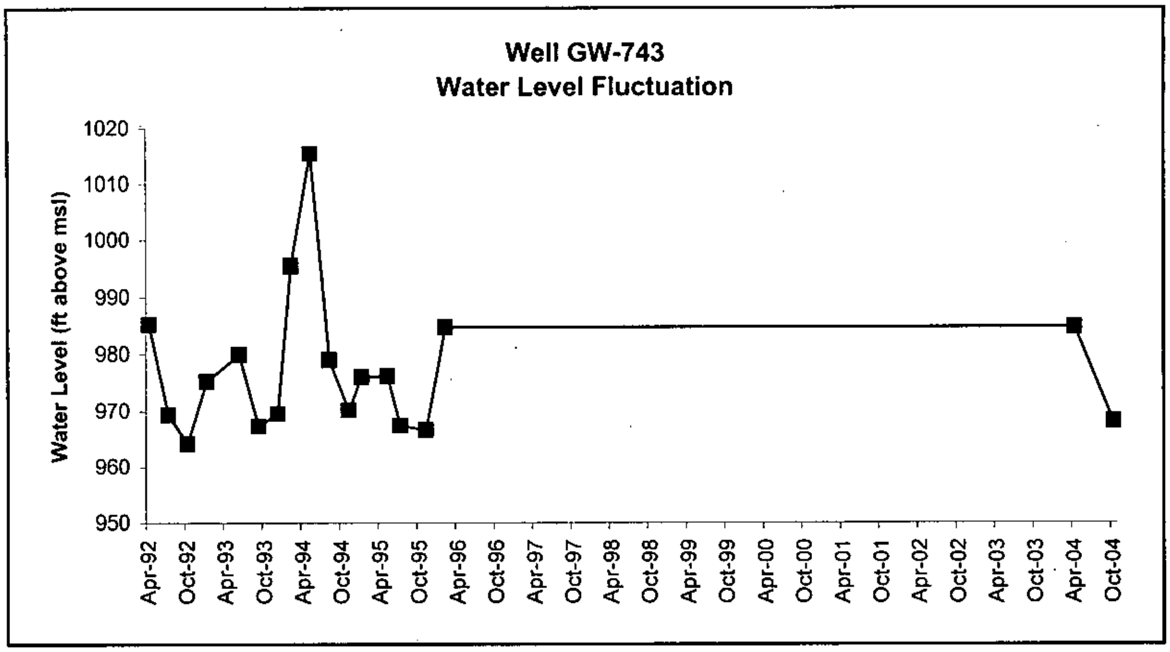
Four groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.4 pCi/L in November 1995) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, Y/TS-1001, prepared for Martin Marietta Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.



Well GW-743
Water Level Fluctuation
Water Level (ft above msl)
1020
1010
1000
990
980
970
960
950
Apr-92
Oct-92
Apr-93
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04
Oct-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-744

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID K1
Y-12 GRID EAST COORDINATE: 64,323.62
Y-12 GRID NORTH COORDINATE: 30,282.34
SURFACE ELEVATION: 905.05 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/08/92 PAIRED/CLUSTERED WITH: GW-745 GW-746
TAG DEPTH (measured): 69.28 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 907.43 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	55.0	850.05
BOTTOM (filter pack or open hole):	69.5	835.55
MIDPOINT (filter pack or open hole):	62.3	842.80
PUMP INTAKE:	65.12	839.93
WATER LEVEL (average):	4.09	900.96

GEOLOGIC FORMATION: Pumpkin Valley Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	35		
CONVENTIONAL SAMPLING METHOD:	20 samples	04/28/92	04/16/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/08/97	11/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/24/04	.	11/10/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.71 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-744

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1992, completed with a screened monitored interval from 55 to 69.5 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-745 and GW-746 and is located in Bear Creek Valley east of Y-12, near the intersection of Bear Creek Road and Scarboro Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 20 samples between April 1992 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Pumpkin Valley Shale). The average static groundwater level in the well is about 4 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<4 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 184 – 323 mg/L;
- pH (field measurements) of 7.0 – 8.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Three groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2.2 mg/L in January 1994) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.004 mg/L in May 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, methylene chloride (0.6 μg/L) was detected in the sample collected in January 1993. This result is probably an artifact.

5.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.9 pCi/L in May 2002) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.45 pCi/L in October 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-747

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID K2
Y-12 GRID EAST COORDINATE: 64,569.57
Y-12 GRID NORTH COORDINATE: 29,729.81
SURFACE ELEVATION: 918.33 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/28/92 PAIRED/CLUSTERED WITH: GW-748 GW-749
TAG DEPTH (measured): 82.33 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 920.96 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	67.4	850.93
BOTTOM (filter pack or open hole):	79.6	838.73
MIDPOINT (filter pack or open hole):	73.5	844.83
PUMP INTAKE:	75.37	842.96
WATER LEVEL (average):	2.66	915.67

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	19 samples	08/08/92	04/17/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/09/97	11/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	.	05/26/04	.	11/10/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.58 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	13 µg/L	11/18/95	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-747

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1992, completed with a screened monitored interval from 67.4 to 79.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-748 and GW-749 and is located in Bear Creek Valley east of Y-12, adjacent to Scarboro Road about 800 ft east of Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between August 1992 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 2.7 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<7 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 225 – 314 mg/L;
- pH (field measurements) of 6.8 – 7.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Two groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.17 mg/L in December 1997) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the groundwater sample collected in April 2000 (0.000879 mg/L) exceeds the analytical reporting limit. This result is substantially below the MCL for uranium (0.03 mg/L) and is probably an analytical artifact.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, 2-butanone was detected (13 μg/L) in the sample collected in November 1995. This result is a suspected sampling or analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Only one groundwater sample had gross alpha activity above the applicable MDA and corresponding CE (1.2 pCi/L in May 2002) which was substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.74 pCi/L in August 1993) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-750

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Exit Pathway Picket J
Y-12 GRID EAST COORDINATE: 64,835.48
Y-12 GRID NORTH COORDINATE: 28,974.53
SURFACE ELEVATION: 915.96 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/06/92 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 75.49 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 919.03 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.6 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	61.2	854.76
BOTTOM (filter pack or open hole):	72.7	843.26
MIDPOINT (filter pack or open hole):	67.0	849.01
PUMP INTAKE:	67.63	848.33
WATER LEVEL (average):	8.92	907.04

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	34		
CONVENTIONAL SAMPLING METHOD:	19 samples	08/09/92	04/14/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/03/97	11/05/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/26/04	.	11/05/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 9.09 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	12 µg/L	06/04/98	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-750

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 1992, completed with a screened monitored interval from 61.2 to 72.7 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley east of Y-12, about 300 ft west of Scarboro Road and 800 ft east (hydraulically downgradient) of New Hope Pond (NHP). NHP is a closed surface water impoundment formerly used to regulate flow in Upper East Fork Poplar Creek, and is covered with a low-permeability multilayer cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 19 samples between August 1992 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Maynardville Limestone). The average static groundwater level in the well is 9 ft bgs. Presampling depth-to-water measurements for the well indicate moderate (<10 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 270 – 331 mg/L;
- pH (field measurements) of 6.6 – 7.7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Only the nitrate concentration reported for the groundwater sample collected in May 2004 (0.0294 mg/L) exceeds the applicable analytical reporting limit. This result is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Only the uranium concentration reported for the groundwater sample collected in October 2003 (0.002 mg/L) exceeds the applicable analytical reporting limit. This result is substantially below the MCL for uranium (0.03 mg/L) and is probably an analytical artifact.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only two groundwater samples. The single detection of acetone (12 µg/L in June 1998) and carbon disulfide (3 µg/L in June 1999) are suspected sampling or analytical artifacts and considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Only the gross alpha activity reported for the groundwater sample collected in August 1992 (2.41 pCi/L) exceeds the MDA and corresponding CE. This result is substantially below the MCL for gross alpha activity (15 pCi/L) and is probably an analytical artifact.

5.5 GROSS BETA ACTIVITY

Twelve groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.8 pCi/L in June 1998) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	<7.5	<25

GW-757

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill II
Y-12 GRID EAST COORDINATE: 53,302.52
Y-12 GRID NORTH COORDINATE: 25,409.50
SURFACE ELEVATION: 958.65 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 04/24/92 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 168.54 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 961.64 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.62 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	134.0	824.65
BOTTOM (filter pack or open hole):	166.5	792.15
MIDPOINT (filter pack or open hole):	150.3	808.40
PUMP INTAKE:	155.01	803.64
WATER LEVEL (average):	81.58	877.07

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	33		
CONVENTIONAL SAMPLING METHOD:	18 samples	06/15/92	04/03/97
LOW-FLOW SAMPLING METHOD:	15 samples	10/16/97	07/22/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/20/04	.	07/22/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: X LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 23.45 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	110 µg/L	04/21/98	Outliers
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-757

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in April 1992, completed with a screened monitored interval from 134 to 166.5 ft bgs, and constructed with 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 100 ft south-southeast (hydraulically downgradient) of the Industrial Landfill II, which is a closed landfill which operated between 1983 and 1996 for the disposal of combustible and decomposable nonhazardous solid waste, construction spoil, and special wastes (e.g., asbestos and beryllium oxide) generated from DOE operations at Y-12 and elsewhere on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-three groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 18 samples between June 1992 and April 1997, and the low-flow sampling method used to obtain 15 samples between October 1997 and July 2004.

Groundwater samples from the well exhibit conspicuous geochemical characteristics (see Section 4.0) attributable to contamination from the cement (grout) lost into the surrounding bedrock during installation of the well. To ensure collection of representative groundwater samples, the conventional sampling method should be used; redevelopment of the well before sampling also may be necessary.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is 82 ft below ground surface. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

Groundwater samples from this well exhibit atypical levels of carbonate and bicarbonate, high pH (>9), elevated potassium (>10 mg/L) and sodium (>30 mg/L) concentrations, and substantially lower concentrations (<5 mg/L) of calcium and magnesium compared to other wells in the Chestnut Ridge Regime. As noted in Section 2.0, this atypical groundwater geochemistry probably is a consequence of localized grout contamination. Of particular interest is the apparent correlation between the sharp increases in pH levels and potassium and sodium concentrations (and gross beta activity) following the change from conventional sampling to low-flow sampling (Figure 1). This suggests that the conventional sampling method induces greater inflow of "fresh" groundwater into the well, which effectively dilutes the grout-contaminated groundwater entering the well; thus buffering the pH and lowering the concentrations of potassium and sodium. Nevertheless, considering that the well was installed in 1992, the persistent grout contamination in the well is a chronic problem with respect to obtaining representative groundwater samples.

Aside from the geochemical indicators of grout contamination, the (unfiltered) groundwater samples from the well typically have total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nineteen groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (0.66 mg/L in August 2000) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-one groundwater samples had uranium concentrations above the analytical reporting limit, with the highest concentration (0.0069 mg/L in October 1998) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only five of the groundwater samples from the well. A low (estimated) concentration of 111TCA (4 µg/L) was detected in the sample collected in April 1999. Acetone has been detected in three samples (110 µg/L in April 1998, 2 µg/L in October 1998, and 1.8 µg/L in July 2001) and 2-butanone has been detected once (9 µg/L in October 1995). Acetone and 2-butanone are common laboratory reagents, and the results for these VOCs may be analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

Eighteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (6.73 pCi/L in January 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twenty groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (18.9 pCi/L in July 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L). Although gross beta activity in the groundwater at this well is less than the SDWA screening level, a time-series plot of the beta activities shows a generally increasing trend (Figure 2). Assuming that Industrial Landfill II received only the nonhazardous wastes for which it was permitted, there is not a confirmed source of radiological contaminants hydraulically upgradient of the well. Alternatively, the elevated gross beta activity may be a consequence of the elevated potassium concentrations in the grout-contaminated groundwater samples form the well. Potassium concentrations show a generally increasing trend that is similar to the gross beta trend (Figure 2). Potassium-40 (K-40) is a beta-emitting isotope and, based on the natural ratio of K-40 to total potassium (K-40 = 0.0119% of total potassium; Brownlow 1979), 14 of the samples contained at least 0.05 mg/L K-40, with the highest levels evident in January 2003 (0.23 mg/L), January 2002 (0.21), and January 2001 (0.2 mg/L). Thus, elevated gross beta activity may be an artifact of the grout contamination in well.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Brownlow, A.H. 1979. *Geochemistry*. Prentice-Hall, Inc., Englewood Cliffs, NJ.

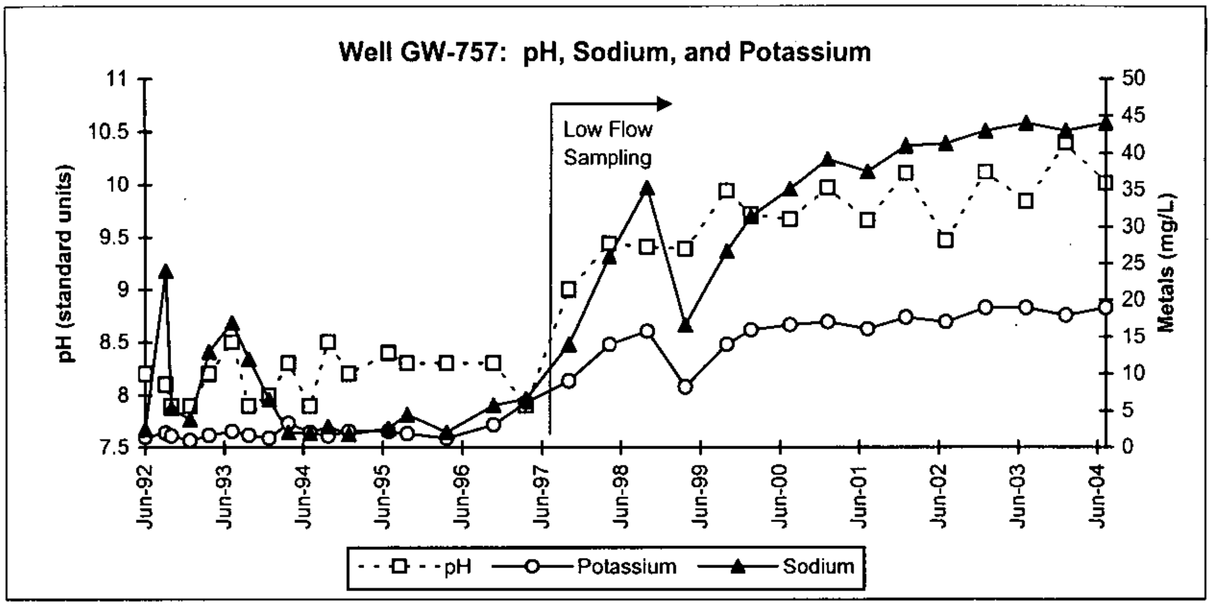


Figure 1

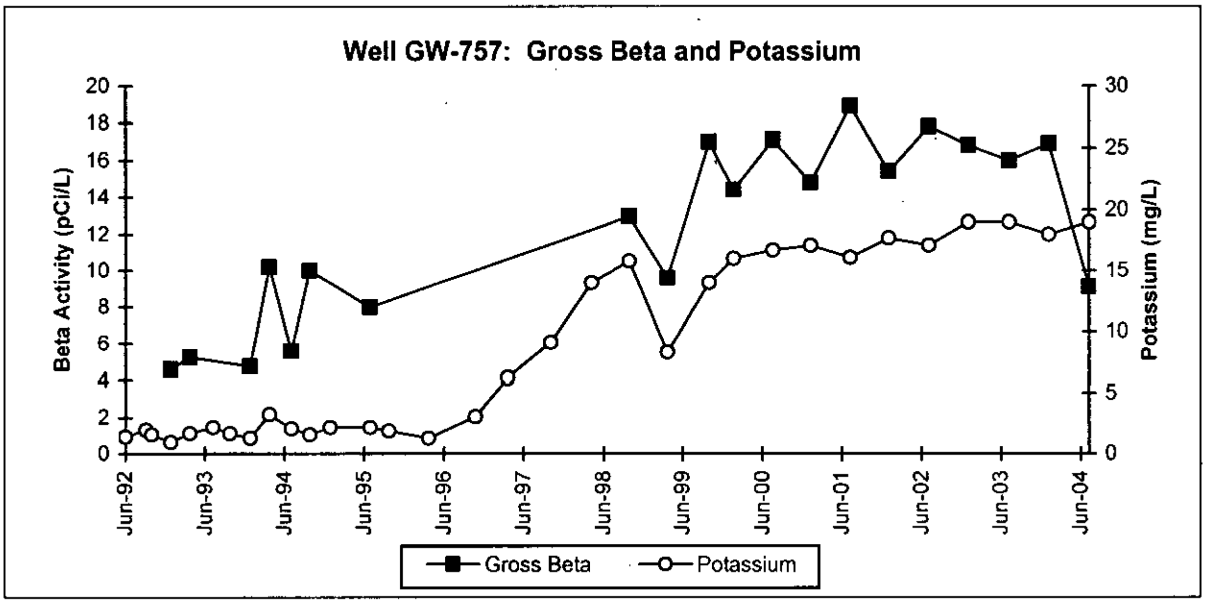


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-760

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID G2
Y-12 GRID EAST COORDINATE: 60,207.30
Y-12 GRID NORTH COORDINATE: 30,160.44
SURFACE ELEVATION: 966.51 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/01/92 PAIRED/CLUSTERED WITH: GW-761
TAG DEPTH (measured): 63.30 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 970.02 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	48.3	918.21
BOTTOM (filter pack or open hole):	60.1	906.41
MIDPOINT (filter pack or open hole):	54.2	912.31
PUMP INTAKE:	54.49	912.02
WATER LEVEL (average):	7.66	958.85

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	14 samples	07/26/92	11/15/95
LOW-FLOW SAMPLING METHOD:	3 samples	06/04/03	04/27/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	04/27/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 4.69 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-760

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 48.3 to 60.1 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-761 and is located in Bear Creek Valley in the east-central section of Y-12, about 250 ft north of Bldg. 9202.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between July 1992 and November 1995, and the low-flow sampling method used to obtain three samples between June 2003 and April 2004.

A conspicuous characteristic of the groundwater samples from this well are elevated concentrations of chromium (maximum = 0.39 mg/L in November 1994) and nickel (maximum = 0.34 mg/L in May 1995) that are most likely attributable to chemical and/or microbiologically-induced corrosion (MIC) of the stainless steel well casing and/or screen. Corrosion of stainless steel may be caused by many different species of bacteria, including iron-related and sulfate-reducing organisms that typically attack the area near welds. Once a colony attaches to the metal it forms a nodule in which to live. The micro-environment within the nodule creates conditions (e.g., acidic pH) that enable the colony to expand and deepen the nodule, which eventually creates a pit or crevice in the metal and facilitates corrosion per the mechanisms described by Driscoll (1986). The following considerations suggest that elevated concentrations of nickel and chromium in the groundwater samples from this well are most likely attributable to corrosion of the stainless steel (Type 304) well screen: (1) there are no known sources of these metals near the well; (2) mobile species of these metals are not typically present in groundwater with the neutral pH evident in the well; (3) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); (4) indicator parameters (e.g., dissolved oxygen >1 mg/L and pH between 5.5 and 9) are in the optimum range for MIC by iron-related bacteria (Sarouhan et al. 1998); and (5) elevated chloride levels in the groundwater (see Section 4.0) may play a role in maintaining the elevated chromium and nickel concentrations in the samples from the well because chloride may combine with available metal cations to form soluble complexes that do not readily adsorb to mineral surfaces in the filter pack material and surrounding bedrock (McLean and Bledsoe 1992)

The Y-12 GWPP requested biological testing to assess microbial activity in groundwater at this well in April 2004. The results (shown below) are qualitative bacterial counts of four specific bacteria types that are estimates based on the appearance of the sample after an eight- to ten-day growth period.

Well	**Date Sampled**	**Metals (mg/L)**		**Bacteria Activity (colony forming units/milliliter)**			
		Chromium	Nickel	Heterotrophic Aerobic	Iron-Related	Slime Forming	Sulfate-Reducing
GW-760	04/27/04	0.0614	0.248	<100	>100	>100	100

The low bacterial count in this sample suggests that the elevated chromium and nickel concentrations probably reflect chemical corrosion of the stainless steel, and these metal ions may be kept in solution by the elevated chloride concentration.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 7.7 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<5 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 440 – 774 mg/L, excluding an outlier (1,030 mg/L) in June 2003;
- pH (field measurements) of 7.0 – 8.0;
- very high (>200 mg/L) chloride concentrations;
- low molar proportions of potassium, sulfate, and nitrate (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals, excluding chromium and nickel, that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Fourteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.55 mg/L in October 2003) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0023 mg/L in November 1995) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, 2-hexanone was detected (1 µg/L) in the groundwater sample collected from the well in October 1992. This result is a suspected sampling or analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.53 pCi/L in April 1993) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (24 pCi/L in June 2003) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division, St. Paul, Minnesota.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*, EPA/540/S-92/018, U.S. Environmental Protection Agency, Office of Research and Development.

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells*. Bechtel National Inc., San Diego, CA.

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-761

LOCATION

HYDROGEOLOGIC REGIME:	East Fork Regime
FUNCTIONAL AREA:	GRID G2
Y-12 GRID EAST COORDINATE:	60,201.31
Y-12 GRID NORTH COORDINATE:	30,133.05
SURFACE ELEVATION:	964.91 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	X
OTHER:	.

WELL CONSTRUCTION

DATE INSTALLED:	05/04/92	PAIRED/CLUSTERED WITH:	GW-760
TAG DEPTH (measured):	18.51 ft below top of casing (TOC)		
MEASURING POINT ELEVATION:	968.23 ft above msl	MEASURING POINT:	TOC
WELL BORE DIAMETER:	9.87 inches		
WELL CASING MATERIAL:	SS304		
WELL CASING DIAMETER:	4.5 inches (outside diameter)		
WELL SCREEN TYPE:	SS/SW/0.01		
DEDICATED SAMPLING EQUIPMENT:	Well Wizard	Sampling Port No.: .	Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	3.6	961.31
BOTTOM (filter pack or open hole):	15.3	949.61
MIDPOINT (filter pack or open hole):	9.5	955.46
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	7.19	957.72
GEOLOGIC FORMATION:	Maryville Limestone	
HYDROGEOLOGIC ZONE:	Water Table	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	07/26/92	11/15/95
LOW-FLOW SAMPLING METHOD:	2 samples	06/04/03	10/29/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	.	06/04/03	.	10/29/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION:	.	TDS:	L	(L <150; H >800 mg/L)
GROUT CONTAMINATION:	.	LOW pH:	.	(<5.5)
SAMPLING METHOD SENSITIVITY:	.	OTHER:	.	
WATER LEVEL FLUCTUATION:	5.42 pre-sampling measurements (ft)			

PRINCIPAL CONTAMINANTS — Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-761

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 3.6 to 15.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-760 and is located in Bear Creek Valley in the east-central section of Y-12, about 250 ft north of Bldg. 9202.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between July 1992 and November 1995, and the low-flow sampling method used to obtain samples in June and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 7 ft bgs and exhibit moderate seasonal fluctuations (<6 ft). The well forms a cluster with well GW-760.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- low TDS (<150 mg/L), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths;
- pH (field measurements) of 6.1 – 7.3;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Ten groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.46 mg/L in February 2005) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.001 mg/L in July 1992 and August 1994) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for 15 groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime. A low (estimated) concentration of methylene chloride (1 μg/L) was detected in the sample collected in July 1992. This result is probably a sampling or analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.34 pCi/L in January 1993) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.26 pCi/L in November 1993) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	500 - 5,000	<7.5	<25

GW-762

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID J3
Y-12 GRID EAST COORDINATE: 63,192.53
Y-12 GRID NORTH COORDINATE: 29,114.91
SURFACE ELEVATION: 911.85 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/15/92 PAIRED/CLUSTERED WITH: GW-763
TAG DEPTH (measured): 62.04 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 915.56 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	46.4	865.45
BOTTOM (filter pack or open hole):	58.7	853.15
MIDPOINT (filter pack or open hole):	52.6	859.30
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	10.24	901.61
GEOLOGIC FORMATION:	Nolichucky Shale	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	25		
CONVENTIONAL SAMPLING METHOD:	13 samples	08/11/92	05/17/95
LOW-FLOW SAMPLING METHOD:	12 samples	02/09/99	08/05/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	02/11/04	.	08/05/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.45 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	24	3,399 µg/L	02/11/04	Increasing, Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-762

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 46.4 to 58.7 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-763 and is located in Bear Creek Valley at Comprehensive Monitoring Plan Grid J3, which is in the eastern Y-12 area near the northeast corner of Bldg. 9720-6 and about 500 ft west-southwest (hydraulically upgradient) of Lake Reality. Lake Reality is a lined surface impoundment used to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality replaced New Hope Pond (NHP), which was an unlined surface impoundment constructed in 1963, closed in 1988, and covered with a multi-layer low-permeability cap in 1989. During normal operations, flow in UEFPC bypasses Lake Reality and is directed through a concrete-lined distribution channel that borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-five groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between August 1992 and May 1995, and the low-flow sampling method used to obtain 12 samples between February 1999 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits seasonal fluctuations of about 10 ft. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically at least 3 ft higher in well GW-762 that in well GW-763, which is completed at a shallower depth (19 ft bgs) in the Nolichucky Shale. Based on the distance (42 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous presampling groundwater elevations indicate consistently upward vertical hydraulic gradients (0.05 to 0.14) during seasonally high and seasonally low flow conditions.

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-762 indicate south and southeasterly flow toward the Maynardville Limestone and the UEFPC drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, groundwater flow in the Nolichucky Shale is strongly anisotropic, with preferred flow in directions that parallel geologic strike, which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 309 – 470 mg/L;
- pH (field measurements) of 6.7 – 7.3;
- chloride concentrations above 30 mg/L;
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). However, as illustrated by the most recent monitoring data summarized in Table 1, several indicator parameters suggest that the geochemical conditions in groundwater at this well (particularly the REDOX) are not especially conducive to the biotic degradation of chlorinated hydrocarbons.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eight groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with the highest value (2.8 mg/L in August 2000) being substantially below the drinking water MCL (10 mg/L)

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected 24 of the groundwater samples collected to date (Table 2): methylene chloride, PCE, TCE, VC, 12DCE (isomers), 11DCA, 11DCE, and 111TCA. Methylene chloride was detected in only two samples which are considered to be outliers. Based on the very high concentrations of PCE in the groundwater at this well, which exceed 1% of pure-phase solubility for PCE (1,500 μg/L), the source of the dissolved VOCs may be DNAPL in the subsurface near Building 9720-6 (DOE 1998). Biologically mediated degradation (dechlorination) of PCE and TCE may account for the presence of 11DCE, 12DCE isomers, and VC in the groundwater, but as noted in Section 4.0, results for several geochemical indicator parameters (e.g., REDOX) lie outside the respective optimum range for biotic degradation of chlorinated hydrocarbons. Considering the upward hydraulic gradient indicated by presampling groundwater elevations (see Section 3.0), perhaps the monitored interval in the well intercepts groundwater flow/transport pathways for dissolved VOCs moving upward from DNAPL deeper in the bedrock where conditions are better suited for biodegradation.

The principal VOC in the groundwater samples is PCE, which has been detected in every sample, with concentrations of 1,000 μg/L or more reported for all but six of the samples (Table 2). Secondary VOCs in the samples are TCE and 12DCE; one or both compounds were detected in all but three of the samples, with historical maximum concentrations of 180 μg/L and 85 μg/L, respectively. Also, analytical results for samples collected since February 1999 show that c12DCE is the principal 12DCE isomer in the samples. The most recent sampling results show that PCE and TCE concentrations remain several orders-of-magnitude higher than the respective drinking water MCLs (5 μg/L), with concentrations of c12DCE at or below the MCL (70 μg/L). Historical maximum concentrations exceed 50 μg/L for 11DCE, but the highest concentrations of VC, 11DCA, and 111TCA are less than 20 μg/L, with the most recent sampling results showing concentrations of 11DCE and VC above respective MCLs (Table 2).

A time-series plot of summed VOC concentrations for each groundwater sample (Figure 1) shows an increasing long-term trend (Figure 1). Nevertheless, results for individual compounds show divergent temporal trends, including strongly increasing trends for PCE and TCE, indeterminate trends for VC and 111TCA, and a generally decreasing trend for (total) 12DCE (see data in Table 2). The significance of these divergent concentration trends with respect to the relative flux of VOCs along the flowpaths intercepted by the well is not clear from the available data.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater samples collected in August 1992 (2.8 pCi/L), January 1996 (1.96 pCi/L), July 2001 (2.57 pCi/L), and February 2004 (1.82 pCi/L). Each result is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eighteen groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (7.89 pCi/L in February 2003) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-762: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	February 2004	August 2004
Nitrate < 1 mg/L	ND	0.02
Iron (II) > 1 mg/L	0.02 **	ND **
Sulfate < 20 mg/L	15	16
Dissolved Oxygen < 0.5 ppm	0.65 **	0.59 **
REDOX < 50 mV	176 **	75 **
pH >5 and < 9 st. units	7.17 **	7.05 **
Note: **Field measurement; ND = not detected.		

Table 2. Well GW-762: summary of VOC results

Date Sampled	VOC Concentration (µg/L)				
	PCE	TCE	12DCE		
			Total	c12DCE	t12DCE
08/11/92	680	36	80	NR	NR
10/16/92	1,000	38	81	NR	NR
02/22/93	900	38	85	NR	NR
04/20/93	1,000	46	.	NR	NR
08/04/93	920	.	71	NR	NR
10/28/93	1,000	44	78	NR	NR
02/03/94	400	18	.	NR	NR
05/05/94	700	40	52	NR	NR
09/21/94	1,100	53	58	NR	NR
11/09/94	820	75	82	NR	NR
02/20/95	1,100	69	69	NR	NR
05/17/95	1,300	71	60	NR	NR
02/09/99	1,300	91	47	47	NR
08/24/99	1,600	130	64	61	3 J
05/16/00	2,200	150	74	66	3 J
08/21/00	2,400	140	67	64	3 J
01/16/01	1,900	160	61	59	2 J
07/30/01	1,900	140	64	62	2 J
01/31/02	2,200	110	72	70	2 J
07/31/02	2,400	150	52	50	2 J
02/11/03	2,200	180	74	71	3 J
08/11/03	2,200	160	62	60	2 J
02/11/04	3,100	130	70	66	4 J
08/05/04	2,400	130	58	55	3 J
MCL	**5**	**5**	**NA**	**70**	**100**

Table 2. (Continued)

Date Sampled	VOC Concentration (µg/L)			
	11DCE	VC	111TCA	11DCA
08/11/92	9	5	5	1 J
10/16/92	.	.	.	.
02/22/93	12	.	.	.
04/20/93	.	.	.	.
08/04/93	.	.	.	.
10/28/93	.	.	.	.
02/03/94	.	.	.	.
05/05/94	.	.	.	.
09/21/94	13	.	3 J	.
11/09/94	.	.	.	.
02/20/95	16	.	.	.
05/17/95	.	.	.	.
02/09/99	24	.	.	.
08/24/99	51	4 J	6	8
05/16/00	51	6	6	10
08/21/00	43	5	5	10
01/16/01	56	5	5	10
07/30/01	64	5	5	13
01/31/02	.	4 J	6	15
07/31/02	44	4 J	4 J	10
02/11/03	.	9	6	15
08/11/03	62	6	4 J	12
02/11/04	69	7	5	18
08/05/04	51	5	4 J	13
MCL	**7**	**2**	**200**	**NA**

Notes: "." = Not detected; J = Estimated concentration; NA = Not applicable; NR = Not reported

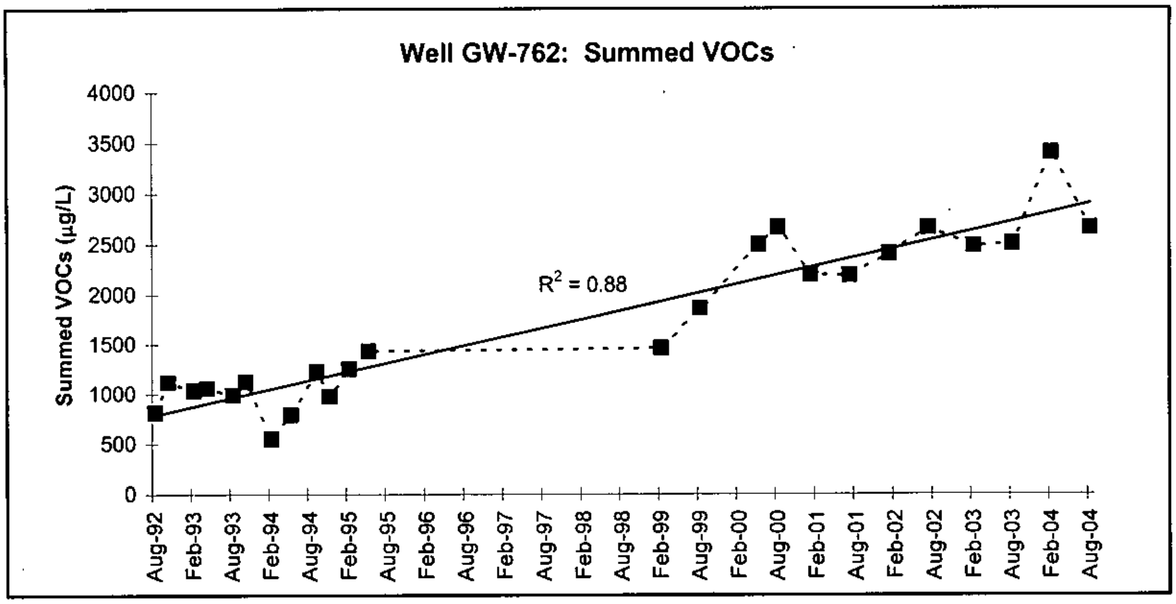

Well GW-762: Summed VOCs
Summed VOCs (µg/L)
4000
3500
3000
2500
2000
1500
1000
500
0
R2 = 0.88
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	ND	50 - 500	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-763

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID J3
Y-12 GRID EAST COORDINATE: 63,219.76
Y-12 GRID NORTH COORDINATE: 29,117.17
SURFACE ELEVATION: 911.38 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/13/92 PAIRED/CLUSTERED WITH: GW-762
TAG DEPTH (measured): 20.41 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 915.03 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 8 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.0	907.38
BOTTOM (filter pack or open hole):	16.0	895.38
MIDPOINT (filter pack or open hole):	10.0	901.38
PUMP INTAKE:	11.75	899.63
WATER LEVEL (average):	6.28	905.10

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	37		
CONVENTIONAL SAMPLING METHOD:	21 samples	08/11/92	10/11/00
LOW-FLOW SAMPLING METHOD:	16 samples	12/02/97	11/01/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/17/04	.	11/01/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 3.31 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	30	480 µg/L	06/12/03	Indeterminate
GROSS ALPHA (15 pCi/L):	1	27 pCi/L	10/22/01	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-763

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 4 to 16 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-762 and is located in Bear Creek Valley at Comprehensive Monitoring Plan Grid J3, which is in the eastern Y-12 area near the northeast corner of Bldg. 9720-6 and about 500 ft west-southwest (hydraulically upgradient) of Lake Reality. Lake Reality is a lined surface impoundment used to regulate the quantity and quality of surface water exiting Y-12 via Upper East Fork Poplar Creek (UEFPC). Lake Reality replaced New Hope Pond (NHP), which was an unlined surface impoundment constructed in 1963, closed in 1988, and covered with a multi-layer low-permeability cap in 1989. During normal operations, flow in UEFPC bypasses Lake Reality and is directed through a concrete-lined diversion channel that borders the south and east sides of NHP/Lake Reality.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-seven groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 21 samples between August 1992 and October 2000, and the low-flow sampling method used to obtain 16 samples between December 1997 and November 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially lower contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired" sampling performed during May and October 2000, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the sampling-method bias. As shown by the data summarized in Table 1, the groundwater samples obtained with the conventional sampling method have significantly higher dissolved oxygen, negative rather than positive oxidation-reduction potential (REDOX), and about 30 to 50% more suspended solids. Both sampling methods provide similar results for major ions and trace metals, whereas the low-flow sampling method seems to obtain samples with significantly lower VOC concentrations.

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at a flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of clean groundwater into the well, and effectively dilutes the VOC concentrations.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs *in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike* fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits seasonal fluctuations of about 3 ft. Also, presampling groundwater elevations recorded during contemporaneous sampling events (i.e., within 24 hours) are typically at least 3 ft lower in well GW-763 than in well GW-762, which is completed deeper (60 ft bgs) in the Nolichucky Shale. Based on the distance (42 ft) between the monitored interval midpoint (elevation) in each well, the contemporaneous presampling groundwater elevations indicate consistently upward vertical hydraulic gradients (0.05 to 0.14) during seasonally high and seasonally low flow conditions.

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-763 indicate easterly flow toward the UEFPC drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that this well yields chloride-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 286 – 448 mg/L;
- pH (field measurements) of 6.3 – 7.6;
- unusually high chloride concentrations (>50 mg/L);
- low molar proportions of potassium, sodium, and sulfate (<10% of total anions/cations);
- very high total iron concentrations (>20 mg/L); and
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). As illustrated by the most recent monitoring data summarized in Table 2, several indicator parameters, including the strongly negative REDOX and very high iron concentrations, suggest the geochemical conditions in groundwater at this well are conducive to the biotic degradation of chlorinated hydrocarbons.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Only the nitrate concentration reported for the groundwater sample collected in November 1994 (0.42 mg/L) exceeds the applicable analytical reporting limit and this result is substantially below the drinking water MCL (10 mg/L).

5.2 URANIUM

Uranium concentrations at or above the applicable analytical reporting limit were reported for groundwater samples collected in March 1996 (0.0015 mg/L) and May 2000 (0.00129 mg/L); both values are an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in 34 of the groundwater samples collected to date (Table 3): acetone, bromomethane, 1,1,2-trichloro-1,2,2-trifluoroethane (freon-113), PCE, TCE, VC, 12DCE (isomers), 11DCA, 11DCE, and 111TCA. The suspected source of the dissolved VOCs in the groundwater at this well (and paired well GW-762) is DNAPL believed to be present in the subsurface near Building 9720-6 (DOE 1998). Also, biologically mediated degradation (dechlorination) of PCE and TCE may account for the presence of 11DCE, 12DCE isomers, and VC in the groundwater and, as noted in Section 4.0, geochemical conditions in the well appear to be conducive to biodegradation of these chlorinated hydrocarbons. Moreover, the low levels of dissolved oxygen in the well (Table 2) combined with the high concentrations of VC (Table 3), suggest the strongly reducing (methanogenic) geochemical conditions necessary to transform 12DCE isomers to VC (Chapelle. 1996). Also, in light of the upward vertical hydraulic gradients indicated by presampling groundwater elevations (see Section 3.0), the presence of VOCs in the shallow groundwater at this well potentially result from upward migration from the suspected DNAPL deeper in the bedrock.

The primary VOCs in the groundwater samples are PCE, TCE, c12DCE, and VC; one or more of these compounds were detected in the groundwater samples (Table 3). The highest concentrations are evident for c12DCE (350 μg/L), VC (92 μg/L), and PCE (65 μg/L), with the most recent monitoring results showing that the concentrations of these VOCs (and TCE) remain above respective drinking water MCLs (Table 3). Secondary VOCs in the samples are 11DCE and 11DCA, which have been detected less consistently and at substantially lower concentrations (almost all are estimated values below 5 μg/L), although the 11DCE concentration evident in March 2003 (13 μg/L) exceeds the historical maximum concentration (5 μg/L in May 2000) and the MCL (7 μg/L). Acetone, bromomethane, and freon-113 each were detected only in one sample.

As noted in Section 2.0, the groundwater sampling method appears to influence the concentrations of VOCs in the groundwater samples, as illustrated by the results of consecutive daily sampling in May and October 2000 (Table 4). In May 2000, VOCs were not detected in the sample collected using the low-flow sampling method, but several compounds dominated by PCE and c12DCE were detected in the sample obtained with the conventional sampling method the next day. Each of these same VOCs except 11DCA were detected in the groundwater samples obtained with each sampling method in October 2000, and there is not any significant difference between the respective concentrations of VOCs reported for either of these groundwater samples.

Respective time-series plots of summed concentrations of VOCs detected in the groundwater samples obtained with the conventional and low-flow sampling methods show two different long-term trends (Figure 1). The conventional sampling data show a widely fluctuating and indeterminate trend, as illustrated by the summed VOC concentrations evident in October 1992 (171 μg/L), November 1996 (102 μg/L) and October 2000 (125 μg/L). In contrast, the low-flow sampling results show a similarly fluctuating but clearly increasing trend, with the highest summed VOC concentration evident in June 2003 (476 μg/L). This increasing trend is primarily attributable to higher relative concentrations of c12DCE (Table 3), which increased more than 1,000% between June 1999 (29 μg/L) and June 2003 (350 μg/L), followed by lower concentrations in 2004 (7-142 μg/L). Increasing trends are evident for each compound, which suggests a corresponding increase in the overall flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater samples collected in August 1992 (2.86 pCi/L), October 1993 (3.94 pCi/L), and October 2001 (27 pCi/L). The latter result exceeds the drinking water MCL for gross alpha activity (15 pCi/L), but appears to be an outlier compared to the other results.

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in October 1993 (4.1 pCi/L) and this result is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons.* Batelle Press, Columbus, OH.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-763: consecutive daily conventional/low-flow sampling results for selected analytes

Analyte	Units	May 2000		October 2000	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	6.96	7.16	6.78	6.65
Dissolved Oxygen	ppm	0.2	5.27	0.65	4.43
REDOX	mV	141	-102	123	-65
Dissolved Solids	mg/L	364	397	401	408
Suspended Solids	mg/L	41	61	31	66
Calcium	mg/L	109	129	107	111
Chloride	mg/L	71.3	56	69.1	70.2
Barium	mg/L	0.0515	0.0929	0.0543	0.0693
Iron	mg/L	26.9	27.4	23.8	25.7
Summed VOCs	µg/L	0	246	138	125

Table 2. Well GW-763: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	May 2004	November 2004
Nitrate < 1 mg/L	<0.02	<0.02
Iron (II) > 1 mg/L	26.1*	24.2*
Sulfate < 20 mg/L	0.28	1.46
Dissolved Oxygen < 0.5 ppm	1.11**	1.5**
REDOX < 50 mV	-130 **	-121 **
pH >5 and < 9 st. units	6.85 **	6.67 **

Note: *Results are for total iron; **Field measurement.

Table 3. Well GW-763: summary of VOC results

Date Sampled	VOC Concentration (µg/L)				
	PCE	TCE	12DCE		
			Total	c12DCE	t12DCE
Conventional Sampling					
08/11/92	10	4 J	260	NR	NR
10/17/92	11	5	120	NR	NR
01/25/93	8	2 J	59	NR	NR
04/21/93	5	1 J	42	NR	NR
08/05/93	27	4 J	98	NR	NR
10/29/93	41	7	120	NR	NR
02/03/94	6	2 J	.	NR	NR
05/05/94	8	2 J	68	NR	NR
09/21/94	8	2 J	43	NR	NR
11/09/94	9	3 J	70	NR	NR
02/20/95	15	4 J	70	NR	NR
05/18/95	8	2 J	37	NR	NR
08/22/95	9	3 J	51	NR	NR
11/27/95	19	5	100	NR	NR
03/06/96	18	5	76	NR	NR
06/10/96	21	6	75	NR	NR
08/20/96	22	5	78	NR	NR
11/14/96	59	12	.	NR	NR
05/20/97	35	8	173	170	3 J
05/11/00	62	14	150	150	.
10/11/00	20	7	90	90	.
Low-Flow Sampling					
12/03/98	.	.	.	.	.
06/01/99	12	3 J	29	29	.
05/10/00	.	.	.	.	.
10/10/00	28	7	98	98	.
10/22/01	.	.	4 J	4 J	.
06/12/02	32	8	79	79	.
10/21/02	43	10	130	130	.
06/12/03	65	18	353	350	3 J
10/15/03	41	11	202	200	2 J
05/17/04	1 J	.	7	7	.
11/01/04	30	8	142	140	2 J
MCL	**5**	**5**	**NA**	**70**	**NA**

Table 3 (continued)

Date Sampled	VOC Concentration (µg/L)			
	VC	11DCE	11DCA	Freon-113
Conventional Sampling				
08/11/92	92	2 J	.	NR
10/17/92	35	.	.	NR
01/25/93	45	.	.	NR
04/21/93	35	.	.	NR
08/05/93	48	.	.	NR
10/29/93	59	2 J	.	NR
02/03/94	25	.	.	NR
05/05/94	29	.	.	NR
09/21/94	16	1 J	.	NR
11/09/94	26	.	.	NR
02/20/95	18	1 J	.	NR
05/18/95	.	.	.	NR
08/22/95	11	1 J	.	NR
11/27/95	20	.	.	NR
03/06/96	13	2 J	.	NR
06/10/96	12	2 J	.	NR
08/20/96	12	2 J	.	NR
11/14/96	26	4 J	1 J	NR
05/20/97	24	4 J	2 J	NR
05/11/00	13	5	2 J	NR
10/11/00	8	.	.	NR
Low-Flow Sampling				
12/03/98	2 J	.	.	NR
06/01/99	4 J	.	.	NR
05/10/00	.	.	.	NR
10/10/00	5	.	.	NR
10/22/01	1 J	.	.	NR
06/12/02	5	3 J	.	NR
10/21/02	10	4 J	.	NR
06/12/03	26	13	4 J	NR
10/15/03	19	6	2 J	NR
05/17/04	.	.	.	.
11/01/04	9	6	2 J	9
MCL	**2**	**7**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported

Table 4. Well GW-763: summary of VOC results from consecutive daily sampling in May and October 2000

VOC	VOC Concentration ($\mu g/L$)			
	May 2000		October 2000	
	Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
PCE	.	62	28	20
TCE	.	14	7	7
c12DCE	.	150	98	90
11DCA	.	2 J	.	.
11DCE	.	5	.	.
VC	.	13	5	8

Note: "." = Not detected; J = Estimated concentration below the analytical reporting limit

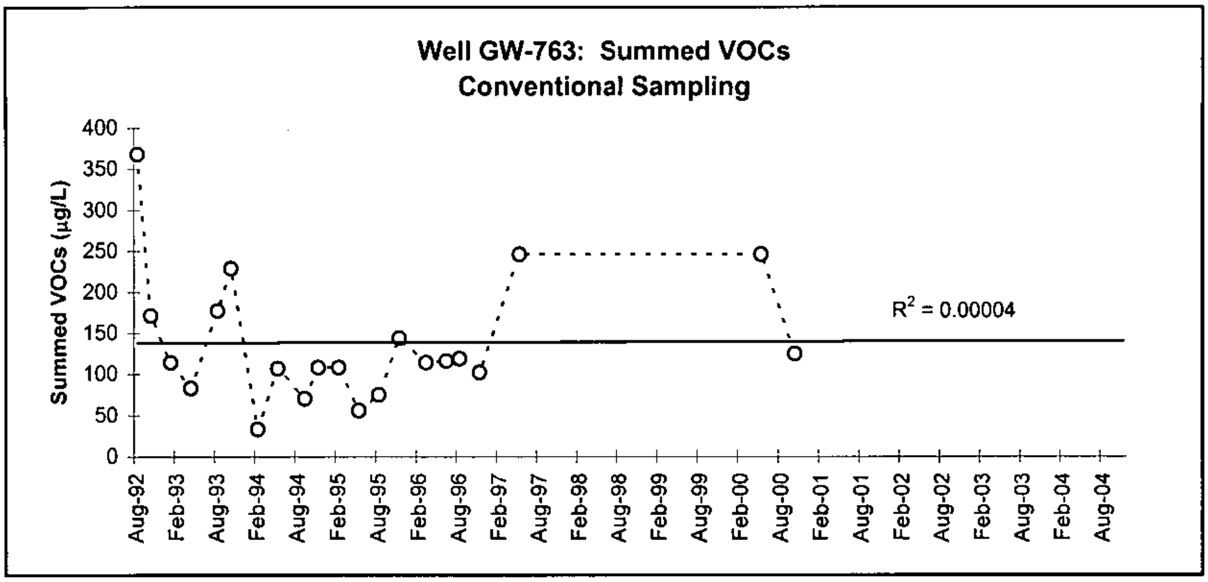


Figure 1

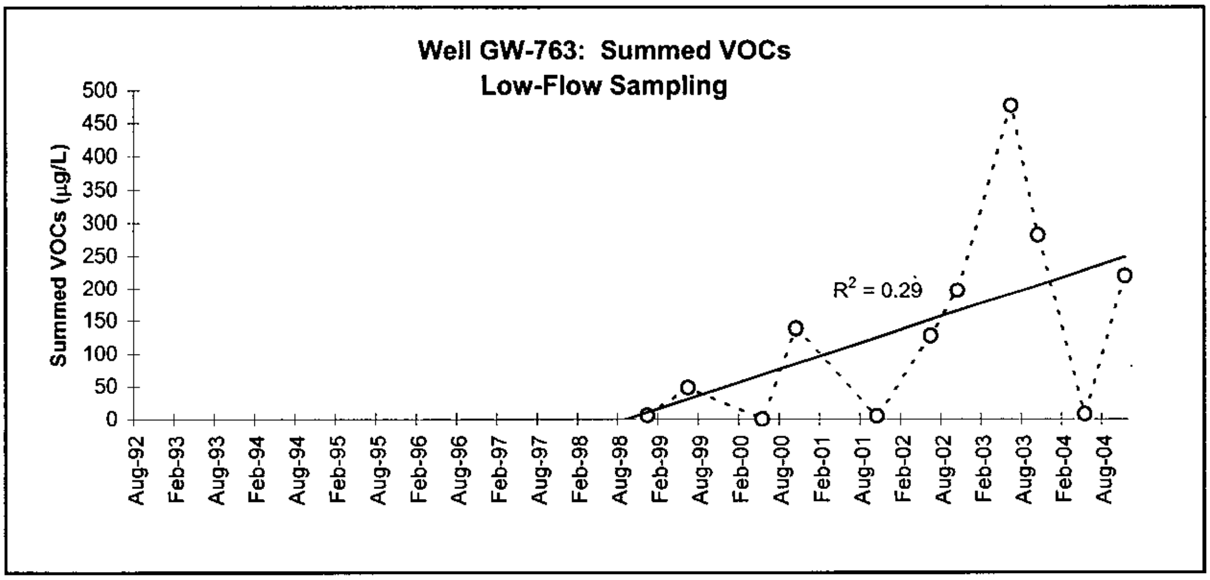


Figure 2

MAXIMUM CONCENTRATION: 2003

ND	ND	ND	ND	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-764

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E1
Y-12 GRID EAST COORDINATE: 58,461.86
Y-12 GRID NORTH COORDINATE: 31,026.68
SURFACE ELEVATION: 1,006.72 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/08/92 PAIRED/CLUSTERED WITH: GW-765
TAG DEPTH (measured): 68.14 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,009.87 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	53.9	952.82
BOTTOM (filter pack or open hole):	65.0	941.72
MIDPOINT (filter pack or open hole):	59.5	947.27
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	17.32	989.40

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16		
CONVENTIONAL SAMPLING METHOD:	14 samples	07/28/92	11/13/95
LOW-FLOW SAMPLING METHOD:	2 samples	06/02/03	10/27/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	.	06/02/03	.	10/27/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.4 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-764

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 53.9 to 65 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-765 and is located in Bear Creek Valley in the east-central section of Y-12, about 200 ft south of Bear Creek Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Sixteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between July 1992 and November 1995, and the low-flow sampling method used to obtain samples in June and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Rogersville Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits minor seasonal fluctuations (<3 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 7.2 – 7.9;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit and this result (0.001 mg/L in November 1993) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for 16 groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime. The single detections at low concentrations (estimated values) of methylene chloride (1 μg/L in July 1992) and 12DCE (4 μg/L in November 1995) are suspected outliers.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.35 pCi/L in April 1993) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eight groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (9.71 pCi/L in November 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-765

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E1
Y-12 GRID EAST COORDINATE: 58,481.71
Y-12 GRID NORTH COORDINATE: 31,025.53
SURFACE ELEVATION: 1,005.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/13/92 PAIRED/CLUSTERED WITH: GW-764
TAG DEPTH (measured): 35.05 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,008.54 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	19.9	985.63
BOTTOM (filter pack or open hole):	32.4	973.13
MIDPOINT (filter pack or open hole):	26.2	979.38
PUMP INTAKE:	26.99	978.54
WATER LEVEL (average):	16.97	988.56

GEOLOGIC FORMATION: Rogersville Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	15 samples	07/28/92	02/15/96
LOW-FLOW SAMPLING METHOD:	3 samples	06/02/03	04/27/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	04/27/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.57 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	2	43.3 pCi/L	07/28/92	Outliers
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-765

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1992, completed with a screened monitored interval from 19.9 to 32.4 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-764 and is located in Bear Creek Valley in the east-central section of Y-12, about 200 ft south of Bear Creek Road.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between July 1992 and February 1996, and the low-flow sampling method used to obtain 3 samples between June 2003 and April 2004.

The Y-12 GWPP requested biological testing to assess microbial activity in groundwater at this well in April 2004. The results (shown below) are qualitative bacterial counts of four specific bacteria types that are estimates based on the appearance of the sample after an eight- to ten-day growth period.

Well	Date Sampled	Bacteria Activity (colony forming units/milliliter)			
		Heterotrophic Aerobic	Iron Related	Slime Forming	Sulfate Reducing
GW-765	04/27/04	1,000	>100	>100	<100

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Rogersville Shale). Presampling depth-to-water measurements for the well show that the static water level in the well occurs at an average depth of about 17 ft bgs and exhibits minor seasonal fluctuations (<3 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 304 – 460 mg/L;
- pH (field measurements) of 6.5 – 7.3;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

None of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit.

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit and both results (0.001 mg/L in July and October 1992) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime. Carbon disulfide was detected (4 µg/L) in one sample (November 2003), but this result is a probable artifact and considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the results for the samples collected in July 1992 (43.3 pCi/L) and September 1993 (17.5 pCi/L) exceeding the MCL for gross alpha activity (15 pCi/L). Both results may be outliers because all the other gross alpha results are less than 6 pCi/L.

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (47.9 pCi/L in July 1992) being slightly below the SDWA screening level for gross beta activity (50 pCi/L). This result is clearly an outlier compared to the other gross beta results, which are all below 10 pCi/L.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	50 - 500	ND	ND

GW-769

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID G3
Y-12 GRID EAST COORDINATE: 60,230.01
Y-12 GRID NORTH COORDINATE: 29,510.42
SURFACE ELEVATION: 941.53 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/04/92 PAIRED/CLUSTERED WITH: GW-770
TAG DEPTH (measured): 62.73 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 944.43 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.62 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	48.2	893.33
BOTTOM (filter pack or open hole):	60.3	881.23
MIDPOINT (filter pack or open hole):	54.3	887.28
PUMP INTAKE:	54.90	886.63
WATER LEVEL (average):	7.73	933.80

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	16 samples	01/27/93	05/13/97
LOW-FLOW SAMPLING METHOD:	15 samples	11/17/97	10/28/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/17/04	.	10/28/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level: # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	207 µg/L	10/30/02	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-769

1.0 *INSTALLATION, CONSTRUCTION, AND LOCATION*

This well was installed in June 1992, completed with a screened monitored interval from 48.2 to 60.3 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-770 and is located in Bear Creek Valley at Comprehensive Monitoring Plan Grid G3, which is in the east-central part of Y-12, directly across Second Street (north) from Bldg. 9201-2.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between January 1993 and May 1997, and the low-flow sampling method used to obtain 15 samples between November 1997 and October 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of Upper East Fork Poplar Creek (UEFPC) and other subsurface components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits seasonal fluctuations of less than 5 ft. Also, results of contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in the well are usually 2 to 3 ft higher than the presampling groundwater elevations in well GW-770, which is completed at a shallower depth (19 ft bgs) in the Nolichucky Shale. Based on the difference between the midpoint elevation of the monitored interval in each well (41.1 ft), the presampling groundwater elevations indicate consistently upward vertical hydraulic gradients (0.05 – 0.1).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-769 indicate south and southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 258 – 334 mg/L, excluding an outlier (36 mg/L) in November 1995;
- pH (field measurements) of 7.0 – 7.6;
- sulfate concentrations above 20 mg/L;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-two groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, with each concentration being less than 1 mg/L and substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Uranium concentrations at or above the applicable analytical reporting limit were reported for the groundwater samples collected in September 1993 (0.001 mg/L), August 1994 (0.001 mg/L), and February 1995 (0.00052 mg/L); each result is at least an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 1): CTET, chloroform, methylene chloride, PCE, TCE, 12DCE (c12DCE), 11DCA, 11DCE, 111TCA, and 1,1,2-trichloro-1,2,2-trifluoroethane (freon-113). The source(s) of the VOCs in the groundwater at this well has not been conclusively identified. However, because basement sumps in Bldg. 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) may be north of the well, possibly Buildings 9202, 9203, and 9205 where large amounts of CTET were used to convert uranium trioxide to uranium tetrachloride (DOE 1998). Also, considering the upward vertical hydraulic gradient noted in Section 3.0, the VOCs transported via the groundwater flowpaths intercepted by the monitored interval in the well would be expected to move upward into the shallow flow system. Indeed, operation of the basement sumps in Bldg. 9201-2 may induce or increase the upward flow of contaminated groundwater from deeper in the bedrock.

The primary VOCs in the groundwater samples are CTET and PCE, both of which were detected in all but one of the samples, with historical maximum concentrations 160 μg/L and 22 μg/L, respectively (Table 1). The most recent sampling results show that the concentrations of CTET and PCE remain above respective drinking water MCLs of 5 μg/L. Secondary compounds in the samples are chloroform and TCE, which were detected in all but 11 of the samples, with the bulk of the results being estimated values below 5 μg/L. Other compounds (11DCE, 12DCE, 11DCA, 111TCA, and freon-113) have been detected less frequently, with almost all the concentrations are estimated values below 5 μg/L. Additionally, methylene chloride was only detected in one sample and the result is considered to be an outlier.

A time-series plot of summed VOC concentrations for each groundwater sample (Figure 1) shows an indeterminate trend between January 1993 (18 μg/L) and October 1999 (11 μg/L), followed by a widely fluctuating but clearly increasing trend through October 2004 (131 μg/L). Also, the VOC results obtained since October 1999 show temporal concentration fluctuations that appear to correlate with seasonal groundwater flow conditions, with the highest VOC concentration typically evident in samples collected during seasonally low flow conditions (summer and fall). This relationship suggests dilution-related concentration fluctuations, with greater relative inflow of "clean" groundwater into the well effectively lowering the VOC concentrations in the samples collected during seasonally (and episodically) high flow conditions. Also, increasing summed VOC concentrations are primarily attributable to CTET and PCE, the concentrations of which increased significantly between January 1993 (CTET = 9 μg/L; PCE = 4 μg/L) and October 2004 (CTET = 100 μg/L; PCE = 16 μg/L). However, similar concentration increases are less evident for the other VOCs (Table 1).

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in April 2002 (2.9 pCi/L) and this result is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (10 pCi/L in October 1999) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-769: summary of VOC results

Date Sampled	VOC Concentration (µg/L)			
	CTET	Chloroform	PCE	TCE
01/27/93	9	1 J	4 J	1 J
04/19/93	5	1 J	4 J	1 J
09/14/93	5	0.9 J	3 J	1 J
11/30/93	6	0.7 J	2 J	0.7 J
02/08/94	5	0.7 J	3 J	0.8 J
08/31/94	5	.	3 J	.
11/07/94	7	.	3 J	1 J
02/20/95	9	2 J	6	2 J
05/27/95	10	2 J	8	2 J
08/07/95	15	2 J	8	.
11/15/95	18	3 J	13	4 J
01/11/96	7	1 J	5	1 J
05/20/96	6	1 J	6	2 J
10/15/96	.	FP	8	.
05/13/97	3 J	FP	2 J	.
11/17/97	11	2 J	5	1 J
05/19/98	11	2 J	6	2 J
11/11/98	12	2 J	7	2 J
04/20/99	9	.	5	.
10/21/99	7	.	4 J	.
04/27/00	25	3 J	8	.
10/03/00	75	3 J	12	3 J
04/17/01	38	5	12	3 J
10/16/01	73	4 J	15	4 J
04/29/02	58	3 J	11	3 J
10/30/02	160	6	22	6
06/10/03	56	3 J	16	3 J
10/09/03	75	3 J	15	3 J
05/17/04	60	3 J	11	2 J
10/28/04	100	4 J	16	3 J
MCL	**5**	**80***	**5**	**5**

Table 1 (continued)

Date Sampled	VOC Concentration (µg/L)					
	Total 12DCE	c12DCE	11DCE	111TCA	11DCA	Freon-113
01/27/93	1 J	NR	1 J	.	1 J	NR
04/19/93	.	NR	1 J	0.8 J	1 J	NR
09/14/93	.	NR	.	0.4 J	.	NR
11/30/93	.	NR	.	.	.	NR
02/08/94	.	NR	.	.	.	NR
08/31/94	.	NR	.	.	.	NR
11/07/94	.	NR	.	.	.	NR
02/20/95	2 J	NR	1 J	.	.	NR
05/27/95	.	NR	1 J	FP	.	NR
08/07/95	.	NR	.	.	.	NR
11/15/95	4 J	NR	2 J	FP	.	NR
01/11/96	2 J	NR	1 J	.	.	NR
05/20/96	2 J	NR	1 J	.	.	NR
10/15/96	.	NR	.	.	.	NR
05/13/97	.	.	.	.	.	NR
11/17/97	2 J	2 J	1 J	.	.	NR
05/19/98	1 J	1 J	1 J	.	.	NR
11/11/98	2 J	2 J	1 J	.	.	NR
04/20/99	.	.	.	.	.	NR
10/21/99	.	.	.	.	.	NR
04/27/00	.	.	.	.	.	NR
10/03/00	3 J	3 J	.	.	.	NR
04/17/01	.	.	.	.	.	NR
10/16/01	4 J	4 J	.	.	.	NR
04/29/02	3 J	3 J	.	.	.	NR
10/30/02	6	6	.	.	.	NR
06/10/03	3 J	3 J	.	.	.	NR
10/09/03	3 J	3 J	1 J	.	.	NR
05/17/04	2 J	2 J	2 J	.	.	2 J
10/28/04	3 J	3 J	2 J	.	.	.
MCL	**NA**	**70**	**7**	**200**	**NA**	**NA**

Note: "." = Not detected; FP = False positive; J = Estimated value; NA = Not applicable; NR = Not reported; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane

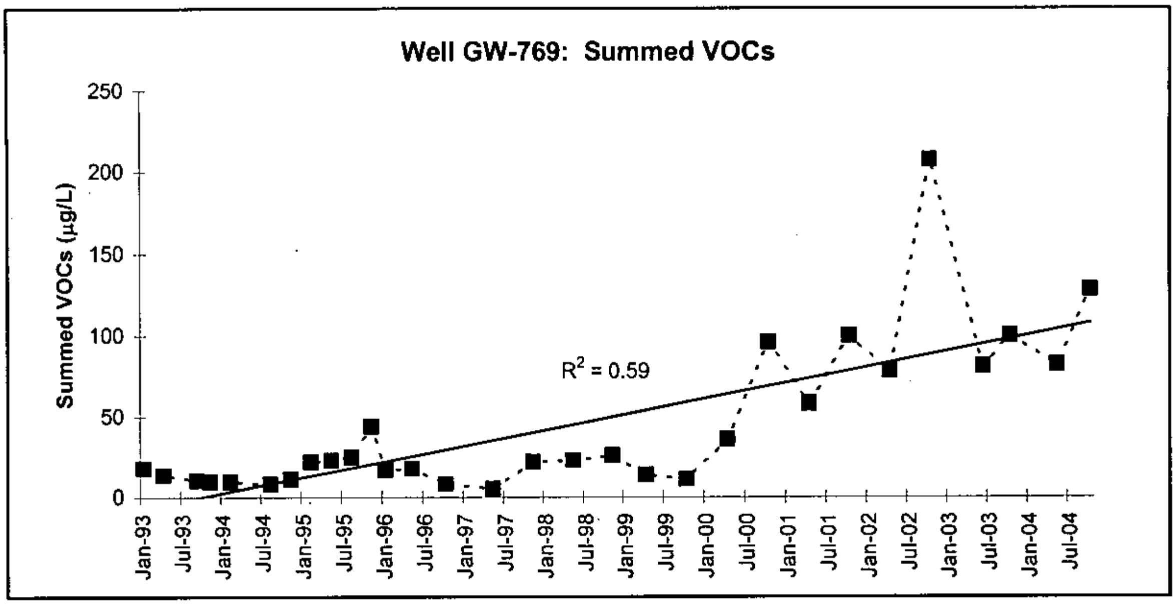

Well GW-769: Summed VOCs
Summed VOCs (µg/L)
250
200
150
100
50
0
R^2 = 0.59
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	ND	ND

GW-770

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID G3
Y-12 GRID EAST COORDINATE: 60,255.00
Y-12 GRID NORTH COORDINATE: 29,504.56
SURFACE ELEVATION: 941.67 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/04/92 PAIRED/CLUSTERED WITH: GW-769
TAG DEPTH (measured): 21.68 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 944.72 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10.62 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	7.5	934.17
BOTTOM (filter pack or open hole):	19.0	922.67
MIDPOINT (filter pack or open hole):	13.3	928.42
PUMP INTAKE:	13.65	928.02
WATER LEVEL (average):	10.16	931.51

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	31		
CONVENTIONAL SAMPLING METHOD:	16 samples	01/27/93	05/12/97
LOW-FLOW SAMPLING METHOD:	15 samples	11/17/97	10/28/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	04/26/04	.	10/28/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.98 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	21	60 µg/L	05/19/98	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-770

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1992, completed with a screened monitored interval from 7.5 to 19 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-769 and is located in Bear Creek Valley at Comprehensive Monitoring Plan Grid G3, which is in the east-central part of Y-12, directly across Second Street (north) from Bldg. 9201-2.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between January 1993 and May 1997, and the low-flow sampling method used to obtain 15 samples between November 1997 and October 2004.

The Y-12 GWPP requested biological testing to assess microbial activity in groundwater at this well in April 2004. The results (shown below) are qualitative bacterial counts of four specific bacteria types that are estimates based on the appearance of the sample after an eight- to ten-day growth period.

Well	Date Sampled	Bacteria Activity (colony forming units/milliliter)			
		Heterotrophic Aerobic	Iron Related	Slime Forming	Sulfate Reducing
GW-770	04/28/04	500,000	5,000	1,000	100

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of Upper East Fork Poplar Creek (UEFPC) and other subsurface components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits seasonal fluctuations of about 5 ft. Also, results of contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in the well are usually 2 to 3 ft lower than the presampling groundwater elevations in well GW-769, which is completed at a greater depth (60.3 ft bgs) in the Nolichucky Shale. Based on the difference between the midpoint elevation of the monitored interval in each well (41.1 ft), the presampling groundwater elevations indicate consistently upward vertical hydraulic gradients (0.05-0.1).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells the vicinity of well GW-770 indicate south and southeasterly flow toward the Maynardville Limestone and the Upper East Fork Poplar Creek (UEFPC) drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 154 – 266 mg/L;
- pH (field measurements) of 6.0 – 7.4;
- sulfate concentrations above 20 mg/L;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate concentrations at or above the applicable analytical reporting limit were reported for each groundwater sample collected to date, with each concentration being less than 1 mg/L and substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-one groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0018 mg/L in November 1997) being substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in 30 of the groundwater samples collected to date (Table 1): acetone, CTET, chloroform, and PCE. The source(s) of the VOCs in the groundwater at this well has not been conclusively identified.

However, because basement sumps in Bldg. 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) may be north of the well, possibly Buildings 9202, 9203, and 9205 where large amounts of CTET were used to convert uranium trioxide to uranium tetrachloride (DOE 1998). Also, considering the upward vertical hydraulic gradient noted in Section 3.0, the VOCs transported via the groundwater flowpaths intercepted by the monitored interval in the well would be expected to move upward into the shallow flow system. Indeed, operation of the basement sumps in Bldg. 9201-2 may induce or increase the upward flow of contaminated groundwater from deeper in the bedrock.

The primary VOCs in the groundwater samples are CTET and chloroform, with one or both compounds detected in each sample (Table 1). Historical maximum concentrations of these compounds are slightly above (CTET) and below (chloroform) 10 µg/L, with the bulk of the concentrations being estimated values below 5 µg/L. Nevertheless, the most recent monitoring data show that CTET concentrations exceed the drinking water MCL (Table 1). In contrast, acetone and PCE were detected in one sample each, and both of these results are considered to be outliers.

A time-series plot of summed VOC (CTET and chloroform) concentrations for each groundwater sample (excluding the outliers mentioned above, see Table 1) shows a widely fluctuating and generally increasing trend (Figure 1). Also, the VOC concentration fluctuations often correlate with seasonal groundwater flow conditions, with the highest concentrations typically reported for samples collected during seasonally low groundwater flow conditions (summer and fall). This relationship suggests that greater relative inflow of clean groundwater into the well effectively dilutes the VOC concentrations in the samples collected during seasonally (and episodically) high flow conditions.

5.4 GROSS ALPHA ACTIVITY

Eight groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.96 pCi/L in April 1993) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Six groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.38 pCi/L in August 1994) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

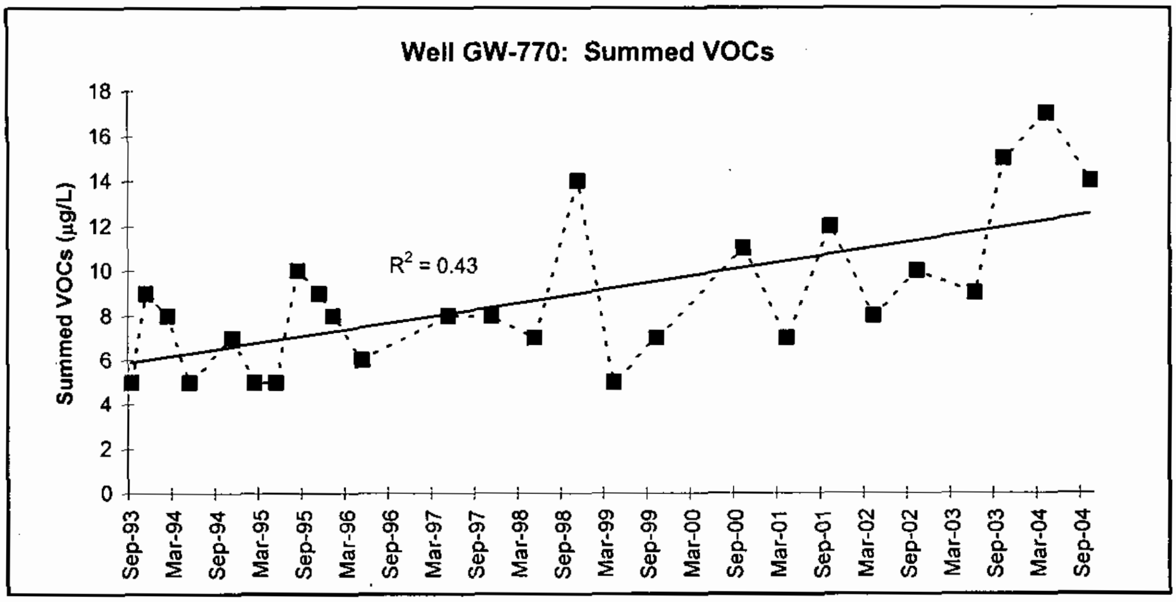
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-770: summary of VOC results

Date Sampled	VOC Concentration (µg/L)		
	CTET	Chloroform	Other
09/14/93	.	5	.
11/29/93	.	9	.
02/08/94	.	8	.
05/10/94	.	5	.
11/07/94	2 J	5	.
02/19/95	2 J	3 J	.
05/27/95	2 J	3 J	.
08/07/95	6	4 J	.
11/15/95	5	4 J	PCE (1 J)
01/11/96	5	3 J	.
05/20/96	3 J	3 J	.
05/12/97	5	3 J	.
11/17/97	4 J	4 J	.
05/19/98	3 J	4 J	Acetone (53)
11/10/98	7	7	.
04/20/99	.	5	.
10/21/99	.	7	.
10/02/00	4 J	7	.
04/17/01	.	7	.
10/15/01	4 J	8	.
04/29/02	3 J	5	.
10/30/02	7	3 J	.
06/10/03	6	3 J	.
10/09/03	11	4 J	.
04/26/04	14	3 J	.
10/28/04	12	2 J	.
MCL	**5**	**80***	**PCE (5)**

Note: "." = Not detected; J = Estimated value; * MCL is for total trihalomethanes: chloroform + bromoform + bromodichloromethane + dibromochloromethane



Well GW-770: Summed VOCs
Summed VOCs (µg/L)
0
2
4
6
8
10
12
14
16
18
R^2 = 0.43
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	.	.

GW-775

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID H3
Y-12 GRID EAST COORDINATE: 61,277.82
Y-12 GRID NORTH COORDINATE: 29,272.38
SURFACE ELEVATION: 931.48 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/16/92 PAIRED/CLUSTERED WITH: GW-776
TAG DEPTH (measured): 55.98 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 931.35 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.62 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	45.0	886.48
BOTTOM (filter pack or open hole):	56.4	875.08
MIDPOINT (filter pack or open hole):	50.7	880.78
PUMP INTAKE:	51.13	880.35
WATER LEVEL (average):	13.93	917.55

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	24		
CONVENTIONAL SAMPLING METHOD:	16 samples	02/04/93	05/12/97
LOW-FLOW SAMPLING METHOD:	8 samples	11/19/97	04/28/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/28/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.25 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	11	17 µg/L	01/31/94	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-775

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1992, completed with a screened monitored interval from 45 to 56 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-776 and is located in Bear Creek Valley in the east-central section of Y-12, about 150 ft northeast of the intersection of Second Street and "B" Road, approximately 500 ft north of the exposed section of Upper East Fork Poplar Creek (UEFPC).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-four groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 16 samples between February 1993 and May 1997, and the low-flow sampling method used to obtain 8 samples between November 1997 and April 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group) near the geologic contact with the overlying Maynardville Limestone. The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of UEFPC and other subsurface components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 14 ft bgs and exhibits moderate seasonal fluctuations (<10 ft). Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-775 are typically higher than evident in well GW-776, which is completed at a shallower depth (24 ft bgs) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well (33.9 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients (0.005 to 0.131) from the shallow bedrock interval (GW-775) to the water table interval (GW-776).

Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-775 indicate south and southeasterly flow toward the Maynardville Limestone and the UEFPC drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sulfate-enriched calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 178 – 343 mg/L, excluding an apparent outlier (36 mg/L) reported for the sample collected in November 1995;
- pH (field measurements) of 6.9 – 7.6;
- chloride and sulfate concentrations above 30 mg/L;
- low molar proportions of nitrate, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The elevated sulfate and chloride concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking sanitary sewers or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the primary contaminants present in the groundwater at this well.

5.1 NITRATE

Twenty-three groundwater samples collected to date had nitrate concentrations at or above the applicable analytical reporting limit, and the maximum value (1.2 mg/L in July 1995) is substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Three groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, and the maximum result (0.001 mg/L in August 1994) is substantially below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in all but one of the groundwater samples collected to date (Table 1): CTET, chloroform, methylene chloride (MC), acetone, PCE, and TCE. The source(s) of the VOCs in the groundwater at this well has not been conclusively identified. However, because basement sumps in Bldg. 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) may be north of the well, possibly Buildings 9202, 9203, and 9205 where large amounts of CTET were used to convert uranium trioxide to uranium tetrachloride (DOE 1998). Also, considering the upward vertical hydraulic gradient noted in Section 3.0, the VOCs transported via the groundwater flowpaths intercepted by the monitored interval in the well would be expected to move upward into the shallow flow system. Indeed, operation of the basement sumps in Bldg. 9201-2 may induce or increase the upward flow of contaminated groundwater from deeper in the bedrock.

As shown by the data in Table 1, TCE was detected in all but one of the groundwater samples, whereas the other compounds were detected infrequently, with acetone, CTET and PCE each detected in one sample, MC detected in two samples, and chloroform detected in four samples. The bulk of the VOC results are estimated values below 5 μg/L, with the highest concentration reported for acetone (17 μg/L in January 1994). Excluding false positive results, TCE is the only compound detected in any of the samples collected since November 1997, with the most recent analytical results (April and October 2002) showing concentrations just below (4 μg/L) and above (6 μg/L) the drinking water MCL (5 μg/L).

A time-series plot of TCE concentrations for each groundwater sample (Figure 1) shows a generally indeterminate long-term trend (Figure 1), as illustrated by the TCE results reported for the samples collected in October 1993 (5 μg/L), June 1998 (6 μg/L), and October 2002 (6 μg/L). Also, the TCE results show temporal concentration fluctuations that appear to correlate with seasonal groundwater flow conditions, with temporal "peak" concentrations typically evident in samples collected during seasonally low flow conditions (summer and fall). This relationship suggests dilution-related concentration fluctuations, with greater relative inflow of "clean" groundwater into the well slightly lowering the TCE concentrations in the samples collected during seasonally (and episodically) high flow conditions.

Minimal biotic degradation of the TCE in the groundwater at this well is indicated by the relatively unchanged long-term concentration trend and the consistent lack of TCE degradation products (e.g., c12DCE) in the groundwater samples. A groundwater sample was collected (as a control sample) in April 2004 to assess microbiologically-induced corrosion of stainless steel casing and screens and, based on the appearance of the sample after an 8-10 day growth period, qualitative bacterial counts for specific bacteria types, summarized below, confirm the presence of a fairly low level of microbial activity in the well.

Date Sampled	**Bacteria Activity (colony forming units/milliliter)**			
	Heterotrophic Aerobic	Iron Related	Slime Forming	Sulfate Reducing
04/28/04	100	5,000	1,000	1,000

As shown in the following data summary, results for selected indicator parameters reported for samples collected in April and October 2002 indicate that the geochemical characteristics of the groundwater are only marginally favorable for biologically mediated degradation of chlorinated hydrocarbons.

Geochemical Parameter/Optimum Range (Wilson et al. 1996)	April 2002	October 2002
Nitrate < 1 mg/L	0.383	0.657
Iron (II) > 1 mg/L	<0.05*	<0.05*
Sulfate < 20 mg/L	30.4	33.8
Dissolved Oxygen < 0.5 ppm	0.2**	0.56**
REDOX < 50 mV	49**	119**
pH >5 and < 9 st. units	7.44**	6.9**
Note: *Result is for total iron; **Field measurement.		

The limited microbial activity, the marginal geochemical conditions, and the absence of degradation products support the lack of biotic degradation of TCE in the groundwater near well GW-775.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample collected to date had gross alpha activity above the applicable MDA and corresponding CE, and this result (6.4 mg/L in October 1999) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.17 pCi/L in January 1995) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-775: summary of VOC results

Date Sampled	VOC Concentration (µg/L)	
	TCE	**OTHER**
02/04/93	5	PCE (0.6 J); Chloroform (1 J)
04/20/93	3 J	MC (3 J)
08/09/93	4 J	.
10/15/93	5	CTET (1 J); Chloroform (0.9 J)
01/31/94	.	Acetone (17)
04/26/94	2 J	.
08/11/94	2 J	MC (3 J)
11/01/94	3 J	.
01/20/95	8	.
05/15/95	5	Chloroform (1 J)
07/14/95	4 J	.
11/19/95	6	.
01/10/96	4 J	.
05/09/96	5	.
10/10/96	6	.
05/12/97	5	Chloroform (1 J)
11/19/97	4 J	.
06/17/98	6	.
11/18/98	4 J	.
04/22/99	5	.
10/27/99	3 J	.
04/30/02	4 J	.
10/31/02	6	.
MCL	**5**	**.**

Note: "." = Not detected; J = Estimated value

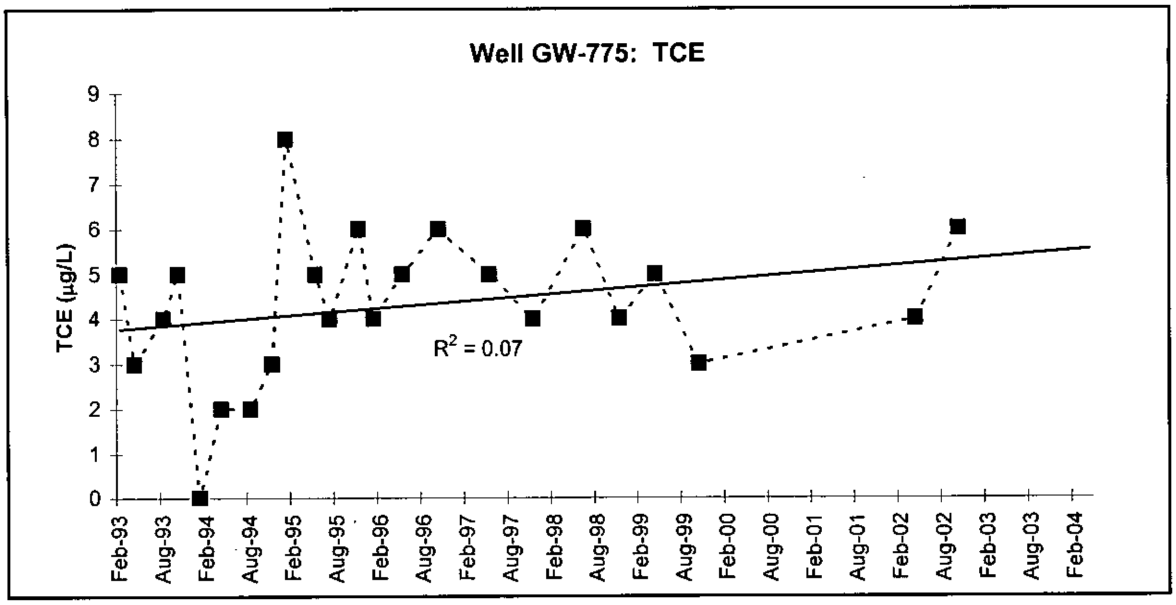

Well GW-775: TCE
TCE (µg/L)
9
8
7
6
5
4
3
2
1
0
R^2 = 0.07
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04

Figure 1

MAXIMUM CONCENTRATION: 2004

<5	<0.015	50 - 500	15 - 150	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-782

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E3
Y-12 GRID EAST COORDINATE: 58,099.21
Y-12 GRID NORTH COORDINATE: 29,718.84
SURFACE ELEVATION: 944.48 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/12/92 PAIRED/CLUSTERED WITH: GW-781 GW-783
TAG DEPTH (measured): 38.23 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 947.73 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	23.8	920.68
BOTTOM (filter pack or open hole):	35.9	908.58
MIDPOINT (filter pack or open hole):	29.9	914.63
PUMP INTAKE:	29.75	914.73
WATER LEVEL (average):	5.92	938.56

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	13 samples	06/16/94	11/13/03
LOW-FLOW SAMPLING METHOD:	16 samples	11/24/97	10/26/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/05/04	.	10/26/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.1 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	29	632 µg/L	11/12/96	Indeterminate
GROSS ALPHA (15 pCi/L):	26	64 pCi/L	04/18/01	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-782

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1992, completed with a screened monitored interval from about 23.8 to 35.9 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-781 and GW-783 and is located in Bear Creek Valley (BCV) at Comprehensive Monitoring Plan Grid E3, which is in the south-central section of Y-12 at the intersection of Second Street and D Road, just west of Bldg. 9731. These wells are on the west side of the concrete foundation for the former Development Incinerator, which was used from 1981 to 1992 for test burns of small quantities of various wastes generated at Y-12, including uranium-contaminated trash and mercury-contaminated soils (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples in between June 1994 and November 2003, and the low-flow sampling method used to obtain 16 samples between November 1997 and October 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: samples obtained with the conventional sampling method had substantially lower gross alpha activity than samples obtained with the low-flow sampling method (AJA 2001). However, the results of "paired sampling" performed during May and November 2003, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, show little if any difference between the results for most analytes, including gross alpha activity (Table 1). Thus, sampling bias does not appear to explain the higher levels of gross alpha activity evident since the change from conventional sampling to low-flow sampling. Instead, the higher gross alpha activity may reflect a coincident increase in the relative flux of alpha-emitting radionuclides via the groundwater flow/transport pathways intercepted by the well (see Section 5.4).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the shallow bedrock interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within a highly permeable zone (the water table interval) near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 6 ft bgs and exhibits seasonal fluctuations up to about 4 ft. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-782 are typically lower than evident in well GW-781, which is completed deeper (69 ft bgs) in the Nolichucky Shale, but are usually higher than evident in well GW-783, which is completed at a much shallower depth (16 ft bgs). Based on the distance between the monitored interval midpoint (elevation) in well GW-782 and well GW-781 (21.2 ft) and well GW-783 (32.6 ft), the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients of 0.01 to 0.046 from the deeper flowpaths (GW-781) and 0.006 to 0.06 from the shallow bedrock interval (GW-782) to the water table interval (GW-783).

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-782 indicate flow primarily to the east-southeast (across geologic strike) toward Maynardville Limestone and an exposed section of the main channel of UEFPC. However, the Nolichucky shale exhibits strongly anisotropic flow in directions that parallel geologic strike and which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Moreover, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 295 – 375 mg/L;
- pH (field measurements) of 7 – 7.8;
- total iron and total strontium concentrations above 1 mg/L;
- low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations);
- total concentrations of trace metals (except iron and strontium) that are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs and gross alpha activity are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Eighteen of the groundwater samples collected to date had nitrate (as N) concentrations above the analytical reporting limit, with the highest value (1.2 mg/L in March 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Twenty-seven of the groundwater samples collected to date had uranium concentrations above the analytical reporting limit, with the historical maximum concentration (0.0045 mg/L in February 1996) being almost an order-of-magnitude below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 2): benzene, CTET, chloroform (CLF), chloromethane (CLM), PCE, toluene, TCE, VC, 11DCA, 111TCA, and 12DCE (c12DCE and t12DCE). These compounds are components of a plume of dissolved VOCs in the groundwater that is believed to originate from one or more source areas, possibly including DNAPL in the subsurface near Bldg. 9204-2, which is about 600 ft directly west of well GW-782, and potential sources associated with operations at Bldg. 9731 and the Development Incinerator (DOE 1998).

The primary VOCs in the groundwater samples are PCE and 11DCA (Table 2), both of which were detected at the highest concentrations (>100 µg/L), including the samples collected most recently (May and October 2004), with the PCE values being substantially above the drinking water MCL (5 µg/L). Secondary compounds are TCE and 11DCE, each having historical maximum concentrations above 50 µg/L and the most recent results showing concentrations substantially above respective MCLs (5 µg/L and 7 µg/L). Tertiary compounds are CLM, 111TCA, and 12DCE, with the latter two compounds detected in all but three of the samples (excluding false positive results for 111TCA), and each compound having a historical maximum concentration above 25 µg/L. Also, the most recent sampling results show that the concentrations of 111TCA and c12DCE remain below respective MCLs (200 µg/L and 70 µg/L). Trace compounds detected in the samples are CTET, CLF, and VC, at least one of which was detected in 25 of the samples, although neither CTET nor CLF have been detected in any of the samples collected since November 1997. Although the bulk of the results are estimated values below 5 µg/L, the most recent sampling results show VC slightly above the MCL (2 µg/L). Acetone, benzene, and toluene were detected in a total of four samples, most recently the sample collected with the low-flow sampling method in May 2003.

As shown by the data summarized in Table 3, contemporaneous monitoring results show that VOC concentrations in the groundwater samples from well GW-782 are an order-of-magnitude higher than the VOC concentrations in the groundwater samples from the wells with which it is clustered (GW-781 and GW-783). This suggests that the respective monitored interval in each well intercepts somewhat stratabound groundwater flow/ transport pathways, which is consistent with the characteristically strike-parallel anisotropy of flow in the Nolichucky Shale. Additionally, the upward hydraulic gradients indicated by contemporaneous presampling groundwater elevations in these wells (see Section 2.0) suggest vertically upward VOC transport/migration patterns.

Several of the VOCs in the groundwater samples are probably present as a result of the biotic and/or abiotic degradation of related parent compounds. For instance, chemical (abiotic) degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), might at least partially account for the preponderance of 11DCA and 11DCE in the samples. Similarly, biologically mediated sequential dechlorination of PCE and TCE by anaerobic (methanotropic) organisms in the groundwater may explain the presence of c12DCE, t12DCE, and VC in the samples. This interpretation is generally supported by monitoring results for several indicator parameters, which show that geochemical conditions in the well are within the optimum range for biotic degradation of chlorinated hydrocarbons (Table 4). However, the REDOX conditions do not indicate the strongly reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC (Chapelle 1996). Considering the upward vertical hydraulic gradients noted previously, perhaps the monitored interval in well GW-782 intercepts groundwater flow/transport pathways for dissolved VOCs moving upward from a source (DNAPL) deeper in the bedrock where conditions are better suited for reductive dechlorination of the VOCs. Results of microbiological sampling performed in CY 2000 (summarized below) suggest limited biotic activity at well GW-782, but much greater biotic activity (particularly iron-related bacteria) in the shallower groundwater flow/transport pathways intercepted by the monitored interval in well GW-783 (AJA 2000).

Well Number	Date Sampled	Bacteria counts (CFU/mL)		
		Iron-Related Bacteria	Sulfate-Reducing Bacteria	Slime-Forming Bacteria
GW-782	05/01/00	100	1000	<100
	05/01/00 D	100	<100	<100
GW-783	05/01/00	5000	100	1000
	05/01/00 D	5000	<100	<100
Note: D = Duplicate sample				

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows a generally indeterminate long-term trend dominated by wide temporal fluctuations (Figure 1), with the highest concentrations typically reported for samples collected during seasonally low groundwater flow conditions. The indeterminate long term trend, illustrated by the nearly equal concentrations of PCE detected in samples collected in June 1994 (140 µg/L) and May 2004 (160 µg/L), suggest minimal overall change in the relative flux of dissolved VOCs along the groundwater flow/transport pathways intercepted by the monitored interval in the well. The temporal changes in VOC concentrations suggest inflow of uncontaminated (or less VOC contaminated) groundwater during seasonally (or episodically) high flow conditions. However, the seasonal fluctuations are not always evident and are not always consistent with seasonal flow conditions, as illustrated by the highest and lowest summed VOC concentration being reported for samples collected during seasonally low flow conditions (632 µg/L in June 1996 and 261 µg/L in November 2003). Also, several of the compounds, notably 12DCE isomers and VC, show little if any temporal fluctuation, with equal or nearly equal concentrations reported for samples obtained during both seasonally high and low groundwater flow conditions.

5.4 GROSS ALPHA ACTIVITY

Twenty-seven of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE (Table 5), with all but two of these results exceeding the drinking water MCL for gross alpha activity (15 pCi/L), including the historical maximum value (64 pCi/L in May 1998 and April 2001). Elevated levels of gross alpha activity are supported by the analytical results for uranium isotopes (Table 3), with relatively high levels of U-234 (36 – 57 pCi/L), but substantially lower levels of U-238 (0.38 – 0.56 pCi/L), reported for the series of five samples collected between April 2001 and November 2002 (the only samples that were analyzed for uranium isotopes). The uranium isotopes are probably present as uranyl cations that, considering the neutral pH of the groundwater in the well, are probably complexed with dissolved anions (e.g., carbonate) in the groundwater (Fetter 1993). The source of the uranium isotopes in the groundwater at this well has not been identified (DOE 1998).

A time-series plot of the gross alpha activity reported for each groundwater sample shows (Figure 2): (1) a relatively indeterminate trend between June 1994 (24.6 pCi/L) and November 1996 (26.2 pCi/L, (2) a sharply increasing trend through Mar 1998 (64 pCi/L), (3) a widely fluctuating but generally indeterminate trend through April 2001 (64 pCi/L), and (4) a steadily decreasing trend through October 2004 (20 pCi/L). The latter trend coincides with an overall decrease in the levels of in U-234 in the groundwater samples (Table 5). This suggests that the temporal trends for gross alpha activity are attributable to corresponding changes in the relative flux of U-234 via the groundwater flow/transport pathways intercepted by the monitored interval in the well.

5.5 GROSS BETA ACTIVITY

Twenty-two of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (18 pCi/L in July 1998) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2000. *Groundwater Protection Program Calendar Year 1999 Evaluation of Groundwater Quality Data for the Upper East Fork Poplar Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Y/SUB/00-MVM64V/2, prepared for Lockheed Martin Energy Systems, Inc, Oak Ridge, TN.

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/00-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

Chapelle, F.H. 1996. *Identifying Redox Conditions that Favor the Natural Attenuation of Chlorinated Ethenes in Contaminated Ground-Water Systems.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water.* Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-782: Consecutive daily sampling results for summed VOCs and other selected analytes, May and November 2003

Analyte	Units	May 27-28, 2003		November 12-13, 2003	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.32	7.16	7.14	7.13
Dissolved Solids	mg/L	302	305	304	302
Suspended Solids	mg/L	5	<1	<1	<1
Calcium	mg/L	76.9	75.5	72.3	74.9
Nitrate	mg/L	0.0889	0.0411	<0.02	<0.02
Barium	mg/L	0.509	0.461	0.485	0.458
Strontium	mg/L	1.14	1.15	1.22	1.23
Uranium	mg/L	0.000887	0.000958	0.000963	0.000772
Summed VOCs	µg/L	414	437	478	261
Gross Alpha Activity	pCi/L	30	27	31	22
Gross Beta Activity	pCi/L	11	7.2	7.3	7.5

Table 2. Well GW-782: summary of VOC results

Sampling Method and Date	Concentration (µg/L)					
	PCE	TCE	12DCE (Total)	c12DCE	t12DCE	11DCE
Conventional Sampling						
06/16/94	140	30	17	NR	NR	31
09/12/94	130	29	15	NR	NR	25
12/02/94	210	49	16	NR	NR	44
03/08/95	120	30	16	NR	NR	26
06/06/95	180	44	16	NR	NR	42
08/23/95	240	59	16	NR	NR	35
11/30/95	190	43	11	NR	NR	35
02/19/96	220	63	19	NR	NR	30
05/28/96	120	27	15	NR	NR	18
11/12/96	270	69	33	NR	NR	56
05/28/03	150	42	15	13	2 J	47
11/13/03	91	28	6	6	.	30
Low-Flow Sampling						
05/14/97	190	52	22	15	7	44
11/24/97	200	63	19	14	5	33
05/20/98	230	64	20	15	5	29
11/12/98	210	64	18	14	4 J	37
05/24/99	180	62	20	15	5	32
10/25/99	170	46	12	12	.	43
05/01/00	220	63	15	12	.	24
10/03/00	160	49	17	14	.	33
04/18/01	200	63	15	12	3 J	28
09/05/01	200	59	18	15	3 J	45
10/16/01	190	54	15	13	2 J	65
05/01/02	170	60	16	13	2 J	48
11/04/02	160	56	15	13	2 J	32
05/27/03	140	48	15	13	2 J	41
11/12/03	150	49	18	16	1 J	54
05/05/04	160	49	14	13	1 J	59
10/26/04	130	40	18	17	1 J	56
MCL	**5**	**5**	**NA**	**70**	**NA**	**7**

Table 2. (continued)

Sampling Method and Date	Concentration (µg/L)					
	VC	111TCA	11DCA	CLM	CTET	CLF
Conventional Sampling						
06/16/94	1 J	15	63	.	18	5
09/12/94	.	11	52	.	16	4 J
12/02/94	.	25	160	.	5	.
03/08/95	.	FP	70	.	14	3 J
06/06/95	2 J	22	150	.	3 J	1 J
08/23/95	3 J	FP	150	.	.	1 J
11/30/95	.	17	140	.	4 J	.
02/19/96	.	3 J	120	.	.	.
05/28/96	.	11	68	.	3 J	.
11/12/96	5	21	170	.	6	2 J
05/28/03	2 J	7	150	24	.	.
11/13/03	.	5	95	6	.	.
Low-Flow Sampling						
05/14/97	3 J	20	150	5	4 J	2 J
11/24/97	3 J	3 J	110	2 J	.	.
05/20/98	1 J	2 J	99	1 J	.	.
11/12/98	4 J	8	150	4 J	.	.
05/24/99	2 J	5	110	2 J	.	.
10/25/99	3 J	15	160	8	.	.
05/01/00	.	.	92	.	.	.
10/03/00	2 J	8	150	.	.	.
04/18/01	.	2 J	120	.	.	.
09/05/01	2 J	13	180	8	.	.
10/16/01	4 J	26	240	26	.	.
05/01/02	.	9	180	12	.	.
11/04/02	2 J	3 J	130	7	.	.
05/27/03	.	5	140	17	.	.
11/12/03	3 J	10	160	34	.	.
05/05/04	.	9	170	19	.	.
10/26/04	3 J	10	150	45	.	.
MCL	**2**	**200**	**NA**	**NA**	**5**	**80***

Note: "." = Not detected; J = Estimated value below analytical reporting limit; FP = False positive; NR = Not reported; NA = Not applicable; * MCL is for total trihalomethanes

Table 3. VOC concentrations in wells GW-781, GW-782, and GW-783

VOC	Concentration (µg/L)					
	May 1999			October 1999		
	GW-781 (69 ft bgs)	GW-782 (36 ft bgs)	GW-783 (16 ft bgs)	GW-781 (69 ft bgs)	GW-782 (36 ft bgs)	GW-783 (16 ft bgs)
PCE	7	180	10	5	170	36
TCE	.	62	5	.	46	15
c12DCE	.	15	6	.	12	17
t12DCE	.	5	3 J	.	.	7
VC	.	2 J	.	.	3 J	.
111TCA	.	5	.	.	15	.
11DCA	.	110	3 J	.	160	11
11DCE	.	32	.	.	43	.
CLM	.	2 J	.	.	8 J	.
Benzene	.	2 J	.	.	.	.
CTET	.	.	2 J	.	.	.
SUMMED VOCs:	7	415	29	5	457	86

Notes: "." = Not detected; J = Estimated concentration below the reporting limit

Table 4. Well GW-782: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	Low-Flow Sampling	
	May 2004	October 2004
Nitrate < 1 mg/L	0.0361	0.0474
Iron (II) > 1 mg/L	<0.05*	<0.05*
Sulfate < 20 mg/L	15.5	14.9
Dissolved Oxygen < 0.5 ppm	0.64**	0**
REDOX < 50 mV	110**	117**
pH >5 and < 9 st. units	7.1 **	6.69**

Note: *Results are for total iron; **Field measurement.

Table 5. Well GW-782: summary of results for gross alpha activity and uranium isotopes

Sampling Method and Date	Concentration (pCi/L)		
	Gross Alpha Activity	U-234	U-238
Conventional Sampling			
06/16/94	24.6	.	.
09/12/94	29.9	.	.
12/02/94	27	.	.
03/08/95	10.7	.	.
06/06/95	26.8	.	.
08/23/95	27.6	.	.
11/30/95	26.2	.	.
02/19/96	52	.	.
05/28/96	30.1	.	.
11/12/96	26.2	.	.
05/14/97	44	.	.
05/28/03	27	.	.
11/13/03	22	.	.
Low-Flow Sampling			
11/24/97	56	.	.
05/20/98	64	.	.
11/12/98	53	.	.
05/24/99	59	.	.
10/25/99	43	.	.
05/01/00	62	.	.
10/03/00	54	.	.
04/18/01	64	57	0.56
09/05/01	<MDA	41	0.28
10/16/01	41	36	0.38
05/01/02	45	49	0.47
11/04/02	38	44	0.53
05/27/03	30	.	.
11/12/03	31	.	.
05/05/04	17	.	.
10/26/04	20	.	.
MCL	**15**	**NA**	

Note: "." = Not analyzed; NA = Not applicable

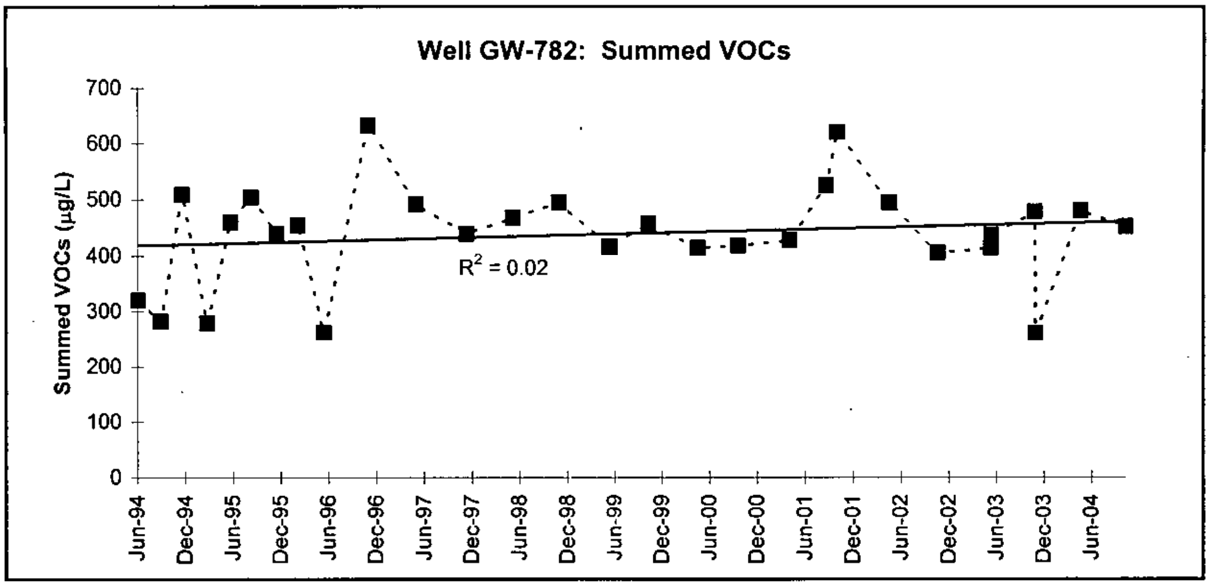


Figure 1

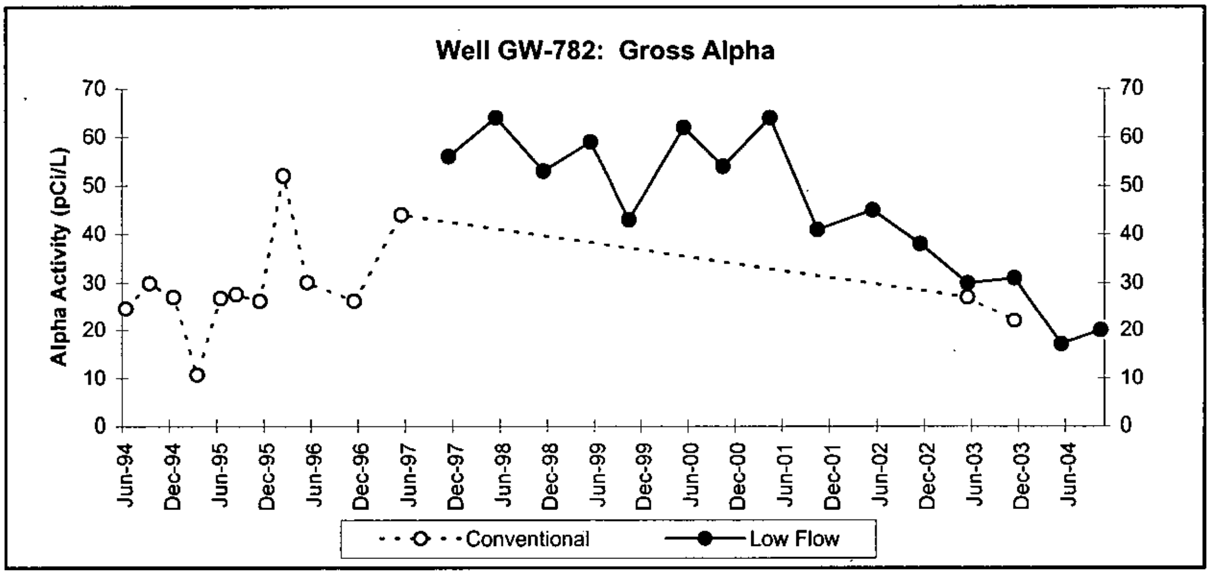


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	<0.015	.	.	.

GW-783

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E3
Y-12 GRID EAST COORDINATE: 58,112.53
Y-12 GRID NORTH COORDINATE: 29,734.28
SURFACE ELEVATION: 945.81 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/13/92 PAIRED/CLUSTERED WITH: GW-781 GW-782
TAG DEPTH (measured): 17.98 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 948.49 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	3.6	942.21
BOTTOM (filter pack or open hole):	16.3	929.51
MIDPOINT (filter pack or open hole):	10.0	935.86
PUMP INTAKE:	10.32	935.49
WATER LEVEL (average):	7.56	938.25

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	11 samples	06/16/94	05/15/97
LOW-FLOW SAMPLING METHOD:	7 samples	11/25/97	04/27/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/27/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: X TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.36 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	16	156 µg/L	12/02/94	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-783

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1992, completed with a screened monitored interval from about 4 to 16 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-781 and GW-782 and is located in Bear Creek Valley (BCV) at Comprehensive Monitoring Plan Grid E3, which is in the south-central section of Y-12 at the intersection of Second Street and D Road, just west of Bldg. 9731. These wells are on the west side of the concrete foundation for the former Development Incinerator, which was used from 1981 to 1992 for test burns of small quantities of various wastes generated at Y-12, including uranium-contaminated trash and mercury-contaminated soils (DOE 1998).

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples in between June 1994 and May 1997, and the low-flow sampling method used to obtain seven samples between November 1997 and April 2004.

Groundwater samples from this well are distinguished by elevated total (unfiltered sample) concentrations of chromium and nickel that are probably attributable to chemical and/or microbiologically-induced corrosion (MIC) of the stainless steel riser casing and/or well screen (see Section 5.6).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Nolichucky Shale (Conasauga Group). The bulk of the groundwater flow in the Nolichucky Shale occurs within this highly permeable zone developed near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs and exhibits temporal (seasonal) fluctuations of 4 ft or less. Also, measurements recorded during contemporaneous sampling events (i.e., within 24 hours) show that presampling groundwater elevations in well GW-783 are typically lower than evident in wells GW-782 and GW-781, which are completed deeper (36 and 69 ft bgs, respectively) in the Nolichucky Shale. Based on the distance between the monitored interval midpoint (elevation) in each well, the contemporaneous groundwater elevations indicate upward vertical hydraulic gradients of 0.01 to 0.046 from the deeper flowpaths (GW-781) to the shallow bedrock interval (well GW-782), and 0.006 to 0.06 from the shallow bedrock interval (GW-782) to the water table interval (GW-783).

Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-783 indicate flow primarily to the east-southeast (across geologic strike) toward Maynardville Limestone and an exposed section of the main channel of UEFPC. However, the Nolichucky shale exhibits strongly anisotropic flow in directions that parallel geologic strike and which may or may not coincide with the flow directions inferred from groundwater elevation isopleths. Moreover, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples collected to date show that the well yields chloride- and sodium-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 282 – 444 mg/L;
- pH (field measurements) of 7 – 7.6;
- elevated concentrations of chloride (>40 mg/L) and sulfate (>20 mg/L) relative to other wells completed at similar depths in the water table interval of the Nolichucky Shale;
- low molar proportions of nitrate, potassium, and sulfate (<10% of total anions/cations);
- total concentrations of trace metals (except chromium and nickel) that are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee (HSW 1995).*

The elevated chloride and sulfate concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Sixteen of the groundwater samples collected to date had nitrate (as N) concentrations above the analytical reporting limit, with the highest value (4.6 mg/L in March 1995) being below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Fifteen of the groundwater samples collected to date had uranium concentrations above the analytical reporting limit, with the historical maximum concentration (0.002 mg/L in June 1994) being substantially below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample collected to date (Table 1): acetone, 2-butanone, CTET, chloroform (CLF), PCE, TCE, 11DCA, 11DCE, 12DCE (c12DCE), and 111TCA. These compounds are components of a plume of dissolved VOCs in the groundwater that is believed to originate from one or more source areas, possibly including DNAPL in the subsurface near Bldg. 9204-2, which is about 600 ft directly west of well GW-783, and potential sources associated with operations at Bldg. 9731 and the Development Incinerator (DOE 1998).

Based on frequency of detection and concentration magnitude, the primary VOCs in the groundwater samples are PCE, TCE, 12DCE, and 11DCA (Table 1), each of which were detected in all but two of the groundwater samples collected to date, with respective historical maximum concentrations of 59 μg/L, 23 μg/L, 35 μg/L, and 26 μg/L. Additionally, the most recent results for VOCs (October 1999) show PCE and TCE concentrations above the respective drinking water MCL (5 μg/L). Secondary compounds in the samples are CTET, 11DCE, and 11TCA, which have all been detected somewhat infrequently compared to the primary VOCs, with only three results (all for 11DCE) being above 5 μg/L. Acetone was detected in only one sample, 2-butanone was detected in two samples, and chloroform was detected in five samples, but none of these compounds have been detected in samples collected since November 1997 (Table 1).

As shown by the data summarized in Table 2, contemporaneous monitoring results show that VOC concentrations in the shallow groundwater at well GW-783 and deepest well GW-781 are an order-of-magnitude lower than the VOC concentrations in the intermediate depth groundwater from well GW-782. This suggests that the respective monitored interval in each well intercepts somewhat stratabound groundwater flow/ transport pathways, which is consistent with the characteristically strike-parallel anisotropy of flow in the Nolichucky Shale. Additionally, the upward hydraulic gradients indicated by contemporaneous presampling groundwater elevations in these wells (see Section 2.0) suggest vertically upward VOC transport/migration patterns.

Several of the VOCs in the groundwater at this well are probably present as a result of the biotic and/or abiotic degradation of related parent compounds. For instance, chemical (abiotic) degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), might at least partially account for the preponderance of 11DCA and 11DCE in the samples. Similarly, biologically mediated sequential dechlorination of PCE and TCE may explain the presence of c12DCE (and 11DCE) in the groundwater. Moreover, results of microbiological groundwater sampling performed in May 2000 and April 2004 (summarized below), which are based on qualitative bacterial counts estimated from the appearance of the groundwater sample after an eight- to ten-day growth period, confirm substantial and varied biotic activity in the shallower groundwater at well GW-783.

Date Sampled	Bacteria counts (CFU/mL)			
	Heterotropic Aerobic Bacteria	**Iron-Related Bacteria**	**Sulfate-Reducing Bacteria**	**Slime-Forming Bacteria**
05/01/00	NR	5,000	100	1,000
05/01/00 D	NR	5,000	<100	<100
04/27/04	500,000	100	100	50,000
Note: D = Duplicate sample; NR = Not reported				

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows a decreasing long-term trend dominated by wide temporal fluctuations

(Figure 1), with the highest concentrations typically reported for samples collected during seasonally low groundwater flow conditions (summer and fall), as illustrated by the temporal "peak" concentrations evident in August 1995 (133 μg/L), November 1996 (147 μg/L), and November 1998 (75 μg/L). Conversely, the lowest summed concentrations are evident for samples collected during seasonally high groundwater flow conditions (winter and spring), as illustrated by the concentrations evident in March 1995 (36 μg/L), March 1996 (45 μg/L), and May 1998 (14 μg/L). Additionally, the concentrations of the primary compounds in the samples (PCE, TCE, 12DCE, and 11DCA) show concurrent temporal (seasonal) fluctuations. This suggests that samples collected during seasonally high flow conditions contain lower VOC concentrations because of the greater relative inflow of uncontaminated (or less VOC-contaminated) recharge via the groundwater flow/transport pathways intercepted by the monitored interval in the well. Considering the upward hydraulic gradients indicated by presampling groundwater elevations (see Section 3.0), VOC-contaminated groundwater upwelling from the groundwater flow system deeper in the Nolichucky Shale may comprise the bulk of the inflow (baseflow) into the well during seasonally low flow conditions.

5.4 GROSS ALPHA ACTIVITY

Six of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.57 pCi/L in November 1995) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.16 pCi/L in December 1994) being less than the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

5.6 OTHER

As noted in Section 2.0, the groundwater samples from this well typically contain elevated chromium and nickel concentrations; all but one of the samples had chromium and/or nickel concentrations above respective UTLs (Table 3). Ten of the samples, including the sample collected most recently (April 2004), had chromium concentrations above the federal drinking water MCL (0.1 mg/L). Similarly, 15 of the samples (including the sample collected in April 2004) had nickel concentrations above the state drinking water MCL (0.1 mg/L). Corrosion of the stainless steel well casing and screen in the well is the suspected source of the nickel (and chromium) in the samples (AJA 2000), primarily because: (1) mobile species of chromium and nickel are not typically present in groundwater with the neutral pH evident in the well; (2) Type 304 stainless steel contains 18-20% chromium and 8-12% nickel and is prone to crevice corrosion (Oakley and Korte 1996); and (3) microbiological sampling results (see Section 5.3) qualitatively confirm the presence of bacteria (e.g., slime-forming bacteria) in the groundwater that are known to cause MIC of stainless steel (Sarouhan et. al. 1998).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2000. *Groundwater Protection Program Calendar Year 1999 Evaluation of Groundwater Quality Data for the Upper East Fork Poplar Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Y/SUB/00-MVM64V/2, prepared for Lockheed Martin Energy Systems, Inc, Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

McCarty, P.L. 1996. *Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water*. Reported in: Symposium on Natural Attenuation of Chlorinated Organics in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/R-96/509).

Oakley, D. and N.E. Korte. 1996. *Nickel and Chromium in Groundwater Supplies as Influenced by Well Construction and Sampling Methods*, as reported in Groundwater Monitoring Review, Winter 1996, pp. 93-99.

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Well GW-783: summary of VOC results

Sampling Method and Date	Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	11DCE
06/16/94	29	12	17	NR	4 J
09/12/94	53	20	25	NR	5
12/02/94	57	23	30	NR	10
03/08/95	15	6	8	NR	2 J
06/06/95	24	10	17	NR	3 J
08/23/95	47	20	30	NR	6
11/30/95	44	15	17	NR	4 J
03/06/96	11	6	11	NR	.
05/23/96	25	11	18	NR	3 J
11/12/96	59	23	35	NR	8
05/15/97	36	15	32	20	4 J
11/25/97	7	.	5	5	.
05/20/98	6	2 J	3 J	3 J	.
11/12/98	24	12	13	13	4 J
05/24/99	10	5	6	6	.
10/25/99	36	15	17	17	.
MCL	**5**	**5**	**NA**	**70**	**7**
Sampling Method and Date	**Concentration (µg/L)**				
	111TCA	**11DCA**	**CTET**	**Other**	
06/16/94	2 J	10	1 J	CLF (0.8 J)	
09/12/94	2 J	14	1 J	CLF (1 J)	
12/02/94	4 J	26	4 J	CLF (2 J)	
03/08/95	FP	5	.	.	
06/06/95	FP	9	1 J	CLF (1 J)	
08/23/95	FP	17	2 J	2-Butanone (10); CLF (1 J)	
11/30/95	2 J	16	1 J	.	
03/06/96	.	6	.	2-Butanone (11)	
05/23/96	1 J	10	.	.	
11/12/96	.	22	.	.	
05/15/97	2 J	15	2 J	.	
11/25/97	1 J	.	.	Acetone (23)	
05/20/98	.	1 J	1 J	.	
11/12/98	2 J	12	2 J	.	
05/24/99	.	3 J	2 J	.	
10/25/99	.	11	.	.	
MCL	**200**	**NA**	**5**	**NA**	

Note: "." = Not detected; FP = False positive result; J = Estimated value; NR = Not reported; NA = Not applicable

Table 2. VOC concentrations in wells GW-781, GW-782, and GW-783

VOC	Concentration (µg/L)					
	May 1999			October 1999		
	GW-781 (69 ft bgs)	GW-782 (36 ft bgs)	GW-783 (16 ft bgs)	GW-781 (69 ft bgs)	GW-782 (36 ft bgs)	GW-783 (16 ft bgs)
PCE	7	180	10	5	170	36
TCE	.	62	5	.	46	15
c12DCE	.	15	6	.	12	17
t12DCE	.	5	3 J	.	.	7
VC	.	2 J	.	.	3 J	.
111TCA	.	5	.	.	15	.
11DCA	.	110	3 J	.	160	11
11DCE	.	32	.	.	43	.
CLM	.	2 J	.	.	8 J	.
Benzene	.	2 J	.	.	.	.
CT	.	.	2 J	.	.	.
SUMMED VOCs:	7	415	29	5	457	86

Notes: "." = Not detected; J = Estimated concentration below the reporting limit

Table 3. Well GW-783: summary of chromium and nickel results

Date Sampled	Total Concentration (mg/L)	
	Chromium	**Nickel**
06/16/94	<0.01	0.049
09/12/94	0.012	0.24
12/02/94	0.88	0.28
03/08/95	0.52	0.15
06/06/95	0.8	0.64
08/23/95	0.6	0.41
11/30/95	0.04	0.26
03/06/96	0.37	0.21
05/23/96	1.00	0.69
11/12/96	0.61	0.58
05/15/97	0.44	0.24
11/25/97	0.059	0.045
05/20/98	0.0808	0.432
11/12/98	<0.01	0.635
05/24/99	0.598	0.698
10/25/99	0.0428	0.287
04/27/04	0.19	0.402
UTL	**0.029**	**0.06**
MCL	**0.1 (Federal)**	**0.1 (State)**

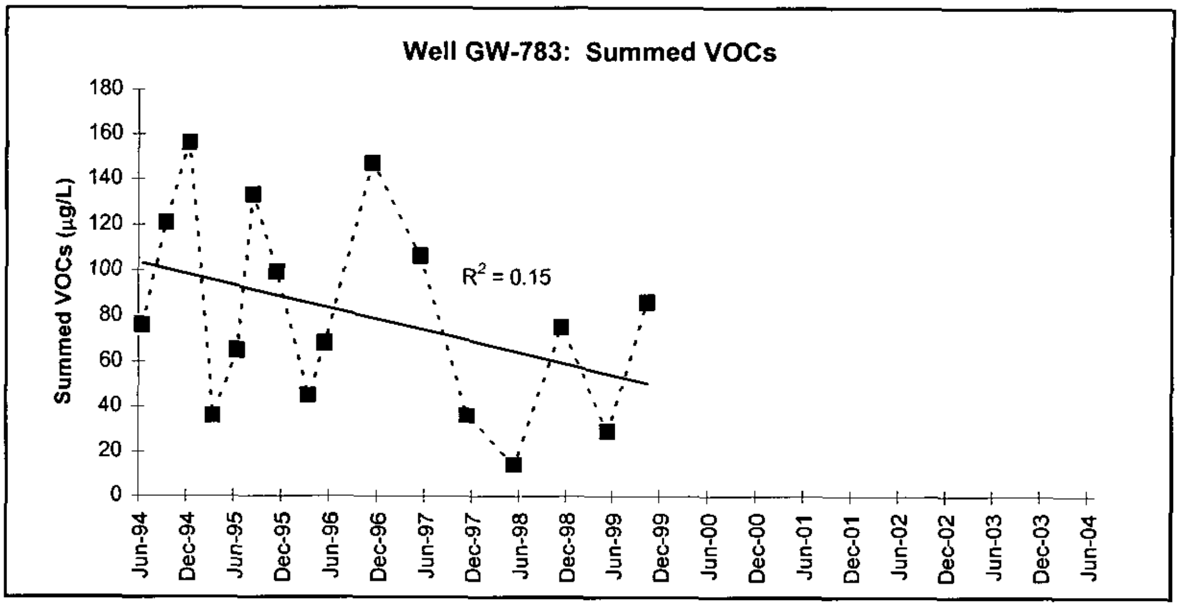

Well GW-783: Summed VOCs
Summed VOCs (µg/L)
180
160
140
120
100
80
60
40
20
0
R^2 = 0.15
Jun-94
Dec-94
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04

Figure 1

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

GW-786

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E2
Y-12 GRID EAST COORDINATE: 58,589.75
Y-12 GRID NORTH COORDINATE: 30,456.28
SURFACE ELEVATION: 985.23 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/28/92 PAIRED/CLUSTERED WITH: GW-787
TAG DEPTH (measured): 66.77 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 987.80 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	52.9	932.33
BOTTOM (filter pack or open hole):	64.9	920.33
MIDPOINT (filter pack or open hole):	58.9	926.33
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	7.22	978.02

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	12		
CONVENTIONAL SAMPLING METHOD:	10 samples	06/08/94	11/07/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/03/03	10/28/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	.	06/03/03	.	10/28/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.94 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-786

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 1992, completed with a screened monitored interval from 52.9 to 64.9 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with well GW-787 and is located in Bear Creek Valley in the east-central section of Y-12, about 400 ft north of First Street and 150 ft northwest of Bldg. 9704-2.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twelve groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between June 1994 and November 1996, and the low-flow sampling method used to obtain samples in June and October 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval (<100 ft bgs) in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 7.2 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<6 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 7.0 – 7.8;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

One groundwater sample had a nitrate concentration above the applicable analytical reporting limit, and this result (0.04 mg/L in November 1996) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the East Fork Regime.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (2.79 pCi/L in September 1994) is substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.21 pCi/L in September 1994) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

<5	ND	ND	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-787

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID E2
Y-12 GRID EAST COORDINATE: 58,588.32
Y-12 GRID NORTH COORDINATE: 30,437.24
SURFACE ELEVATION: 984.81 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/01/92 PAIRED/CLUSTERED WITH: GW-786
TAG DEPTH (measured): 19.97 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 987.85 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	5.3	979.51
BOTTOM (filter pack or open hole):	18.1	966.71
MIDPOINT (filter pack or open hole):	11.7	973.11
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	12.74	972.07

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	12		
CONVENTIONAL SAMPLING METHOD:	10 samples	06/08/94	11/07/96
LOW-FLOW SAMPLING METHOD:	2 samples	06/03/03	10/28/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	.	06/03/03	.	10/28/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: X (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.3 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-787

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in September 1992, completed with screened monitored interval from 5.3 to 18.1 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-786 and is located at Comprehensive Monitoring Plan Grid E2, which is in the north-central Y-12 area about 350 ft north of First Street and about 130 ft west of Bldg 9704-2.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twelve groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain ten samples between June 1994 and November 1996, and the low-flow sampling method used to obtain the samples in June and October 2003.

Groundwater samples from the well are conspicuous with regard to their unusual combination of low TDS and acidic pH (see Section 3.0).

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Conasauga Group (Maryville Limestone). Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 13 ft bgs and exhibits seasonal fluctuations of about 5 ft.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium bicarbonate groundwater generally characterized by:

- extremely low TDS (<100 mg/L), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths;
- pH (field measurements) of 4.8 – 5.7;
- unusually low (<5 mg/L) calcium and magnesium concentrations;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nitrate concentrations at or above the applicable analytical reporting limit were reported for all but one of the groundwater samples, with each concentration being less than 1 mg/L and substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, none of the VOCs that are known to be groundwater contaminants at Y-12 were detected in the groundwater samples.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (8.1 pCi/L in October 2003) being less than the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for the groundwater samples collected in June 1994 (7.94 pCi/L), August 1995 (3.56 pCi/L), and June 2003 (6.7 pCi/L); each result being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	500 - 5,000	ND	ND

GW-791

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: GRID D2
Y-12 GRID EAST COORDINATE: 57,423.24
Y-12 GRID NORTH COORDINATE: 30,482.73
SURFACE ELEVATION: 988.51 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 09/21/92 PAIRED/CLUSTERED WITH: GW-792
TAG DEPTH (measured): 72.45 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 992.13 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	57.5	931.01
BOTTOM (filter pack or open hole):	70.6	917.91
MIDPOINT (filter pack or open hole):	64.1	924.46
PUMP INTAKE:	63.78	924.73
WATER LEVEL (average):	19.64	968.87

GEOLOGIC FORMATION: Maryville Limestone
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	13 samples	06/07/94	10/04/00
LOW-FLOW SAMPLING METHOD:	15 samples	11/20/97	10/25/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/03/04	.	10/25/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: X OTHER: .
WATER LEVEL FLUCTUATION: 3.45 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	28	3,500 µg/L	09/06/94	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-791

1.0 *INSTALLATION, CONSTRUCTION, AND LOCATION*

This well was installed in September 1992, completed with screened monitored interval from 57.5 to 70.6 ft bgs, and constructed with nominal 4.5-inch diameter steel stainless steel (type 304) riser casing and well screen (0.01 slot wire-wound). The well is clustered with well GW-792 and is located in the northern section of the central Y-12 area, about 170 ft directly south of Bldg. 9212

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between June 1994 and October 2000, and the low-flow sampling method used to obtain 15 samples between November 1997 and October 2004.

An evaluation of the monitoring data available through August 2000 indicated potential bias related to the groundwater sampling method: (unfiltered) samples obtained with the conventional sampling method had substantially higher contaminant (VOC) concentrations than samples obtained with the low-flow sampling method (AJA 2001). Results of "paired" sampling performed during May and October 2000, when groundwater samples were collected with the low-flow sampling method one day and the conventional sampling method the next day, confirm the apparent sampling-method bias. As shown by the data summarized in Table 1, although both methods yield groundwater samples with similar geochemical characteristics (aside from the higher dissolved oxygen and REDOX for samples obtained with the conventional method), the samples obtained with the low-flow sampling method have significantly lower VOC concentrations than the samples obtained with the conventional sampling method.

Inherent differences in the manner in which each sampling method induces inflow of groundwater into the well may explain the disparity between the conventional and low-flow sampling results for VOCs. Conventional sampling involves purging up to three well volumes of groundwater from the well at about 1-2 gallons per minute, which may substantially lower the water level in the well and induce inflow from water-producing features (i.e., fractures, cavities, conduits) that may not contribute to well recharge under normal conditions. In contrast, low-flow sampling involves purging the well at flow rate low enough (<300 milliliters per minute) to ensure minimal water-level drawdown in the well (<1 ft per quarter hour), which induces groundwater inflow only from the water-producing feature(s) proximal to the monitored interval. Thus, the conventional sampling method has much greater local hydrologic influence (particularly in directions parallel with geologic strike) and substantially increases the relative inflow of VOC-contaminated groundwater into the well.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maryville Limestone (Conasauga Group). The bulk of the groundwater flow in the Maryville Limestone occurs within this highly permeable zone, which occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into the buried northern tributaries of Upper East Fork Poplar Creek (UEFPC) and other subsurface components of the subsurface drainage system within the highly industrialized areas of Y-12 (DOE 1998). Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, a highly permeable (karst) formation that stratigraphically overlies the Nolichucky Shale and subcrops along the axis of BCV and the original main channel of UEFPC.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 20 ft bgs and exhibits seasonal fluctuations of about 3 ft. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells the vicinity of well GW-791 indicate south and southeasterly flow toward the Maynardville Limestone and the UEFPC drainage system. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the Nolichucky Shale exhibits strongly anisotropic groundwater flow patterns, with preferred flow in directions that parallel geologic strike (i.e., bedding-plane fractures), which may or may not coincide with the flow directions inferred from groundwater elevation isopleths.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields calcium-magnesium bicarbonate groundwater generally characterized by:

- TDS of 236 – 324 mg/L, excluding suspected outliers in November 1995 (482 mg/L) and April 1996 (108 mg/L);
- pH (field measurements) of 7.1 – 7.9;
- average water temperature (field measurements) above 20 degrees Centigrade, reflects steam condensate discharge points located about 70 ft north (upgradient) of the well;
- low molar proportions chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

The nitrate concentration reported for the groundwater sample collected in September 1994 (0.5 mg/L) exceeds the analytical reporting limit but is an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L) and is probably an analytical artifact.

5.2 URANIUM

None of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

At least one of the following three VOCs was detected in at least one of the groundwater samples collected to date: PCE, TCE, and c12DCE (Table 2). The primary VOC in the samples is PCE, which was detected in each sample, whereas TCE was detected in about half of the samples and c12DCE was detected only in recent samples (June 2003, October 2003, and October 2004). Additionally, several of the PCE results, particularly the results reported for the samples collected during the mid-1990s (Table 2), show that the concentrations exceed 1% of pure-phase solubility for PCE (1,500 μg/L). This suggests that that the PCE may be present as DNAPL in the subsurface near the production complex in the vicinity of Building 9212 (DOE 1998). Conversely, almost all of the TCE and c12DCE concentrations are below 10 μg/L, and many of these results are estimated values below 5 μg/L (Table 2). This suggests little if any natural biodegradation (dechlorination) of the PCE in the groundwater, an interpretation supported by microbiologic sampling results, which indicate minimal microbial activity in the groundwater at this well (AJA 2001). Moreover, as noted in Section 2.0, the VOC concentrations are strongly influenced by the method used to collect the samples. This is illustrated by the "paired" sampling results, which show substantially higher PCE concentrations in the groundwater samples obtained with the conventional sampling method (Table 1).

A time-series plot of the PCE results reported for the groundwater samples obtained with the conventional sampling method shows a generally decreasing concentration trend (Figure 1), with the concentration evident in October 2000 (730 μg/L) being about 80% lower than the concentration evident in September 1994 (3,500 μg/L). A similar plot of the low-flow sampling results for PCE shows an indeterminate or slightly decreasing concentration trend through October 2000 followed by a generally increasing trend (Figure 1), with the PCE concentration reported for the sample collected in May 2003 (1,400 μg/L) being the highest detected in the well since April 1997 (2,100 μg/L).

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for he groundwater samples collected in September 1994 (1.79 pCi/L), November 1995 (1.73 pCi/L), and May 2000 (2 pCi/L); each result is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for he groundwater samples collected in September 1994 (4.25 pCi/L), May 2000 (13 pCi/L), and October 2000 (8.6 pCi/L); each result is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

AJA Technical Services, Inc. (AJA). 2001. *Groundwater Monitoring Data Evaluation Report for the U.S. Department of Energy Y-12 National Security Complex, Oak Ridge, Tennessee,* Appendix C: Groundwater Sampling Method Sensitivity Evaluation for the Y-12 Groundwater Protection Program, Y/SUB/02-012529/2, prepared for BWXT Y-12 L.L.C., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

Table 1. Well GW-791: consecutive daily sampling results for selected analytes, May and October 2000

Analyte	Units	May 2000		October 2000	
		Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
pH	St. units	7.33	7.43	NR	NR
Dissolved Oxygen	ppm	0.66	2.52	NR	NR
REDOX	mV	7	90	NR	NR
Dissolved Solids	mg/L	262	271	236	277
Suspended Solids	mg/L	.	.	..	2
Calcium	mg/L	68.2	71.1	63.9	66.5
Chloride	mg/L	6.07	6.68	6.3	6.99
Barium	mg/L	0.27	0.261	0.266	0.266
Strontium	mg/L	0.425	0.379	0.44	0.384
PCE	µg/L	40	1,200	21	730
TCE	µg/L	.	3	.	.
c12DCE	µg/L	.	.	.	.

Note: "." = Not detected; NR = Not reported

Table 2. Well GW-791: summary of VOC data

Date Sampled	VOC Concentration (µg/L)		
	PCE	TCE	c12DCE
Conventional Sampling			
06/07/94	420	11	.
09/06/94	3,500	.	.
12/01/94	3,300	.	.
03/06/95	2,200	.	.
06/05/95	2,600	.	.
08/21/95	1,900	6	.
11/29/95	2,900	.	.
03/06/96	1,200	.	.
05/23/96	1,400	.	.
11/12/96	410	6	.
04/08/97	2,100	7	.
05/03/00	1,200	3 J	.
10/04/00	730	.	.
Low-Flow Sampling		.	.
11/20/97	710	.	.
05/20/98	330	2 J	.
11/16/98	70	.	.
05/25/99	220	2 J	.
11/28/99	73	.	.
05/02/00	40	.	.
10/03/00	21	.	.
04/19/01	53	.	.
10/17/01	100	.	.
05/01/02	260	2 J	.
11/06/02	650	3 J	.
05/22/03	1,400	5	3 J
11/11/03	570	3 J	3 J
05/03/04	400	.	.
10/25/04	500	4 J	1 J
MCL	**5**	**5**	**70**
Note: "." = Not detected; J = Estimated value			

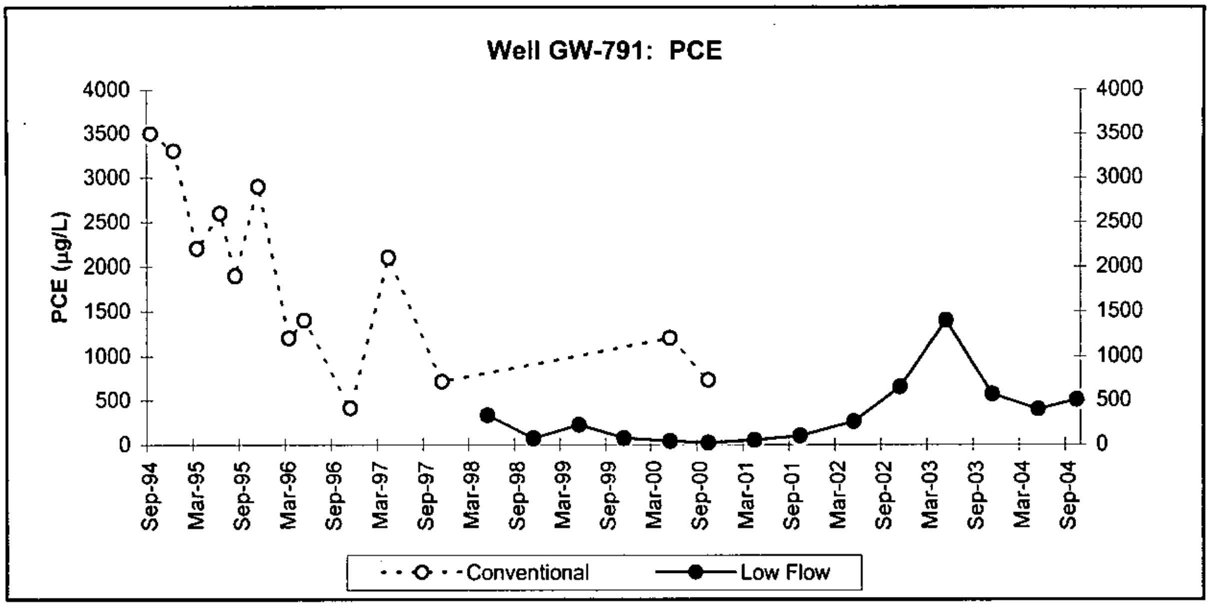

Well GW-791: PCE
PCE (µg/L)
4000
3500
3000
2500
2000
1500
1000
500
0
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Conventional
Low Flow

Figure 1

MAXIMUM CONCENTRATION: 2004

ND	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-795

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Above Grade Low Level Waste Storage Facility
Y-12 GRID EAST COORDINATE: 45,630.06
Y-12 GRID NORTH COORDINATE: 29,286.69
SURFACE ELEVATION: 922.92 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 10/13/92 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 22.61 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 926.18 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	7.5	915.42
BOTTOM (filter pack or open hole):	20.1	902.82
MIDPOINT (filter pack or open hole):	13.8	909.12
PUMP INTAKE:	14.24	908.68
WATER LEVEL (average):	3.81	919.11

GEOLOGIC FORMATION: Nolichucky Shale
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	15 samples	12/03/92	08/26/96
LOW-FLOW SAMPLING METHOD:	2 samples	02/12/04	08/17/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/12/04	.	08/17/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 7.31 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-795

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in October 1992, completed with a screened monitored interval from approximately 7.5 to 20 ft bgs, and constructed with nominal 4.5-inch stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well is located in Bear Creek Valley (BCV) about one and one-half miles west of Y-12, adjacent to the main channel of Bear Creek just upstream (east) of the confluence with a northern tributary (NT) of the creek (NT-5) that drains the western sections of the Above Grade Low Level Storage Facility (AGLLSF). The AGLLSF is an operating facility used for storage of low-level radioactive wastes.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 15 samples between December 1992 and August 1996, and the low-flow sampling method used to obtain samples in February and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the uppermost part of the Nolichucky Shale (Conasauga Group) near the geologic contact with the overlying Maynardville Limestone. The water table interval is a highly permeable zone that occurs near the transition between unconsolidated material (residuum and weathered bedrock) and bedrock and transmits the bulk of the groundwater in the Nolichucky Shale. Groundwater flow in the water table interval is relatively rapid and primarily occurs via flowpaths that discharge into nearby northern tributaries of Bear Creek, which traverse the Nolichucky Shale from northeast to southwest throughout BCV west of Y-12 and are numbered in ascending order downstream from the headwaters of the creek. Relatively little recharge (about 1% of available groundwater) occurs in the much less permeable, fracture-dominated flow system deeper in the bedrock, where groundwater flux decreases with depth as a result of reduced fracture aperture and increased fracture spacing (Solomon et. al. 1992). Groundwater flow in the bedrock intervals (shallow, intermediate, and deep) primarily occurs in directions parallel with geologic strike (i.e., bedding plane fractures) until a cross-strike fracture is encountered, which may promote upward discharge into the water table interval or lateral inflow into the Maynardville Limestone, which is a highly permeable (karst) formation that subcrops beneath the axis of BCV and the main channel of Bear Creek.

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 4 ft bgs and exhibits moderate (7 ft) seasonal fluctuations. Groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for selected monitoring wells in the vicinity of well GW-795 indicate flow to the west, parallel with geologic strike (i.e., bedding-plane fractures) in the Nolichucky Shale.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 216 – 316 mg/L;
- pH (field measurements) of 4.5 – 7.6;
- elevated sulfate concentrations (e.g., 19.3 mg/L in February 2004) compared to other wells that yield groundwater from similarly shallow depths in the Nolichucky Shale;

- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date indicate that none of these contaminants are present in the groundwater at this well.

5.1 NITRATE

Four of the groundwater samples collected to date had nitrate concentrations above the analytical reporting limit, with the highest value (5.2 mg/L in October 1993) being below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

All but two of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.004 mg/L in October 1995) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, only one of the groundwater samples collected to date contained VOCs: a trace of acetone (1 µg/L) was detected in the sample collected in March 1993. This result is may be an analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Two of the groundwater samples collected to date had gross alpha activity above the applicable MDA and corresponding CE, and both results (3.24 pCi/L in October 1993 and 1.74 pCi/L in August 1994) are substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eight of the groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.3 pCi/L in October 1995) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	<5	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-796

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill V
Y-12 GRID EAST COORDINATE: 58,206.40
Y-12 GRID NORTH COORDINATE: 27,923.90
SURFACE ELEVATION: 1,048.80 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/04/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 139.82 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,052.62 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	122.9	925.90
BOTTOM (filter pack or open hole):	136.5	912.30
MIDPOINT (filter pack or open hole):	129.7	919.10
PUMP INTAKE:	131.18	917.62
WATER LEVEL (average):	68.84	979.96
GEOLOGIC FORMATION:	Knox Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	14 samples	05/27/93	07/10/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/14/98	07/20/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/13/04	.	07/20/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 54.76 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	18 µg/L	07/15/98	Outliers
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-796

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1993, completed with a screened monitored interval from 122.9 to 136.5 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 600 ft northwest (hydraulically upgradient) of Industrial Landfill V, which is an operating disposal facility for nonhazardous solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group. The average static groundwater level in the well is 69 ft below ground surface. Presampling depth-to-water measurements for the well indicate unusually wide (>50 ft) fluctuations in seasonal groundwater surface elevations (Figure 1). The average result of several falling head permeability tests performed in well GW-796 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 9.85×10^{-4} cm/s (2.79 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 77 – 150 mg/L, excluding a suspected outlier (212 mg/L) in October 1996;
- pH (field measurements) of 6.4 – 9.3;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Eighteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.52 mg/L) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the applicable analytical reporting limit, and both results (0.001 mg/L in May 1993 and April 1994) are substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Traces of 111TCA (<1 μg/L) have been detected in 21 of the groundwater samples collected from the well. Although the concentrations are very low, the consistent detection of 111TCA suggests that this compound is present in the groundwater at the well and is not an artifact of sample collection, handling, storage, or analysis in the laboratory. Also, the results suggest an indeterminate long-term trend, as illustrated by the 111TCA concentrations evident in March 1994 (1 μg/L), January 1998 (1 μg/L), January 2001 (0.65 μg/L), and January 2004 (0.77 μg/L). The presence of 111TCA in the groundwater at this well most likely reflects transport from the Chestnut Ridge Security Pits (CRSP), which are the only known source of 111TCA and other VOCs hydraulically upgradient of the well, which is about 500 ft directly south of the site. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast (parallel with geologic strike), with less extensive transport to the north and south down the flanks of Chestnut Ridge. The elongated geometry of the VOC plume suggests preferred groundwater flow along strike-parallel flowpaths in the Knox Group (e.g., bedding-plane fractures), which may or may not coincide with the direction of maximum hydraulic gradient inferred from groundwater elevation isopleths. Because well GW-796 is hydraulically downgradient of the CRSP across geologic strike, the presence of dissolved VOCs in the well may reflect transport via cross-strike "quickflow" conduits in the Knox Group (Shevenell 1994). This interpretation is supported by the characteristically low levels of dissolved solids in the groundwater from the well (see Section 4) and the results of falling head permeability tests for the well which indicate that the monitored interval for the well intercepts highly permeable groundwater flowpaths (see Section 3). Note that acetone was detected in the samples collected from the well in July 1998 (17 μg/L), January 2000 (8.6 μg/L), and January 2003 (4.3 μg/L); however these results are suspected outliers.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.3 pCi/L in July 2002) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Five groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (22.4 pCi/L January 2001) being below the SDWA screening level for gross beta activity (50 pCi/L). Moreover, the unusually high gross beta activity evident in the sample collected in January 2001 is probably an analytical artifact considering that all the other gross beta results that exceed the MDA are below 3 pCi/L.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, (Y/TS/1001), Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

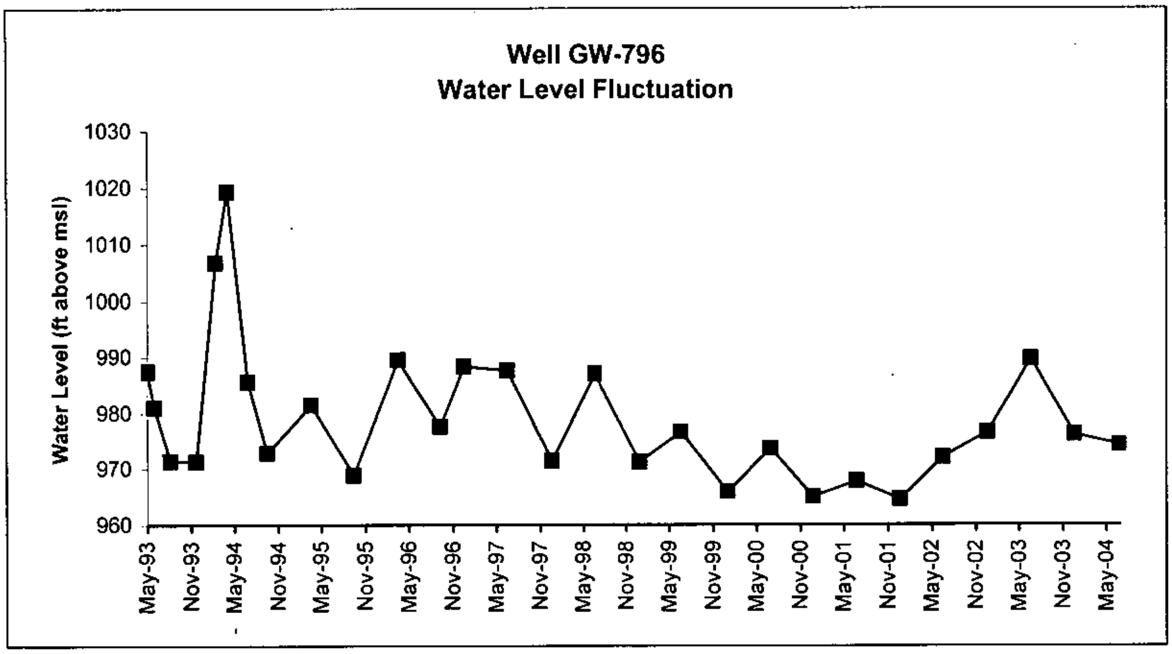

Well GW-796
Water Level Fluctuation
Water Level (ft above msl)
1030
1020
1010
1000
990
980
970
960
May-93
Nov-93
May-94
Nov-94
May-95
Nov-95
May-96
Nov-96
May-97
Nov-97
May-98
Nov-98
May-99
Nov-99
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	<5	ND	ND

GW-797

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill V
Y-12 GRID EAST COORDINATE: 58,550.40
Y-12 GRID NORTH COORDINATE: 27,446.60
SURFACE ELEVATION: 1,056.10 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/16/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 135.71 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,060.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	118.0	938.10
BOTTOM (filter pack or open hole):	134.1	922.00
MIDPOINT (filter pack or open hole):	126.1	930.05
PUMP INTAKE:	128.10	928.00
WATER LEVEL (average):	65.15	990.95

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	29		
CONVENTIONAL SAMPLING METHOD:	14 samples	05/27/93	07/09/97
LOW-FLOW SAMPLING METHOD:	15 samples	01/14/98	07/15/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/15/04	.	07/15/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 24.53 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	21 µg/L	04/11/95	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-797

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1993, completed with a screened monitored interval from 118 to 134.1 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 200 ft directly west (hydraulically downgradient) of Industrial Landfill V, a landfill operated since 1994 and used for disposal of nonhazardous and nonradioactive combustible and decomposable solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-nine groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Copper Ridge Dolomite). The average static groundwater level in the well is about 65 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations, which is typical of many wells in the Knox Group on Chestnut Ridge. The average result of several falling head permeability tests performed in well GW-797 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 2.9×10^{-5} cm/s (0.08 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 146 – 300 mg/L;
- pH (field measurements) of 6.5 – 9.0;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Nineteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.4 mg/L in July 2004) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater sample had a uranium concentration above the applicable analytical reporting limit, and this result (0.001 mg/L in July 1994) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in five groundwater samples: carbon disulfide in August 1993 (1 μg/L) and July 2004 (0.33 μg/L); acetone in April 1995 (21 μg/L), February 2000 (9.3 μg/L), and July 2001 (2 μg/L); and chloromethane in July 2001 (0.41 μg/L). These sporadic detections are considered sampling or analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (2.65 pCi/L in March 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Two groundwater samples had gross beta activity above the applicable MDA and corresponding CE, and both results (4.17 pCi/L in March 1994 and 2.74 pCi/L in October 1994) are substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-798

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VII
Y-12 GRID EAST COORDINATE: 60,309.95
Y-12 GRID NORTH COORDINATE: 27,264.85
SURFACE ELEVATION: 1,002.42 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/18/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 134.00 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,006.00 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	122.0	880.42
BOTTOM (filter pack or open hole):	135.4	867.02
MIDPOINT (filter pack or open hole):	128.7	873.72
PUMP INTAKE:	125.92	876.50
WATER LEVEL (average):	72.36	930.06

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	38		
CONVENTIONAL SAMPLING METHOD:	13 samples	06/23/93	07/15/97
LOW-FLOW SAMPLING METHOD:	25 samples	01/12/98	07/20/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/12/04	.	07/20/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 43.03 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	20	57.96 µg/L	01/14/03	Increasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-798

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1993, completed with a screened monitored interval from 122 to 135.4 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 100 ft northeast (hydraulically upgradient) of Construction/Demolition Landfill VII, is an operating disposal facility for nonhazardous solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between June 1993 and July 1997, and the low-flow sampling method used to obtain 25 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is 72 ft below ground surface. Presampling depth-to-water measurements for the well indicate unusually wide (>40 ft) water level fluctuations (Figure 1). However, excluding the unusually high groundwater elevations evident in March 1994 (957 ft above msl) and April 1994 (962 ft above msl), water levels fluctuations are typically less than 20 ft. In either case, large seasonal and episodic groundwater elevation fluctuations are characteristic of many wells in karst aquifers such as the Knox Group. The average result of several falling head permeability tests performed in well GW-798 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.19×10^{-3} cm/s (3.38 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 92 – 330 mg/L;
- pH (field measurements) of 6.4 – 8.2;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-eight groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1 mg/L) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

One groundwater samples had a uranium concentration above the applicable analytical reporting limit, and this result (0.001 mg/L) is substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs were detected in 20 of the groundwater samples collected from the well since January 2000: PCE, TCE, c12DCE, 11DCE, 111TCA, 11DCA, CTET, chloromethane, and TCFM. Historical data show that individual VOC concentrations are relatively low, ranging from less than 1 µg/L (CTET and chloromethane) to more than 10 µg/L (PCE and TCFM), with PCE concentrations at or above the MCL (5 µg/L) reported for each groundwater sample collected from January 2002 to January 2004. As illustrated by the data for PCE (Figure 2), 111TCA (Figure 3), and TCFM (Figure 4), VOC concentrations have steadily increased following their initial detection, with the historical peak summed VOC concentrations evident in January 2003 (58 µg/L). Note that the concentrations of each compound show a decreasing trend since January 2003, possibly suggesting that a "pulse" of dissolved VOCs has been transported along the groundwater flowpaths intercepted by the monitored interval in the well. The Chestnut Ridge Security Pits (CRSP) are the only known source of VOCs hydraulically upgradient of the well, which is about 1,500 ft east-southeast of the site, and VOC concentrations in each well located near the CRSP have decreased substantially since closure of the site. Historical operation of the former waste disposal trenches at the CRSP emplaced an elongated plume of dissolved VOCs in the groundwater that extends more than 2,500 ft east-northeast (parallel with geologic strike), but only about 500 ft to the north and south down the flanks of Chestnut Ridge. The geometry of the VOC plume suggests preferred groundwater flow along strike-parallel flowpaths in the Knox Group (e.g., bedding-plane fractures), which may or may not coincide with the direction of maximum hydraulic gradient inferred from groundwater elevation isopleths. Because well GW-798 is hydraulically downgradient of the CRSP across geologic strike, the presence of dissolved VOCs in the well may reflect transport via cross-strike "quickflow" conduits in the Knox Group (Shevenell 1994).

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.76 pCi/L in March 1994) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Eleven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.41 pCi/L in January 2003) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

Shevenell, L.A. 1994. *Chemical Characteristics of Water in Karst Formations at the Oak Ridge Y-12 Plant*, (Y/TS/1001), Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

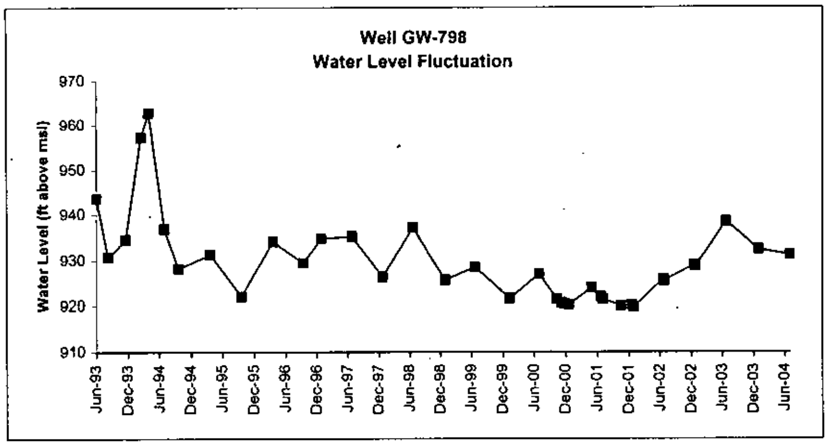


Figure 1

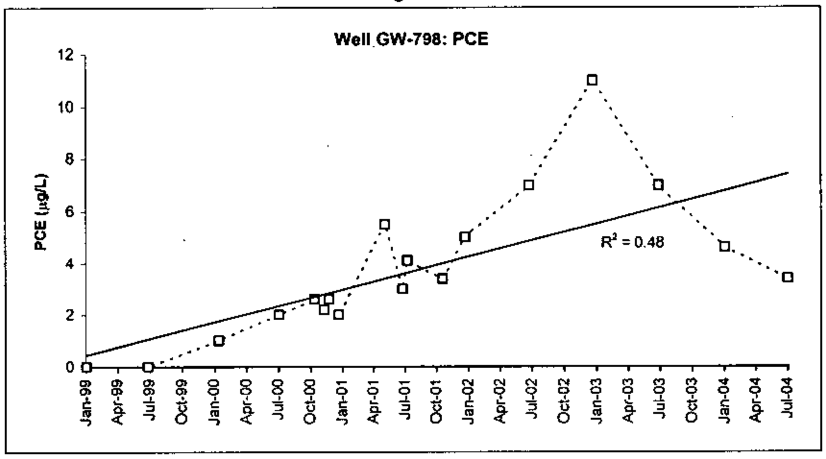


Figure 2

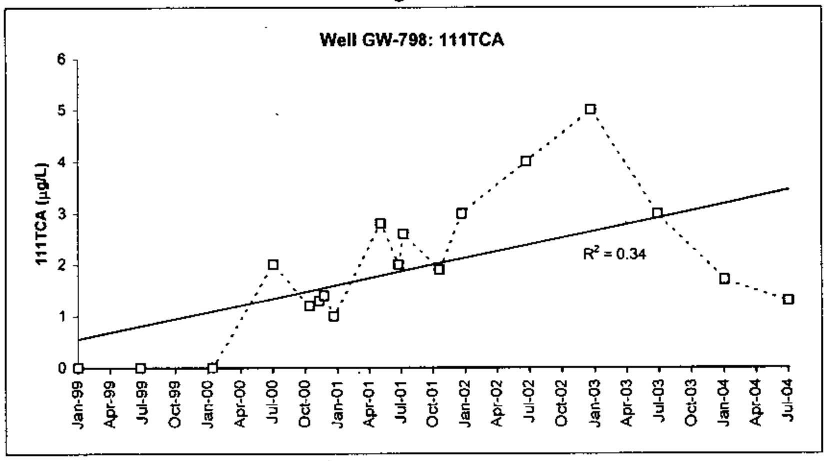


Figure 3

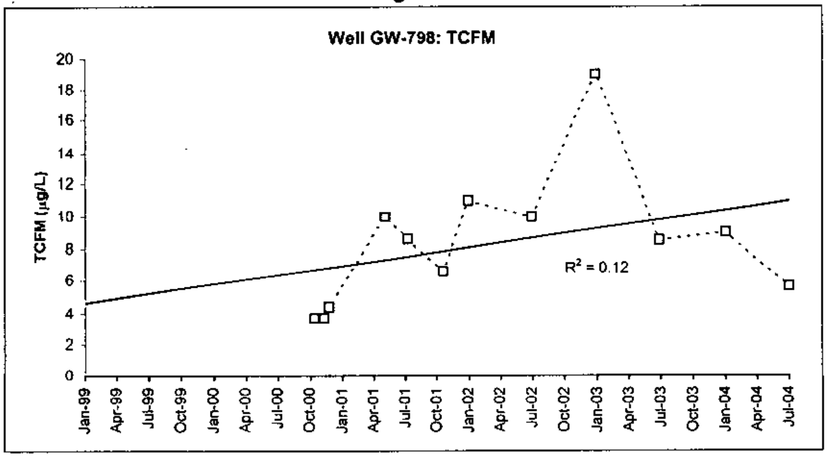


Figure 4

GW-798

MAXIMUM CONCENTRATION: 2004

<5	ND	5 - 50	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-799

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill V
Y-12 GRID EAST COORDINATE: 59,961.20
Y-12 GRID NORTH COORDINATE: 26,745.50
SURFACE ELEVATION: 978.10 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/25/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 97.58 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 981.29 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	78.7	899.40
BOTTOM (filter pack or open hole):	92.0	886.10
MIDPOINT (filter pack or open hole):	85.4	892.75
PUMP INTAKE:	84.08	893.29
WATER LEVEL (average):	8.76	969.34

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	14 samples	05/27/93	07/09/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/13/98	07/19/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/15/04	.	07/19/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 19.76 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	3	31 µg/L	01/27/00	Outliers
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-799

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 1993, completed with a screened monitored interval from 78.7 to 92 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 200 ft southeast (hydraulically downgradient) of Industrial Landfill V, a landfill operated since 1994 and used for disposal of nonhazardous and nonradioactive combustible and decomposable solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 14 samples between May 1993 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

This well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is about 9 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge. The average result of several falling head permeability tests performed in well GW-799 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.56×10^{-4} cm/s (0.44 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 118 – 184 mg/L;
- pH (field measurements) of 6.6 – 8.5;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Twenty-seven groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (2.885 mg/L in July 1999) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Six groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.002 mg/L in April 1994) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in five groundwater samples: acetone in July 1997 (23 µg/L), July 1998 (2 µg/L), January 2000 (31 µg/L), January 2003 (3.6 µg/L), and January 2004 (9.5 µg/L). Additionally, very low levels of 2-butanone (2 µg/L in July 1998) and chloromethane (0.26 µg/L in January 2003) have been reported for two of these samples. Acetone and 2-butanone are common laboratory reagents, and these results may be sampling or analytical artifacts.

5.4 GROSS ALPHA ACTIVITY

Two groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, and both results (3.4 pCi/L in July 1999 and 1.6 pCi/L in January 2002) are substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	<5	<7.5	ND

GW-801

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Industrial Landfill V
Y-12 GRID EAST COORDINATE: 58,779.90
Y-12 GRID NORTH COORDINATE: 26,807.80
SURFACE ELEVATION: 1,093.82 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/01/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 190.92 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,097.16 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	175.8	918.02
BOTTOM (filter pack or open hole):	188.9	904.92
MIDPOINT (filter pack or open hole):	182.4	911.47
PUMP INTAKE:	177.66	916.16
WATER LEVEL (average):	101.95	991.87

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	28		
CONVENTIONAL SAMPLING METHOD:	13 samples	07/24/93	07/10/97
LOW-FLOW SAMPLING METHOD:	15 samples	01/13/98	07/15/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/13/04	.	07/15/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: L (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 34.84 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-801

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1993, completed with a screened monitored interval from 175.8 to 188.9 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12, about 200 ft southwest (hydraulically downgradient) of Industrial Landfill V, a landfill operated since 1994 and used for disposal of nonhazardous and nonradioactive combustible and decomposable solid waste generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-eight groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 13 samples between July 1993 and July 1997, and the low-flow sampling method used to obtain 15 samples between January 1998 and July 2004.

This well yields groundwater samples with low TDS (see Section 4.0), which suggests short groundwater residence time and indicates that the monitored interval in the well intercepts hydraulically active flowpaths.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is about 102 ft bgs, and presampling depth-to-water measurements for the well suggest wide (>30 ft) water-level fluctuations (Figure 1). The average result of several falling head permeability tests performed in well GW-801 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 1.77×10^{-4} cm/s (0.5 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 78 – 170 mg/L;
- pH (field measurements) of 7.4 – 8.4;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Eighteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (1.6 mg/L in January 2003) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

None of the groundwater samples had uranium concentrations above the applicable analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected at low (estimated) levels in three groundwater samples: 111TCA (4 μg/L) in January 1998; 2-butanone (2 μg/L) in July 1998; and carbon disulfide (0.25 μg/L) in July 2004. These single detections may be sampling or analytical artifacts and are considered to be outliers.

5.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, and the highest result (2.3 pCi/L in March 1994) is substantially below the MCL for gross alpha activity (15 pCi/L).

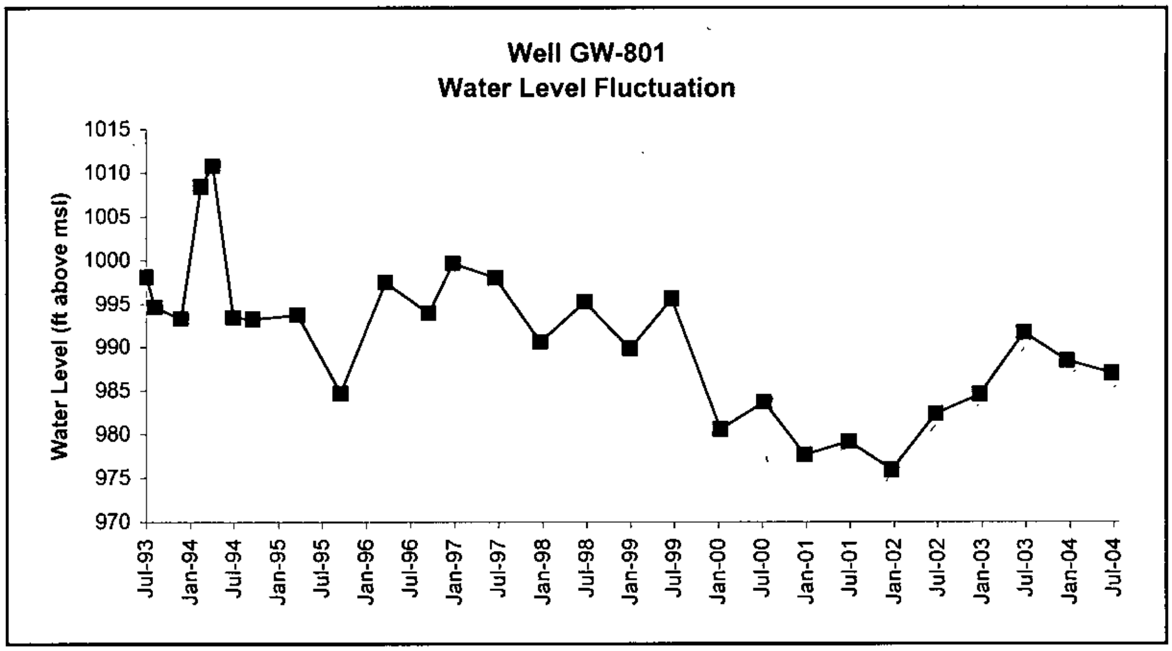
5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (13.5 pCi/L in April 1996) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.



Well GW-801
Water Level Fluctuation
Water Level (ft above msl)
1015
1010
1005
1000
995
990
985
980
975
970
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-802

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: East End Fuel Facility
Y-12 GRID EAST COORDINATE: 62,216.80
Y-12 GRID NORTH COORDINATE: 29,654.70
SURFACE ELEVATION: 942.30 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/25/93 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 25.42 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 941.83 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 10.62 inches
WELL CASING MATERIAL: PVC40
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.01
DEDICATED SAMPLING EQUIPMENT: Peristaltic pump Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	13.3	929.00
BOTTOM (filter pack or open hole):	26.5	915.80
MIDPOINT (filter pack or open hole):	19.9	922.40
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	6.46	935.84
GEOLOGIC FORMATION:	Nolichucky Shale	
HYDROGEOLOGIC ZONE:	Water Table	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	5		
CONVENTIONAL SAMPLING METHOD:	5 samples	03/18/97	05/10/04
LOW-FLOW SAMPLING METHOD:	. samples	.	.

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/10/04	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.74 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	.	. mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	8 µg/L	07/23/98	Outlier
GROSS ALPHA (15 pCi/L):	1	117 pCi/L	03/18/97	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-802

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1993, completed with a screened monitored interval from 13.3 to 26.5 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and PVC (#40) well screen (0.01 slot). The well is in Bear Creek Valley near the east end of Y-12, about 200 ft south-southeast (hydraulically downgradient across geologic strike) of the Bldg. 9754-2 Fuel Facility, and is flush-mounted in the asphalt pavement near the intersection of First Street and Agate Drive.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Five groundwater samples were collected from the well between March 1997 and May 2004 using the conventional sampling method and a peristaltic pump.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 6 ft bgs. Presampling depth-to-water measurements for the well indicate minimal (<1 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

Data regarding the geochemical characteristics of the groundwater in the well are not available (groundwater samples from the well have not been analyzed for the primary anions and cations). Also, the required analyses have not been performed to determine if the trace metals concentrations in the well are below respective analytical reporting limits or within the range of background levels in groundwater at Y-12.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Groundwater samples from this well have not been analyzed for nitrate.

5.2 URANIUM

Only one groundwater sample (March 1997) was analyzed for uranium and the concentration did not exceed the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Of the five groundwater samples analyzed for VOCs, only acetone was detected (8 μg/L) in the sample collected in July 1998. This result is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample was analyzed for gross alpha activity (March 1997), and the result for this sample (117 pCi/L) is substantially higher than the MCL for gross alpha activity (15 pCi/L). However, the high gross alpha value is not supported by the U-234 (1.13 pCi/L) and U-238 (0.65 pCi/L) activities reported for this groundwater sample (uranium isotopes are the most likely radiological contaminants in the well).

5.5 GROSS BETA ACTIVITY

One groundwater sample was analyzed for gross beta activity (March 1997), and the result for this sample (47.2 pCi/L) is just below the SWDA screening level for gross beta activity (50 pCi/L). Notably, this sample also was analyzed for technetium-99 activity and the result was less than the MDA.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	<7.5	ND

GW-816

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Scarboro Road
Y-12 GRID EAST COORDINATE: 64,031.36
Y-12 GRID NORTH COORDINATE: 31,581.50
SURFACE ELEVATION: 894.56 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 06/02/94 PAIRED/CLUSTERED WITH: GW-207 GW-208
TAG DEPTH (measured): 17.99 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 898.42 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 10 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	2.9	891.66
BOTTOM (filter pack or open hole):	15.8	878.76
MIDPOINT (filter pack or open hole):	9.4	885.21
PUMP INTAKE:	11.14	883.42
WATER LEVEL (average):	9	885.56

GEOLOGIC FORMATION: Rome
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	26		
CONVENTIONAL SAMPLING METHOD:	11 samples	09/21/94	04/16/97
LOW-FLOW SAMPLING METHOD:	15 samples	12/04/97	11/09/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	.	05/24/04	.	11/09/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 3.11 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-816

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in June 1994, completed with a screened monitored interval from 2.9 to 15.8 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). The well forms a cluster with wells GW-207 and GW-208 and is located near Scarboro Road about 50 ft east of the section of Upper East Fork Poplar Creek that passes through a gap in Pine Ridge directly northeast of Y-12.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-six groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain 11 samples between September 1994 and April 1997, and the low-flow sampling method used to obtain 15 samples between December 1997 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Rome Formation. The average static groundwater level in the well is about 9 ft bgs. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<4 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 156 – 306 mg/L, excluding an outlier (128 mg/L) in September 1996;
- pH (field measurements) of 6.3 – 7.0;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Three groundwater samples had nitrate concentrations above the analytical reporting limit, with the highest concentration (0.52 mg/L in November 1994) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Two groundwater samples had uranium concentrations above the analytical reporting limit, with the highest concentration (0.00124 mg/L in May 2001) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, acetone was detected in one sample (5 µg/L in June 1995) and the result is a suspected analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Six of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest activity (5.34 pCi/L in September 1994) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Twelve of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest activity (16.1 pCi/L in September 1994) being below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	<0.015	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-818

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-2
Y-12 GRID EAST COORDINATE: 60,140.25
Y-12 GRID NORTH COORDINATE: 29,118.66
SURFACE ELEVATION: 928.18 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 11.71 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 927.93 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: NA
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	NA	NA
BOTTOM (filter pack or open hole):	NA	NA
MIDPOINT (filter pack or open hole):	NA	NA
PUMP INTAKE:	8.25	919.93
WATER LEVEL (average):	8.44	919.75

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	2		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	2 samples	03/26/98	02/10/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/10/04	.	.	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.17 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	1	7 µg/L	03/26/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-818

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

The date for installation of this well is not known, but available information show that the well was completed with a screened monitored interval to a total depth of about 12 ft bgs, and is constructed with nominal 4.5-inch diameter PVC riser casing. The well is located in Bear Creek Valley (BCV) in the east-central section of Y-12, on the north side of the main channel of Upper East Fork Poplar Creek (UEFPC) near the southeast corner of Building 9201-2. This well was plugged and abandoned in April 2004.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Two groundwater samples have been collected from the well to date, with the low-flow sampling method used to obtain samples in March 1998 and February 2004.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Maynardville Limestone (upper Conasauga Group). Most groundwater flow in the Maynardville Limestone occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 8 ft bgs. Based on contemporaneous depth-to-water measurements for selected monitoring wells in BCV, groundwater elevation isopleths in the vicinity of well GW-818 indicate flow primarily to the east, parallel with geologic strike in the Maynardville Limestone and the exposed portion of the UEFPC channel. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local groundwater flow directions may be strongly influenced by subsurface process lines, utilities, and storm sewers, the buried northern tributaries and main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998).

4.0 GEOCHEMCICAL CHARACTERISTICS

Analytical results for the groundwater samples collected to date indicate that the well yields sulfate-enriched, calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 337 – 387 mg/L;
- pH of 6.7 – 7.1 (field measurements);
- negative oxidation-reduction potential (REDOX) and low dissolved oxygen (DO) indicative of reducing conditions (REDOX = -72mV and DO = 0.09 ppm in February 2004);
- elevated concentrations (>75 mg/L) of sulfate relative to other wells of similar depth in the Maynardville Limestone;
- low molar proportions of chloride, potassium, and sodium (<10% of total anions/cations);
- unusually high total (unfiltered concentrations) of iron (>9 mg/L) and manganese (>1 mg/L); and

- total concentrations of other trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, none of the principal contaminants are generally present in the groundwater at this well.

5.1 NITRATE

One of the groundwater samples collected to date had nitrate concentrations at or above the analytical reporting limit, and this result (0.481 mg/L in March 1998) is an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

Both groundwater samples collected to date had total uranium concentrations above the applicable analytical reporting limit, with the highest value (0.005 mg/L in March 1998) being an order-of-magnitude below the drinking water MCL for total uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

The groundwater sample collected in March 1998 contained low concentrations of TCE (6 μg/L) and c12DCE (1 μg/L); no VOCs were detected in the groundwater sample collected in February 2004.

5.4 GROSS ALPHA ACTIVITY

None of the groundwater samples collected to date had gross alpha activity above the applicable MDA.

5.5 GROSS BETA ACTIVITY

None of the groundwater samples collected to date had gross beta activity above the applicable MDA.

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant,* Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

ND	ND	>5,000	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-820

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-2
Y-12 GRID EAST COORDINATE: 59,772.96
Y-12 GRID NORTH COORDINATE: 29,174.65
SURFACE ELEVATION: 929.67 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: NA PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 17.18 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 929.57 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: NA
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: NA

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	NA	NA
BOTTOM (filter pack or open hole):	17.3	912.37
MIDPOINT (filter pack or open hole):	NA	NA
PUMP INTAKE:	15.10	914.57
WATER LEVEL (average):	9.96	919.71

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	6		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	6 samples	03/26/98	10/13/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	.	06/12/03	.	10/13/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 0.47 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	6	9,633 μg/L	06/12/03	Increasing, Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-820

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

Documentation regarding the installation date and construction details for this well is not available; the well has nominal 4.5-inch PVC (#40) riser casing and is completed at a depth of 17.3 ft bgs. The well is located in the eastern part of Y-12 near the southwest corner of Bldg. 9201-2.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Six groundwater samples were collected from the well between March 1998 and October 2003, all of which were obtained using the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). Presampling depth-to-water measurements show that the static water level in the well occurs at an average depth of about 10 ft bgs and exhibits minimal (<1 ft) seasonal fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for unfiltered groundwater samples show that the well yields chloride- and sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>300 mg/L);
- pH (field measurements) of 7.1 – 7.5;
- unusually high concentrations of chloride (>20 mg/L) and sulfate (>30 mg/L) compared to other wells that yield groundwater from similar depths in the Maynardville Limestone;
- low molar proportions of potassium and sodium (<10% of total anions/cations); and
- total concentrations of trace metals (except iron and manganese) that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The unusually high chloride and sulfate concentrations in the groundwater samples may reflect local geochemical conditions or contamination from one or more sources within Y-12, including numerous potential non-specific sources such as leaking industrial process lines, sanitary sewers, or storm drains. Additionally, the elevated chloride levels may be a consequence of the biologically mediated degradation (dechlorination) of the chlorinated hydrocarbons in the groundwater (Hinchee et al. 1995). As shown by the data summarized in Table 1, the groundwater in the well exhibits geochemical conditions (aside from the elevated sulfate levels) that are favorable to the biotic degradation of chlorinated hydrocarbons.

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. As discussed in the following sections, monitoring data obtained to date show that VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

Nitrate was not detected in the groundwater samples.

5.2 URANIUM

Uranium was not detected in the groundwater samples.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, one or more of the following VOCs were detected in each groundwater sample (Table 2): PCE, TCE, 11DCA, 11DCE, c12DCE, and VC. The source of these VOCs has not been confirmed, but the concentrations of PCE exceed 1% of pure-phase solubility (1,500 μg/L), which suggests that PCE may be present as DNAPL in the subsurface near the western (upgradient) end of Bldg. 9201-2 (DOE 1998). Additionally, the high concentrations of c12DCE potentially result from the biotic degradation of the PCE and TCE, with very low dissolved oxygen and strongly negative REDOX (see Table 1) suggesting the strongly reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC (Chapelle 1996), which may account for the high VC concentrations in the groundwater.

The primary VOCs in the groundwater samples are PCE and c12DCE, which have been detected in each sample and have historical maximum concentrations above 5,000 μg/L and 2,500 μg/L, respectively (Table 2). Also, the most recent sampling results show that the concentrations of both compounds remain several orders-of-magnitude higher than respective MCLs. Secondary VOCs in the samples are TCE and VC, which also were detected in each sample, with the highest concentrations of both compounds reported for the samples collected in June 2003 (TCE = 1,100 μg/L) and October 2003 (VC = 220 μg/L). Other compounds have been detected at substantially lower concentrations (Table 2), the highest being reported for t12DCE (16 μg/L), although the most recent results show concentrations of 11DCE at or slightly above the MCL (7 μg/L).

A time-series plot of the summed concentrations of VOCs detected in each groundwater sample shows a generally indeterminate long-term trend that is probably an artifact of the relatively limited sampling history for the well, which encompasses a total of six samples collected between March 1998 and October 2003 (Figure 1). Also, the concentrations of individual compounds show divergent temporal changes. For example, the concentration of PCE evident in June 2003 (6,500 μg/L) is about 30% higher than the PCE concentration in October 2003 (5,000 μg/L), whereas the concentration of c12DCE in June 2003 (1,900 μg/L) is about 50% lower than the c12DCE concentration in October 2003 (2,800 μg/L). Additionally, the results for several compounds, particularly c12DCE and VC, suggest clearly increasing long-term concentration trends (Table 2). In general, the PCE concentration trend is similar to the TCE trend, and the c12DCE concentration trend is similar to the VC trend (Figure 2). The mechanism(s) governing wide temporal concentration fluctuations and the significance of the long-term concentration trends, considering the limited sampling history for the well, are not characterized by available data.

5.4 GROSS ALPHA ACTIVITY

Gross alpha activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in June 2000 (2 pCi/L); this result is substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Gross beta activity above the applicable MDA and corresponding CE was reported for the groundwater sample collected in June 2000 (8.2 pCi/L); this result is substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Hinchee, R.E., J.A. Kittel, and J.J. Reisinger, eds. 1995. *Applied Bioremediation of Petroleum Hydrocarbons*. Batelle Press, Columbus, OH.

U.S. Department of Energy (DOE). 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-164/V3&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chorinated Compounds*. Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-820: geochemical indicators for biotic degradation of VOCs

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	June 2000	October 2000	June 2003	May 2003
Nitrate < 1 mg/L	<0.02	<0.02	<0.02	<0.02
Iron (II) > 1 mg/L	0.74 *	1.19*	0.174 *	0.797*
Sulfate < 20 mg/L	36.3	40.1	33.9	37.8
Dissolved Oxygen < 1 ppm	0.62**	0.91**	0.22**	0.26**
REDOX < 50 mV	-97 **	-110 **	-64**	-123**
pH 5 < pH < 9	7.16 **	7.33**	7.25 **	7.27**

Note: *Results are for total iron; **Field measurement.

Table 2. Well GW-820: summary of VOC data for well GW-820

Date Sampled	VOC Concentration (µg/L)			
	PCE	**TCE**	**12DCE**	**c12DCE**
03/26/98	7,300	590	876	870
09/10/99	1,500	250	960	940
06/13/00	3,500	560	1,000	1,000
10/26/00	2,600	480	1,200	1,200
06/12/03	6,500	1,100	1,900	1,900
10/13/03	5,000	980	2,800	2,800
MCL	**5**	**5**	**NA**	**70**
Date Sampled	**VOC Concentration (µg/L)**			
	t12DCE	**11DCE**	**VC**	**11DCA**
03/26/98	6	4 J	65	1 J
09/10/99	16	4 J	130	.
06/13/00	5	4 J	89	.
10/26/00	8	6	110	.
06/12/03	9	7	120	.
10/13/03	13	9	220	.
MCL	**NA**	**7**	**2**	**NA**

Note: "." = Not detected; J = Estimated value below analytical reporting limit; NA = Not applicable

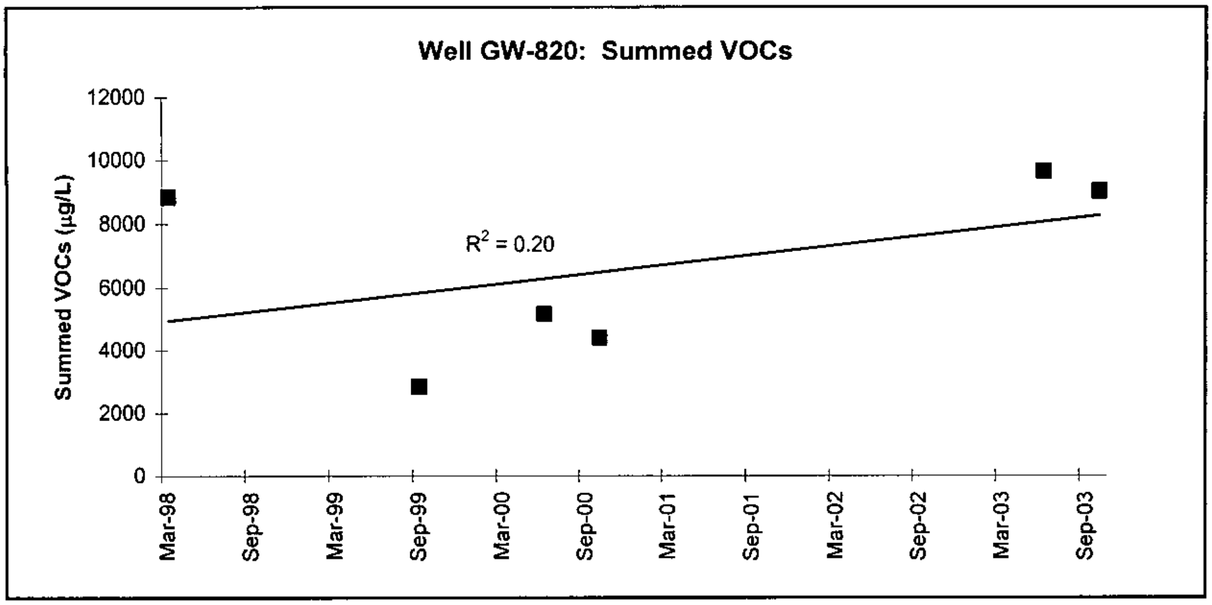


Figure 1

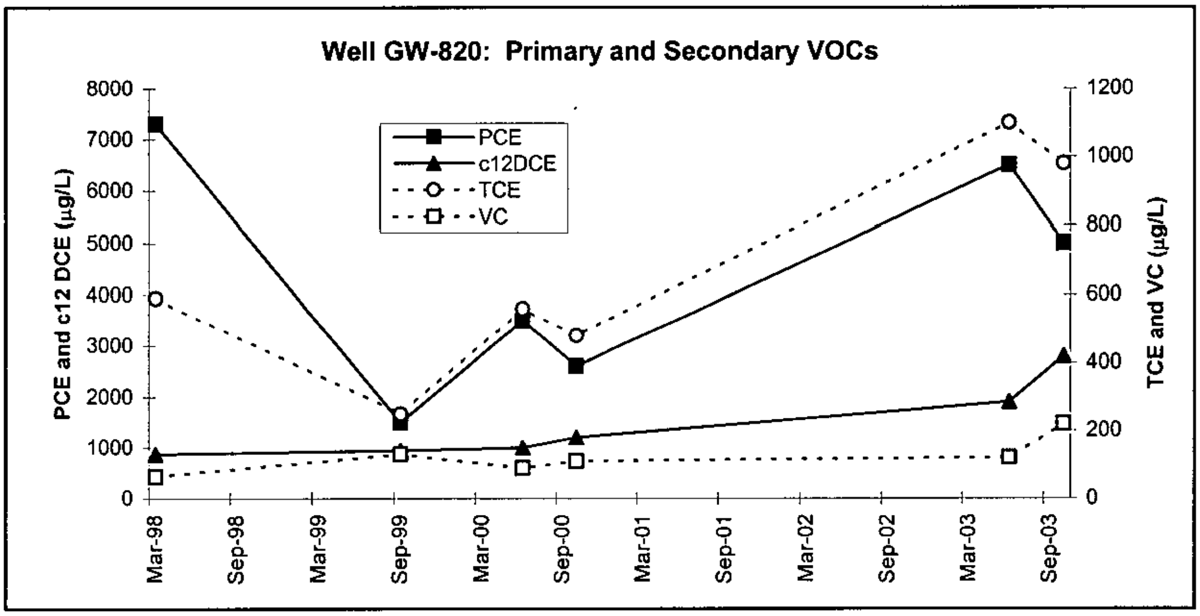


Figure 2

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

GW-827

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Construction/Demolition Landfill VI
Y-12 GRID EAST COORDINATE: 51,826.32
Y-12 GRID NORTH COORDINATE: 27,721.42
SURFACE ELEVATION: 1,048.13 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: SWDF
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/24/95 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 137.22 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,051.60 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	122.1	926.03
BOTTOM (filter pack or open hole):	134.8	913.33
MIDPOINT (filter pack or open hole):	128.5	919.68
PUMP INTAKE:	128.73	919.40
WATER LEVEL (average):	37.57	1010.56

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	22		
CONVENTIONAL SAMPLING METHOD:	6 samples	04/05/95	04/01/97
LOW-FLOW SAMPLING METHOD:	16 samples	10/14/97	07/20/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/15/04	.	07/20/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 16.7 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-827

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 1995, completed with a screened monitored interval from 122.1 to 134.8 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located on the southern flank of Chestnut Ridge directly south of Y-12 (unless noted otherwise, directions are in reference to the Y-12 grid system), about 200 ft north (hydraulically upgradient) of Construction/Demolition Landfill VI. This closed landfill operated from 1994 to 2003 and received nonhazardous and nonradioactive solid wastes, including construction spoil (concrete, wood, metal, plastic, and roofing material) and soil wastes, generated from DOE operations on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-two groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain six samples between April 1995 and April 1997, and the low-flow sampling method used to obtain 16 samples between October 1997 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Chepultepec Dolomite). The average static groundwater level in the well is 38 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (17 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge. The result of a falling head permeability test performed in well GW-827 (Jones 2004) indicates that the hydraulic conductivity of the bedrock near the well is about 5.91×10^{-4} cm/s (1.7 ft/day).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 130 – 192 mg/L;
- pH (field measurements) of 6.9 – 8;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Seventeen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.67 mg/L in April 1998) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.000764 mg/L in October 1999) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, a trace of toluene was detected in one sample (1.4 µg/L in February 2000) and the result is a suspected analytical artifact.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (0.962 pCi/L in July 2000) is substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (4.4 pCi/L in January 2002) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Jones, S.B. 2004. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at Y-12, 1994-1999.* Electronic mail to T.R. Harrison and J.R. Walker, Elvado Environmental LLC. November 22, 2004.

MAXIMUM CONCENTRATION: 2004

.	ND	ND	<7.5	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-831

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Filled Coal Ash Pond
Y-12 GRID EAST COORDINATE: 56,593.48
Y-12 GRID NORTH COORDINATE: 26,653.53
SURFACE ELEVATION: 1,088.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: RCRA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/30/96 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 198.06 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,091.29 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: 9.87 inches
WELL CASING MATERIAL: SLS
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	182.0	906.04
BOTTOM (filter pack or open hole):	199.6	888.44
MIDPOINT (filter pack or open hole):	190.8	897.24
PUMP INTAKE:	188.75	899.29
WATER LEVEL (average):	124.63	963.41

GEOLOGIC FORMATION: Knox Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18		
CONVENTIONAL SAMPLING METHOD:	4 samples	08/27/96	07/23/97
LOW-FLOW SAMPLING METHOD:	14 samples	01/06/98	07/12/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	01/13/04	.	07/12/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 10.6 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-831

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1996, completed with a screened monitored interval from 182 to 199.6 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well serves RCRA plume delineation monitoring purposes and is located on the southern flank of Chestnut Ridge, about 2000 ft southwest of the Chestnut Ridge Security Pits (CRSP). The CRSP include two contiguous former waste disposal areas, each consisting of a series of unlined, east-west oriented trenches that were about 8 to 10 ft wide, 10 to 18 ft deep, and 700 to 800 ft long. Beginning in 1973, the disposal trenches at the site received a variety of hazardous waste until December 1984 and nonhazardous wastes until November 1988. All the disposal trenches are covered by a multi-layer low-permeability cap installed during RCRA closure of the site in 1989.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Eighteen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain four samples between August 1996 and July 1997, and the low-flow sampling method used to obtain 14 samples between January 1998 and July 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the bedrock interval in the Knox Group (Kingsport Formation/Longview Dolomite). The average static groundwater level in the well is 125 ft bgs. Presampling depth-to-water measurements for the well indicate substantial (10 - 25 ft) water-level fluctuations, which is typical of many Knox Group wells on Chestnut Ridge.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 139 – 230 mg/L;
- pH (field measurements) of 6.9 – 8.8;
- equal or nearly equal calcium:magnesium ratios (which is characteristic of water in contact with dolomite) and low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four groundwater samples (between August 1996 and January 1999) had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (0.072 mg/L in January 1997) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four groundwater samples had uranium concentrations above the applicable analytical reporting limit, with the highest concentration (0.0021 mg/L in July 1998) being substantially below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, a trace of acetone was reported for one sample (2 µg/L in July 1998), and the result is a suspected analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.31 pCi/L in January 2001) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (16.9 pCi/L in July 2001) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	<7.5	<25

GW-832

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: New Hope Pond
Y-12 GRID EAST COORDINATE: 64,133.61
Y-12 GRID NORTH COORDINATE: 29,141.95
SURFACE ELEVATION: 906.83 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 05/09/96 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 10.36 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 906.18 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 12 inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 6.63 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/0.02
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	4.0	902.83
BOTTOM (filter pack or open hole):	11.8	895.03
MIDPOINT (filter pack or open hole):	7.9	898.93
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	7.94	898.89

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	17		
CONVENTIONAL SAMPLING METHOD:	3 samples	05/14/96	08/29/97
LOW-FLOW SAMPLING METHOD:	14 samples	02/18/98	08/16/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	02/18/04	.	08/16/04	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.7 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	16	55 µg/L	02/09/99	Decreasing, Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-832

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in May 1996, completed with a screened monitored interval from 4 to 11.8 ft bgs, and constructed with nominal 6.5-inch diameter PVC (#40) riser casing and well screen (0.02 slot). The well is in Bear Creek Valley near the east end of Y-12 and intercepts the gravel underdrain Upper East Fork Poplar Creek (UEFPC) distribution channel at the southeast corner of Lake Reality. Lake Reality is a lined surface impoundment that was built in 1988 to replace New Hope Pond, an unlined surface impoundment built in 1963 to help regulate the quantity and quality of surface water exiting Y-12 via UEFPC.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seventeen groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain samples in May 1996, April 1997, and August 1997 and the low-flow sampling method used to obtain 14 samples between February 1998 and August 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from a gravel underdrain beneath the UEFPC distribution channel. The underdain appears to function as a highly permeable groundwater flowpath and a constant head recharge boundary and strongly influences local groundwater flow patterns (SAIC 1998). Presampling depth-to-water measurements for the well show that the average static groundwater level is about 8 ft below ground surface and exhibits minor water-level fluctuations (<2 ft). This well served as the pumping well for a short-term aquifer pumping test performed in May 1995, the results of which demonstrated a direct hydraulic connection between the well and the Lake Reality Sump (SAIC 1998).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.7 – 8.1;
- low molar proportions of potassium and sodium (<10% of total anions/cations);
- unusually high concentrations of chloride (>20 mg/L) and sulfate (>30 mg/L); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Seventeen groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest concentration (4.4 mg/L in August 2000) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Ten groundwater samples were analyzed for uranium and concentrations above the applicable analytical reporting limit were reported for seven samples, with the highest concentration (0.0166 mg/L in July 2001) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

One or more of the following VOCs confirmed as groundwater contaminants in the East Fork Regime were detected in all but one of the groundwater samples from this well: CTET, chloroform, PCE, and TCE. Of these, CTET is the dominant compound, with concentrations ranging from 6 µg/L in August 2002 to 44 µg/L in February and August 1999. Concentrations of the other compounds are all below 10 µg/L, although the PCE concentrations evident in May 1996 (6 µg/L), February 1998 (7 µg/L), February 1999 (6 µg/L), August 1999 (6 µg/L), July 2001 (6 µg/L), and February 2004 (6 µg/L) slightly exceed the MCL (5 µg/L). These PCE results also reflect an indeterminate long-term concentration trend, as illustrated by the summed concentrations of VOCs detected in each sample from the well (Figure 1). The indeterminate concentration trend suggests that the CERCLA East End VOC Plume Intercept Action has not yet influenced the migration/transport of contaminants in the UEFPC distribution channel underdrain (DOE 2002).

5.4 GROSS ALPHA ACTIVITY

Fifteen groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (11.67 pCi/L in February 2003) being slightly below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Fourteen groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (11.49 pCi/L in July 1998) being substantially below the SDWA screening level for gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Science Applications International Corporation (SAIC). 1998. *East End VOC Plume Pump and Tracer Test Technical Memorandum*, BJC/OR-103, Bechtel Jacobs Company LLC, Oak Ridge, TN.

U. S. Department of Energy (DOE). 2002. 2001 *Remediation Effectiveness Report/CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1941&D2/R1, U.S. Department of Energy, Office of Environmental Protection, Oak Ridge, TN.

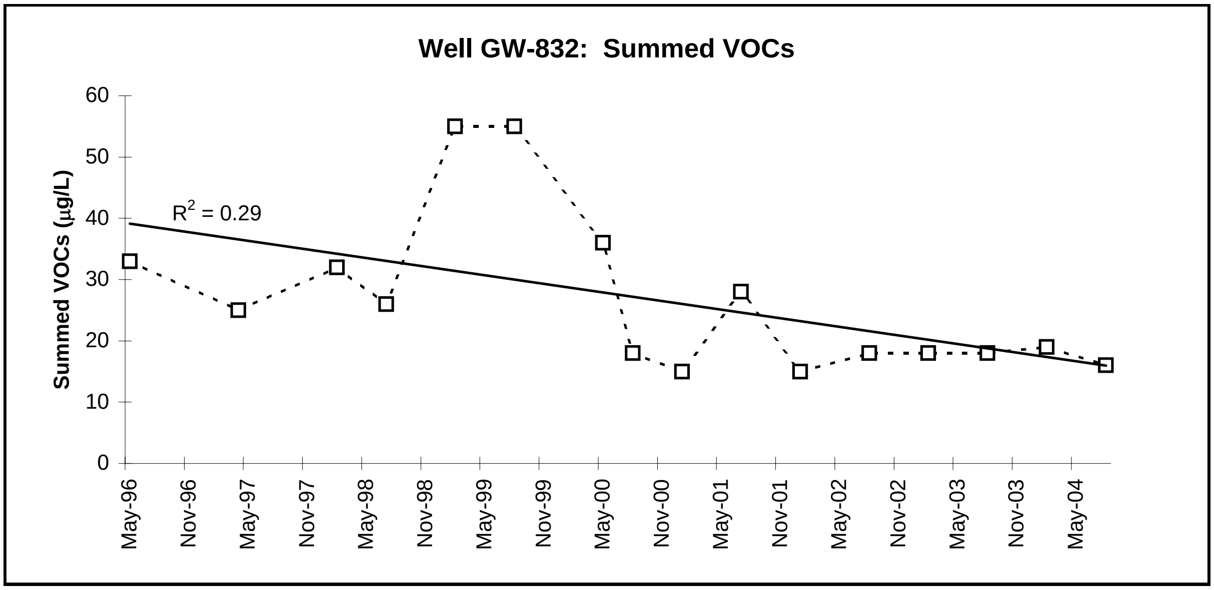


Figure 1

GW-832

MAXIMUM CONCENTRATION: 2003

10 - 100	0.3 - 3.0	5 - 50	.	.
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-835

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: S-3 Site
Y-12 GRID EAST COORDINATE: 51,358.36
Y-12 GRID NORTH COORDINATE: 29,822.02
SURFACE ELEVATION: 998.04 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 07/11/96 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 19.20 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,000.91 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: PVC
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: PVC/SL/NA
DEDICATED SAMPLING EQUIPMENT: NA Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	16.2	981.84
BOTTOM (filter pack or open hole):	19.2	978.84
MIDPOINT (filter pack or open hole):	17.7	980.34
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	12.35	985.69

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	21		
CONVENTIONAL SAMPLING METHOD:	1 samples	04/16/97	04/16/97
LOW-FLOW SAMPLING METHOD:	20 samples	10/31/97	08/21/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	02/20/03	06/05/03	08/21/03	.

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.13 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	15	128 mg/L	04/16/97	Decreasing
URANIUM (0.03 mg/L):	21	1.92 mg/L	05/16/01	Indeterminate
SUMMED VOCs (5 µg/L):	5	81 µg/L	12/01/97	Indeterminate
GROSS ALPHA (15 pCi/L):	6	315 pCi/L	04/16/97	Indeterminate
GROSS BETA (50 pCi/L):	6	315 pCi/L	04/16/97	Indeterminate

WELL GW-835

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in July 1996, completed with a screened monitored interval from 16.2 to 19.2 ft bgs, and constructed with nominal 4.5-inch diameter PVC (#40) riser casing and well screen. The well is located in Bear Creek Valley west of Y-12, on the north side of Bear Creek about 800 ft southeast (hydraulically downgradient) of the former S-3 Ponds, which are a major source of groundwater contamination in Bear Creek Valley. Located at the headwaters of Bear Creek, the S-3 Ponds consisted of four unlined surface impoundments, each with a 2.5 million gallon capacity, that were used between 1951 and 1984 for the disposal of acidic, radioactive liquid wastes generated primarily at Y-12. The S-3 Ponds were covered with a multi-layer, low permeability cap (including asphalt paving) during RCRA closure of the site in 1988.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Twenty-one groundwater samples have been collected from the well to date, with the conventional sampling method used to obtain the initial sample from the well in April 1997 and 20 samples obtained with the low-flow sampling method between October 1997 and August 2003.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maynardville Limestone). The Maynardville Limestone underlies Bear Creek throughout the Bear Creek Regime and most groundwater flow in the formation occurs at shallow depths (<100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Hydraulic interactions between Bear Creek and the shallow karst network provide the primary exit-pathways for groundwater and surface water contaminants originating from source areas in Bear Creek Valley west of Y-12. The average static groundwater level in the well is about 12 ft below ground surface. Presampling depth-to-water measurements for the well indicate moderate water-level fluctuations (<10 ft).

An aquifer pumping test performed in November 1996 involved pumping groundwater from well GW-835 and monitoring the water level in nine nearby piezometers (LMES 1997). A constant water level drawdown (about 4 ft below static level) was achieved in well GW-835 at a pumping rate of about 6 liters per minute. The pumping test continued for about nine hours and little response was noted in the observation piezometers.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields nitrate-contaminated calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.1 – 6.8;
- low molar proportions of potassium and sodium (<10% of total anions/cations);
- unusually high concentrations of chloride (>20 mg/L) and sulfate (>100 mg/L); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Groundwater at this well is contaminated by nitrate that originates from the contaminant plume emplaced during operation of the former S-3 Ponds. Available data for the well show a wide range of nitrate concentrations, with a minimum value of 0.621 mg/L in January 1998 and a maximum value of 128 mg/L in April 1997. Nitrate concentrations in the well appear to fluctuate seasonally (Figure 1), with higher nitrate levels typically evident during seasonally low flow conditions (summer and fall). Although skewed by the highest and lowest values, the nitrate data for the well suggest a decreasing long-term concentration trend, punctuated by a sharp concentration "spike" in August 1998 (97.2 mg/L), with relatively stable concentrations just above and below the MCL (10 mg/L) evident since May 2002 (Figure 1).

5.2 URANIUM

Groundwater at this well is contaminated by uranium that originates from the contaminant plume emplaced during operation of the former S-3 Ponds. Available data for the well show (total) uranium concentrations ranging from 0.62 mg/L in January 1998 to 1.92 mg/L in May 2001; all of these results exceed the MCL for uranium (0.03 mg/L). As shown on Figure 2, the uranium concentrations in the well do not appear to fluctuate and the long-term concentration trend is dominated by a series of concentration "spikes" evident in October 1997 (1.22 mg/L), June 2000 (1.07 mg/L), and May 2001 (1.92 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Groundwater at this well is contaminated by a mixture of dissolved VOCs that originate from the contaminant plume emplaced during operation of the former S-3 Ponds. Compounds detected in the groundwater samples from the well include acetone, benzene, PCE, TCE, and c12DCE. Acetone has been detected at the highest concentration (68 μg/L), but PCE has been detected the most frequently (16 of 21 samples), with PCE concentrations at or above the MCL (5 μg/L) reported for the samples collected in October 1997 (9.6 μg/L), November 2000 (5 μg/L), and May 2001 (5 μg/L). As illustrated by summed VOC concentrations (Figure 3), the available data suggest an indeterminate long-term trend near 5 μg/L that is punctuated by sharp "spikes" attributable to high concentrations of acetone detected in the samples collected by December 1997 (68 μg/L), January 1998 (29 μg/L), and June 2003 (20 μg/L).

5.4 GROSS ALPHA ACTIVITY

Groundwater at this well is contaminated by alpha-emitting radioisotopes that originate from the contaminant plume emplaced during operation of the former S-3 Ponds. Six of the groundwater samples from this well were analyzed for gross alpha activity and the results for these samples show gross alpha levels that substantially exceed the MCL (15 pCi/L), with the lowest level reported for the sample collected in February 1998 (51 pCi/L) and the highest level reported for the sample collected in April 1997 (315 pCi/L). In addition to or in lieu of gross alpha activity, 16 of the groundwater samples collected from the well were analyzed for uranium isotopes. Analytical results for these samples show U-234 and U-238 levels above the applicable MDA and corresponding CE, with U-234 values of 37 to 177 pCi/L and the U-238 values of 91 to 472 pCi/L. Also, data for both isotopes suggest increasing long-term concentration trends (Figure 4), which is somewhat surprising in light of the decreasing long-term trend evident for nitrate.

5.5 GROSS BETA ACTIVITY

Six of the groundwater samples from this well were analyzed for gross beta activity and the results for these samples show gross beta levels that substantially exceed the SDWA screening level (50 pCi/L), with the lowest level reported for the sample collected in January 1998 (108 pCi/L) and the highest level reported for the sample collected in April 1997 (315 pCi/L). The primary beta-emitting radioisotope in the groundwater at the well is probably Tc-99, which is a principal component of the contaminant plume emplaced during operation of the former S-3 Ponds and is highly mobile in groundwater. However, none of the groundwater samples collected from the well to date have been analyzed for Tc-99. Gross beta activity in the groundwater at the well also reflects contributions from applicable related daughter products (e.g., Th-234) of U-238 in the groundwater.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

LMES 1997. *Field characterization report on Phase 1 of the Bear Creek Valley treatability study, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-286.

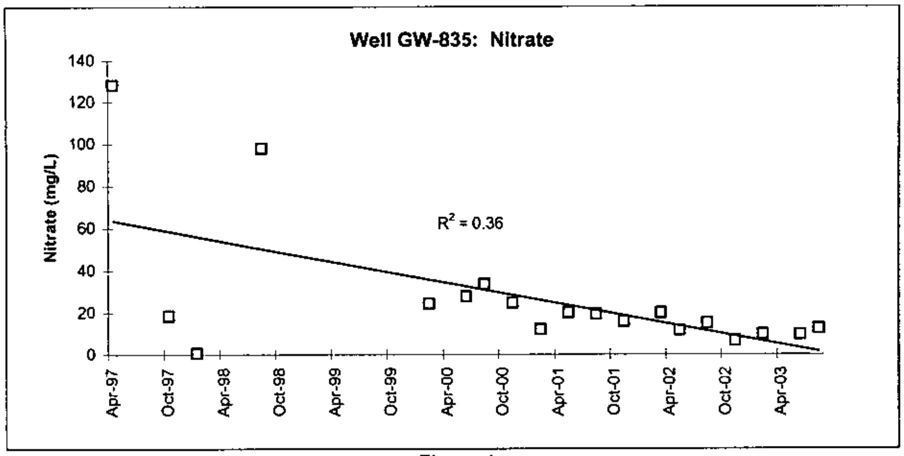


Figure 1

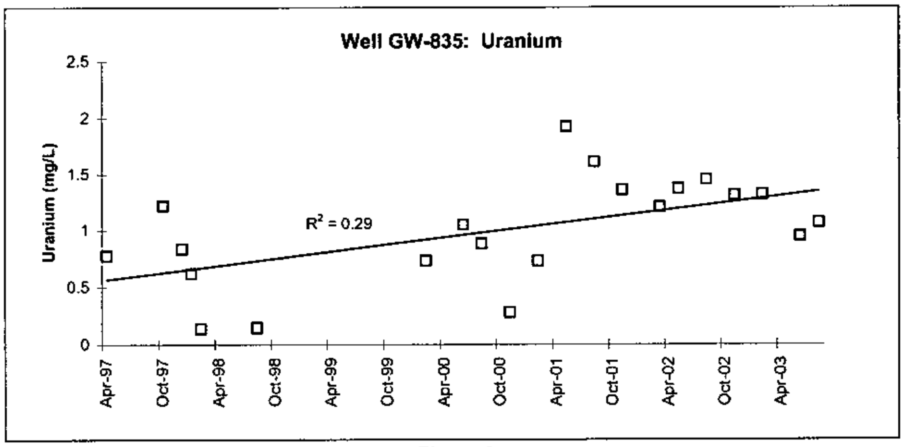


Figure 2

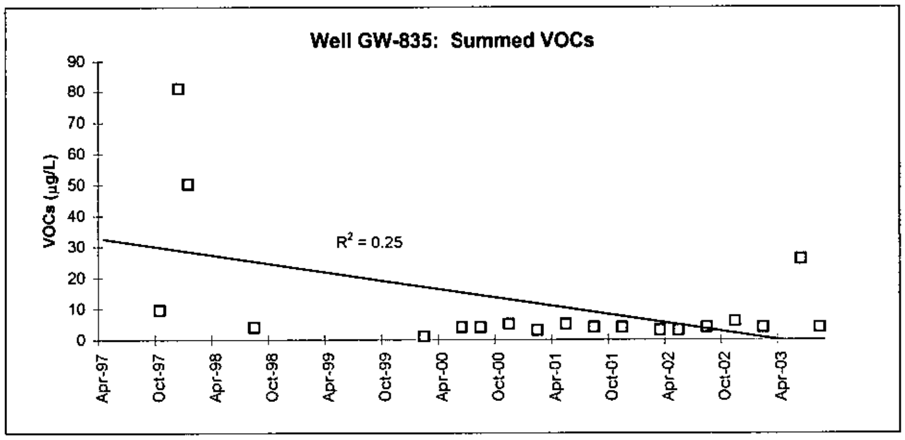


Figure 3

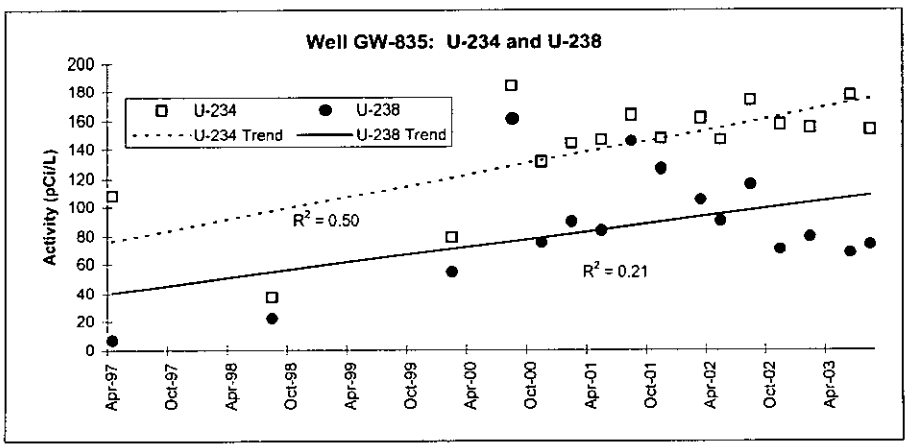


Figure 4

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-916

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 48,275.78
Y-12 GRID NORTH COORDINATE: 31,186.00
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/29/01 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,002.85 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: NA inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	13.0	.
BOTTOM (filter pack or open hole):	36.0	.
MIDPOINT (filter pack or open hole):	24.5	.
PUMP INTAKE:	27.50 (TOC)	975.35
WATER LEVEL (average):	5.58 (TOC)	997.27

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/02/01	11/10/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/08/04	06/02/04	09/13/04	11/10/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 3.31 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	12 μg/L	09/04/03	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-916

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 13 to 36 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley on the northeast side of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operation in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples were collected from the well to date, all of which were obtained with the low-flow sampling method between April 2001 and November 2004.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the lower Conasauga Group (undifferentiated). The average static groundwater level in the well is about 6 ft below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.7 – 7.7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four groundwater samples were analyzed for nitrate (between April and December 2001). Results that exceed the analytical reporting limit were reported for each of these samples, with the highest concentration (0.19 mg/L in April 2001) being below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five groundwater samples were analyzed for uranium and the uranium results for these samples do not exceed the corresponding analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in two groundwater samples. The sample collected in September 2003 had low levels of PCE (2 μg/L) and TCE (10 μg/L), and the sample collected in September 2004 had a trace of TCE (0.2 μg/L).

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Twelve of the samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 1.57 pCi/L in April 2001) being within the range of background levels in Bear Creek Valley.

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-917

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,914.08
Y-12 GRID NORTH COORDINATE: 30,462.57
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/22/01 PAIRED/CLUSTERED WITH: GW-927
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 997.10 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	18.0	.
BOTTOM (filter pack or open hole):	51.0	.
MIDPOINT (filter pack or open hole):	34.5	.
PUMP INTAKE:	37.50 (TOC)	959.60
WATER LEVEL (average):	21 (TOC)	976.10
GEOLOGIC FORMATION:	Conasauga Group	
HYDROGEOLOGIC ZONE:	Water Table	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/03/01	11/04/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/09/04	06/03/04	09/07/04	11/04/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.47 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-917

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 18 to 51 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley, about 200 ft east of the Environmental Management Waste Management Facility. Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operation in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is about 21 ft below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<6 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 5.9 – 7.5;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate. Results that exceed the analytical reporting limit were reported for three samples, with the highest concentration (0.99 mg/L in August 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium and the uranium results for these samples do not exceed the corresponding analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, a trace of acetone (0.4 µg/L) was detected in one groundwater sample (September 2003). This result is probably a sampling or analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Ten samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 1.16 pCi/L in February 2003) being within the range of background levels in Bear Creek Valley.

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and/or CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-918

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,549.25
Y-12 GRID NORTH COORDINATE: 31,672.26
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/02/01 PAIRED/CLUSTERED WITH: .
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,067.96 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: NA inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	18.0	.
BOTTOM (filter pack or open hole):	33.0	.
MIDPOINT (filter pack or open hole):	25.5	.
PUMP INTAKE:	28.50 (TOC)	1039.46
WATER LEVEL (average):	5.58 (TOC)	1062.38

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/02/01	11/10/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/15/04	06/02/04	09/09/04	11/10/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.09 pre-sampling measurements (ft)

TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-918

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 2001, completed with a screened monitored interval from 18 to 33 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley, about 300 ft north (hydraulically upgradient) of the Environmental Management Waste Management Facility. Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the lower Conasauga Group (undifferentiated). The average static groundwater level in the well is about 6 ft 21 ft below the top of the well casing. Presampling depth-to-water measurements for the well indicate minor water-level fluctuations (<2 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 5.6 – 6.7;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four groundwater samples were analyzed for nitrate. Results that exceed the analytical reporting limit were reported for one sample (0.17 mg/L in December 2001) and this result is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium and the uranium results for these samples do not exceed the corresponding analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, trace levels of TCE (0.4 μg/L) and toluene (0.3 μg/L) were detected in one groundwater sample (September 2004). This significance of these results is questionable because neither compound was detected in the subsequent quarterly sample (November 2004).

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-235. Seven samples had U-234 or U-235 activity above the MDA and corresponding CE, with the highest activity for either isotope (0.96 pCi/L in December 2001) being less than 1 pCi/L.

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	<5	ND	<25

GW-919

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,325.88
Y-12 GRID NORTH COORDINATE: 30,739.25
SURFACE ELEVATION: 987.50 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 08/21/01 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 993.56 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.38 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	11.6	975.90
BOTTOM (filter pack or open hole):	32.0	955.50
MIDPOINT (filter pack or open hole):	21.8	965.70
PUMP INTAKE:	NA	NA
WATER LEVEL (average):	-0.27	987.77

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	7		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	7 samples	12/04/01	11/04/03

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2003	03/04/03	05/27/03	09/08/03	11/04/03

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 2.31 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-919

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in August 2001, completed with a screened monitored interval from 11.6 to 32 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley on the east side (hydraulically downgradient) of the Environmental Management Waste Management Facility. Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Seven groundwater samples have been collected from the well since December 2001, all of which were obtained with the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is –0.3 ft above the ground surface, indicating artesian conditions. Presampling depth-to-water measurements for the well indicate minor water-level fluctuations (<3 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- moderate TDS (>150 mg/L<800 mg/L);
- pH (field measurements) of 6.8 – 7.4;
- low molar proportions of chloride, potassium, sulfate, and sodium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Only one of the groundwater samples was analyzed for nitrate, and the nitrate result for this sample did not exceed the analytical reporting limit.

5.2 URANIUM

Only two of the groundwater samples were analyzed for uranium, and neither of these uranium results exceeds the analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for six groundwater samples show non-detect values or false positive results for all of the VOCs that are confirmed groundwater contaminants in the Bear Creek Regime. A sample collected in September 2003 had a trace of acetone (0.5 μg/L), which is probably a sampling or analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-235. Six samples had U-234 or U-235 activity above the MDA and corresponding CE, with the highest activity for either isotope (2.14 pCi/L in December 2001) being within the range of background levels in Bear Creek Valley.

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and/or CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-920

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,375.12
Y-12 GRID NORTH COORDINATE: 30,192.58
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/16/01 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 967.43 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	22.0	.
BOTTOM (filter pack or open hole):	55.0	.
MIDPOINT (filter pack or open hole):	38.5	.
PUMP INTAKE:	41.50 (TOC)	925.93
WATER LEVEL (average):	8.17 (TOC)	959.26

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/04/01	11/09/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/11/04	06/01/04	09/02/04	11/09/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 4.91 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	1	60.74 pCi/L	06/11/01	

WELL GW-920

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 22 to 55 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is in Bear Creek Valley about 300 ft south (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 8 ft below the top of the well casing. Presampling depth-to-water measurements for the well indicate minor water-level fluctuations (<5 ft).

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 5.9 – 8.1;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate. Results that exceed the analytical reporting limit were reported for two samples, and both results (2 mg/L June 2001 and 0.025 mg/L in December 2001) are substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium; none of the uranium results exceed the corresponding analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for each groundwater sample showed non-detect values or false positive results for all of the VOCs analyzed.

5.4 GROSS ALPHA ACTIVITY

Four groundwater samples were analyzed for gross alpha activity (between June 2001 and May 2003), and none of the results were above the MDA. Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Six samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 0.93 pCi/L in November 2004) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample collected from this well to date was analyzed for beta-emitting radionuclides, including Tc-99. Only the sample collected in August 2002 had Tc-99 activity above the applicable MDA and corresponding CE, and this result (7.42 pCi/L) is very low. Gross beta activity was analyzed in four of the samples from the well, and only one result was above the applicable MDA and corresponding CE (60.74 pCi/L in June 2001), which also exceeded the SWDA screening level for gross beta (50 pCi/L). However, this result is a suspected outlier.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

.	.	ND	.	.
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GW-921

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,138.93
Y-12 GRID NORTH COORDINATE: 30,350.07
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/31/01 PAIRED/CLUSTERED WITH: GW-925
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 971.29 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	16.0	.
BOTTOM (filter pack or open hole):	50.0	.
MIDPOINT (filter pack or open hole):	33.0	.
PUMP INTAKE:	36.00 (TOC)	935.29
WATER LEVEL (average):	6.88 (TOC)	964.41

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/03/01	11/04/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/08/04	06/01/04	09/02/04	11/04/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 5.21 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-921

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 16 to 50 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well forms a cluster with well GW-925 and is located in Bear Creek Valley adjacent to the south side (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 7 ft below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.7 – 7.7;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate. Nitrate above the analytical reporting limit was detected only in the sample collected in August 2001 and this result (0.18 mg/L) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003); none of these results exceed the corresponding analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples show non-detect values or false positive results for all of the VOCs analyzed, except for a trace of TCE (0.1 μg/L) in the September 2004 sample. The significance of this result is questionable because TCE was not detected in the subsequent sample (November 2004).

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Six samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 0.66 pCi/L in May 2001) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. Only the sample collected in December 2002 had Tc-99 activity above the applicable MDA and corresponding CE, and this result (8.27 pCi/L) is substantially below the SDWA screening level of gross beta activity (50 pCi/L).

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-922

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,146.86
Y-12 GRID NORTH COORDINATE: 30,024.00
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/17/01 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 956.91 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	23.0	.
BOTTOM (filter pack or open hole):	46.0	.
MIDPOINT (filter pack or open hole):	34.5	.
PUMP INTAKE:	37.50 (TOC)	919.41
WATER LEVEL (average):	5.3 (TOC)	951.61

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 14

	Samples	First Date	Last Date
CONVENTIONAL SAMPLING METHOD:	.	. .	.
LOW-FLOW SAMPLING METHOD:	14	04/04/01	11/15/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/10/04	06/02/04	09/09/04	11/15/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: .
GROUT CONTAMINATION: .
SAMPLING METHOD SENSITIVITY: .
WATER LEVEL FLUCTUATION: 1.8 pre-sampling measurements (ft)
TDS: . (L <150; H >800 mg/L)
LOW pH: . (<5.5)
OTHER: .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-922

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 23 to 46 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is located in Bear Creek Valley, about 500 ft south (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 5 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate minor (<5 ft) water-level fluctuations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.4 – 7.9;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples (between April and December 2001) were analyzed for nitrate. Only the nitrate concentration detected in the sample collected in August 2001 exceeds the analytical reporting limit and this result (0.06 mg/L) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003); none of the results exceed the corresponding analytical reporting limit.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results the groundwater samples to date show non-detect values or false positive results for all of the VOCs analyzed, except for a trace of toluene (0.1 µg/L) reported for the September 2004 sample. This result may be a sampling or analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Eight of the samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 1.06 pCi/L in April 2001) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and/or CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-923

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 48,183.73
Y-12 GRID NORTH COORDINATE: 30,821.98
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/01/01 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 1,016.73 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	36.0	.
BOTTOM (filter pack or open hole):	75.0	.
MIDPOINT (filter pack or open hole):	55.5	.
PUMP INTAKE:	58.50 (TOC)	958.23
WATER LEVEL (average):	34.01 (TOC)	982.72

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	15 samples	04/02/01	11/16/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/15/04	.	.	11/16/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 38.6 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-923

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 2001, completed with a screened monitored interval from 36 to 75 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well is in Bear Creek Valley about 100 ft directly east (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 34 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate unusually wide (>25 ft) fluctuations in seasonal groundwater surface elevations. A time-series plot of the water levels (Figure 1) shows that the initial water level in the well was about 30 ft lower than currently observed, and that the water levels measured since August 2001 have shown moderate (<10 ft) fluctuation.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.7 – 7.5;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples (between April and December 2001) were analyzed for nitrate. Nitrate results that exceed the analytical reporting limit were reported for each sample, with the highest concentration (0.62 mg/L in April 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003). Uranium results that exceed the analytical reporting limit were reported for three samples collected in 2001, with the highest concentration (0.012 mg/L in August 2001) being below the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples to date show non-detect values or false positive results for all of the VOCs analyzed, except for a trace of benzene (0.1 μg/L) reported for the December 2001 sample. This result may be a sampling or analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Ten of the groundwater samples were analyzed for alpha-emitting radionuclides, including U-234 and U-238. All the samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 2.99 pCi/L in April 2001) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Ten of the groundwater samples were analyzed for beta-emitting radionuclides, including Tc-99. Only one sample had Tc-99 activity above the applicable MDA and corresponding CE, and this result (11.42 pCi/L in December 2001) is substantially below the SDWA screening level of gross beta activity (50 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

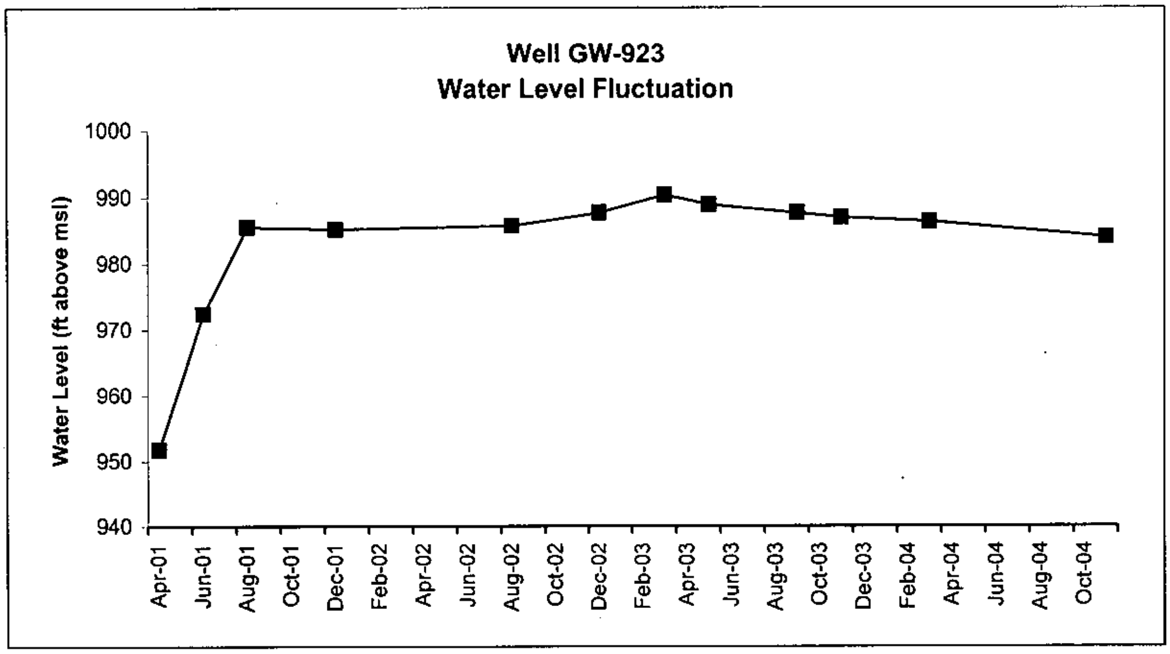

Well GW-923
Water Level Fluctuation
Water Level (ft above msl)
1000
990
980
970
960
950
940
Apr-01
Jun-01
Aug-01
Oct-01
Dec-01
Feb-02
Apr-02
Jun-02
Aug-02
Oct-02
Dec-02
Feb-03
Apr-03
Jun-03
Aug-03
Oct-03
Dec-03
Feb-04
Apr-04
Jun-04
Aug-04
Oct-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-924

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 46,299.54
Y-12 GRID NORTH COORDINATE: 30,184.77
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: X
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 01/29/01 PAIRED/CLUSTERED WITH: GW-926
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 968.90 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	21.0	.
BOTTOM (filter pack or open hole):	54.0	.
MIDPOINT (filter pack or open hole):	37.5	.
PUMP INTAKE:	40.50 (TOC)	928.40
WATER LEVEL (average):	10.66 (TOC)	958.24
GEOLOGIC FORMATION:	Conasauga Group	
HYDROGEOLOGIC ZONE:	Water Table	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	13		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	13 samples	06/05/01	11/17/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/11/04	06/07/04	09/07/04	11/17/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.22 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-924

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in January 2001, completed with a screened monitored interval from 21 to 54 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well forms a cluster with well GW-926 and is located in Bear Creek Valley directly south (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Thirteen groundwater samples have been collected from the well since June 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the water table interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 11 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 6.3 – 7.6;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Three of the groundwater samples were analyzed for nitrate. Nitrate concentrations above the analytical reporting limit were reported for each sample, with the highest concentration (0.051 mg/L in December 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Four of the groundwater samples were analyzed for uranium and none of these results exceed the analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples to date show non-detect values or false positive results for all of the VOCs analyzed, except for a trace of chloroform (0.1 μg/L) reported for the sample collected in March 2004. This result may be a sampling or analytical artifact and is considered to be an outlier.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Six samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 0.84 pCi/L in November 2004) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. The Tc-99 activity reported for each sample does not exceed the MDA and corresponding CE.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-925

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,128.22
Y-12 GRID NORTH COORDINATE: 30,348.97
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/05/01 PAIRED/CLUSTERED WITH: GW-921
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 971.14 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	92.0	.
BOTTOM (filter pack or open hole):	148.0	.
MIDPOINT (filter pack or open hole):	120.0	.
PUMP INTAKE:	123.00 (TOC)	848.14
WATER LEVEL (average):	4.01 (TOC)	967.13
GEOLOGIC FORMATION:	Conasauga Group	
HYDROGEOLOGIC ZONE:	Bedrock	

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/03/01	11/08/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/09/04	06/01/04	09/01/04	11/08/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 16.26 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-925

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 2001, completed with a screened monitored interval from 92 to 148 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well forms a cluster with well GW-921 and is located in Bear Creek Valley adjacent to the south side (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the intermediate bedrock interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 4 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate substantial fluctuations (15-20 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sodium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 7.7 – 9.4;
- high sodium concentrations (>100 mg/L);
- low molar proportions of calcium, magnesium, and potassium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The sodium-enriched geochemistry of the groundwater from this well is observed elsewhere in Bear Creek Valley and reflects a fairly abrupt change from the calcium-magnesium-bicarbonate groundwater encountered at shallower depths in the Conasauga Group. The sharp transition to the sodium-bicarbonate groundwater is believed to be a function of the more poorly connected flowpaths with longer groundwater residence time as a consequence of reduced fracture aperture and/or increased fracture spacing at depth (Solomon et. al. 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate (between April and November 2001). Nitrate results that exceed the analytical reporting limit were reported for each of these samples, with the highest concentration (0.03 mg/L in April 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003), and uranium concentrations above the analytical reporting limits were reported for three samples, with the highest concentration (0.0166 mg/L in August 2001) being less than the MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples show non-detect values or false positive results for all of the VOCs analyzed except for trace levels of acetone (0.8 μg/L in November 2003) and TCE (0.2 μg/L in September 2004). The significance of these results is questionable because each compound was detected only once.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Seven samples had U-234 or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 4.47 pCi/L in April 2001) being below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. Only one sample had Tc-99 activity above the applicable MDA and corresponding CE, and this result (12.8 pCi/L in November 2001) is substantially below the SDWA screening level of gross beta activity (50 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

GW-926

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 46,290.39
Y-12 GRID NORTH COORDINATE: 30,184.96
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/01/01 PAIRED/CLUSTERED WITH: GW-924
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 968.94 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL

TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	103.0	.
BOTTOM (filter pack or open hole):	145.0	.
MIDPOINT (filter pack or open hole):	124.0	.
PUMP INTAKE:	127.00 (TOC)	841.94
WATER LEVEL (average):	8.7 (TOC)	960.24

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	14		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	14 samples	04/02/01	11/17/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/11/04	06/07/04	09/07/04	11/17/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 6.68 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-926

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 2001, completed with a screened monitored interval from 103 to 145 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well forms a cluster with well GW-924 and is in Bear Creek Valley directly south (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fourteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the intermediate bedrock interval in the Conasauga Group (Nolichucky Shale). The average static groundwater level in the well is 9 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields sodium-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 7.0 – 8.1;
- low molar proportions of potassium (<10% of total anions/cations); and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

The sodium-enriched geochemistry of the groundwater from this well is observed elsewhere in Bear Creek Valley and reflects a fairly abrupt change from the calcium-magnesium-bicarbonate groundwater encountered at shallower depths in the Conasauga Group. The sharp transition to the sodium-bicarbonate groundwater is believed to be a function of the more poorly connected flowpaths with longer-groundwater residence time as a consequence of reduced fracture aperture and/or increased fracture spacing at depth (Solomon et. al. 1992).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate (between April and November 2001). Nitrate results that exceed the analytical reporting limit were reported for each of these samples, with the highest concentration (0.32 mg/L in November 2001) being substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003) and none of these results exceed the analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples show non-detect values or false positive results for all of the VOCs analyzed except for trace levels of benzene (1 µg/L) in November 2001, acetone (0.3 µg/L) in November 2003, and toluene (0.2 µg/L) and PCE (0.1 µg/L) in June 2004. The significance of these results is questionable because each compound was detected only once.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Five samples had U-234 and/or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 0.75 pCi/L in June 2004) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. Only the sample collected in August 2003 had Tc-99 activity above the applicable MDA and corresponding CE, and this result (11.6 pCi/L) is substantially below the SDWA screening level of gross beta activity (50 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation*, ORNL/TM-12053, Oak Ridge National Laboratory.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

GW-927

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Environmental Management Waste Management Facility
Y-12 GRID EAST COORDINATE: 47,905.71
Y-12 GRID NORTH COORDINATE: 30,462.61
SURFACE ELEVATION: NA ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 02/01/01 PAIRED/CLUSTERED WITH: GW-917
TAG DEPTH (measured): NA ft below top of casing (TOC)
MEASURING POINT ELEVATION: 997.19 ft above msl MEASURING POINT: TOWW
WELL BORE DIAMETER: NA inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 2.37 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	57.0	.
BOTTOM (filter pack or open hole):	92.0	.
MIDPOINT (filter pack or open hole):	74.5	.
PUMP INTAKE:	77.50 (TOC)	919.69
WATER LEVEL (average):	16.97	980.22

GEOLOGIC FORMATION: Conasauga Group
HYDROGEOLOGIC ZONE: Bedrock

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	15		
CONVENTIONAL SAMPLING METHOD:	. samples	.	.
LOW-FLOW SAMPLING METHOD:	15 samples	04/03/01	11/16/04

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR 2004	03/09/04	06/03/04	09/07/04	11/16/04

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 8.36 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

WELL GW-927

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in February 2001, completed with a screened monitored interval from 57 to 92 ft bgs, and constructed with nominal 2.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). This well forms a cluster with well GW-917 and is located in Bear Creek Valley about 200 ft south-southeast (hydraulically downgradient) of the Environmental Management Waste Management Facility (EMWMF). Located about 1.5 miles west of Y-12, the EMWMF is a hazardous and mixed-waste landfill that began operating in June 2002 as a disposal site for wastes generated from CERCLA remedial actions on the ORR.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Fifteen groundwater samples have been collected from the well since April 2001, all of which were obtained with the low-flow sampling.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well yields groundwater from the shallow bedrock interval in the Conasauga Group (Maryville Limestone). The average static groundwater level in the well is 17 ft below below the top of the well casing. Presampling depth-to-water measurements for the well indicate moderate fluctuations (<10 ft) in seasonal groundwater surface elevations.

4.0 GEOCHEMICAL CHARACTERISTICS

The well yields calcium-magnesium-bicarbonate groundwater generally characterized by:

- pH (field measurements) of 5.8 – 8.0;
- low molar proportions of potassium and sodium; and
- total (unfiltered sample) concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12 and are the focus of the following discussion.

5.1 NITRATE

Four of the groundwater samples were analyzed for nitrate (between April and December 2001). Nitrate results that exceed the analytical reporting limit were reported for one sample and the nitrate concentration for this sample (1.6 mg/L in April 2001) is substantially below the MCL for nitrate (10 mg/L).

5.2 URANIUM

Five of the groundwater samples were analyzed for uranium (between April 2001 and May 2003) and none of these results exceed the analytical reporting limits.

5.3 VOLATILE ORGANIC COMPOUNDS

Analytical results for the groundwater samples show non-detect values or false positive results for all of the VOCs analyzed except for a trace level of acetone (0.3 μg/L) reported for a sample collected in November 2003. Acetone is a common laboratory contaminant and may be an analytical artifact.

5.4 GROSS ALPHA ACTIVITY

Each groundwater sample was analyzed for alpha-emitting radionuclides, including U-234 and U-238. Five samples had U-234 and/or U-238 activity above the MDA and corresponding CE, with the highest activity for either isotope (U-234 = 1.53 pCi/L in November 2004) being substantially below the MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Each groundwater sample was analyzed for beta-emitting radionuclides, including Tc-99. Only the sample collected in November 2003 had Tc-99 activity above the applicable MDA and corresponding CE, and this result (4.42 pCi/L) is substantially below the SDWA screening level of gross beta activity (50 pCi/L) and is probably an analytical artifact.

6.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2005

<5	<0.015	50 - 500	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GW-959

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-2
Y-12 GRID EAST COORDINATE: 60,189.27
Y-12 GRID NORTH COORDINATE: 29,115.05
SURFACE ELEVATION: 928.32 ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

WELL CONSTRUCTION

DATE INSTALLED: 03/11/05 PAIRED/CLUSTERED WITH:
TAG DEPTH (measured): 8.22 ft below top of casing (TOC)
MEASURING POINT ELEVATION: 927.69 ft above msl MEASURING POINT: TOC
WELL BORE DIAMETER: 7.5 inches
WELL CASING MATERIAL: SS304
WELL CASING DIAMETER: 4.5 inches (outside diameter)
WELL SCREEN TYPE: SS/SW/0.01
DEDICATED SAMPLING EQUIPMENT: Well Wizard Sampling Port No.: . Port Depth : . (ft bgs)

MONITORED INTERVAL TYPE: Screened

	Depth (ft bgs)	Elevation (ft above msl)
TOP (filter pack or open hole):	2.4	925.92
BOTTOM (filter pack or open hole):	9.0	919.92
MIDPOINT (filter pack or open hole):	5.4	922.92
PUMP INTAKE:	.	.
WATER LEVEL (average):	3.45	924.88

GEOLOGIC FORMATION: Maynardville Limestone
HYDROGEOLOGIC ZONE: Water Table

SAMPLING HISTORY

			First Date	Last Date
TOTAL SAMPLING EVENTS:	4			
CONVENTIONAL SAMPLING METHOD:	.	samples	.	.
LOW-FLOW SAMPLING METHOD:	4	samples	03/30/05	11/01/05

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2005	03/30/05	06/28/05	08/25/05	11/01/05

SAMPLING CHARACTERISTICS

WELL CASING/SCREEN CORROSION: . TDS: . (L <150; H >800 mg/L)
GROUT CONTAMINATION: . LOW pH: . (<5.5)
SAMPLING METHOD SENSITIVITY: . OTHER: .
WATER LEVEL FLUCTUATION: 1.29 pre-sampling measurements (ft)

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L	.	
URANIUM (0.03 mg/L):	0	< mg/L	.	
SUMMED VOCs (5 µg/L):	4	304 µg/L	08/25/05	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L	.	
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

WELL GW-959

1.0 INSTALLATION, CONSTRUCTION, AND LOCATION

This well was installed in March 2005, completed with a screened monitored interval from 2.4 to 9 ft bgs, and constructed with nominal 4.5-inch diameter stainless steel (Type 304) riser casing and well screen (0.01 slot wire-wound). Installed to replace well 60-2A, which was plugged and abandoned in April 2004 to accommodate construction of the Big Spring Mercury Treatment Facility, this well is located in the central Y-12 area at the southeast corner of Bldg. 9201-2, approximately 100 ft north of the main channel of UEFPC. Additionally, the location of the well was selected so as to intercept the buried original (pre-construction) streambed of the UEFPC. The lithologic log prepared during drilling shows that the monitored interval is in a primarily clay zone with bedrock (auger refusal) encountered at 9 ft, which may be shallower than the presumed depth to the original streambed.

2.0 SAMPLING HISTORY AND CHARACTERISTICS

Groundwater samples were collected from the well in March, June, August, and October 2005 using the low-flow sampling method.

The well does not exhibit conspicuous sampling characteristics.

3.0 HYDROLOGIC CHARACTERISTICS

This well produces groundwater from the water table interval of the Maynardville Limestone (Conasauga Group), which trends northeast-southwest along the axis of BCV, dips southeast at an angle of 45º - 55º, and underlies the main channel of UEFPC. The water-table interval is a highly permeable zone that often occurs within the unconsolidated material overlying the Maynardville Limestone, which exhibits the hydrologic characteristics typical of karst aquifers, with most of the groundwater flow occurring at shallow depths (i.e., <100 ft bgs) in an extensively interconnected network of solution conduits and cavities (shallow karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct lithologic and hydrologic characteristics (Shevenell et al. 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation, but Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995).

The static groundwater level in the well occurs at an average depth of approximately 3.5 ft bgs and exhibits seasonal fluctuations of about 1 ft. Directions of groundwater flow near the well, as indicated by groundwater elevation isopleths determined from contemporaneous depth-to-water measurements for nearby monitoring wells, are primarily to the east, parallel with the geologic strike of bedding in the Maynardville Limestone. However, the shallow subsurface throughout the industrialized areas of Y-12 has been extensively reworked and local flow directions may be strongly influenced by subsurface utilities (process lines and storm sewers), the buried northern tributaries and original main channel of UEFPC, and the intermittent and continuous operation of building basement sumps (DOE 1998). Moreover, the elevations of the groundwater surface in the well are higher than the levels in nearby wells (e.g., well 60-1A located 100 ft north of the well), which suggests that the well may be completed in an area influenced by discharge from Big Spring.

4.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the (unfiltered) groundwater samples collected to date show that the well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater generally characterized by:

- TDS of 242 – 502 mg/L;
- pH of 7.13 – 7.28 (field measurements);
- low molar proportions of chloride, potassium, and nitrate (<5% of total anions/cations);
- conspicuously high concentrations sodium (>20 mg/L) and sulfate (>100 mg/L) concentrations compared to respective levels typically evident in groundwater from other wells completed at similarly shallow depths in the Maynardville Limestone;
- high concentrations (>1 mg/L) of aluminum, iron, and manganese in the initial three samples from the well, which are probably sampling artifacts related to elevated suspended solids (>30 mg/L); and
- total (unfiltered sample) concentrations of trace metals in the most recent sample that are either below respective analytical reporting limits or are within the range of background levels in groundwater at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

5.0 CONTAMINATION

Nitrate, uranium, VOCs, gross alpha activity, and gross beta activity are the primary groundwater contaminants at Y-12. Based on the results reported for the groundwater samples collected to date, VOCs are the principal contaminants present in the groundwater at this well.

5.1 NITRATE

All of the groundwater samples collected to date had nitrate concentrations at or above the applicable reporting limit, with the highest concentration (0.492 mg/L in March 2005) being substantially below the drinking water MCL for nitrate (10 mg/L).

5.2 URANIUM

All of the groundwater samples collected to date had uranium concentrations at or above the applicable analytical reporting limit, with the highest value (0.0027 mg/L in March 2005) being below than the drinking water MCL for uranium (0.03 mg/L).

5.3 VOLATILE ORGANIC COMPOUNDS

At least one of the following VOCs was detected in each of the groundwater samples collected to date: TCE, c12DCE, t12DCE, VC, and chloroform (Table 1). The source of these VOCs is not confirmed, but extremely high concentrations (>2,000 µg/L) of PCE and c12DCE occur in the groundwater at well GW-820, which is located south of Building 9201-2, approximately 400 ft hydraulically upgradient to the west (parallel the geologic strike) of well GW-959.

The primary VOCs detected in the groundwater samples collected to date are c12DCE and VC, which have been detected in every sample, with respective maximum concentrations above 50 µg/L (Table 1). Also, the sampling results show that the concentrations of these compounds in the groundwater exceed the drinking water MCLs (70 µg/L and 2 µg/L, respectively). Other VOCs were detected at estimated concentrations of 3 µg/L or less, and all the results are below applicable MCLs.

Both c12DCE and VC are most likely present in the groundwater as a consequence of biologically-mediated degradation (sequential dechlorination) of related parent compounds (PCE and TCE). However, several of the geochemical characteristics of the groundwater in the well are not consistently conducive to anaerobic biotic degradation (Table 2). Perhaps the monitored interval in the well intercepts groundwater flowpaths that transport dissolved VOCs from the source area where biotic degradation primarily occurs. This may also explain why the parent compounds (PCE and TCE) are either not detected in the groundwater from the well or are present at concentrations substantially lower than either c12DCE or VC, which are more soluble and mobile in groundwater than either parent compound, and thus may be expected to be present at higher concentrations in the shallow groundwater from this well.

5.4 GROSS ALPHA ACTIVITY

One groundwater sample collected to date had gross alpha activity above the applicable MDA and corresponding CE, and this result (2.2 pCi/L in March 2005) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

5.5 GROSS BETA ACTIVITY

Two groundwater samples collected to date had gross beta activity above the applicable MDA and corresponding CE, with the highest value (11 pCi/L in August 2005) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

6.0 REFERENCES

Goldstrand, P.M. 1995. *Stratigraphic Variations and Secondary Porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge Tennessee,* Y/TS-1093, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Shevenell, L.A., B.W. McMaster, and K.M. Desmarais. 1995. *Evaluation of Cross Borehole Tests at Selected Wells in the Maynardville Limestone and Copper Ridge Dolomite at the Oak Ridge Y-12 Plant*, Y/TS-1166, prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Wilson, B.H., J.T. Wilson, and D. Luce. 1996. *Design and Interpretation of Microcosm Studies for Chlorinated Compounds.* Reported in: Symposium on Natural Attenuation of Chlorinated Compounds in Ground Water. U.S. Environmental Protection Agency, Office of Research and Development, Washington DC (EPA/540/R-96/509).

Table 1. Well GW-959: summary of VOC results

Sampling Date	Primary VOCs (µg/L)	
	c12DCE	VC
03/30/05	61	2
06/28/05	160	39
08/25/05	240	59
11/01/05	110	10
MCL	**70**	**2**
Sampling Date	**Other VOCs (µg/L)**	
03/30/05	Chloroform (1 J)	
06/28/05	TCE (2 J), t12DCE (2 J)	
08/25/05	TCE (3 J), t12DCE (2 J)	
11/01/05	TCE (1 J)	
Note: "." = Not detected; J = Estimated value below analytical reporting limit		

Table 2. Well GW-959: geochemical indicators for biodegradation of chlorinated hydrocarbons

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)		March 2005	June 2005	August 2005	October 2005
Nitrate	< 1 mg/L	0.492	0.438	0.102	0.12
Iron (II)	> 1 mg/L	0.9*	3.14*	7.12*	<*
Sulfate	< 20 mg/L	78.1	111	119	148
Dissolved Oxygen	< 0.5 ppm	3.81**	0.39**	0.26**	0**
REDOX	< 50 mV	201**	-51**	-130**	113**
pH	>5 and < 9 st. units	7.13**	7.28**	7.13**	7.24**

Note: *Results are for total iron; **Field measurement; < = not detected.

Y/TS-1983/R1/V5

Y-12 GROUNDWATER PROTECTION PROGRAM
GROUNDWATER MONITORING DATA COMPENDIUM
REVISION 1

SURFACE WATER, SPRINGS, AND SUMPS

December 2006

Prepared by

ELVADO ENVIRONMENTAL LLC
Under Subcontract No. 4300030332

for the

Environmental Compliance Department
Environmental, Safety, and Health Division
Y-12 National Security Complex
Oak Ridge, Tennessee 37831

Managed by

BWXT Y-12, L.L.C.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-00OR22800

Index of monitoring wells included in Volume 5

Well	Regime	Revision Year	Well	Regime	Revision Year
9201-1K-22SU	EF	2004	NT-07	BC	2004
9201-3C-4SP	EF	2004	NT-08	BC	2004
BCK-00.63	BC	2004	NT-8-E	BC	2003
BCK-03.30	BC	2004	NT-8-W	BC	2003
BCK-04.55	BC	2004	OF 51	EF	2004
BCK-07.87	BC	2004	OF 200	EF	2004
BCK-09.20	BC	2004	S07	BC	2004
BCK-09.40	BC	2003	S17	CR	2004
BCK-09.47	BC	2004	SCR1.25SP	CR	2004
BCK-11.54	BC	2004	SCR1.5SW	CR	2004
BCK-11.84	BC	2004	SCR2.1SP	CR	2004
BCK-11.97	BC	2003	SCR2.2SP	CR	2004
BCK-12.34	BC	2004	SCR3.5SP	CR	2004
BCK-12.47	BC	2004	SCR3.5SW	CR	2004
EMWNT-03A	BC	2004	SCR4.3SP	CR	2004
EMWNT-05	BC	2004	SCR7.1SP	UV	2004
EMW-VWEIR	BC	2004	SCR7.8SP	UV	2004
ET-4	BC	2003	SPR14.0SP	EF	2004
GHK2.51ESW	NPR	2004	SS-1	BC	2004
GHK2.51WSW	NPR	2004	SS-4	BC	2004
MCK 2.0	CR	2004	SS-5	BC	2004
MCK 2.05	CR	2004	SS-6	BC	2004
NPR07.0SW	NPR	2004	SS-6.6	BC	2004
NPR12.0SW	NPR	2004	SS-7	BC	2003
NPR23.0SW	NPR	2004	SS-8	BC	2003
NT-01	BC	2004	STATION 8	EF	2004
NT-03	BC	2004	STATION 17	EF	2004
NT-04	BC	2004			

Notes:

BC = Bear Creek Hydrogeologic Regime
CR = Chestnut Ridge Hydrogeologic Regime
EF = Upper East Fork Poplar Creek Hydrogeologic Regime
NPR = North of Pine Ridge
UV = Union Valley (East of the EF Regime)

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	5 - 50	<7.5	ND

9201-1K-22SU

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-1
Y-12 GRID EAST COORDINATE: 59,380.00
Y-12 GRID NORTH COORDINATE: 29,425.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

First Date	Last Date
06/22/04	10/27/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	06/22/04	.	10/27/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level: # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	36 µg/L	06/22/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

BUILDING SUMP SAMPLING STATION
9201-1K-22SU

1.0 LOCATION

This sampling station is located in a basement sump in the eastern portion of the Bldg. 9201-1, which is in the central area of the Y-12 National Security Complex. The sump was installed to dewater the basement after construction of the building was completed and it receives groundwater with possible potable water contributions. Construction of facilities at Y-12 substantially modified UEFPC, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, filled and replaced with an extensive network of underground storm drains. About 70% of dry-weather flow in UEFPC is attributable to once-through non-contact cooling water, condensate, cooling tower blowdown, and potable water treated and discharged from wastewater treatment facilities and the remaining 30% is from groundwater discharge (DOE 1998).

2.0 SAMPLING HISTORY

Two (unfiltered) surface water samples collected in CY 2004 meet the surveillance monitoring objectives of the Y-12 GWPP (June 2004 and October 2004). The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 242 – 289 mg/L;
- TSS of 88 mg/L in the sample collected in June 2004 (<5 mg/L in the October 2004 sample);
- pH of 6.94 – 7.09 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with elevated molar proportions of chloride, sodium, and sulfate (>15% of total anions/cations); and
- total concentrations of trace metals (except aluminum, iron, manganese, and nickel in the June 2004 sample) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Both surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the maximum value (0.556 mg/L in June 2004) being substantially less than the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

The surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, with both of these results (0.00364 mg/L in June and 0.00128 mg/L in October 2004) being substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 MERCURY

The surface water sample collected in June 2004 had a mercury concentration (0.000221 mg/L) slightly above the analytical reporting limit (0.0002 mg/L), which is substantially less than the drinking water MCL for mercury (0.002 mg/L).

4.4 VOLATILE ORGANIC COMPOUNDS

The surface water sample collected in June 2004 had fairly low concentrations (<30 µg/L) of PCE, TCE, c12DCE, and chloroform. The PCE concentration (7 µg/L) exceeded the MCL for PCE (5 µg/L), but chloroform had the highest concentration (21 µg/L) and is the only compound that was also detected in the sample collected in October 2004 (3 µg/L). Trihalomethanes (chloroform, bromoform, bromodichloromethane, and dibromochloromethane) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency 2001). The dissolved chloroform in the samples from this location may reflect a nearby discharge of chlorinated (potable) water.

4.5 GROSS ALPHA ACTIVITY

Gross alpha activity was above the associated MDA and CE in the June 2004 sample (4.4 pCi/L). The significance of this result is questionable because the sample had elevated TSS (see Section 3.0) which can cause interferences in gross alpha activity analyses.

4.6 GROSS BETA ACTIVITY

Neither of the surface water samples had gross beta activity above the associated MDA.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	50 - 500	ND	ND

9201-3C-4SP

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Building 9201-3
Y-12 GRID EAST COORDINATE: 60,528.59
Y-12 GRID NORTH COORDINATE: 29,132.89
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 2

First Date	Last Date
05/18/04	10/27/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	05/18/04	.	10/27/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	2	68 µg/L	10/27/04	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SAMPLING STATION
9201-3C-4SP

1.0 LOCATION

This spring sampling station is located in the southeastern section of the basement of Bldg. 9201-3, which is in the central area of the Y-12 National Security Complex. The sampling location is at the confluence of three perennial springs before they discharge into a dewatering sump in the basement. Construction of facilities at Y-12 substantially modified UEFPC, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, filled and replaced with an extensive network of underground storm drains.

2.0 SAMPLING HISTORY

Two (unfiltered) surface water samples collected in CY 2004 meet the surveillance monitoring objectives of the Y-12 GWPP (May 2004 and October 2004). The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 233 – 274 mg/L;
- pH of 7.65 – 7.47 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with elevated molar proportions of sodium, chloride, and sulfate (>15% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Both surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the maximum value (0.398 mg/L in October 2004) being substantially less than the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

The samples had (total) uranium concentrations above the applicable analytical reporting limit, with both of these results (0.000847 mg/L in May and 0.00314 mg/L in October 2004) being substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 MERCURY

Mercury was not detected above the analytical reporting limit (0.0002 mg/L) in either sample.

4.4 VOLATILE ORGANIC COMPOUNDS

The surface water sample collected in October 2004 had moderately low concentrations (<50 µg/L) of PCE, TCE, c12DCE, bromoform, and chloroform. The PCE concentration (11 µg/L) exceeded the MCL for PCE (5 µg/L), but chloroform had the highest concentration (42 µg/L) and is the only compound that was also detected in the sample collected in May 2004 (9 µg/L). Trihalomethanes (chloroform, bromoform, bromodichloromethane, and dibromochloromethane) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency 2001). The chloroform and bromoform concentrations in the samples from this location are most likely DBPs from a nearby discharge of chlorinated (potable) water.

4.5 GROSS ALPHA ACTIVITY

Neither of the surface water samples had gross alpha activity above the associated MDA.

4.6 GROSS BETA ACTIVITY

Neither of the surface water samples had gross beta activity above the associated MDA.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

BCK-00.63

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Bear Creek
Y-12 GRID EAST COORDINATE:	22,929.00
Y-12 GRID NORTH COORDINATE:	36,586.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 17

First Date	Last Date
08/06/96	07/20/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/27/04	.	07/20/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	8	0.0399 mg/L	02/09/00	Decreasing
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	3	22 pCi/L	02/23/99	Decreasing
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
BCK-00.63

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 0.63 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-00.63).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

A total of 17 (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1996 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 107 – 384 mg/L;
- pH of 6.5 – 8.5 (field measurements);
- elevated concentrations of sulfate (>20 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nitrate concentrations above the applicable analytical reporting limit were reported for all of the groundwater samples (Table 1), with the results ranging between the historical minimum value of 0.176 mg/L in July 2002 and 2.78 mg/L in February 2000, which is substantially below the drinking water MCL for nitrate (10 mg/L). A time series plot of the nitrate results shows an indeterminate long-term concentration trend dominated by seasonal fluctuations (Figure 1), with the highest concentrations evident during seasonally high flow conditions (January and February).

4.2 URANIUM

All of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with results for eight samples, including the maximum historical value (0.039 mg/L in February 2000), exceeding the drinking water MCL for uranium (0.03 mg/L). As with the nitrate concentration trend, a time-series plot of the uranium results shows a generally decreasing long-term concentration trend dominated by wide concentration fluctuations (Figure 2). Like nitrate results, the uranium concentrations are typically highest in samples collected during seasonally high flow conditions.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Thirteen of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with results for three samples, including the historical maximum value (22 pCi/L in February 1999 and February 2000), exceeding the drinking water MCL for gross alpha activity (15 pCi/L). Like the uranium concentration trend, a time-series plot of the results for gross alpha activity shows a generally decreasing long-term concentration trend dominated by wide concentration fluctuations, with the highest values reported for samples collected during seasonally high flow conditions (Figure 3).

4.5 GROSS BETA ACTIVITY

Twelve of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (18 pCi/L in January 2001) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-00.63: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
08/06/96	1.13	0.031	12.5	8.62
02/04/97	2.16	0.019	<MDA	9
08/28/97	2.1	0.021	11	<MDA
02/18/98	1.01	0.012	<MDA	<MDA
07/29/98	0.477	0.0127	6.6	<MDA
02/23/99	1.89	0.0334	22	8
08/10/99	0.756	0.0221	16	11
02/09/00	2.78	0.0399	22	16
08/01/00	1.19	0.0141	15	15
01/11/01	2.55	0.0223	8.7	18
07/11/01	1.16	0.0165	8.1	7.7
01/08/02	2.82	0.0242	9	15
07/10/02	0.176	0.0118	5.7	10
01/29/03	1.44	0.00755	4.3	<MDA
07/28/03	0.979	0.0119	<MDA	<MDA
01/27/04	1.13	0.00787	5.9	7.3
07/20/04	1.88	0.0144	<MDA	11.46
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

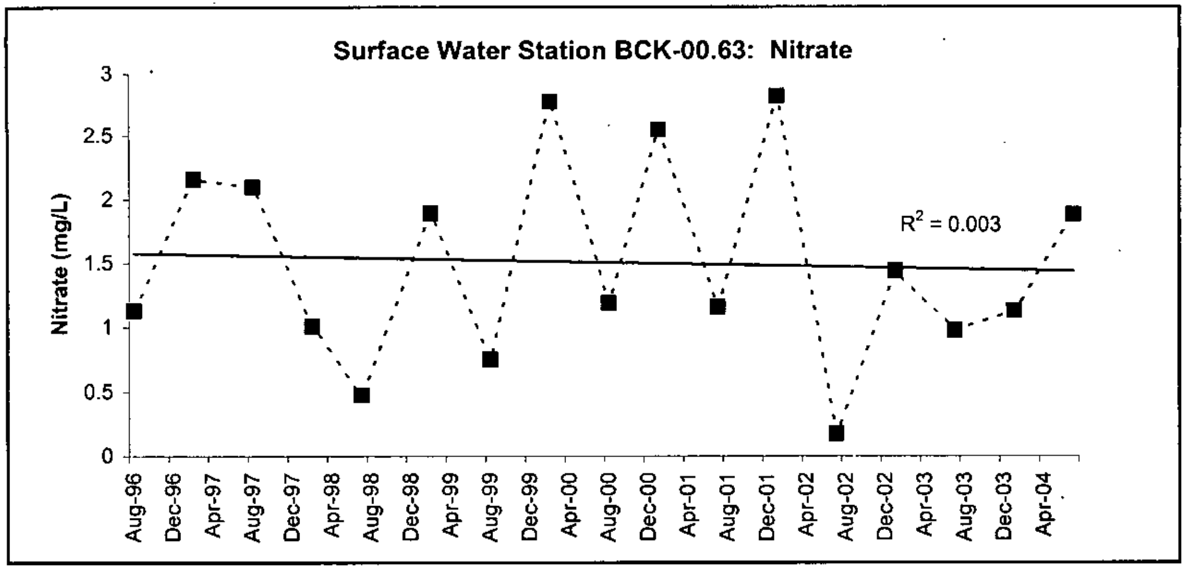


Figure 1

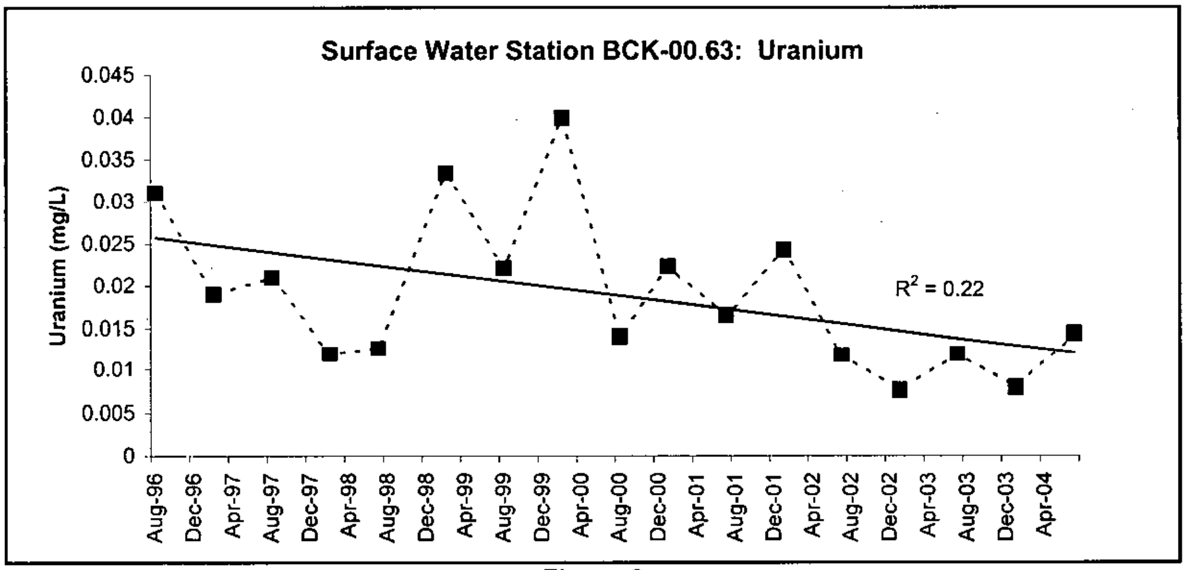


Figure 2

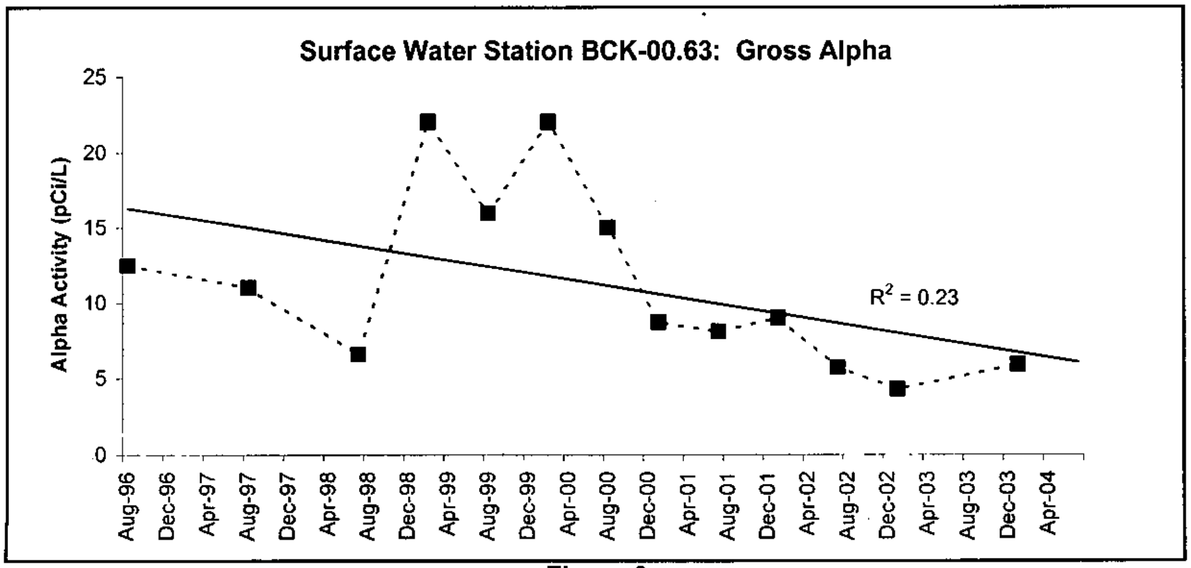


Figure 3

MAXIMUM CONCENTRATION: 2004

<5	0.015 - 0.03	.	.	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

BCK-03.30

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
ADMIN. GRID EAST COORDINATE: 26,304.42
ADMIN. GRID NORTH COORDINATE: 32,636.46
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
03/22/01	09/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/02/04	.	09/14/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	2	0.0345 mg/L	03/12/02	Decreasing
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION BCK-03.30

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 3.3 kilometers upstream of the confluence between Bear Creek and Upper East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-09.20). Each northern tributary (NT) of the creek is designated by a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 2001 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 123 – 265 mg/L;
- pH of 7.4 – 8.6 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Eight of the surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (4.1 mg/L in March 2002) being less than the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Eight of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, including two results (0.0325 mg/L in March 2001 and 0.345 mg/L in March 2002) that exceed the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

One of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE, and this result (11.67 pCi/L in March 2001) is less than the drinking water MCL for gross alpha activity.

4.5 GROSS BETA ACTIVITY

Eight of the surface water samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (15.96 pCi/L in March 2002) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	0.03 - 0.3	ND	7.5 - 15	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

BCK-04.55

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 27,613.00
Y-12 GRID NORTH COORDINATE: 28,965.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 36

First Date	Last Date
08/30/90	07/20/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/27/04	.	07/20/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	1	10.3 mg/L	11/08/93	Decreasing
URANIUM (0.03 mg/L):	15	0.0691 mg/L	02/09/00	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	13	35 pCi/L	02/09/00	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
BCK-04.55

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 4.55 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-04.55).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-six (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2004. The grab sampling method was used to collect each surface water sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 5400.5. Also, grab sampling and/or flow-proportionate composite sampling is performed for NPDES purposes.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 104 – 376 mg/L;
- pH of 6.6 – 8.4 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Thirty-four of the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the results ranging between the historical minimum value of 0.234 mg/L in July 2002 and 10.3 mg/L in November 1993, which is the only result that exceeds the drinking water MCL for nitrate (10 mg/L). A time series plot of the nitrate results shows a widely fluctuating but generally decreasing long-term concentration trend (Figure 1). Concentration fluctuations typically correlate with seasonal flow conditions, with higher nitrate concentrations evident for samples collected during winter and spring.

4.2 URANIUM

Thirty-three of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1); the non-detect result reported for the sample collected in September 1992 is an outlier. Uranium concentrations reported for 15 samples, including the maximum historical value (0.0691 mg/L in February 2000), exceed the drinking water MCL for uranium (0.03 mg/L). A time-series plot of the uranium results shows an indeterminate long-term trend totally dominated by wide concentration fluctuations (Figure 2). Many of these "peak" uranium concentrations coincide with the nitrate levels and are evident for samples collected during seasonally high flow conditions (e.g., 0.0568 mg/L in January 2002).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only one of the surface water samples (acetone = 1 μg/L in March 1993).

4.4 GROSS ALPHA ACTIVITY

Thirty-three of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with results for 13 samples, including the historical maximum value (35 pCi/L in February 2000), exceeding the drinking water MCL for gross alpha activity (15 pCi/L). Like the uranium concentration trend, a time-series plot of the results for gross alpha activity shows an indeterminate long-term concentration trend dominated by wide concentration fluctuations, with the highest values (e.g., 21 pCi/L in January 2002) reported for samples collected during winter and spring (Figure 3). Analytical results summarized below show that uranium isotopes are the source of the elevated gross alpha activity in the surface water samples.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
01/18/91	3.24	6.49
04/10/91	2.09	3.34
07/29/91	3.27	6.13
12/04/91	6.26	18.4
03/10/92	<CE	2.45
06/01/92	3.68	4.91
09/08/92	<CE	<CE
12/16/92	<CE	<CE
01/11/01	6.1	13
07/12/01	3.7	7.1
01/09/02	7.5	17
07/10/02	1.6	2.5

4.5 GROSS BETA ACTIVITY

Thirty of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (37.28 pCi/L in July 1991) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Additionally, available analytical results, summarized below, are inconclusive with regard to the concentrations of Tc-99, a beta-emitting radionuclide and a known groundwater and surface water contaminant in BCV.

Sampling Date	Tc-99 (pCi/L)
03/10/92	9.79
06/01/92	3,710
09/08/92	4,780
12/16/92	<CE
01/11/01	28
07/12/01	<MDA
01/09/02	38
07/10/02	<MDA

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983).

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-04.55: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	3	0.024	16.26	10.75
04/10/91	5	0.023	13.65	24.49
07/29/91	6.6	0.04	13.22	37.28
12/04/91	1.93	0.056	21.6	23.5
03/10/92	1.62	0.02	23.8	30.5
06/01/92	4.4	0.029	13.3	21.7
09/08/92	4.9	<0.001	10.8	19
12/16/92	10	0.067	27.3	22.2
03/09/93	2.3	0.019	7.94	13.9
05/03/93	2.6	0.021	5.81	8.17
08/16/93	6.3	0.03	11.7	21.8
11/08/93	10.3	0.045	12.1	30.5
02/14/94	1.56	0.033	15.1	13.7
09/06/94	3.9	0.031	9.74	12.9
03/09/95	1.5	0.018	7.06	9.99
07/25/95	1.2	0.016	7.9	6.36
01/30/96	1.57	0.039	14.4	11.3
07/14/96	2.77	0.024	<MDA	<MDA
02/04/97	3.61	0.025	13	17
08/28/97	5.68	0.046	19	<MDA
02/18/98	1.4	0.018	4.5	<MDA
07/29/98	0.915	0.0176	16	<MDA
02/23/99	2.75	0.053	21	11
08/10/99	1.293	0.0416	15	16
02/09/00	4.86	0.0691	35	32
08/01/00	2.2	0.0262	17	20
01/11/01	5.36	0.0416	20	29
07/12/01	1.66	0.0227	12	19
01/09/02	6.69	0.0568	21	32
07/10/02	0.234	0.00916	5.3	11
01/29/03	5.32	0.0336	19	29
07/28/03	2.89	0.0278	11	17
01/27/04	1.6	0.0155	4.8	8.9
07/20/04	4.43	0.0303	13	21
MCL	**10**	**0.03**	**15**	**50***

Note: * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

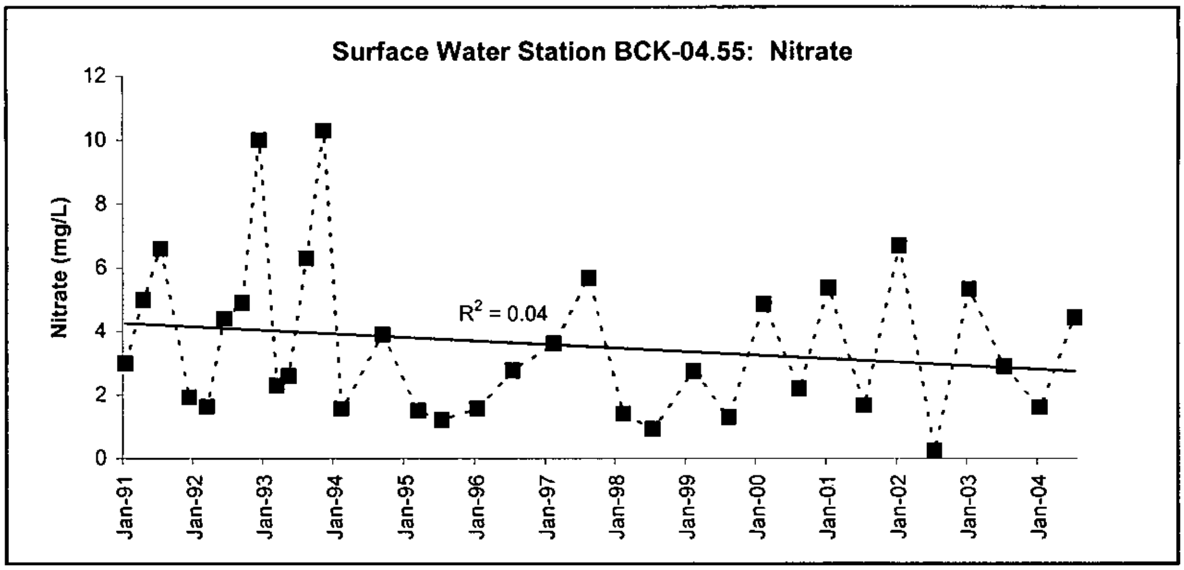


Figure 1

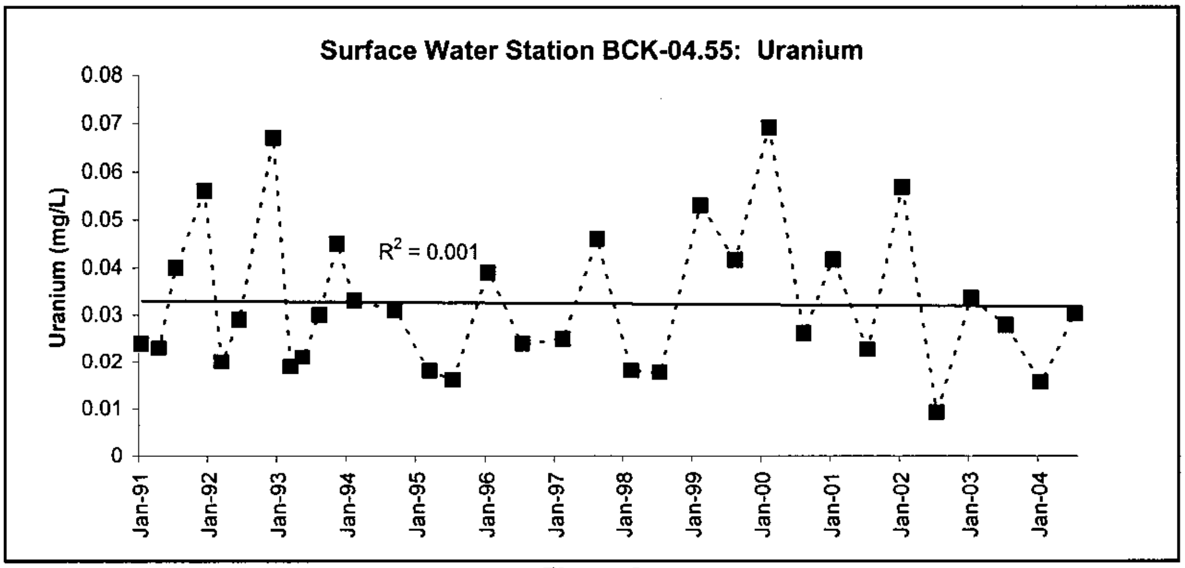


Figure 2

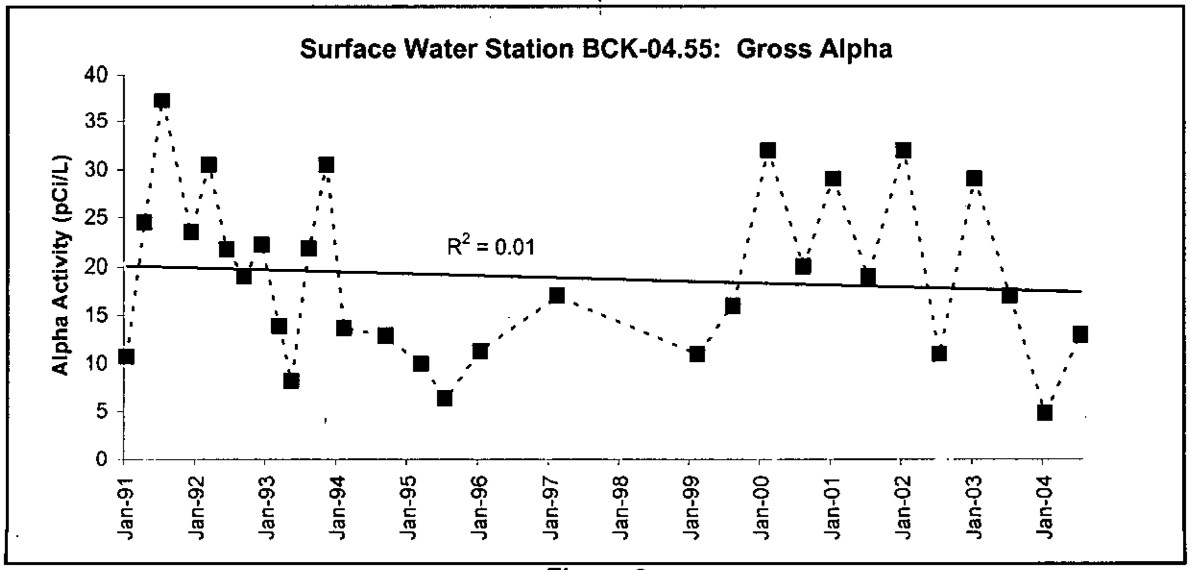


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
5 - 10	0.03 - 0.3	.	.	25 - 50

BCK-07.87

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
ADMIN. GRID EAST COORDINATE: 36,600.00
ADMIN. GRID NORTH COORDINATE: 29,000.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 15

First Date	Last Date
08/11/98	09/14/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/02/04	.	09/14/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	6	18.8 mg/L	08/11/98	Decreasing
URANIUM (0.03 mg/L):	13	0.155 mg/L	02/09/00	Decreasing
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	10	72 pCi/L	02/09/00	Decreasing
GROSS BETA (50 pCi/L):	4	110 pCi/L	01/08/02	Decreasing

SURFACE WATER SAMPLING STATION
BCK-07.87

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 7.87 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-07.87). Each northern tributary (NT) of the creek is designated by a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Fifteen (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1998 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 185 – 369 mg/L;
- pH of 7.0 – 8.4 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Thirteen surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with results for six samples, including the historical maximum value (18.8 mg/L in August 1998), exceeding the drinking water MCL for nitrate (10 mg/L). A time series plot of the nitrate results shows a widely fluctuating but generally decreasing long-term concentration trend (Figure 1). Concentration fluctuations typically correlate with seasonal flow conditions, with higher nitrate concentrations evident for samples collected during winter and spring.

4.2 URANIUM

Thirteen of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with concentrations above the drinking water MCL for uranium (0.03 mg/L) reported for each sample, ranging between the historical minimum and maximum values of 0.048 mg/L (August 2003) and 0.155 mg/L (February 2000). As with the nitrate concentration trend, a time-series plot of the uranium results shows a generally decreasing long-term trend dominated by wide concentration fluctuations (Figure 2). Many of these "peak" uranium concentrations are evident for samples collected during winter and spring (e.g., 0.0568 mg/L in January 2002). Considering the neutral to slightly basic pH of the surface water samples (see Section 3.0), uranium (and uranium isotopes) probably occurs as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions (Fetter 1993). The decreasing uranium trend may be a consequence of the CERCLA remedial actions at the Boneyard/Burnyard, which were completed in March 2003. These remedial actions involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes in June 2002; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater by December 2002; and the reconstruction of a section of the Bear Creek tributary (NT-3) that drains surface runoff from the site by March 2003 (BJC 2003).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in only one of the surface water samples (c12DCE = 1 μg/L in March 2003).

4.4 GROSS ALPHA ACTIVITY

Ten of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 2), and all of these results, including the historical maximum value (72 pCi/L in February 2000), exceed the drinking water MCL for gross alpha activity (15 pCi/L). Like the uranium concentration trend, a time-series plot of the results for gross alpha activity shows a slightly decreasing long-term concentration trend dominated by wide fluctuations, with the highest values (e.g., 62 pCi/L in January 2002) reported for samples collected during winter and spring (Figure 3). As shown by the data summarized in Table 2, uranium isotopes are the source of the elevated gross alpha activity in the surface water samples. The source of the uranium isotopes is probably the Boneyard/Burnyard and/or the BCBG WMA.

4.5 GROSS BETA ACTIVITY

Thirteen of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 2), with results reported for four samples, including the historical maximum value (110 pCi/L in January 2002), exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). A time-series plot of the results show a generally decreasing long-term trend dominated by a conspicuous "peak" concentration in January 2002 (Figure 4). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Additionally, available analytical results, summarized below, suggest that the gross beta activity also may be attributable to Tc-99, a beta-emitting radionuclide and a known groundwater and surface water contaminant in BCV.

Sampling Date	Tc-99 (pCi/L)
02/03/99	14.39
08/10/99	21.69
02/09/00	<MDA
08/03/00	29.19
01/11/01	89.54
07/11/01	55.03
01/08/02	74.44
07/10/02	21.34
03/04/03	15.3
08/19/03	30.24
03/02/04	15.61
09/14/04	37.58

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983).

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee*, BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-07.87: summary of results for nitrate and uranium

Date Sampled	Concentration (mg/L)	
	Nitrate	Uranium
08/11/98	18.8	0.0659
02/23/99	6.71	0.115
08/10/99	6.325	0.0844
02/09/00	11.5	0.155
08/01/00	10.5	0.1
01/11/01	16.7	0.113
07/11/01	10.7	0.0662
01/08/02	17	0.153
07/10/02	3.52	0.0693
03/04/03	4.2	0.0539
08/19/03	9.9	0.048
03/02/04	4.4	0.0461
09/14/04	7.6	0.0567
MCL	**10**	**0.03**

Table 2. Surface Water Sampling Station BCK-07.87: summary of results for gross alpha activity, gross beta activity, and uranium isotopes

Date Sampled	Concentration (pCi/L)			
	Gross Alpha Activity	Gross Beta Activity	U-234	U-238
08/11/98	25	65	.	.
02/03/99	.	.	21.05	47.73
02/23/99	52	34	.	.
08/10/99	35	32	15.45	30.51
02/09/00	72	62	29.34	63.78
08/01/00	33	48	.	.
08/03/00	.	.	15.86	33.32
01/11/01	57	69	21.78	39.08
07/11/01	30	46	11.95	26.07
01/08/02	62	110	18.4	44.05
07/10/02	31	33	12.52	21.56
03/04/03	26.73	28.98	8.08	19.39
08/19/03	.	43.59	7.81	16.81
03/02/04	.	16.84	5.26	15.47
09/14/04	.	36.43	11.42	19.13
MCL	**15**	**50***	**NA**	

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

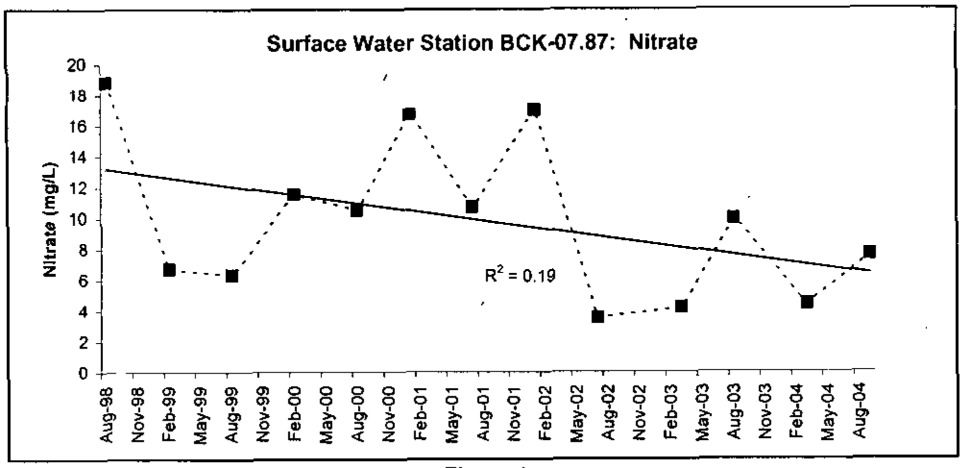


Figure 1

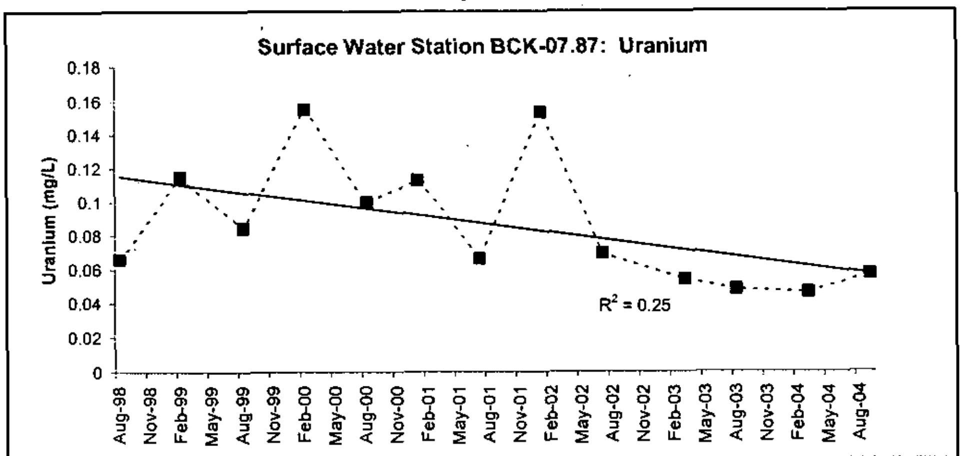


Figure 2

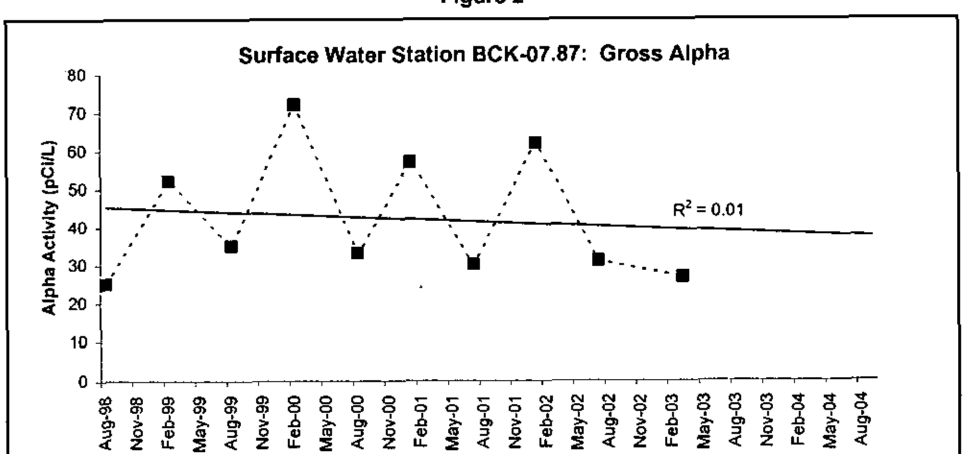


Figure 3

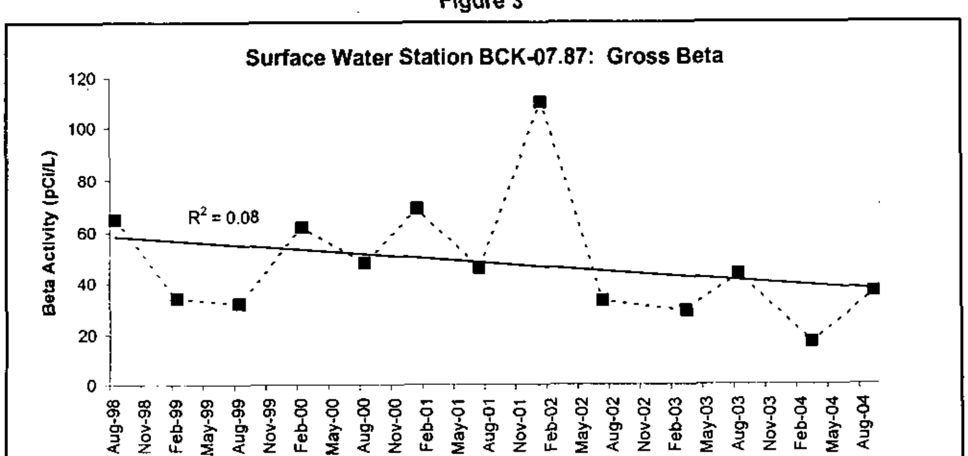


Figure 4

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
5 - 10	0.03 - 0.3	5 - 50	.	25 - 50

BCK-09.20

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 39,972.94
Y-12 GRID NORTH COORDINATE: 28,638.95
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
03/21/01	09/13/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/01/04	.	09/13/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	3	17.6 mg/L	08/18/03	Indeterminate
URANIUM (0.03 mg/L):	8	0.121 mg/L	03/11/02	Decreasing
SUMMED VOCs (5 µg/L):	1	8 µg/L	03/01/04	
GROSS ALPHA (15 pCi/L):	1	29.92 pCi/L	03/21/01	Indeterminate
GROSS BETA (50 pCi/L):	2	55.32 pCi/L	08/18/03	Indeterminate

SURFACE WATER SAMPLING STATION
BCK-09.20

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 9.2 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-09.20). Each northern tributary (NT) of the creek is designated by a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 2001 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 188 – 390 mg/L;
- pH of 6.4 – 8.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Eight surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with results for three samples, including the historical maximum value (17.6 mg/L in August 2003), exceeding the drinking water MCL for nitrate (10 mg/L). A time-series plot of the nitrate results shows a widely fluctuating, indeterminate long-term concentration trend (Figure 1). Concentration fluctuations typically correlate with seasonal flow conditions, with higher nitrate concentrations evident for samples collected during winter and spring.

4.2 URANIUM

Eight surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all of these results, which range from 0.0522 mg/L (August 2003) to 0.121 mg/L (March 2002), exceed the drinking water MCL for uranium (0.03 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Elevated uranium concentrations in the surface water at this Bear Creek sampling station primarily reflects a combination of: (1) downstream transport of uranium from the former Boneyard/Burnyard, which was identified as a primary source of elemental uranium in BCV; (2) inflow of uranium-contaminated surface water from the catchments of the tributaries (NT-7 an NT-8) that drain the Bear Creek Burial Grounds (BCBG) waste management area (WMA); and (3) recharge of uranium-contaminated groundwater discharged into the creek from springs SS-4 and SS-5 (DOE 1997).

Unlike the nitrate concentration trend, a time-series plot of the uranium results reported for the surface water samples shows a decreasing long-term trend (Figure 2). The decreasing trend may be a consequence of the CERCLA remedial actions at the Boneyard/Burnyard, which were completed in March 2003. These remedial actions involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes in June 2002; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater by December 2002; and the reconstruction of a section of the Bear Creek tributary (NT-3) that drains surface runoff from the site by March 2003 (BJC 2003).

4.3 VOLATILE ORGANIC COMPOUNDS

Four of the surface water samples had low concentrations of VOCs: c12DCE was detected in March 2001 (5 μg/L), March 2002 (2 μg/L), March 2003 (5 μg/L), and March 2004 (6 μg/L). Trace levels of PCE (1 μg/L) and TCE (1 μg/L) were also detected in the sample collected in March 2004. There are multiple sources of VOCs in BCV, with the compounds present in this section of Bear Creek probably indicative of the inflow of VOC-contaminated surface water from the catchments of the Bear Creek tributaries (NT-7 and NT-8) that receive surface runoff (and groundwater discharge) from the BCBG WMA and enter the main channel of Bear Creek upstream of this sampling station.

4.4 GROSS ALPHA ACTIVITY

Only one of the surface water samples was analyzed for gross alpha activity (Table 1), and this result (29.92 pCi/L in March 2001) exceeds the drinking water MCL for gross alpha activity (15 pCi/L). Instead of gross alpha activity, the samples were analyzed for uranium isotopes; analytical results are summarized below.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
03/21/01	14.59	34.9
09/17/01	13.18	28.2
03/11/02	14.19	30.29
09/09/02	11.26	19.12
03/03/03	10.21	19.4
08/18/03	8.86	17.98
03/01/04	6.47	16.66
09/13/04	11.55	18.21

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects downstream transport from the former Boneyard/Burnyard combined with inflow of contaminated surface water from the catchments of the tributaries that drain the BCBG WMA and recharge of uranium-contaminated groundwater discharged into the creek from springs SS-4 and SS-5 (DOE 1997).

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (55.32 pCi/L in August 2003) being slightly above the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). A time-series plot of the results for gross beta activity shows an indeterminate long-term trend (Figure 3). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Additionally, available analytical results, summarized below, suggest that the gross beta activity also may be attributable to Tc-99, a beta-emitting radionuclide and a known groundwater and surface water contaminant in BCV.

Sampling Date	Tc-99 (pCi/L)
03/21/01	50.43
09/17/01	63.3
03/11/02	69.84
09/09/02	54.47
03/03/03	21.18
08/18/03	49.17
03/01/04	35.32
09/13/04	41.98

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983).

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-09.20: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
03/21/01	9.4	0.116	29.92	33.1
09/17/01	10.4	0.106	.	34.24
03/11/02	15.9	0.121	.	50.04
09/09/02	9.9	0.0625	.	48.28
03/03/03	4.5	0.059	.	35.26
08/18/03	17.6	0.0522	.	55.32
03/01/04	8.1	0.0655	.	28.8
09/13/04	8.6	0.0588	.	37.42
MCL	**10**	**0.03**	**15**	**50***
Note: * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)				

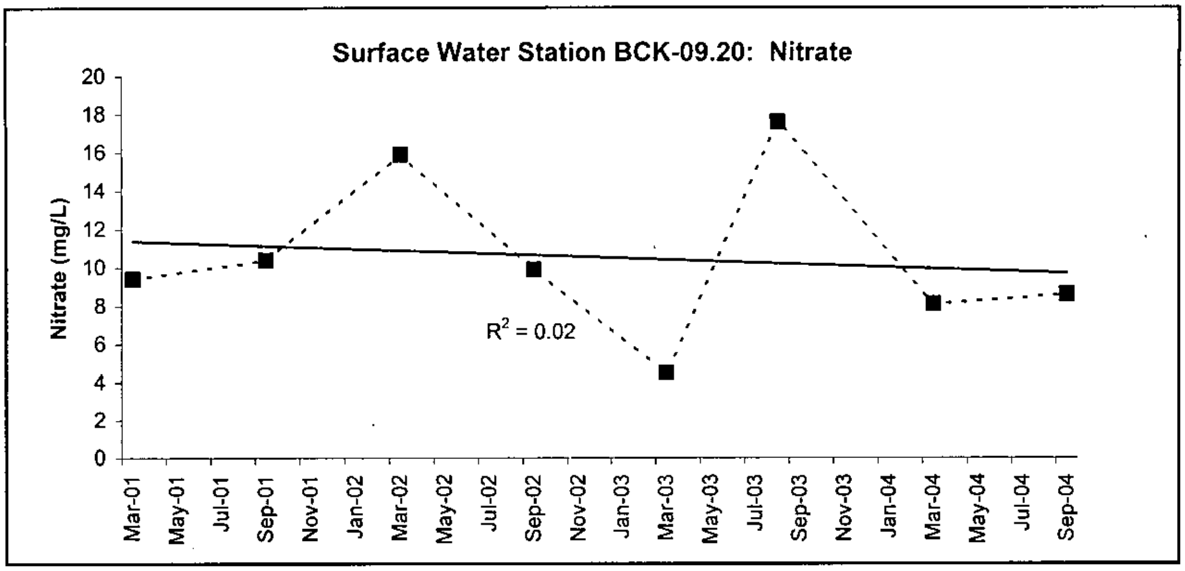


Figure 1

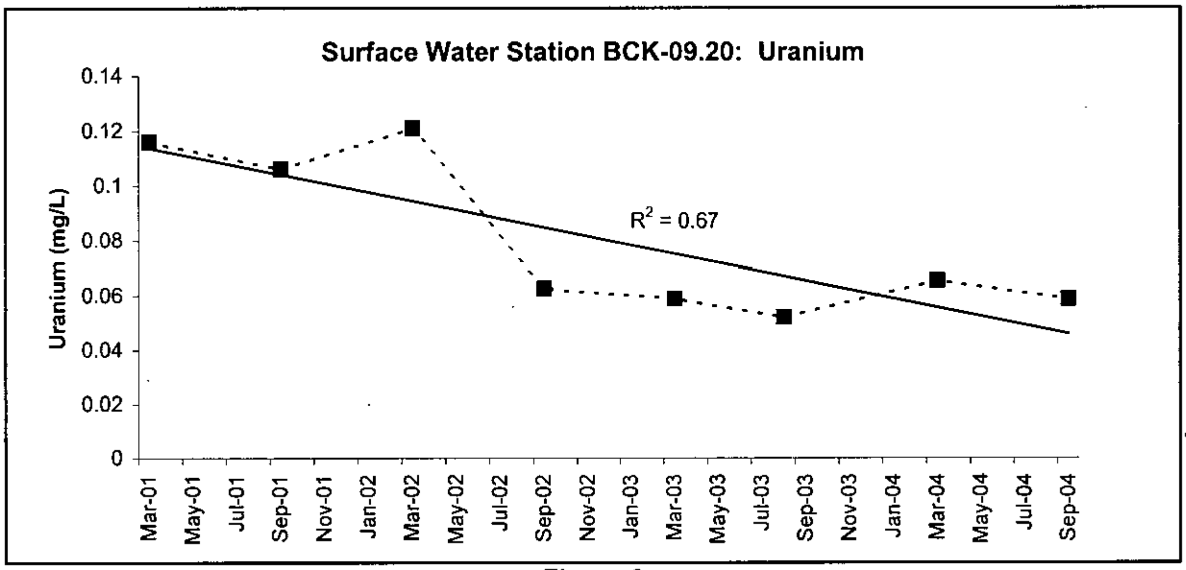


Figure 2

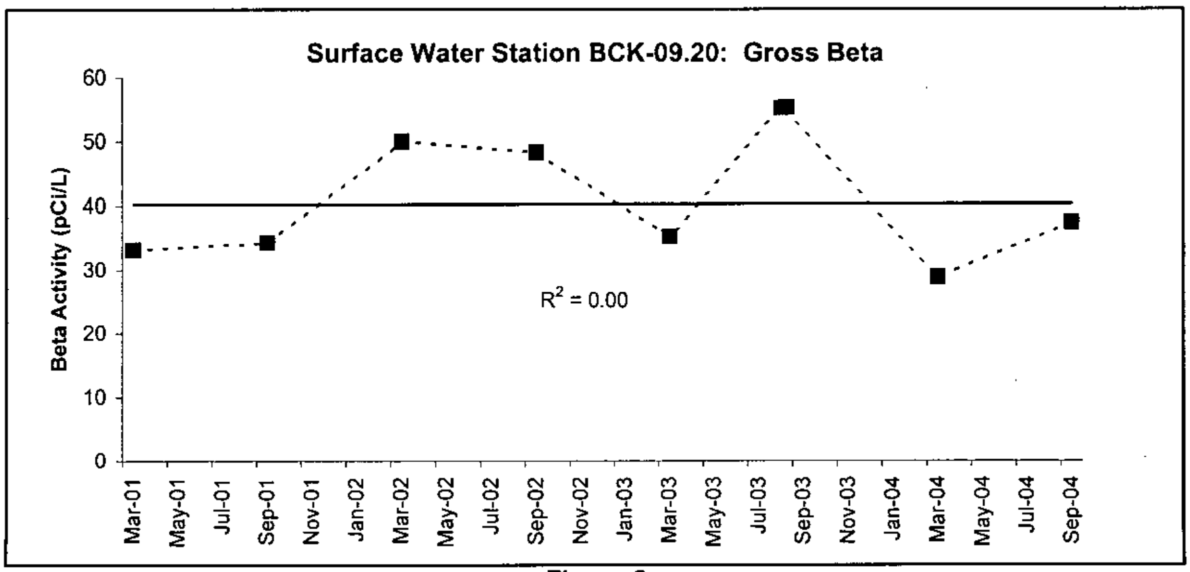


Figure 3

MAXIMUM CONCENTRATION: 2003

5 - 10	0.03 - 0.3	5 - 50	15 - 150	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

BCK-09.40

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 41,208.90
Y-12 GRID NORTH COORDINATE: 28,651.98
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 34

First Date	Last Date
08/30/90	07/29/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	01/30/03	.	07/29/03	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	17	36 mg/L	07/29/91	Indeterminate
URANIUM (0.03 mg/L):	30	0.259 mg/L	01/10/01	Increasing
SUMMED VOCs (5 μg/L):	22	86 μg/L	03/10/92	Indeterminate
GROSS ALPHA (15 pCi/L):	29	127 pCi/L	12/16/92	Indeterminate
GROSS BETA (50 pCi/L):	16	120 pCi/L	08/02/00	Indeterminate

SURFACE WATER SAMPLING STATION
BCK-09.40

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 9.40 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-09.40). Each northern tributary (NT) of the creek is designated by a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-four (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2003. The grab sampling method was used to collect each sample. Note that the sample collected on November 1993 may have been inadvertently misidentified as a sample that was collected the same day from spring SS-6, and vice versa. Misidentification of these samples in the field is suspected because the analytical results reported for the sample from BCK-09.40 are more consistent with the historical data for SS-6 and the analytical results reported for the sample from spring SS-6 are more consistent with the historical data for BCK-09.40. However, there are not any available records that prove the misidentification of these samples; consequently, the analytical results for both samples are considered unusable for the purposes of the Y-12 GWPP.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 168 – 492 mg/L;
- pH of 6.9 – 8.6 (field measurements);
- elevated concentrations of chloride (>20 mg/L); and

- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with results for 18 samples, including the historical maximum value (36 mg/L in July 1991), exceeding the drinking water MCL for nitrate (10 mg/L). A time-series plot of the nitrate results shows a widely fluctuating, indeterminate long-term concentration trend (Figure 1). Concentration fluctuations typically correlate with seasonal flow conditions, with higher nitrate concentrations evident for samples collected during winter and spring.

4.2 URANIUM

All of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all but one of these results, which range from 0.023 mg/L (February 1998) to 0.259 mg/L (January 2001), exceed the drinking water MCL for uranium (0.03 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Elevated uranium concentrations in the surface water at this Bear Creek sampling station primarily reflects a combination of: (1) downstream transport of uranium from the former Boneyard/Burnyard, which was identified as a primary source of elemental uranium in BCV; (2) inflow of uranium-contaminated surface water from the catchments of the tributaries (NT-7 an NT-8) that drain the Bear Creek Burial Grounds (BCBG) waste management area (WMA); and (3) recharge of uranium-contaminated groundwater discharged into the creek from spring SS-4 (DOE 1997).

A time-series plot of the uranium results reported for the surface water samples shows a generally increasing long-term trend that is skewed by results for a three-year period (February 1999-July 2002) when samples had much higher uranium concentrations (>0.15 mg/L) than all other samples (Figure 2). Recent samples show that uranium concentrations decreased by an order of magnitude from January 2001 (0.259 mg/L) to January 2003 (0.0316 mg/L). This decreasing trend may be a consequence of the CERCLA remedial actions at the Boneyard/Burnyard, which were completed in March 2003 and involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater; and the reconstruction of a section of the Bear Creek tributary (NT-3) that drains surface runoff from the site (BJC 2003).

4.3 VOLATILE ORGANIC COMPOUNDS

At least one of the following VOCs was detected in 28 of the surface water samples: PCE, TCE, 12DCE (c12DCE), 11DCA and 111TCA (Table 2). Based on the frequency of detection and the highest concentration, 12DCE (c12DCE) is the primary VOC in the samples and has been detected in 27 samples at concentrations ranging from 1 μg/L in August 1993 to 50 μg/L in January 2001. The other compounds were detected much more infrequently, with the bulk of the results being estimated values below 5 μg/L. There are multiple sources of VOCs in BCV, with the compounds present in this section of Bear Creek probably indicative of the inflow of VOC-contaminated surface water from the catchments of the Bear Creek tributaries (NT-7 and NT-8) that receive surface runoff (and groundwater discharge) from the BCBG WMA and enter the main channel of Bear Creek upstream of this sampling station.

A time-series plot of the summed concentration of VOCs detected (excluding false positive results) in each surface water sample shows a widely fluctuating, indeterminate long-term trend (Figure 2). Note that these "peak" concentrations occurred during the winter months suggesting greater inflow of VOC-contaminated surface water during periods of seasonally high flow conditions. The samples with the highest VOC concentrations (> 20 μg/L; January 1999-January 2002) were collected during the same three-year time period when there was a "pulse" of higher uranium concentrations (see Section 4.2).

4.4 GROSS ALPHA ACTIVITY

All of the surface water samples had gross alpha activity above the associated MDA and CE (Table 1), and all but one of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L), including three results that exceed 100 pCi/L. Indeed, compared to the other results, the historical minimum value (6.8 pCi/L in February 1998), appears to be an outlier compared to the other results for gross alpha activity. A time-series plot of the results for gross alpha activity shows an indeterminate long-term concentration trend (Figure 4) that includes a three-year period (January 1999-July 2002) of elevated activity that coincides with the "pulse" of elevated uranium concentrations (see Section 4.2).

Analytical results for applicable surface water samples, summarized below, suggest that uranium isotopes are the source of the elevated gross alpha activity in the surface water at this sampling location.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
03/18/91	7.51	22.5
04/10/91	2.16	3.46
07/29/91	7.54	18
12/04/91	32.9	82.6
03/10/92	4.75	8.07
06/01/92	7.84	<CE
09/08/92	<CE	<CE
12/16/92	<CE	38

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects downstream transport from the former Boneyard/Burnyard combined with inflow of contaminated surface water from the catchments of the tributaries that drain the BCBG WMA and recharge of uranium-contaminated groundwater discharged into the creek from springs SS-4 and SS-5 (DOE 1997).

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for 15 samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity), including the historical maximum value (120 pCi/L in August 2000 and January 2002). A time-series plot of the results for gross beta activity shows an indeterminate long-term trend similar to the trend for gross alpha activity (Figure 4). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples.

Analytical results for applicable surface water samples, summarized below, are somewhat inconclusive with regard to the presence of Tc-99, a beta-emitting radionuclide and a known groundwater and surface water contaminant in BCV.

Sampling Date	Tc-99 (pCi/L)
03/10/92	7.02
06/01/92	<CE
09/08/92	<CE
12/16/92	<CE
02/14/94	158
09/06/94	80
03/09/95	<CE
07/25/95	<CE
03/16/96	37
07/29/96	30.5

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-09.40: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	13	0.098	48.06	55.09
04/10/91	15	0.081	27.52	67.75
07/29/91	36	0.1	43.32	119.76
12/04/91	7.47	0.12	75.5	85.7
03/10/92	4.43	0.052	18.9	18.7
06/01/92	18.7	0.12	38.6	71.8
09/08/92	18	0.095	41.1	55.4
12/16/92	11	0.088	127	99.8
03/09/93	11	0.074	26.8	41.3
05/03/93	13	0.087	19.1	43.8
08/16/93	18.8	0.129	41	95.5
02/14/94	6.62	0.152	60.2	58.9
09/06/94	22	0.139	44.6	68.2
03/09/95	3.9	0.066	27.6	37.2
07/25/95	6	0.089	33.2	32.6
03/16/96	9.29	0.096	46.7	33.4
07/29/96	7.98	0.081	41.3	28.5
02/04/97	10.6	0.061	32	27
08/29/97	10.3	0.066	28	37
02/18/98	3.16	0.023	6.8	13
08/03/98	10.3	0.0922	33	38
02/24/99	10.5	0.208	110	80
08/11/99	4.701	0.149	64	47
02/10/00	20.1	0.25	96	110
08/02/00	23.3	0.164	61	120
01/10/01	18.7	0.259	100	90
07/11/01	8.26	0.169	67	75
01/09/02	19.4	0.204	80	120
07/11/02	0.042	0.154	68	23
01/30/03	5.36	0.0316	13	29
07/29/03	9.39	0.0798	26	47
MCL	**10**	**0.03**	**15**	**50***

Note: * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Surface Water Sampling Station BCK-09.40: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	TCE	12DCE	c12DCE	111TCA	11DCA
01/18/91	2 J	0.9 J	11	NR	0.4 J	.
04/10/91	.	.	7	NR	.	.
07/29/91	0.5 J	.	5	NR	.	.
12/04/91	.	.	4 J	NR	.	.
06/01/92	.	.	6	NR	.	.
09/08/92	.	2 J	4 J	NR	.	.
12/16/92	.	.	6	NR	.	.
03/09/93	1 J	.	8	NR	.	.
05/03/93	1 J	.	9	NR	.	.
08/16/93	.	0.7 J	1 J	NR	.	.
02/14/94	1 J	0.6 J	5	NR	.	.
09/06/94	.	.	6	NR	.	.
03/09/95	.	.	5	NR	.	.
07/25/95	.	2 J	2 J	NR	.	.
03/16/96	.	.	14	NR	1 J	.
07/29/96	.	.	4 J	NR	.	.
02/04/97	1 J	.	5	5	.	.
02/18/98	.	1 J	.	.	1 J	.
08/03/98	.	1 J	2 J	2 J	.	.
02/24/99	3 J	2 J	17	17	.	.
08/11/99	.	.	3 J	3 J	.	.
02/10/00	4 J	3 J	34	34	.	2 J
08/02/00	.	.	4 J	4 J	.	.
01/10/01	5	3 J	50	50	.	3 J
07/11/01	.	.	6	6	.	.
01/09/02	2 J	2 J	21	21	.	.
01/30/03	.	.	8	8	.	.
07/29/03	.	.	6	6	.	.
MCL	**5**	**5**	**NA**	**70**	**200**	**NA**

Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported

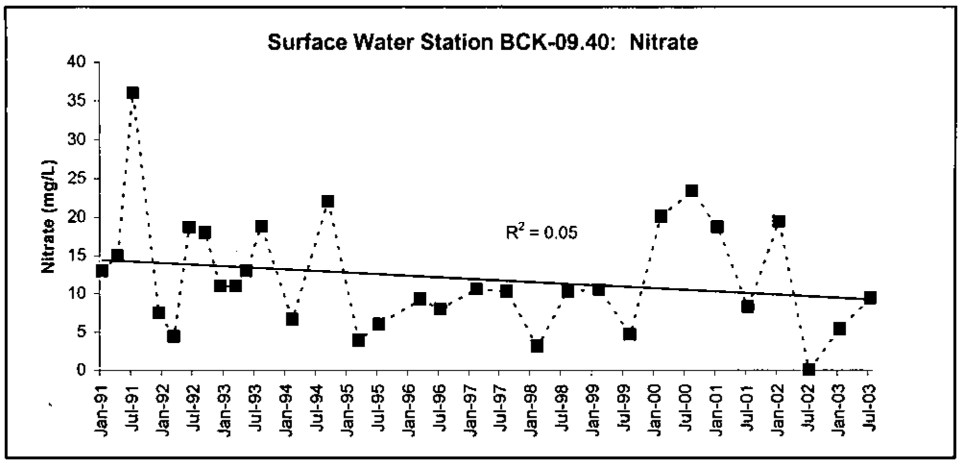


Figure 1

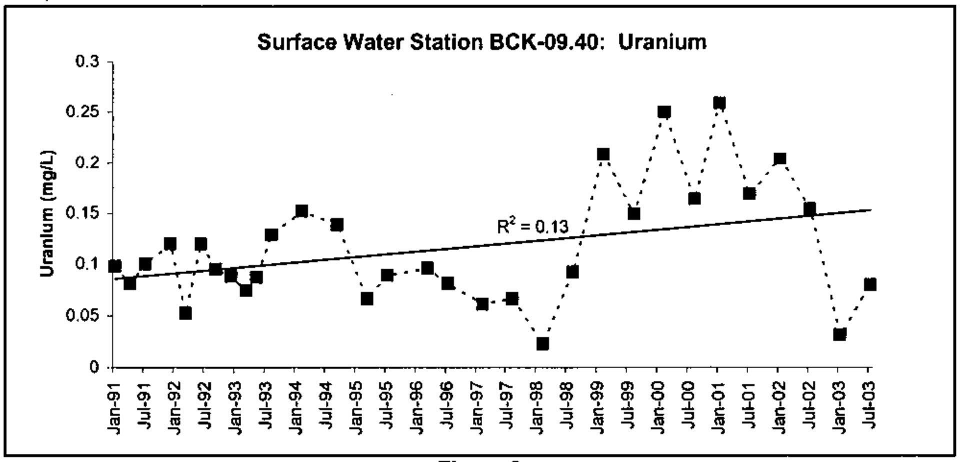


Figure 2

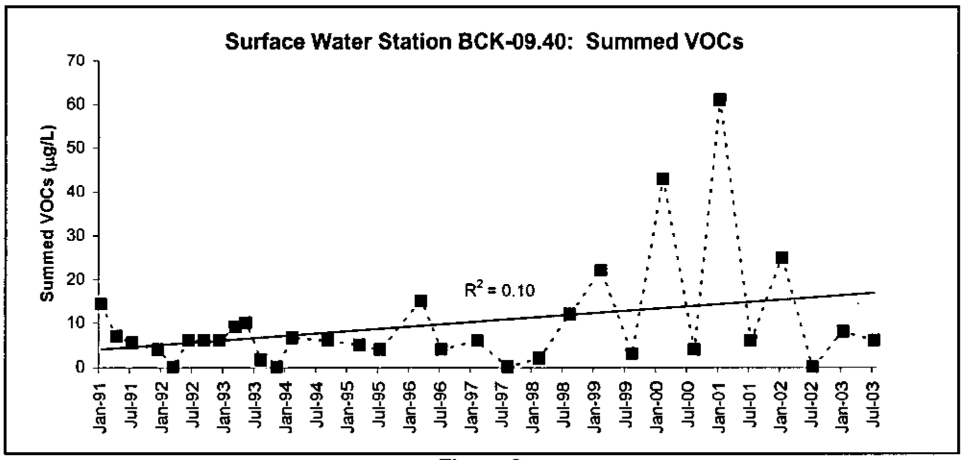


Figure 3

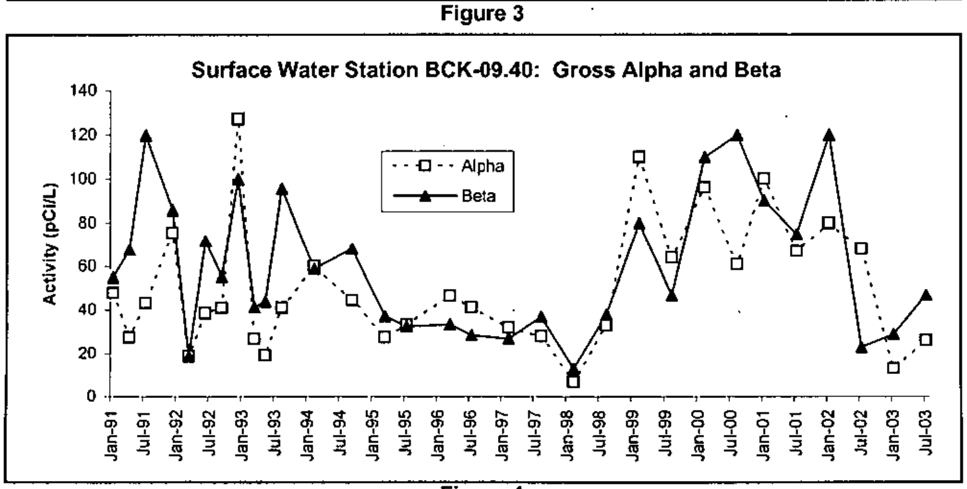


Figure 4

BCK-09.40

MAXIMUM CONCENTRATION: 2004

10 - 100	0.03 - 0.3	5 - 50	.	50 - 500
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

BCK-09.47

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 41,380.00
Y-12 GRID NORTH COORDINATE: 28,800.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 11

First Date	Last Date
02/03/99	09/13/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/01/04	.	09/13/04	. .

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	5	25.2 mg/L	08/18/03	Increasing
URANIUM (0.03 mg/L):	9	0.304 mg/L	01/25/00	Decreasing
SUMMED VOCs (5 µg/L):	7	44 µg/L	01/25/00	Indeterminate
GROSS ALPHA (15 pCi/L):	3	76.29 pCi/L	07/29/99	Indeterminate
GROSS BETA (50 pCi/L):	5	93.36 pCi/L	08/18/03	Increasing

SURFACE WATER SAMPLING STATION
BCK-09.47

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, 9.47 kilometers upstream of the confluence between Bear Creek and East Fork Poplar Creek. From its headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-09.47). Each northern tributary (NT) of the creek is designated by a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Eleven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

In addition to sampling performed to meet the surveillance monitoring objectives of the Y-12 GWPP, numerous samples have been collected to date for the purposes of other monitoring programs, including flow proportionate composite sampling performed in accordance with the Phase I ROD for the Bear Creek watershed (DOE 2000).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 180 – 453 mg/L;
- pH of 6.5 – 8.6 (field measurements);
- elevated concentrations of chloride (>25 mg/L) and sulfate (>20 mg/L); and

- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Ten of the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with results for five samples exceeding the drinking water MCL for nitrate (10 mg/L). A time-series plot of the nitrate results shows a widely fluctuating, but generally increasing long-term concentration trend (Figure 1).

4.2 URANIUM

Nine surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all of these results, which range from 0.0757 mg/L (August 2003) to 0.304 mg/L (January 2001), exceed the drinking water MCL for uranium (0.03 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Elevated uranium concentrations in the surface water at this Bear Creek sampling station primarily reflects a combination of: (1) downstream transport of uranium from the former Boneyard/Burnyard, which was identified as a primary source of elemental uranium in BCV; (2) inflow of uranium-contaminated surface water from the catchments of the tributaries (NT-7 an NT-8) that drain the Bear Creek Burial Grounds (BCBG) waste management area (WMA); and (3) recharge of uranium-contaminated groundwater discharged into the creek from spring SS-4 (DOE 1997).

A time-series plot of the uranium results reported for the surface water samples shows a clearly decreasing long-term trend (Figure 2). The decreasing trend may be a consequence of the CERCLA remedial actions at the Boneyard/Burnyard, which were completed in March 2003. These remedial actions involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes in June 2002; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater by December 2002; and the reconstruction of a section of the Bear Creek tributary (NT-3) that drains surface runoff from the site by March 2003 (BJC 2003).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs was detected in the surface water samples: PCE, TCE, c12DCE, 11DCA, and chloromethane (Table 2). The primary VOC in the samples is c12DCE, which was detected in ten samples, with a historical maximum concentration (32 µg/L in January 2001) being less than the drinking water MCL (70 µg/L). The other compounds were detected much more infrequently, with all of the results being less than or equal to 5 µg/L. There are multiple sources of VOCs in BCV, with the compounds present in this section of Bear Creek probably indicative of the inflow of VOC-contaminated surface water from the catchments of the Bear Creek tributaries (NT-7 and NT-8) that receive surface runoff (and groundwater discharge) from the BCBG WMA and enter the main channel of Bear Creek upstream of this sampling station.

4.4 GROSS ALPHA ACTIVITY

Three surface water samples were analyzed for gross alpha activity (Table 1), with all three results exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, all of the surface water samples were analyzed for uranium isotopes and, as shown in the following data summary, U-234 and U-238 were detected in each sample.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
02/03/99	18.64	48.24
07/29/99	31.27	69.06
01/25/00	37.48	96.52
08/16/00	29.48	86.36
03/21/01	18.44	70.05
09/17/01	16.75	57.75
03/11/02	16.76	44.46
03/03/03	16.33	29.83
08/18/03	10.04	21.19
03/01/04	9.16	23.34
09/13/04	19.56	38.99

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects downstream transport from the former Boneyard/Burnyard combined with inflow of contaminated surface water from the catchments of the tributaries that drain the BCBG WMA and recharge of uranium-contaminated groundwater discharged into the creek from springs SS-4 and SS-5 (DOE 1997).

4.5 GROSS BETA ACTIVITY

Ten of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with results for five samples exceeding the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity), including the historical maximum value (93 pCi/L in August 2003). A time-series plot of the results for gross beta activity shows a generally increasing long-term trend (Figure 3). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Additionally, available analytical results, summarized below, suggest that the gross beta activity also is attributable to Tc-99, a beta-emitting radionuclide and a known groundwater and surface water contaminant in BCV.

Sampling Date	Tc-99 (pCi/L)
07/29/99	38.85
01/25/00	74.57
08/16/00	111.75
03/21/01	52.8
09/17/01	30.6
03/11/02	118.07
03/03/03	27.22
08/18/03	70.88
03/01/04	44.16
09/13/04	66.31

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983).

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2000. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-1750&D4, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-09.47: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
07/29/99	8.8	.	76.29	44.09
01/25/00	11.4	0.304	.	36.66
08/16/00	9.4	0.139	53.48	75.77
03/21/01	9	0.258	73.99	61.65
09/17/01	0.52	0.248	.	18.1
03/11/02	23.4	0.205	.	76.09
03/03/03	6.5	0.0986	.	48.52
08/18/03	25.2	0.0757	.	93.36
03/01/04	10.5	0.0959	.	34.68
09/13/04	14.5	0.12	.	61.07
MCL	**10**	**0.03**	**15**	**50***
Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)				

Table 2. Surface Water Sampling Station BCK-09.47: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	**TCE**	**c12DCE**	**11DCA**	**Chloromethane**
07/29/99	1 J	1 J	15	.	.
01/25/00	5	4 J	33	2 J	.
08/16/00	.	.	3 J	.	.
03/21/01	4 J	3 J	32	2 J	.
09/17/01	.	.	1 J	.	.
03/11/02	2 J	1 J	14	.	2 J
03/03/03	3 J	2 J	12	1 J	.
08/18/03	.	.	6	.	.
03/01/04	3 J	2 J	14	1 J	.
09/13/04	.	.	4 J	.	.
MCL	**5**	**5**	**70**	**NA**	**NA**
Note: "." = Not detected; J = Estimated value; NA = Not applicable					

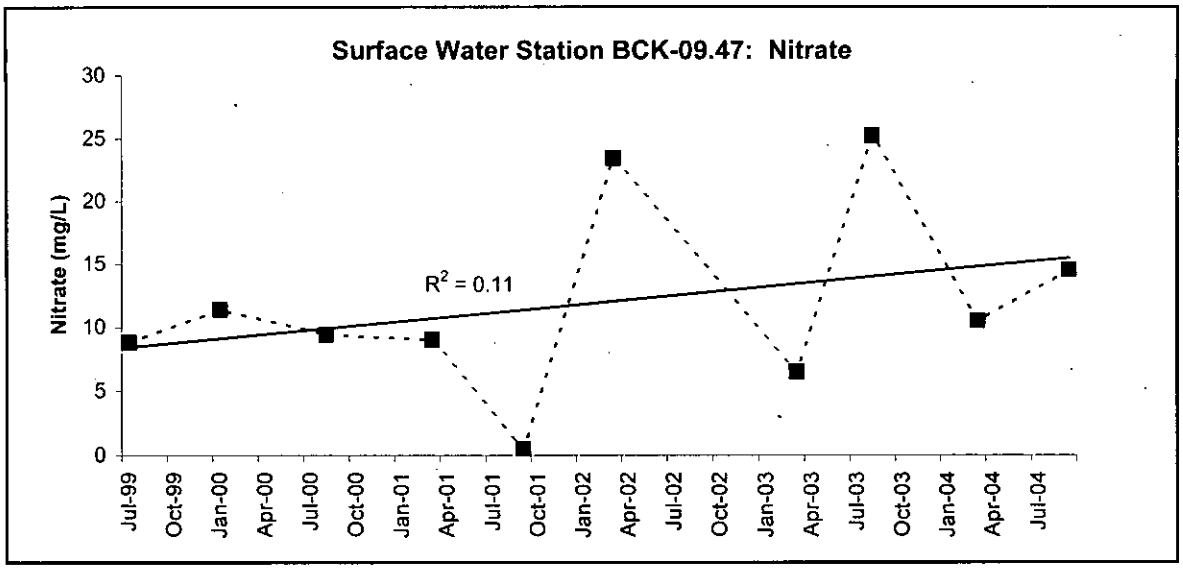


Figure 1

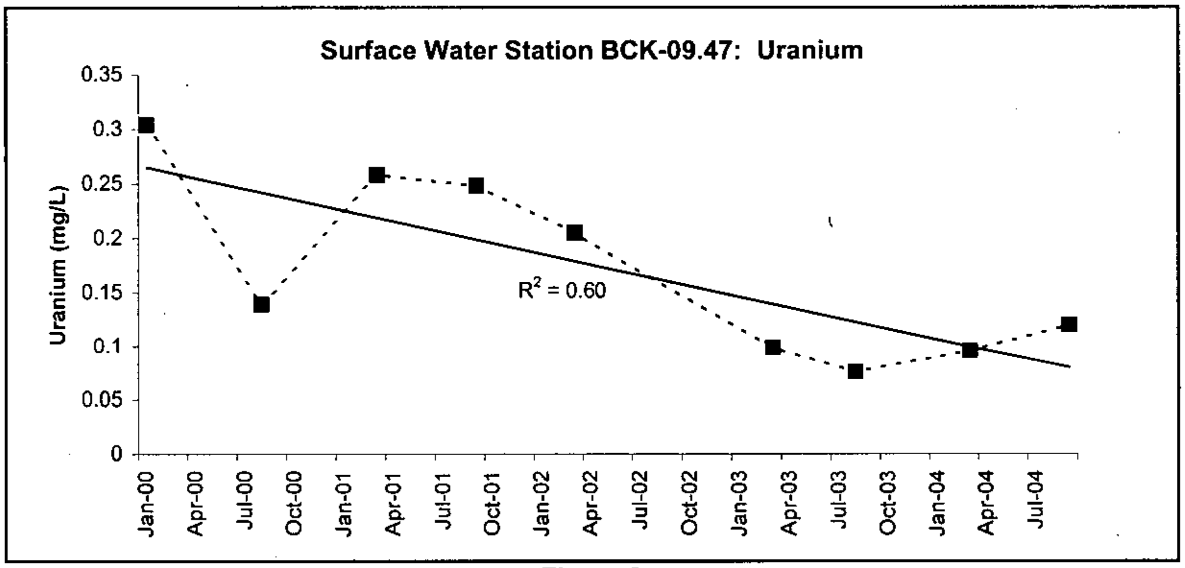


Figure 2

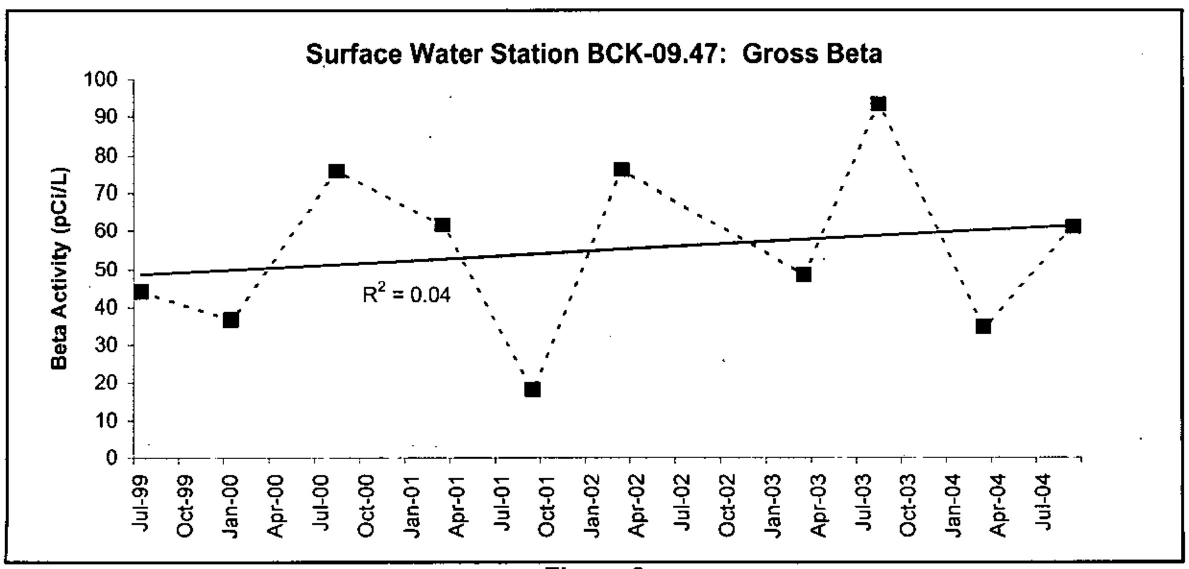


Figure 3

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
10 - 100	0.03 - 0.3	ND	.	50 - 500

BCK-11.54

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Bear Creek
Y-12 GRID EAST COORDINATE:	47,560.00
Y-12 GRID NORTH COORDINATE:	29,200.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	CERCLA
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	7	09/17/01	09/13/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/01/04	.	09/13/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	6	61.2 mg/L	03/11/02	Indeterminate
URANIUM (0.03 mg/L):	6	0.145 mg/L	09/01/04	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	6	158.71 pCi/L	03/11/02	Indeterminate

SURFACE WATER SAMPLING STATION
BCK-11.54

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, just downstream of the confluence between the creek channel and a northern tributary (NT) of the creek (NT-3), which are numbered in ascending order downstream from the headwaters of the creek near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward through a gap in Pine Ridge and flows into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-11.54).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Seven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 2001 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 212 – 713 mg/L;
- pH of 7.3 – 8.3 (field measurements);
- elevated concentrations of chloride (>30 mg/L) and sulfate (>30 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), and all but one of these results, including the historical maximum value (61.2 mg/L in March 2002), exceed the drinking water MCL for nitrate (10 mg/L). The historical minimum value (0.041 mg/L in September 2002) is an outlier when compared to the other results. A time series plot of the nitrate results shows a widely fluctuating and indeterminate trend (Figure 1). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 3,000 ft east-northeast of BCK-11.54, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters Bear Creek via discharge of nitrate-contaminated groundwater from the shallow karst network in the Maynardville Limestone and inflow of nitrate-contaminated surface water from two northern tributaries of Bear Creek (NT-1 and NT-2) that are primary discharge areas for nitrate-contaminated groundwater in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997).

As noted in Section 1.0, the BCK-11.54 sampling station is on the main channel of Bear Creek immediately downstream of the confluence with NT-3, and the sampling results show that nitrate concentrations are typically about 50% lower than evident upstream at the BCK-11.84 sampling station. Lower levels of nitrate at BCK-11.54 are at least partially attributable to dilution from inflow of non-nitrate contaminated groundwater and surface water from the NT-3 catchment.

4.2 URANIUM

All the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all but one of these results, including the historical maximum value (0.145 mg/L in March 2002 and September 2004), exceed the drinking water MCL for uranium (0.03 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Although upstream contamination in Bear Creek from the contaminant plume emplaced during historical operation of the former S-3 Ponds is a likely source of the uranium (and uranium isotopes) in the samples, the primary source is probably the former Boneyard/Burnyard (BYBY). Located about 500 ft east-northeast of the BCK-11.54 sampling station, the BYBY was confirmed as the primary source of uranium (and uranium isotopes) in surface water in Bear Creek (and groundwater in the Maynardville Limestone) downstream of the confluence with NT-3 (DOE 1997).

A time series plot of the uranium results shows a widely fluctuating and indeterminate long term trend (Figure 2). The substantially lower uranium levels in September 2002 appear to be a direct consequence of the CERCLA remedial actions at the BYBY. Completed in March 2003, the CERCLA remedial action involved hydraulically isolating buried wastes in contact with groundwater; the excavation, consolidation, and disposal of about 64,000 yd^3 of these wastes; and the reconstruction of a section of NT-3 to promote better drainage from the site (BJC 2003). The uranium concentrations have increased since completion of the remedial actions, but this increase may reflect an upstream source of contamination (e.g., NT-1) rather than input from NT-3.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Instead of gross alpha activity, the surface water samples were analyzed for uranium isotopes. Analytical results, summarized below, show that relatively low levels of U-234 and U-238 were detected in each sample.

Sampling Date	Concentration (pCi/L)	
	U-234	**U-238**
09/17/01	16.79	29.07
03/11/02	18.07	30.72
09/09/02	2.38	3.66
03/03/03	22	29.39
08/18/03	9.43	18.88
03/01/04	9.69	17
09/13/04	28.97	47.77

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects downstream transport from the contaminant plumes emplaced during historical operations of the former S-3 Ponds and Boneyard/Burnyard, the latter site being the most likely source (DOE 1997).

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1) and all but one of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). The historical minimum value (4.3 pCi/L in September 2002) is an outlier when compared to the other six results, four of which exceed 100 pCi/L. A time series plot of the results for gross beta activity shows a widely fluctuating and indeterminate long term trend (Figure 3). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Nevertheless, available analytical results, summarized below, show that the gross beta activity is mostly attributable to Tc-99, a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997).

Sampling Date	Tc-99 (pCi/L)
09/17/01	288
03/11/02	235.57
09/09/02	<MDA
03/03/03	56.76
08/18/03	99.8
03/01/04	90.53
09/13/04	212.09

Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983). Based on the existing network of sampling locations (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in Bear Creek (and the Maynardville Limestone) closely mirrors that of nitrate.

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-11.54: summary of results for nitrate, uranium, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Beta Activity (pCi/L)
09/17/01	49.7	0.114	148.66
03/11/02	61.2	0.145	158.71
09/09/02	0.041	0.0146	4.3
03/03/03	15.4	0.0824	65.56
08/18/03	44	0.0517	107.57
03/01/04	24	0.0747	54.93
09/13/04	49.5	0.145	147.82
MCL	**10**	**0.03**	**50***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

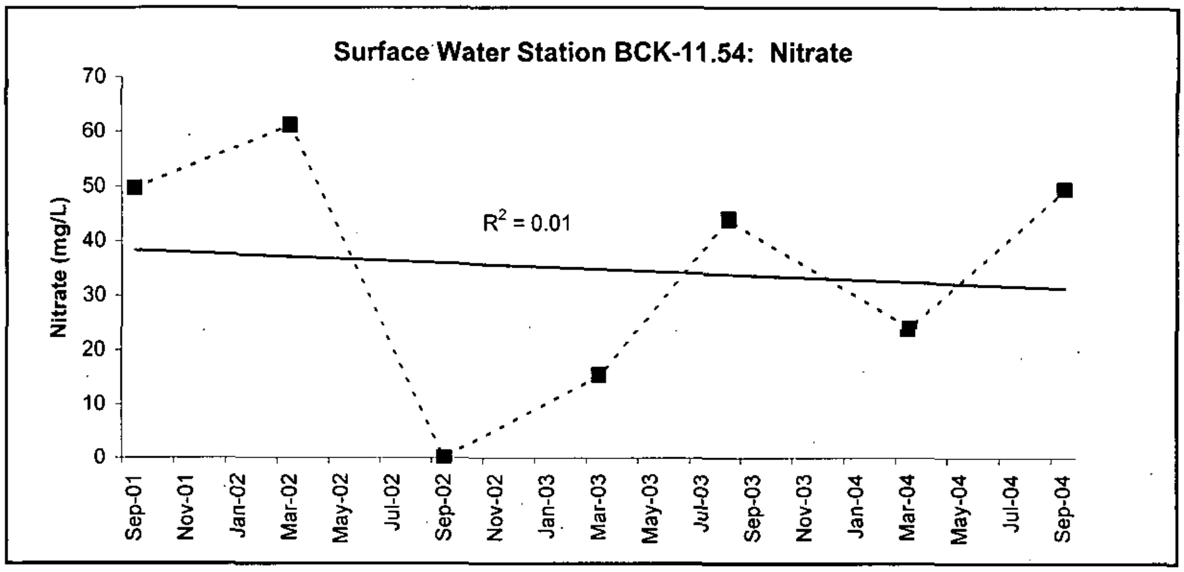


Figure 1

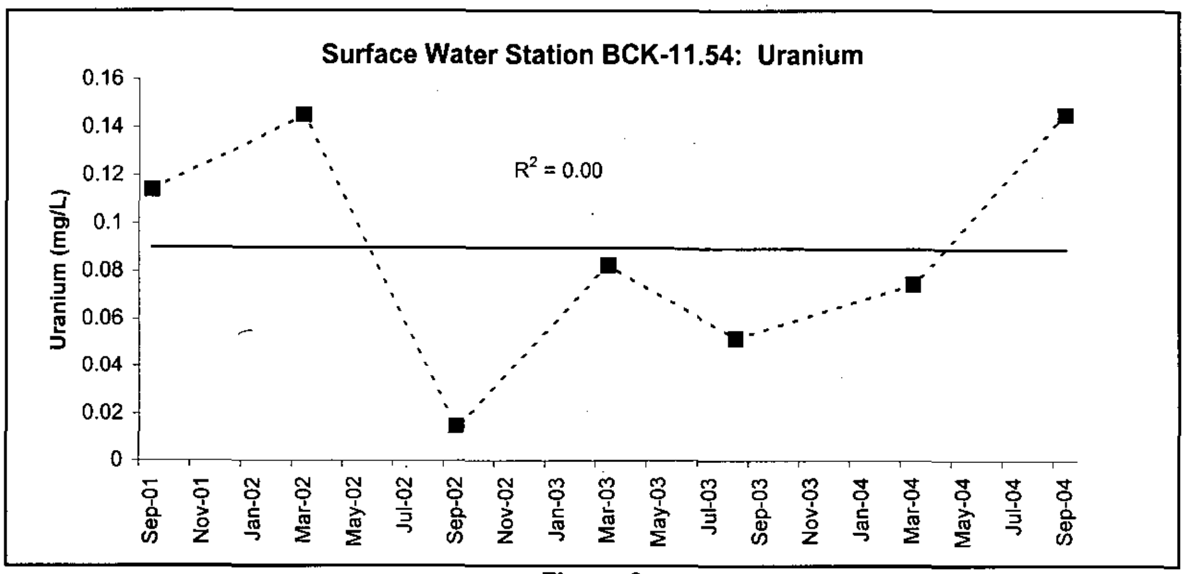


Figure 2

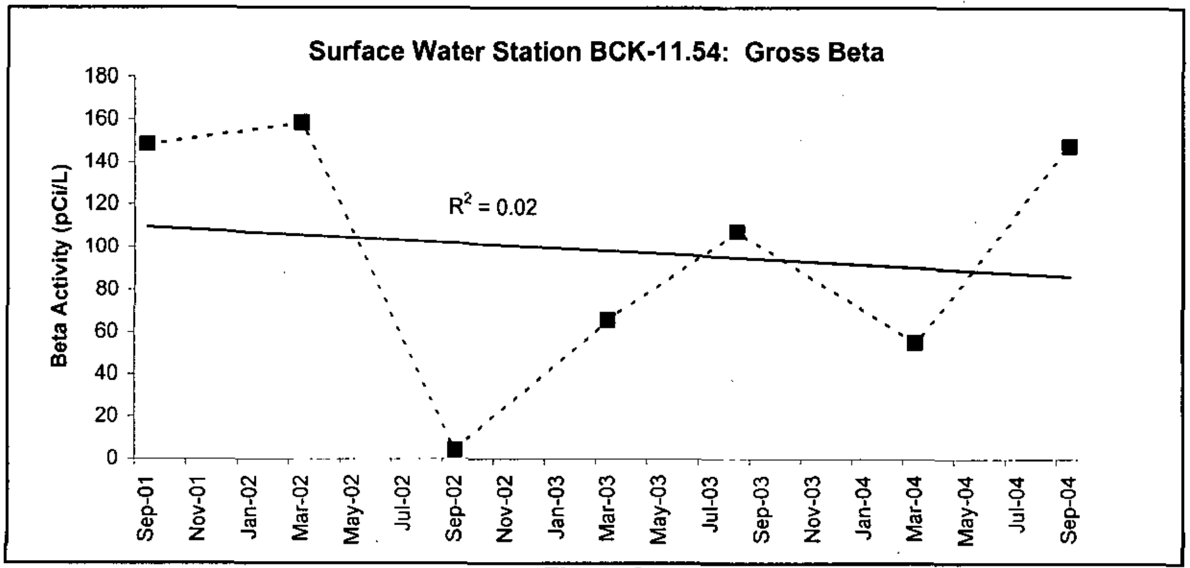


Figure 3

MAXIMUM CONCENTRATION: 2004

10 - 100	0.03 - 0.3	ND	.	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

BCK-11.84

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 48,710.00
Y-12 GRID NORTH COORDINATE: 29,480.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 6

First Date	Last Date
09/17/01	09/13/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/01/04	.	09/13/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	6	98.8 mg/L	09/17/01	Decreasing
URANIUM (0.03 mg/L):	6	0.195 mg/L	09/17/01	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	6	297.72 pCi/L	09/17/01	Decreasing

SURFACE WATER SAMPLING STATION
BCK-11.84

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, about 500 ft downstream (west-southwest) of the confluence between the creek channel and a northern tributary (NT) of the creek (NT-2). These tributaries are numbered in ascending order downstream from the headwaters of the creek near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward through a gap in Pine Ridge and flows into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-11.84).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Six (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 2001 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 428 – 1,380 mg/L;
- pH of 7.9 – 8.1 (field measurements);
- elevated concentrations of chloride (>60 mg/L) and sulfate (>40 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), and all these results exceed the drinking water MCL for nitrate (10 mg/L). A time series plot of nitrate results suggests a decreasing concentration trend (Figure 1). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 2,300 ft east-northeast of BCK-11-84, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters Bear Creek via discharge of nitrate-contaminated groundwater from the shallow karst network in the Maynardville Limestone and inflow of nitrate-contaminated surface water from two northern tributaries of Bear Creek (NT-1 and NT-2) that are primary discharge areas for nitrate-contaminated groundwater in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997).

4.2 URANIUM

All the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all but one of these results, including the historical maximum value (0.195 mg/L in September 2001), exceed the drinking water MCL for uranium (0.03 mg/L). A time series plot of uranium results shows a widely fluctuating indeterminate long term trend (Figure 2). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Uranium is one of the primary inorganic contaminants within the plume emplaced during historical operation of the former S-3 Ponds and, as with nitrate levels, the elevated uranium concentrations in Bear Creek at this surface water sampling station results from the upstream inflow of uranium-contaminated groundwater discharged from the Maynardville Limestone and uranium-contaminated surface water from the NT-1 catchment.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Instead of gross alpha activity, the surface water samples were analyzed for uranium isotopes. Analytical results, summarized below, show relatively high levels of U-234 and U-238 were detected in each sample.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
09/17/01	29.75	49.24
03/11/02	19.38	30.11
03/03/03	26.46	36.26
08/18/03	10.85	18.93
03/01/04	24.17	34.78
09/13/04	36.72	66.65

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects the upstream inflow of U-234/U-238 contaminated groundwater from the Maynardville Limestone and U-234/U-238 contaminated surface water from the NT-1 catchment.

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1) and all of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). A time series plot of the results for gross beta activity shows a generally decreasing long term trend (Figure 3). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Nevertheless, available analytical results, summarized below, show that the gross beta activity is mostly attributable to Tc-99, a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997).

Sampling Date	Tc-99 (pCi/L)
09/17/01	582
03/11/02	403.11
03/03/03	96.35
08/18/03	111.19
03/01/04	141.32
09/13/04	284.95

Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983). Based on the existing network of sampling locations (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in Bear Creek (and the Maynardville Limestone) closely mirrors that of nitrate. Thus, the elevated gross beta activity in Bear Creek at this surface water sampling station is a combined result of the upstream inflow of Tc-99 contaminated groundwater from the Maynardville Limestone and Tc-99 contaminated surface water from NT-1.

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-11.84: summary of results for nitrate, uranium, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Beta Activity (pCi/L)
09/17/01	98.8	0.195	297.72
03/11/02	88.8	0.109	222.91
03/03/03	26.4	0.101	95.88
08/18/03	50.8	0.0543	109.74
03/01/04	36.8	0.112	78.06
09/13/04	67.5	0.187	186.06
MCL	**10**	**0.03**	**50***
Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)			

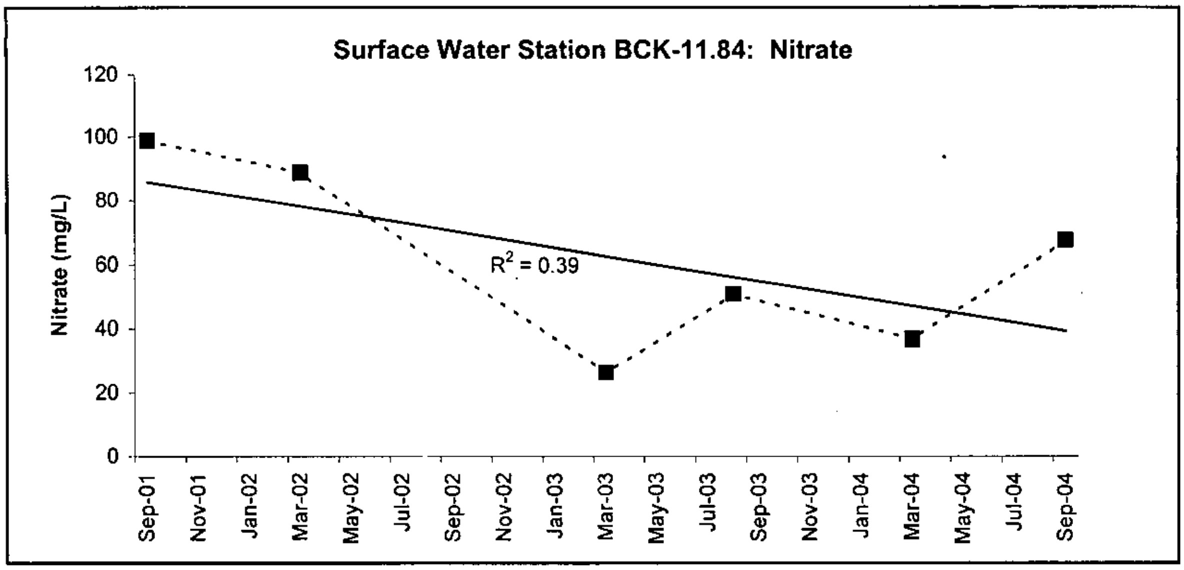


Figure 1

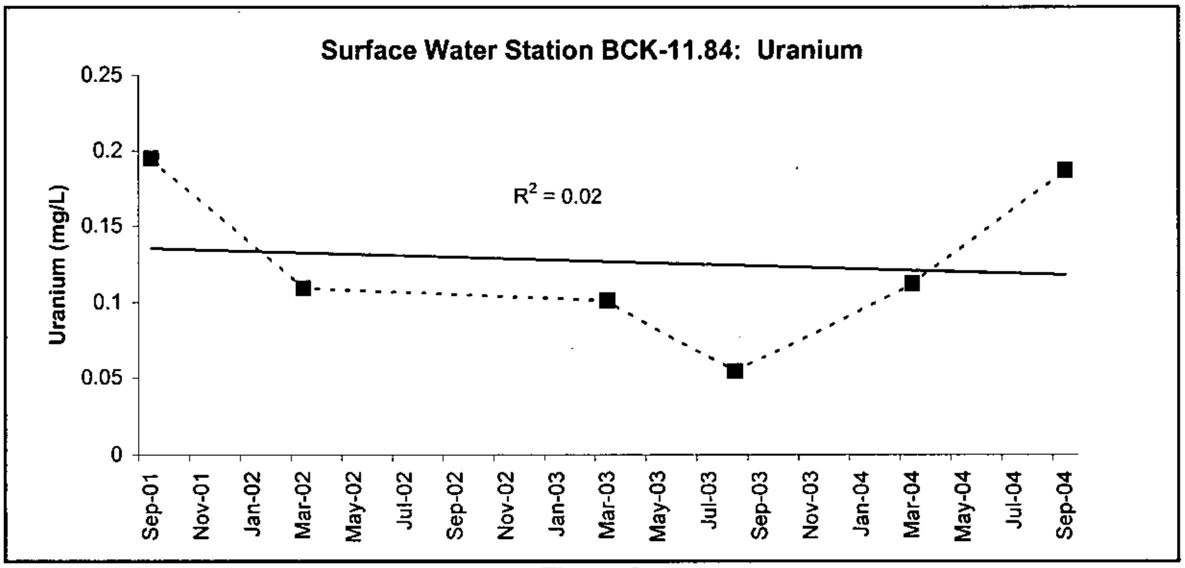


Figure 2

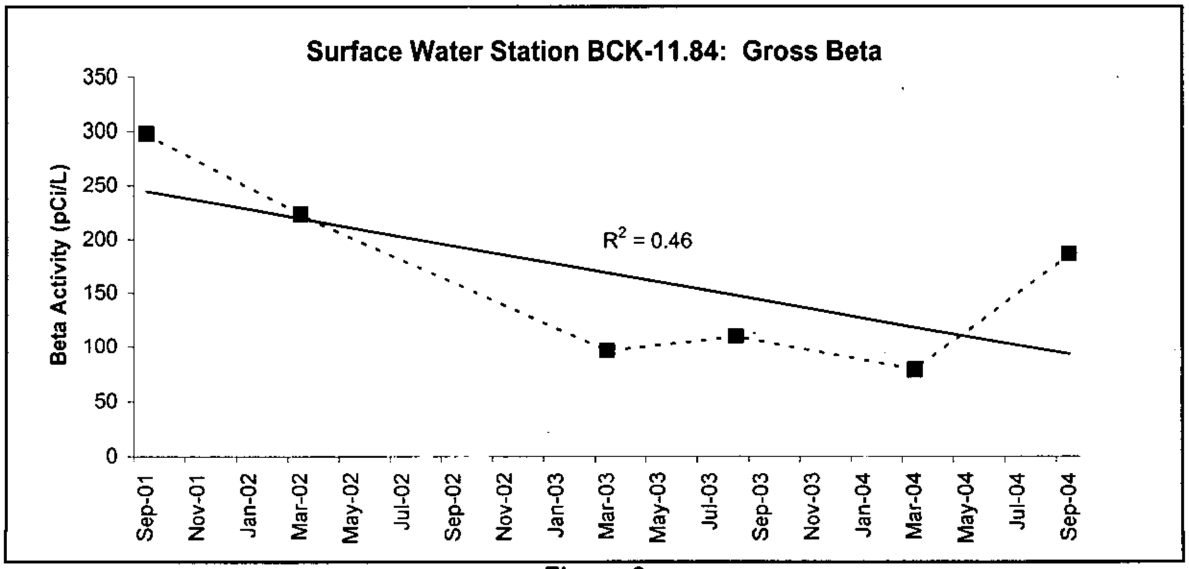


Figure 3

MAXIMUM CONCENTRATION: 2003

100 - 1,000	0.03 - 0.3	<5	15 - 150	50 - 500
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

BCK-11.97

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Bear Creek
Y-12 GRID EAST COORDINATE: 49,188.00
Y-12 GRID NORTH COORDINATE: 29,481.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 31

First Date	Last Date
08/30/90	07/29/03

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2003	01/30/03	.	07/29/03	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	27	257 mg/L	07/11/02	Indeterminate
URANIUM (0.03 mg/L):	27	0.324 mg/L	09/06/94	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	27	96 pCi/L	07/12/01	Indeterminate
GROSS BETA (50 pCi/L):	26	780 pCi/L	07/11/02	Indeterminate

SURFACE WATER SAMPLING STATION
BCK-11.97

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, immediately downstream (west-southwest) of the confluence between the creek channel and a northern tributary (NT) of the creek (NT-2), which are numbered in ascending order downstream from the headwaters of the creek near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward through a gap in Pine Ridge and flows into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-11.97).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-one (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 340 – 2,080 mg/L, excluding suspected outlier results reported for samples collected in August 1990 (22 mg/L) and January 2002 (6,380 mg/L);
- pH of 7.1 – 8.4 (field measurements);
- elevated concentrations of chloride (>100 mg/L), sodium (>60 mg/L), and sulfate (>30 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), and all these results exceed the drinking water MCL for nitrate (10 mg/L), ranging between the historical minimum and maximum values of 15.3 mg/L (August 1996) and 257 mg/L (July 2002). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 2,200 ft east-northeast of BCK-11.97, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters Bear Creek via discharge of nitrate-contaminated groundwater from the shallow karst network in the Maynardville Limestone and inflow of nitrate-contaminated surface water from two northern tributaries of Bear Creek (NT-1 and NT-2) that are primary discharge areas for nitrate-contaminated groundwater in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997).

A time-series plot of the nitrate results reported for the surface water samples shows an indeterminate long-term concentration trend dominated by wide (seasonal) concentration fluctuations (Figure 1). Also, these "peak" nitrate concentrations often are evident for samples collected during summer or fall, which shows that nitrate-contaminated groundwater provides the bulk of the baseflow in the upper reach of Bear Creek.

4.2 URANIUM

All the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1) and all of these results meet or exceed the drinking water MCL for uranium (0.03 mg/L), with the highest concentrations reported for the samples collected in September 1992 (0.31 mg/L) and February 1994 (0.324 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Uranium is a principal component of the contaminant plume emplaced during historical operation of the former S-3 Ponds and, as with nitrate levels, the elevated uranium concentrations at this surface water sampling station are the combined result of upstream inflow of uranium-contaminated groundwater from the Maynardville Limestone and uranium-contaminated surface water from the NT-1 and NT-2 catchments.

A time-series plot of the uranium results reported for the surface water samples shows an indeterminate long-term concentration trend dominated by wide (seasonal) concentration fluctuations (Figure 2). As with nitrate levels, the highest uranium concentrations were reported for samples collected during summer or fall, with conspicuous concentration "peaks" evident in

September 1992 (0.31 mg/L), September 1994 (0.324 mg/L), and August 2000 (0.207 mg/L). This too shows that contaminated groundwater baseflow provides the bulk of the flow in the upper reach of Bear Creek.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, low concentrations of PCE were detected in samples collected in February 1998 (1 μg/L), January 2001 (3 μg/L), and January 2003 (2 μg/L). Also, a trace level of 111TCA (0.4 μg/L) was detected in the sample collected in January 1991 and TCFM (1 μg/L) was detected in the sample collected in August 1998. The sporadic detection and low concentration of these compounds suggests that these results may be sampling or analytical artifacts.

4.4 GROSS ALPHA ACTIVITY

All of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 2), and all but one of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes are the source of the elevated gross alpha activity, which range between the historical minimum and maximum values of 12 pCi/L (February 1997) and 96 pCi/L (July 2001). Radiological analyses performed to data show uranium isotope concentrations ranging from 3.04 pCi/L (U-234) to 67 pCi/L (U-238). As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects the upstream inflow of U-234/U-238 contaminated groundwater from the Maynardville Limestone and U-234/U-238 contaminated surface water from the NT-1.

A time-series plot of the gross alpha activity reported for the surface water samples shows an indeterminate long-term concentration trend dominated by wide (seasonal) concentration fluctuations (Figure 3). These "peak" levels of gross alpha activity are indicated by results for samples collected during seasonally high flow (e.g., 63.9 pCi/L in March 1996) and seasonally low flow (e.g., 96 pCi/L in July 2001) in Bear Creek.

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 2) and all but one of these results substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples. Nevertheless, available analytical results show that the gross beta activity is mostly attributable to Tc-99 (Table 2), a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983). Based on the existing network of sampling locations (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in Bear Creek (and the Maynardville Limestone) closely mirrors that of nitrate. Thus, the elevated gross beta activity in Bear Creek at this surface water sampling station is a combined result of the upstream inflow of Tc-99-contaminated groundwater from the Maynardville Limestone and Tc-99-contaminated surface water from NT-1.

A time-series plot of the gross beta activity reported for the surface water samples shows an indeterminate long-term concentration trend dominated by wide (seasonal) concentration fluctuations (Figure 4). As with nitrate levels, the highest gross beta activity values were reported for samples collected during summer or fall, with conspicuous concentration "peaks" evident in September 1992 (368 pCi/L), July 1995 (600 pCi/L), and July 2002 (780 pCi/L). These results likewise show that contaminated groundwater provides the baseflow in the upper reach of Bear Creek.

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-11.97: summary of results for nitrate and uranium

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)
01/18/91	74	0.166
04/10/91	73	0.147
07/29/91	66	0.15
12/04/91	57	0.13
03/10/92	21.16	0.085
06/01/92	128.6	0.2
09/08/92	239	0.31
12/16/92	43	0.132
02/14/94	44.66	0.15
09/06/94	160	0.324
03/09/95	27	0.081
07/25/95	190	0.14
03/17/96	42.8	0.13
08/13/96	15.3	0.11
02/04/97	25.3	0.03
08/29/97	135	0.11
02/19/98	33.8	0.054
08/04/98	80.1	0.113
02/25/99	62.5	0.142
08/10/99	45.49	0.207
02/10/00	71.4	0.193
08/02/00	75.6	0.11
01/10/01	116	0.101
07/12/01	138	0.139
01/09/02	83.8	0.151
07/11/02	257	0.14
01/30/03	25.7	0.0646
07/29/03	117	0.154
MCL	**10**	**0.03**

Table 2. Surface Water Sampling Station BCK-11.97: summary of results for gross alpha activity, gross beta activity, and uranium isotopes

Date Sampled	Concentration (pCi/L)				
	Gross Alpha Activity	U-234	U-238	Gross Beta Activity	Tc-99
01/18/91	77.24	6.17	11.5	247.57	.
04/10/91	38.3	10.5	23.5	267.54	.
07/29/91	42.77	13.5	38.2	234.65	.
12/04/91	69	23	42.1	189	.
03/10/92	28.5	3.04	7.38	62.3	9.44
06/01/92	61.2	13.5	12.3	255	<CE
09/08/92	40.9	<CE	<CE	368	6.520
12/16/92	44.7	<CE	29.2	62.5	<CE
02/14/94	33.1	.	.	118	263
09/06/94	62	.	.	405	751
03/09/95	28.4	.	.	85.4	143
07/25/95	38.6	.	.	600	994
03/17/96	63.9	.	.	113	186
08/13/96	49.5	.	.	49.7	89.5
02/04/97	12	.	.	36	.
08/29/97	21	17	32	270	450
02/19/98	18	10	20	100	160
08/04/98	35	24	41	190	350
02/25/99	56	25	48	130	260
08/10/99	55	33	66	120	180
02/10/00	68	38	67	220	350
08/02/00	50	21	35	310	390
01/10/01	45	19	31	390	580
07/12/01	96	27	41	470	590
01/09/02	89	26	46	410	400
07/11/02	83	25	43	780	1,500
01/30/03	25	11	18	110	100
07/29/03	28	24	47	350	622
MCL	**15**	**Not Applicable**		**50***	**3,740***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

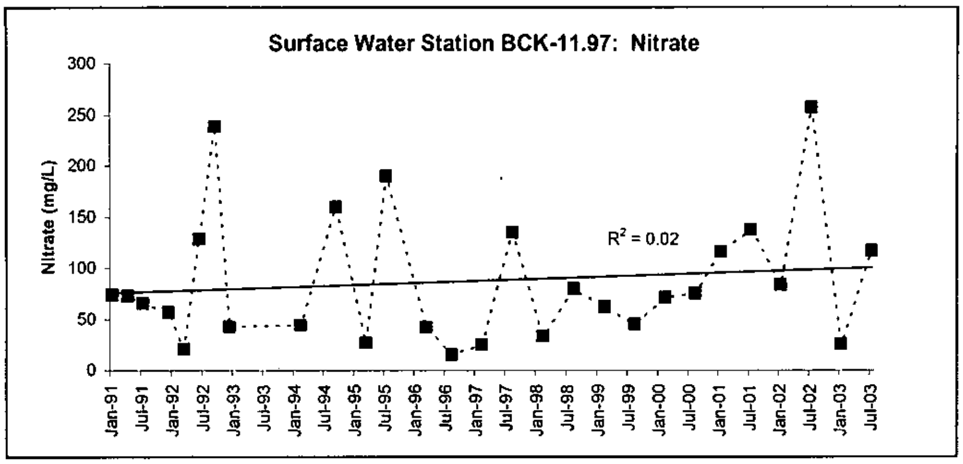


Figure 1

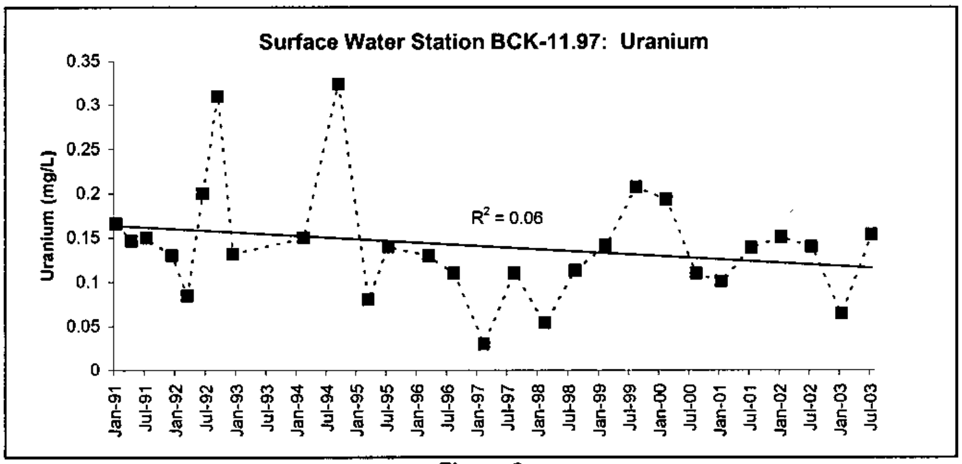


Figure 2

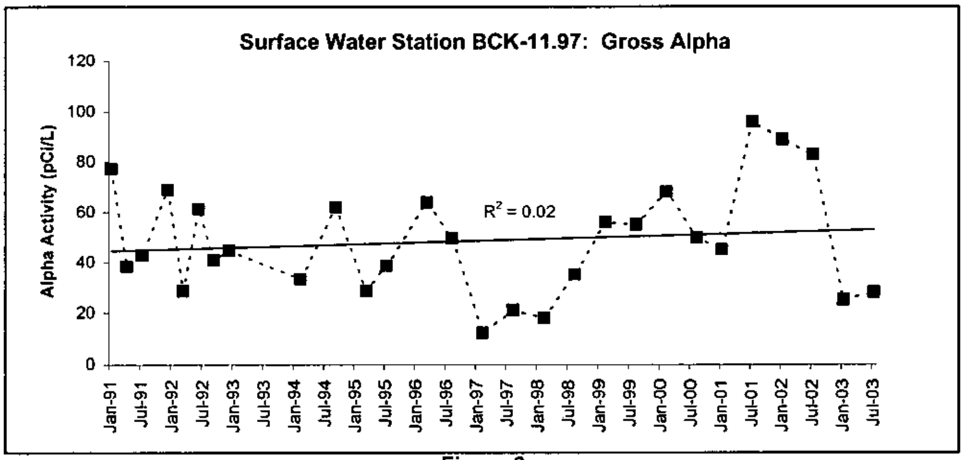


Figure 3

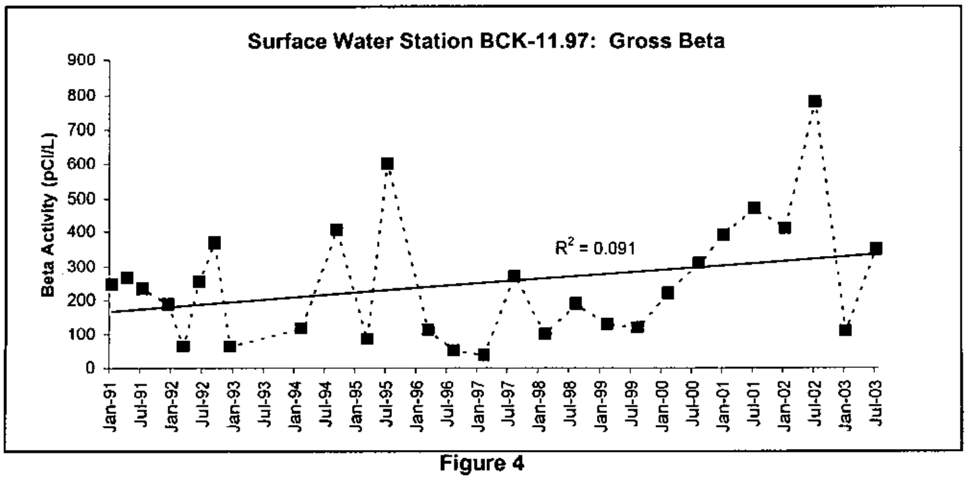


Figure 4

BCK-11.97

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	0.03 - 0.3	.	.	.

BCK-12.34

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Upper Bear Creek
Y-12 GRID EAST COORDINATE: 50,972.87
Y-12 GRID NORTH COORDINATE: 29,686.84
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 6

First Date	Last Date
03/21/01	11/02/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/12/04	06/02/04	07/26/04	11/02/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	2	141 mg/L	09/17/01	Indeterminate
URANIUM (0.03 mg/L):	4	0.281 mg/L	06/02/04	Indeterminate
SUMMED VOCs (5 µg/L):	1	6 µg/L	03/21/01	Indeterminate
GROSS ALPHA (15 pCi/L):	.	< pCi/L		
GROSS BETA (50 pCi/L):	.	< pCi/L		

SURFACE WATER SAMPLING STATION
BCK-12.34

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, just downstream (west-southwest) of the confluence between the creek channel and a northern tributary (NT) of the creek (NT-1). These tributaries are numbered in ascending order downstream from the headwaters of the creek near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles (7.2 km), where it turns northward through a gap in Pine Ridge and flows into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-12.34).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Six (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 2001 and the most recent sample collected in November 2004. This station is currently monitored as part of the remediation effectiveness evaluation under the BCV Phase I ROD, and the samples (collected quarterly) are analyzed only for total uranium. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on limited available data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.92 – 8.18 (field measurements);
- total concentrations of trace metals (except cadmium, manganese, and uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nitrate was detected in the two samples analyzed for nitrate (collected in March and September 2001), and concentrations (59.3 mg/L and 141 mg/L, respectively) were above the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 1,700 ft east-northeast of BCK-12.34, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters Bear Creek upstream of BCK-12.34 via discharge of nitrate-contaminated groundwater from the shallow karst network in the Maynardville Limestone and inflow of nitrate-contaminated surface water from a northern tributary of Bear Creek (NT-1) that is a primary discharge area for nitrate-contaminated groundwater in the Nolichucky Shale west of the former S-3 Ponds (DOE 1997).

4.2 URANIUM

The surface water samples collected in CY 2004 were analyzed for (total) uranium, and the concentration in each sample exceeded the drinking water MCL (0.03 mg/L) for uranium (Table 1). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Uranium is one of the primary inorganic contaminants within the plume emplaced during historical operation of the former S-3 Ponds and, as with nitrate levels, the elevated uranium concentrations in Bear Creek at this surface water sampling station result from the upstream inflow of uranium-contaminated groundwater discharged from the Maynardville Limestone and contaminated surface water from the NT-1 catchment.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, PCE was detected in the two surface water samples analyzed for VOCs, and the concentrations were slightly above and below the MCL (5 μg/L) for PCE (Table 1). As with nitrate and uranium, PCE is one of the contaminants within the plume emplaced during historical operation of the former S-3 Ponds and the elevated PCE concentrations in Bear Creek at this surface water sampling station result from the upstream inflow of contaminated groundwater discharged from the Maynardville Limestone and contaminated surface water from the NT-1 catchment.

4.4 GROSS ALPHA ACTIVITY

None of the six samples collected at this location were analyzed for gross alpha activity; however, two of the surface water samples were analyzed for uranium isotopes. Analytical results (Table 1) show that relatively high levels of U-234 and U-238 were detected in each sample. As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in Bear Creek primarily reflects the upstream inflow of U-234/U-238 contaminated groundwater from the Maynardville Limestone and contaminated surface water from the NT-1 catchment.

4.5 GROSS BETA ACTIVITY

None of the six samples collected at this location were analyzed for gross beta activity. However, two of the surface water samples were analyzed for Tc-99, a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds. Analytical results show that relatively high levels of Tc-99 were detected in each sample (Table 1).

Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983). Based on the existing network of sampling locations (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in Bear Creek (and the Maynardville Limestone) closely mirrors that of nitrate. Thus, the elevated Tc-99 activity in Bear Creek at this surface water sampling station is a result of the upstream inflow of contaminated groundwater from the Maynardville Limestone and contaminated surface water from the NT-1 catchment.

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil*. In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station BCK-12.34: summary of results for nitrate, uranium, PCE, U-234, U-238, and Tc-99

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	PCE (µg/L)	U-234 (pCi/L)	U-238 (pCi/L)	Tc-99 (pCi/L)
03/21/01	59.3	.	6	28.3	47.92	303
09/17/01	141	.	3 J	37.93	60.59	774
01/12/04	.	0.136	.	.	.	.
06/02/04	.	0.281	.	.	.	.
07/26/04	.	0.171	.	.	.	.
11/02/04	.	0.202	.	.	.	.
MCL	**10**	**0.03**	**5**	**NA**	**NA**	**NA**

Note: "." = Not analyzed; J = estimated value; NA = Not applicable

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	0.3 - 3.0	.	.	.

BCK-12.47

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Upper Bear Creek
Y-12 GRID EAST COORDINATE: 50,966.00
Y-12 GRID NORTH COORDINATE: 29,573.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 4

First Date	Last Date
01/12/04	11/02/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	01/12/04	06/02/04	07/26/04	11/02/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum (Results (since 1991) > Screening Level)	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	.	< mg/L		
URANIUM (0.03 mg/L):	4	0.628 mg/L	06/02/04	Indeterminate
SUMMED VOCs (5 μg/L):	.	< μg/L		
GROSS ALPHA (15 pCi/L):	.	< pCi/L		
GROSS BETA (50 pCi/L):	.	< pCi/L		

SURFACE WATER SAMPLING STATION
BCK-12.47

1.0 LOCATION

This surface water sampling station is located on the main channel of Bear Creek, about 400 ft upstream (west-southwest) of the confluence between the creek channel and a northern tributary (NT) of the creek (NT-1). These tributaries are numbered in ascending order downstream from the headwaters of the creek near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward through a gap in Pine Ridge and flows into East Fork Poplar Creek. Monitoring locations along the main channel of Bear Creek are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-12.47).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Four (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in January 2004 and the most recent sample collected in November 2004. This station is currently monitored as part of the remediation effectiveness evaluation under the BCV Phase I ROD, and the samples (collected quarterly) are analyzed only for total uranium. The grab sampling method was used to collect each sample. The grab sampling method was used to collect each sample.

3.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

The surface water samples collected at BCK-12.47 during CY 2004 were analyzed only for (total) uranium, and the concentration of each sample was more than an order-of-magnitude above the MCL for uranium (0.03 mg/L). The uranium concentrations ranged from 0.501 mg/L (November 2004) to 0.628 mg/L (June 2004). Although the pH of the water at this location is unknown, uranium probably occurs in the surface water as uranyl cations, which tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Uranium is one of the primary inorganic contaminants within the plume emplaced during historical operation of the former S-3 Ponds and the elevated uranium concentrations in Bear Creek at this surface water sampling station result from the upstream inflow of uranium-contaminated groundwater discharged from the Maynardville Limestone.

4.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	<5	.	.

EMWNT-03A

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: EMWMF - North Tributary 3, Bear Creek

Y-12 GRID EAST COORDINATE: 48,443.30

Y-12 GRID NORTH COORDINATE: 30,419.70

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 6

First Date	Last Date
09/11/03	12/02/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/09/04	06/08/04	09/02/04	12/02/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level: # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	.	. mg/L		
URANIUM (0.03 mg/L):	.	. mg/L		
SUMMED VOCs (5 µg/L):	1	6 µg/L	09/11/03	Indeterminate
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

SURFACE WATER SAMPLING STATION
EMWNT-03A

1.0 LOCATION

This surface water sampling station is located in the channel of a northern tributary (NT) of Bear Creek (NT-03), which are numbered in ascending order downstream of the creek headwaters, about 1,200 ft upstream of its confluence with the main creek channel. From the headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek.

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Six (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 2003 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample. Note that other samples have been collected at different frequencies and analyzed for different parameters to meet the requirements of the EMWMF Environmental Monitoring Plan (DOE 2001).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.5 and 8.7 (field measurements) and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in

UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The surface water samples were not analyzed for nitrate.

4.2 URANIUM

The surface water samples were not analyzed for uranium.

4.3 VOLATILE ORGANIC COMPOUNDS

Acetone was detected at low levels in two samples: 6 µg/L in September 2003 and 2 µg/L in June 2004. The significance of these results is questionable because acetone is a common laboratory reagent.

4.4 GROSS ALPHA ACTIVITY

The surface water samples were not analyzed for gross alpha activity.

4.5 GROSS BETA ACTIVITY

The surface water samples were not analyzed gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2001. *Remedial Design Report for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee, ES&H Plan*, Attachment B, Appendix 1, DOE/OR/01-1873&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

EMWNT-05

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: EMWMF - North Tributary 5, Bear Creek

ADMIN. GRID EAST COORDINATE: 45,764.20

ADMIN. GRID NORTH COORDINATE: 30,313.57

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
02/25/03	12/02/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/09/04	06/08/04	09/02/04	12/02/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	.	. mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
EMWNT-05

1.0 LOCATION

This surface water sampling station is located in the channel of a northern tributary (NT) of Bear Creek (NT-5), which are numbered in ascending order downstream from the creek headwaters near the west of Y-12, about 100 ft upstream of its confluence with the main channel of the creek. From the headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek.

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 2003 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample. Note that other samples have been collected at different frequencies and analyzed for different parameters to meet the requirements of the EMWMF Environmental Monitoring Plan (DOE 2001).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.7 – 8.9 (field measurements) and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in

UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The surface water samples were not analyzed for nitrate.

4.2 URANIUM

The surface water sample collected in May 2003 was analyzed for (total) uranium, and the result was below the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

The surface water sample collected in May 2003 was analyzed for gross alpha activity, and the result was below the applicable MDA.

4.5 GROSS BETA ACTIVITY

The surface water sample collected in May 2003 was analyzed for gross beta activity, and this result (2.6 pCi/L) was substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2001. *Remedial Design Report for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee, ES&H Plan*, Attachment B, Appendix 1, DOE/OR/01-1873&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

EMW-VWEIR

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: EMWMF - Outfall of the Retention Basin
ADMIN. GRID EAST COORDINATE: 45,667.89
ADMIN. GRID NORTH COORDINATE: 29,741.81
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 5

First Date	Last Date
02/25/03	12/02/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/09/04	.	.	12/02/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	.	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	7.8 µg/L	05/20/03	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
EMW-VWEIR

1.0 LOCATION

This surface water sampling station is located at a weir installed at the outfall of a storm-water retention basin on the southeast side of the Environmental Management Waste Management Facility (EMWMF). The EMWMF is located in Bear Creek Valley about one mile west of Y-12 and is an operating facility used for disposal of hazardous and mixed waste generated from CERCLA remedial action activities at sites located on the DOE Oak Ridge Reservation.

2.0 SAMPLING HISTORY

Five (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 2003 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample. Note that other samples have been collected at different frequencies and analyzed for different parameters to meet the requirements of the EMWMF Environmental Monitoring Plan (DOE 2001).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.4 – 8.6 (field measurements) and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

None of the surface water samples were analyzed for nitrate concentrations.

4.2 URANIUM

The surface water sample collected in May 2003 was analyzed for (total) uranium, and the result is below the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, a low concentration of acetone (7.8 µg/L) was detected in the sample collected in May 2003; this result is probably a sampling or analytical artifact.

4.4 GROSS ALPHA ACTIVITY

The surface water sample collected in May 2003 was analyzed for gross alpha activity, and this result (4.23 pCi/L in May 2003) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

The surface water sample collected in May 2003 was analyzed for gross beta activity, and this result (11.08 pCi/L) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2001. *Remedial Design Report for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee, ES&H Plan*, Attachment B, Appendix 1, DOE/OR/01-1873&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

ND	<0.015	ND	7.5 - 15	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

ET-4

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: White Wing Scrap Yard

Y-12 GRID EAST COORDINATE: 26,280.00

Y-12 GRID NORTH COORDINATE: 35,070.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 3

First Date	Last Date
01/18/01	03/04/03

SAMPLING DATES FOR CALENDAR YEAR:	2003
1st Qtr	03/04/03
2nd Qtr	.
3rd Qtr	.
4th Qtr	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
ET-4

1.0 LOCATION

This surface water sampling station is located on the channel of an unnamed eastern tributary (ET) of Bear Creek, about 2,000 ft upstream of its confluence with the main channel of the creek south of the White Wing Scrap Yard (WWSY). From the headwaters near the west end of Y-12, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek.

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Three (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in January 2001 and the most recent sample collected in March 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 44 – 104 mg/L;
- pH of 6.5 – 8.2 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Two surface water samples had nitrate concentrations above the applicable analytical reporting limit, and both results (0.36 mg/L in January 2001 and 0.1 mg/L in February 2001) are an order of magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

One surface water sample had a (total) uranium concentration above the applicable analytical reporting limit, and this result (0.0088 mg/L in March 2003) is an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Three surface water samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (7.81 pCi/L in March 2003) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Three surface water samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (8.8 pCi/L in March 2003) substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

GHK2.51ESW

LOCATION

HYDROGEOLOGIC REGIME: North of Pine Ridge
FUNCTIONAL AREA: Gum Hollow Branch
Y-12 GRID EAST COORDINATE: 39,870.00
Y-12 GRID NORTH COORDINATE: 34,751.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 10

First Date	Last Date
09/01/99	12/01/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/13/04	.	12/01/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
GHK2.51ESW

1.0 LOCATION

This surface water sampling station is located on the main channel of Gum Hollow Branch north of Pine Ridge on the DOE Oak Ridge Reservation (ORR) about two miles northwest of Y-12. Samples are collected from this location to provide data regarding the quality of surface water in Gum Hollow Branch where it exits the ORR and flows adjacent to the Country Club Estates community.

2.0 SAMPLING HISTORY

Ten (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 1999 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 95 – 226 mg/L;
- pH of 6.5 – 7.8 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nine surface water samples had nitrate concentrations above the applicable analytical reporting limit, and all of these results are less than 1 mg/L and are at least an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

One surface water sample had (total) uranium concentrations above the applicable analytical reporting limit, and this result (0.000889 mg/L in May 2001) is substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

A trace (2 μg/L) of carbon tetrachloride was detected in the surface water sample collected in September 1999; this result is probably a sampling or analytical artifact.

4.4 GROSS ALPHA ACTIVITY

One surface water sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (2.6 pCi/L in May 2003) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Two surface water samples had gross beta activity above the applicable MDA and corresponding CE, and both of these results (6.7 pCi/L in May 2001 and 7.4 pCi/L in May 2002) are substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

GHK2.51WSW

LOCATION

HYDROGEOLOGIC REGIME: North of Pine Ridge
FUNCTIONAL AREA: Gum Hollow Branch
Y-12 GRID EAST COORDINATE: 39,820.00
Y-12 GRID NORTH COORDINATE: 34,751.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 11

First Date	Last Date
09/01/99	12/01/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/13/04	.	12/01/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION GHK2.51WSW

1.0 LOCATION

This surface water sampling station is located on the main channel of Gum Hollow Branch north of Pine Ridge on the DOE Oak Ridge Reservation (ORR) about two miles northwest of Y-12. Samples are collected from this location to provide data regarding the quality of surface water in Gum Hollow Branch where it exits the ORR and flows adjacent to the Country Club Estates community.

2.0 SAMPLING HISTORY

Eleven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 1999 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 51 -153;
- pH of 6.3 – 7.8 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Eleven surface water samples had nitrate concentrations above the applicable analytical reporting limit, and all of these results are less than 1 mg/L and are at least an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Three surface water samples had (total) uranium concentrations above the applicable analytical reporting limit:, with the highest value (0.0012 mg/L in May 2003) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

None of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE.

4.5 GROSS BETA ACTIVITY

None of the surface water samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	ND	.	<7.5	<25

MCK 2.0

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: McCoy Branch
Y-12 GRID EAST COORDINATE: 57,090.00
Y-12 GRID NORTH COORDINATE: 26,210.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 12

First Date	Last Date
02/16/99	08/16/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/18/04	.	08/16/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	.	. µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	1	115.02 pCi/L	02/22/01	Outlier

SURFACE WATER SAMPLING STATION
MCK 2.0

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each drainage feature conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This surface water sampling station is located in the main channel of McCoy Branch, directly downstream of a wetland area constructed immediately south of the Filled Coal Ash Pond (FCAP).

The FCAP is a former settling basin formed by the construction of an earthen dam across the upper reach of McCoy Branch. Beginning in 1955, the basin received coal ash from the Y-12 Steam Plant that was pumped as slurry over the crest of Chestnut Ridge and gravity-drained into the basin. By 1967, the basin had filled with ash and the slurry was allowed to overtop the dam and flow down McCoy Branch into Rogers Quarry until 1989. Remedial action at the FCAP was completed in April 1997 in accordance with a CERCLA ROD approved in February 1996 (DOE 1996). As described in the remedial action report, CERCLA remedial actions at the FCAP included: (1) raising the crest of the dam, (2) removing large trees from and reinforcing the face of the dam; (3) installing a subsurface drain; (4) repairing the emergency spillway for the dam; (5) constructing a settling basin and oxygenation weir at the foot of the dam; and (6) replacing a small wetland area in McCoy Branch immediately downstream of the settling basin (DOE 1997). These remedial actions are intended to minimize the migration of contaminants into surface water, minimize direct contact of humans and animals with the ash, reduce the potential for failure of the dam, and preserve the local habitat over the long term (DOE 1996).

2.0 SAMPLING HISTORY

Twelve (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 90 – 477 mg/L;
- pH of 6.1 – 8.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except arsenic) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The surface water sample collected in February 1999 had nitrate above the applicable analytical reporting limit, and this result (0.6 mg/L) is an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

None of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

None of the samples were analyzed for VOCs.

4.4 GROSS ALPHA ACTIVITY

One surface water sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (1.6 pCi/L in February 2004) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

All of the surface water samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (115.02 pCi/L in February 2001) being substantially above the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). However, this result is an outlier when compared to the other results for gross beta activity, all of which are less than 10 pCi/L.

4.6 OTHER TRACE METALS

Analytical data for surface water samples collected in accordance with the ROD for the FCAP indicate that the wetlands constructed in McCoy Branch immediately upstream of this sampling station continue to be effective at reducing concentrations of arsenic, manganese, iron, and zinc in the influent to the wetlands, as indicated by analytical results for samples from MCK 2.05 (DOE 2004).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge ;Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/02-1410&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee,* DOE/OR/01-1596&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2004. *2004 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2133&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

.	ND	.	15 - 150	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

MCK 2.05

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: McCoy Branch .
Y-12 GRID EAST COORDINATE: 57,105.00
Y-12 GRID NORTH COORDINATE: 26,280.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 12

First Date	Last Date
02/16/99	08/16/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	02/18/04	.	08/16/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	.	. µg/L		
GROSS ALPHA (15 pCi/L):	2	112.59 pCi/L	02/22/01	Outlier
GROSS BETA (50 pCi/L):	1	273.06 pCi/L	02/22/01	Outlier

SURFACE WATER SAMPLING STATION
MCK 2.05

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each drainage feature conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This surface water sampling station is located in the main channel of McCoy Branch, directly upstream of a wetland area constructed immediately south of the Filled Coal Ash Pond (FCAP).

The FCAP is a former settling basin formed by the construction of an earthen dam across the upper reach of McCoy Branch. Beginning in 1955, the basin received coal ash from the Y-12 Steam Plant that was pumped as slurry over the crest of Chestnut Ridge and gravity-drained into the basin. By 1967, the basin had filled with ash and the slurry was allowed to overtop the dam and flow down McCoy Branch into Rogers Quarry until 1989. Remedial action at the FCAP was completed in April 1997 in accordance with a CERCLA ROD approved in February 1996 (DOE 1996). As described in the remedial action report, CERCLA remedial actions at the FCAP included: (1) raising the crest of the dam, (2) removing large trees from and reinforcing the face of the dam;; (3) installing a subsurface drain; (4) repairing the emergency spillway for the dam; (5) constructing a settling basin and oxygenation weir at the foot of the dam; and (6) replacing a small wetland area in McCoy Branch immediately downstream of the settling basin (DOE 1997). These remedial actions are intended to minimize the migration of contaminants into surface water, minimize direct contact of humans and animals with the ash, reduce the potential for failure of the dam, and preserve the local habitat over the long term (DOE 1996).

2.0 SAMPLING HISTORY

Twelve (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 190 – 322 mg/L;
- pH of 6.1 – 8.2 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except arsenic) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The surface water sample collected in February 1999 had nitrate above the applicable analytical reporting limit, and this result (0.1 mg/L) is two orders-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

None of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

None of the surface water samples were analyzed for VOCs.

4.4 GROSS ALPHA ACTIVITY

Five of the 12 surface water samples analyzed for gross alpha activity had results above the applicable MDA and corresponding CE, and two of these results were above the drinking water MCL for gross alpha activity (15 pCi/L). The highest value (112.59 pCi/L in February 2001) is an outlier when compared to other results for gross alpha activity, all of which are less than 6 pCi/L excluding the result for the sample collected in August 2004 (15.2 pCi/L), which probably reflects interferences from the high TSS (866 mg/L) reported for the sample.

4.5 GROSS BETA ACTIVITY

Twelve surface water samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (273 pCi/L in February 2001) being substantially above the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). However, this result is an outlier when compared to other results for gross beta activity, all of which are less than 18 pCi/L.

4.6 OTHER TRACE METALS

Analytical data for surface water samples collected in accordance with the ROD for the FCAP indicate that the wetlands constructed in McCoy Branch immediately downstream of this sampling station continue to be effective at reducing concentrations of arsenic, manganese, iron, and zinc in the effluent from the wetlands, as indicated by analytical results for samples from MCK 2.0 (DOE 2004). The arsenic concentrations in surface water samples at this station are typically about equal to the drinking water MCL for arsenic (0.05 mg/L), but two samples had sharply higher concentrations: 0.339 mg/L in August 2003 and 7.8 mg/L in August 2004. The August 2004 result, as with gross alpha activity, probably reflects interference from high TSS (866 mg/L) in the sample.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/02-1410&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/01-1596&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 2004. *2004 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2133&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	ND	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

NPR07.0SW

LOCATION

HYDROGEOLOGIC REGIME: North of Pine Ridge
FUNCTIONAL AREA: Tributary near Scarboro Community
Y-12 GRID EAST COORDINATE: 59,897.34
Y-12 GRID NORTH COORDINATE: 32,518.75
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 11

First Date	Last Date
09/01/99	12/01/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	.	04/13/04	.	12/01/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
NPR07.0SW

1.0 LOCATION

This surface water sampling station is on the main channel of an unnamed drainage feature located north of Pine Ridge, about 2,000 ft north of Y-12. Samples are collected from this location to provide data regarding the quality of surface water that drains from the north slope of Pine Ridge and flows into the Scarboro Community. The surface-water quality monitoring is performed by the Y-12 GWPP to provide data regarding potential health impacts from Y-12 operations.

2.0 SAMPLING HISTORY

Eleven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 2000 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 42 – 135 mg/L;
- pH of 5.8 – 7.7 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

One surface water sample had a nitrate concentration above the applicable analytical reporting limit (0.04789 September 2004); this result is substantially below the MCL.

4.2 URANIUM

None of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

One surface water sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (3.7 pCi/L in October 2002) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Two surface water samples had gross beta activity above the applicable MDA and corresponding CE, and both results (10 pCi/L in November 2001 and 9.8 pCi/L in October 2002) are substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	ND	ND	ND	ND

NPR12.0SW

LOCATION

HYDROGEOLOGIC REGIME: North of Pine Ridge

FUNCTIONAL AREA: Tributary near Scarboro Community

Y-12 GRID EAST COORDINATE: 57,202.90

Y-12 GRID NORTH COORDINATE: 32,566.40

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 11

First Date	Last Date
09/01/99	12/01/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	04/13/04	.	12/01/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
NPR12.0SW

1.0 LOCATION

This surface water sampling station is on the main channel of an unnamed drainage feature located in north of Pine Ridge, about 1,500 ft north of Y-12. Samples are collected from this location to provide data regarding the quality of surface water that drains from the north slope of Pine Ridge and flows into the Scarboro Community. The surface-water quality monitoring is performed by the Y-12 GWPP to provide data regarding potential health impacts from Y-12 operations.

2.0 SAMPLING HISTORY

Eleven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 1999 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 42 – 121 mg/L;
- pH of 5.8 – 7.6 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

One surface water sample had nitrate concentrations above the applicable analytical reporting limit, and this result (0.056 mg/L in September 1999) is several orders-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

One surface water sample had (total) uranium concentrations above the applicable analytical reporting limit, and this result (0.000572 mg/L) is several orders-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Two surface water samples had gross alpha activity above the applicable MDA and corresponding CE, and both results (3.5 pCi/L in November 2001 and 6.8 pCi/L in May 2002) are less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Two surface water samples had gross beta activity above the applicable MDA and corresponding CE, and both results (11 pCi/L in May 2002 and 6.9 pCi/L in October 2002) are substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

ND	ND	ND	<7.5	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

NPR23.0SW

LOCATION

HYDROGEOLOGIC REGIME: North of Pine Ridge
FUNCTIONAL AREA: Tributary near Scarboro Community
Y-12 GRID EAST COORDINATE: 49,980.89
Y-12 GRID NORTH COORDINATE: 34,378.71
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
05/09/01	12/01/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	.	04/13/04	.	12/01/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
NPR23.0SW

1.0 LOCATION

This surface water sampling station is on an upper reach of Mill Branch north of Pine Ridge, about one mile northwest of Y-12. Samples are collected from this location to provide data regarding the quality of surface water that drains from the north slope of Pine Ridge and flows into a residential area along Wiltshire Drive. The surface-water quality monitoring is performed by the Y-12 GWPP to provide data regarding potential off-site health impacts from Y-12 operations.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in May 2001 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 41 – 138 mg/L;
- pH of 6.6 – 7.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

None of the surface water samples had nitrate concentrations above the applicable analytical reporting limit.

4.2 URANIUM

None of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Three surface water samples had gross alpha activity above the applicable MDA and corresponding CE, and the highest result (4.4 pCi/L in April 2004) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

One surface water samples had gross beta activity above the applicable MDA and corresponding CE, and this result (6.1 pCi/L in May 2003) are substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

100 - 1,000	0.03 - 0.3	5 - 50	15 - 150	500 - 5,000
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

NT-01

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: North Tributary 1, Bear Creek
Y-12 GRID EAST COORDINATE: 50,585.00
Y-12 GRID NORTH COORDINATE: 29,720.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 37

First Date	Last Date
03/09/93	11/02/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/12/04	06/02/04	07/20/04	11/02/04

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	29	1180 mg/L	07/11/02	Increasing
URANIUM (0.03 mg/L):	15	0.32 mg/L	10/13/97	Indeterminate
SUMMED VOCs (5 µg/L):	20	70 µg/L	07/12/01	Increasing
GROSS ALPHA (15 pCi/L):	17	150 pCi/L	07/11/02	Increasing
GROSS BETA (50 pCi/L):	30	6000 pCi/L	07/11/02	Increasing

SURFACE WATER SAMPLING STATION
NT-01

1.0 LOCATION

This surface water sampling station is in a northern tributary (NT) of Bear Creek (NT-1) immediately upstream of its confluence with the main creek channel. Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries trend northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). Upstream of this sampling station, the channel of NT-1 traverses an undeveloped area about 1,200 ft west of the former S-3 Ponds.

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-seven (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 1993 and the most recent sample collected in November 2004. The grab sampling method was used to collect each sample. Note that numerous surface water samples have been collected for other monitoring programs, including CERCLA monitoring performed at the former S-3 Ponds.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 290 – 7,540 mg/L;
- pH of 6.1 – 7.6 (field measurements);
- elevated concentrations of chloride (>200 mg/L), potassium (>10 mg/L), sodium (>60 mg/L), and sulfate (>20 mg/L); and
- total concentrations of several trace metals, including barium, cadmium, manganese, strontium, and uranium, that substantially exceed the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Thirty of the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1). The one non-detect value (<0.02 mg/L) reported for the sample collected in March 1996 is an outlier when compared to the other nitrate results, all of which exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds. Located at the headwaters of Bear Creek near the west end of Y-12, the S-3 Ponds were four contiguous, unlined surface impoundments used from 1951 to 1984 for the infiltration/evaporation of several million gallons of nitric acid wastes generated at Y-12. Now covered with a multilayer low-permeability cap constructed in 1988, the former S-3 Ponds emplaced a heterogeneous mixture of inorganic, organic, and radiological contamination in the underlying Nolichucky Shale. Nitrate is a primary component of the plume and is transported in the shallow groundwater system to the south toward Bear Creek and to the west, parallel with geologic strike, toward discharge areas in NT-1 and NT-2 (DOE 1997). Additionally, nitrate in the deeper (>150 ft bgs) groundwater flow/transport pathways in the Nolichucky Shale moves westward along strike and, under vertically upward hydraulic gradients, enters the shallow flow system and ultimately discharges into NT-1 and NT-2. Thus, elevated nitrate concentrations in the surface water at this sampling station result from the upstream discharge of nitrate-contaminated groundwater into NT-1.

Excluding the non-detect result noted above, the nitrate concentrations reported for the surface water samples show a wide range, with six results below 50 mg/L and three results above 500 mg/L, including the historical maximum value of 1,180 mg/L in July 2002 (Table 1). A time-series plot of these nitrate results shows a generally increasing long-term concentration trend dominated by wide seasonal concentration fluctuations (Figure 1). Also, these "peak" nitrate concentrations often are evident for samples collected during summer or fall, which shows that inflow of nitrate-contaminated groundwater from the Nolichucky Shale provides baseflow in NT-1.

4.2 URANIUM

Thirty-four of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with 15 samples having concentrations above the drinking water MCL for uranium (0.03 mg/L). Considering the pH of the samples (see Section 3.0), uranium probably occurs in the surface water as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble, mobile complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Uranium is a principal component of the contaminant plume emplaced during historical operation of the former S-3 Ponds. As with nitrate levels, the elevated uranium concentrations in the surface water in NT-1 are attributable to the upstream inflow of uranium-contaminated groundwater from the Nolichucky Shale.

A time-series plot of the uranium results reported for the surface water samples shows an indeterminate long-term concentration trend dominated by wide seasonal concentration fluctuations (Figure 2). As with nitrate levels, the highest uranium concentrations were reported for samples collected during summer or fall (dry season), as illustrated by the conspicuous concentration "peaks" evident in October 1997 (0.32 mg/L), August 1998 (0.149 mg/L), and July 2002 (0.132 mg/L). This too shows that inflow of contaminated groundwater from the Nolichucky Shale provides baseflow in NT-1 and that the uranium concentrations evident in samples collected during winter and spring (wet season) reflect dilution from uncontaminated (or less contaminated) recharge.

4.3 VOLATILE ORGANIC COMPOUNDS

At least one of the following VOCs was detected in 28 of the surface water samples: acetone, chloroform, methylene chloride, PCE, TCE, and c12DCE (Table 2). Each compound is a confirmed component of the contaminant plume emplaced during historical operation of the former S-3 Ponds. Like nitrate and uranium, the presence of these compounds in the surface water in NT-1 (and NT-2) results from the discharge of VOC-contaminated groundwater in the Nolichucky Shale west of the site.

Based on the detection frequency and concentration, PCE is the primary VOC in the surface water samples (Table 2). This compound was detected in all but three of the samples, with concentrations above the drinking water MCL for PCE (5 μg/L) reported for 18 samples. A time-series plot of the PCE results shows a generally increasing concentration trend (Figure 3). The other compounds are detected much less frequently, with one or more of these VOCs detected (excluding false positive results) in only seven of the samples and all of the results being estimated values below 5 μg/L (Table 2).

4.4 GROSS ALPHA ACTIVITY

Twenty-seven of the surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), and results for 17 of the samples exceed the drinking water MCL for gross alpha activity (15 pCi/L). The contaminant plume emplaced during historical operation of the former S-3 Ponds includes several alpha-particle emitting radionuclides, including uranium isotopes. Radiological analyses performed to date, summarized below, confirm the presence of U-234 and U-238 in the surface water samples.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
02/20/98	1.64	3.33
07/29/98	32.16	68.55
01/55/01	55	84
07/12/01	18	37

As with total uranium, the presence of uranium isotopes in the surface water at this sampling location in NT-1 reflects the upstream inflow of uranium-contaminated groundwater from the Nolichucky Shale.

A time-series plot of the gross alpha activity reported for the surface water samples shows a slightly increasing long-term concentration trend dominated by wide short-term concentration fluctuations (Figure 4). These "peak" levels of gross alpha activity are indicated by results for samples collected during seasonally low flow (e.g., 150 pCi/L in July 2002) and seasonally high flow (e.g., 120 pCi/L in January 2001). Thus, the short-term changes in gross alpha activity do not appear to be directly related to groundwater seasonal flow conditions.

4.5 GROSS BETA ACTIVITY

Thirty-one of the surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1) and all but one of these results substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Indeed, the one result below 50 pCi/L (18.1 pCi/L in March 1995) appears to be an outlier compared to the other results for gross beta activity. Although uranium isotopes (and related beta-particle emitting daughter products) contribute to the level of gross beta activity in the surface water samples, available analytical results, summarized below, show that the gross beta activity is mostly attributable to Tc-99, a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (DOE 1997).

Sampling Date	Tc-99 (pCi/L)
03/09/93	<CE
05/03/93	<CE
08/16/93	1,120
11/08/93	708
02/14/94	458
09/07/94	786
03/09/95	165
07/25/95	956
03/18/96	313
08/13/96	107
11/10/97	2,440
12/01/97	541
01/10/01	280
07/12/01	5,900

Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile (Gee et al. 1983). Thus, the elevated gross beta activity in the surface water samples from NT-01 reflect the upstream inflow of Tc-99 contaminated groundwater from the Nolichucky Shale.

A time-series plot of the gross beta activity reported for the surface water samples shows a generally increasing long-term concentration trend dominated by wide seasonal concentration fluctuations (Figure 5). As with nitrate levels, the highest gross beta activity values were reported for samples collected during summer or fall (dry season), as illustrated by the conspicuous concentration "peaks" evident in July 2001 (4,400 pCi/L), July 2002 (6,000 pCi/L; the historical maximum value for NT-01), and July 2002 (1,000 pCi/L). These results indicate that contaminated groundwater provides the baseflow in the upper reach of Bear Creek and that the gross beta activity reported for samples collected during winter and spring (wet season) reflect dilution from uncontaminated (or less contaminated) recharge.

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station NT-01: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
03/09/93	112	0.012	8.78	63.6
05/03/93	31	0.031	16.3	64.4
08/16/93	286.1	0.18	45.5	384
11/08/93	259	0.185	72.8	318
02/14/94	83.62	0.013	6.26	166
09/07/94	228	0.03	8.11	364
03/09/95	34	0.008	< CE	18.1
07/25/95	170	0.047	23.5	694
03/18/96	<0.2	0.014	11.7	173
08/13/96	24.7	0.012	11.5	67.8
02/03/97	25.3	0.004	<MDA	71
10/13/97	382	0.32	100	920
10/31/97	408	0.05	70	940
11/10/97	318	0.0346	63	747
12/01/97	88.7	0.0179	22	318
01/02/98	206	0.0202	68	637
02/06/98	34.1	<0.004	14	247
02/19/98	63.5	0.0058	<MDA	180
08/05/98	252	0.149	45	500
02/25/99	141	0.00927	6.4	220
08/11/99	520.2	0.0672	23	500
02/10/00	217	0.0166	12	450
08/02/00	48.6	0.14	51	230
01/10/01	81.7	0.254	120	230
07/12/01	1,110	0.117	90	4,400
01/09/02	479	0.0286	20	970
07/11/02	1,180	0.132	150	6,000
01/30/03	40.3	0.00475	6.2	160
07/29/03	378	0.0568	<MDA	1,000
01/12/04	.	0.012	.	.
01/27/04	52.8	0.00575	3.9	170
06/02/04	.	0.026	.	.
07/20/04	183	0.0315	17	600
07/26/04	.	0.0266	.	.
11/02/04	.	0.0225	.	.
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Surface water station NT-01: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	c12DCE	MC	Chloroform	TCE	Acetone
03/09/93	4 J	.	FP	.	.	.
05/03/93	1 J	.	FP	.	.	3 J
08/16/93	2 J	.	FP	.	.	.
11/08/93	3 J	.	.	.	.	.
02/14/94	4 J	.	FP	.	.	.
09/07/94	6	.	.	.	.	.
03/09/95	2 J	.	.	.	.	.
07/25/95	6	.	.	.	.	.
03/18/96	4 J	.	.	.	2 J	.
08/13/96	1 J	.	.	.	.	.
10/13/97	19	1 J	.	.	1 J	FP
10/31/97	38	.	.	.	.	.
11/10/97	34	.	.	.	.	.
12/01/97	14	.	.	.	.	.
01/02/98	25	.	.	.	.	.
02/06/98	7	.	.	.	.	.
02/19/98	7	.	.	.	.	FP
08/05/98	6	.	.	.	.	FP
02/25/99	5	.	.	.	.	.
02/10/00	4 J	.	.	.	.	.
01/10/01	8	.	.	.	.	.
07/12/01	62	2 J	3 J	3 J	.	.
01/09/02	62	2 J	4 J	.	.	.
07/11/02	58	2 J	3 J	2 J	.	.
01/30/03	9	.	.	.	.	.
07/29/03	59	1 J	2 J	1 J	.	.
01/27/04	12	.	.	.	.	.
07/20/04	25	.	.	.	.	.
MCL	**5**	**70**	**5**	**NA**	**5**	**NA**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; FP = false positive result; NA = Not applicable

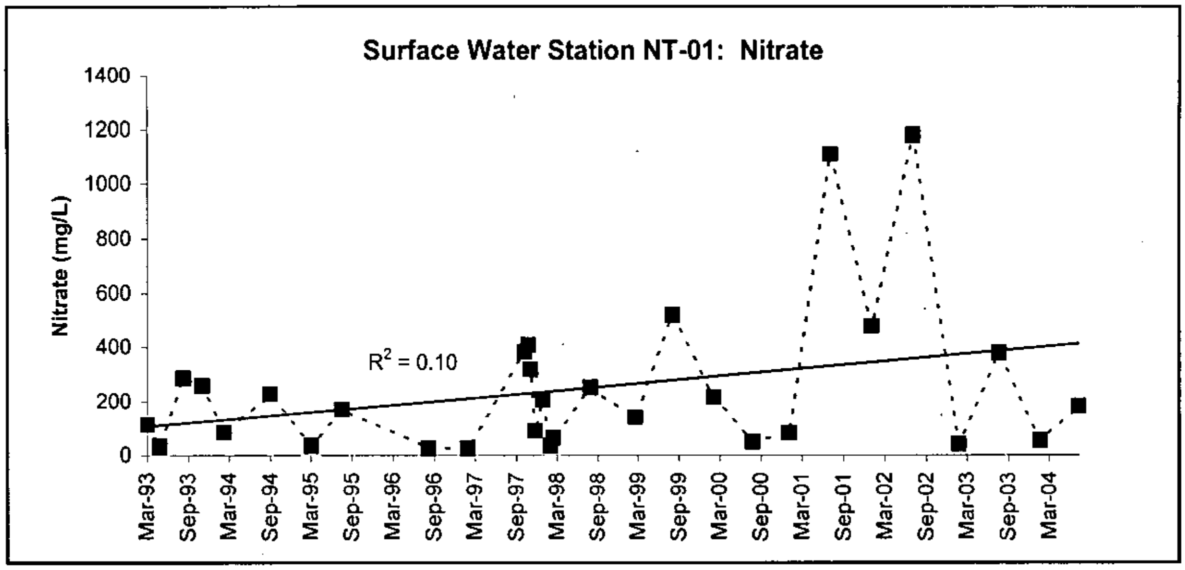


Figure 1

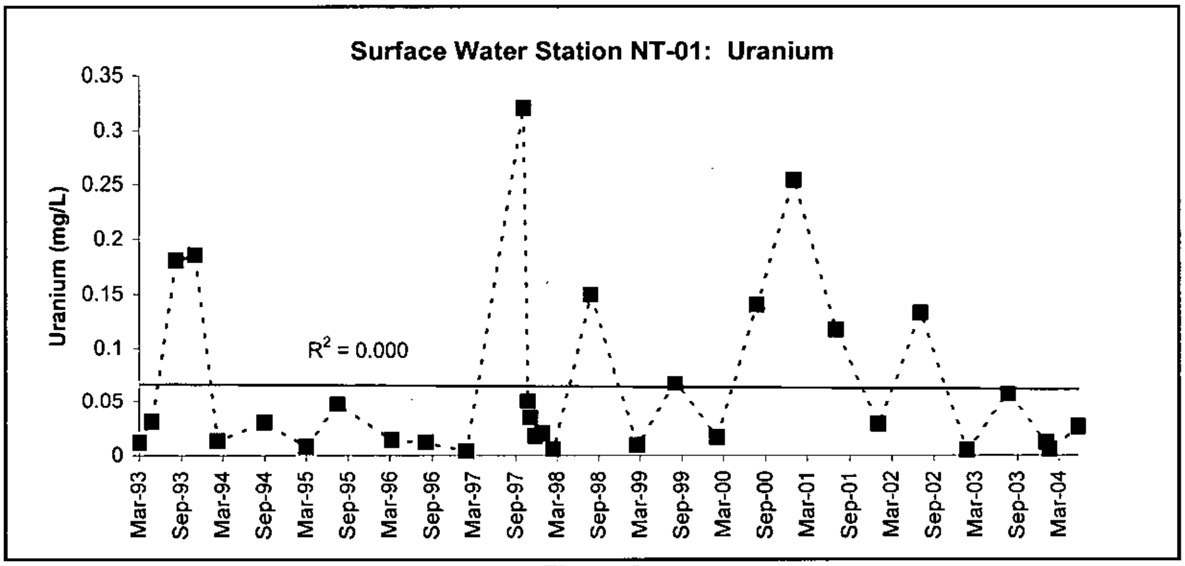


Figure 2

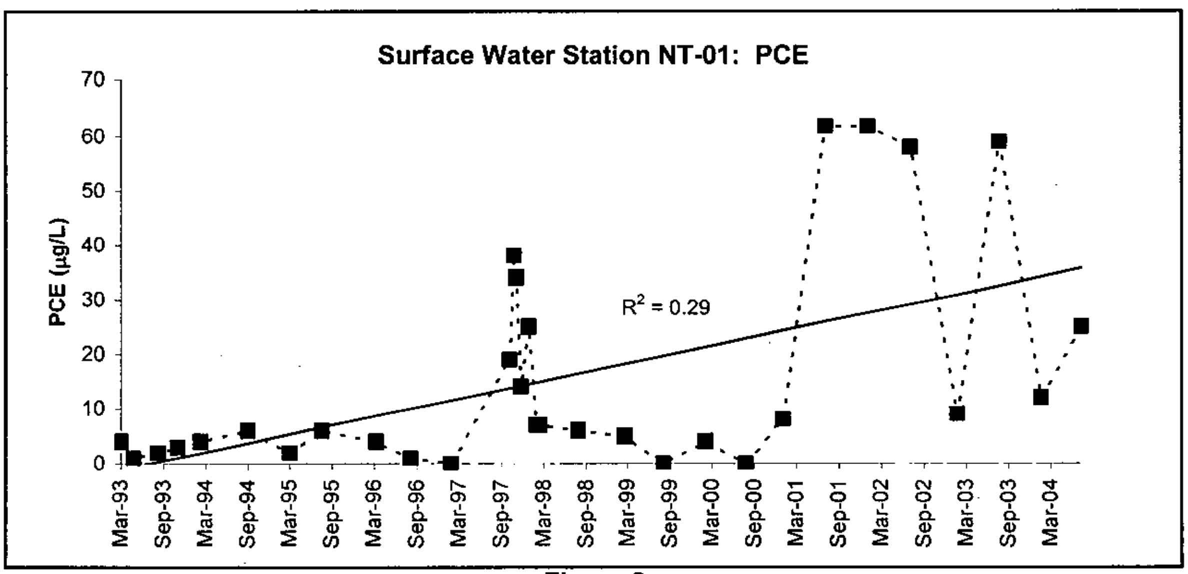


Figure 3

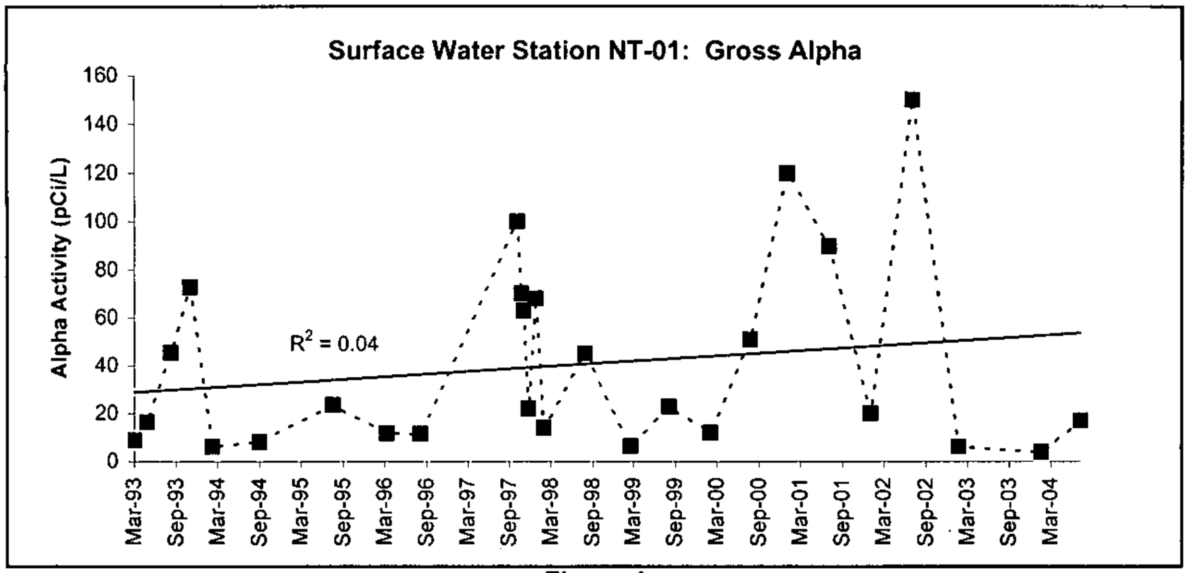


Figure 4

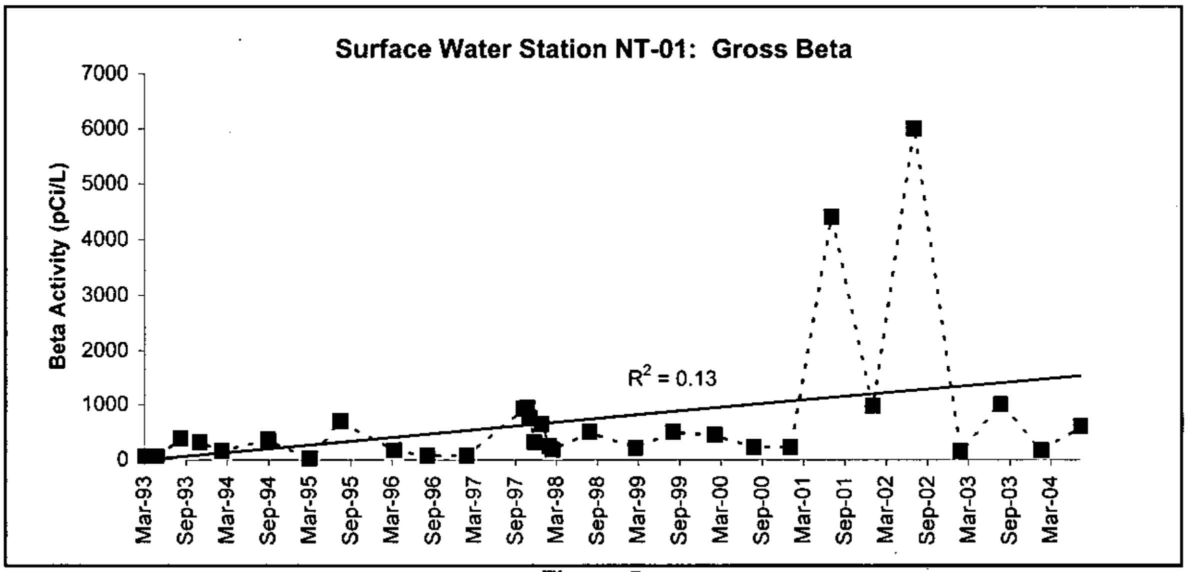


Figure 5

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	.	ND	.	.

NT-03

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: North Tributary 3, Bear Creek

ADMIN. GRID EAST COORDINATE: 48,094.14

ADMIN. GRID NORTH COORDINATE: 29,452.57

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 9

First Date	Last Date
04/18/97	09/13/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/01/04	.	09/13/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	.	. mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	2	445.99 pCi/L	06/25/98	Indeterminate
GROSS BETA (50 pCi/L):	2	200.05 pCi/L	06/25/98	Indeterminate

SURFACE WATER SAMPLING STATION NT-03

1.0 LOCATION

This surface water sampling station is located in a northern tributary (NT) of Bear Creek (NT-3) immediately upstream of its confluence with the main creek channel. Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries trend northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). Upstream of this sampling station, the channel of NT-3 traverses the east-central section of the Oil Landfarm waste management area. Additionally, a section of tributary channel upstream of the NT-03 sampling station was extensively modified and reconstructed during CERCLA remedial action at the Boneyard/Burnyard (BYBY) (see Section 4.2).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Major springs along the south side (SS) of Bear Creek, which are numbered in ascending order downstream from the headwaters (e.g., SS-1) and occur along the Maynardville Limestone/Copper Ridge Dolomite boundary, dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main creek channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Nine (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 1997 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

In addition to sampling performed to meet the surveillance monitoring objectives of the Y-12 GWPP, samples have been collected to date for the purposes of other monitoring programs, including flow proportionate composite sampling performed in accordance with the Phase I ROD for the Bear Creek watershed (DOE 2000).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 5.8 – 8.6 (field measurements) and

- total concentrations of several trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Four samples had nitrate concentrations above the applicable analytical reporting limit, with very low concentrations (<1 mg/L) that are an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

The surface water samples were not analyzed for total uranium.

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Two of the surface water samples were analyzed for gross alpha activity and both results (264 pCi/L in April 1997 and 445.99 pCi/L in June 1998) substantially exceed the drinking water MCL for gross alpha activity (15 pCi/L). Results of radiological analyses performed to date, summarized below, confirm the presence of U-234 and U-238 in the surface water samples.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
04/18/97	78	159
06/25/98	179.6	378.2
12/30/98	599.9	1,267
03/12/01	131.8	286.1

The source of the uranium isotopes is the former BYBY. A CERCLA remedial action at the site, completed in March 2003, involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes in June 2002; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater by December 2002; and the reconstruction of a section of the Bear Creek tributary (NT-3) that drains surface runoff from the site by March 2003 (BJC 2003).

4.5 GROSS BETA ACTIVITY

Two of the surface water samples were analyzed for gross beta activity and both results (190 pCi/L in April 1997 and 200.05 pCi/L in June 1998) substantially exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Uranium isotopes (and related beta-particle emitting daughter products) are the primary source of the gross beta activity in the surface water samples. Additionally, available analytical results, summarized below, show that the gross beta activity is probably not attributable to Tc-99, a beta-emitting radionuclide that is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds (DOE 1997).

Sampling Date	Tc-99 (pCi/L)
03/21/01	58.66
03/11/02	30.16
03/03/03	<MDA
08/18/03	<MDA
03/01/04	<MDA
09/13/04	<MDA

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

NT-04

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: EMWMF - North Tributary 4, Bear Creek
ADMIN. GRID EAST COORDINATE: 46,744.05
ADMIN. GRID NORTH COORDINATE: 29,540.03
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
02/25/03	12/02/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/09/04	06/08/04	09/02/04	12/02/04

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	.	. mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	5.5 µg/L	05/20/03	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
NT-04

1.0 LOCATION

This surface water sampling station is located in a northern tributary (NT) of Bear Creek (NT-4) about 270 ft upstream of its confluence with the main creek channel. Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries trend northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). Upstream of the NT-04 sampling station, the channel of NT-4 drains the EMWMF and meanders between the western side of the Oil Landfarm waste management area and the Above Ground Low Level Storage Facility. A French drain installed to bypass surface water drainage from Pine Ridge and to lower the water table beneath the EMWMF discharges groundwater into NT-4 upstream of the sampling location.

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 2003 and the most recent sample collected in December 2004. The grab sampling method was used to collect each sample.

In addition to sampling performed to meet the surveillance monitoring objectives of the Y-12 GWPP, samples have been collected to date for the purposes of other monitoring programs, including flow proportionate composite sampling performed in accordance with the Phase I ROD for the Bear Creek watershed (DOE 2000).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data for the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.0 – 8.2 (field measurements) and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The surface water samples were not analyzed for nitrate.

4.2 URANIUM

One surface water sample was analyzed for (total) uranium concentrations, and this result (0.00781 mg/L in May 2003) is more than an order-of-magnitude lower than the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, a low concentration (5.5 μg/L) of c12DCE was detected in the surface water sample collected in May 2003.

4.4 GROSS ALPHA ACTIVITY

One surface water sample was analyzed for gross alpha activity, and this result (4.66 pCi/L in May 2003) is below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

One surface water sample was analyzed for gross beta activity, and this result (5.23 pCi/L in May 2003) is substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	50 - 500	.	.

NT-07

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	North Tributary 7, Bear Creek
Y-12 GRID EAST COORDINATE:	42,914.00
Y-12 GRID NORTH COORDINATE:	29,070.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	CERCLA
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	16	04/03/97	09/14/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	03/02/04	.	09/14/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	15	638 µg/L	01/25/00	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
NT-07

1.0 LOCATION

This surface water sampling station is located in a northern tributary (NT) of Bear Creek (NT-7) immediately upstream of its confluence with the main creek channel. Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries trend northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). Upstream of this sampling station, the channel of NT-7 traverses the west-central section of the Bear Creek Burial Grounds (BCBG) waste management area (WMA).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite contact on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Sixteen (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 1997 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 146 – 470 mg/L;
- pH of 6.1 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Seven surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (0.31 mg/L in January 2000) being an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Ten surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, with a historical maximum value of 0.0275 in September 2001. Although less than the drinking water MCL for uranium (0.03 mg/L), these uranium concentrations exceed the range of background levels in BCV. Wastes disposed at the BCBG are known sources of uranium and other inorganic (and organic) contaminants present in the surface water in the northern tributaries of Bear Creek (NT-6, NT-7, and NT-8) that drain the WMA (DOE 1997). Uranium leached from the wastes enters the shallow groundwater and is transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features (e.g., NT-7). Thus, the uranium concentrations in the surface water at this sampling station reflect the upstream inflow of contaminated groundwater into NT-7.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs were detected in 15 of the groundwater samples: chloroform, chloromethane, PCE, TCE, VC, 11DCA, 12DCA, 12DCE (c12DCE), and 111TCA (Table 1). These compounds are all components of the groundwater contaminant plume emplaced during historical operation of the BCBG WMA. Dissolved VOCs in the shallow groundwater are transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features (e.g., NT-7). Thus, the presence of VOCs in the surface water at this sampling station is a result of the upstream inflow of VOC-contaminated groundwater into NT-7.

Based on the detection frequency, the primary VOCs in the surface water samples are PCE, TCE, 11DCA, and 12DCE (Table 1). These compounds were each detected in all but six of the samples, with respective historical maximum values of 99 µg/L, 74 µg/L, 25 µg/L, and 410 µg/L. The most recent sampling results (September 2004) show PCE and TCE concentrations below their respective 5 µg/L MCL for drinking water. Chloroform, chloromethane, VC, 11DCE, 12DCE, and 111TCA were detected less frequently; chloromethane and 12DCA were detected in only one sample (Table 1). Additionally, the bulk of the results for these compounds are estimated values below 5 µg/L, with concentrations above 10 µg/L reported only for VC (22 µg/L in January 2000).

A times-series plot of summed concentrations of VOCs detected (excluding false positive results) in each applicable surface water sample (some samples were not analyzed for VOCs) shows a generally decreasing long-term trend dominated by wide (seasonal) concentration fluctuations

(Figure 1). Note that these "peak" concentrations typically are represented by summed VOC concentrations determined for samples collected during winter and spring (wet season). Indeed, all of the summed VOC concentrations that are below 100 µg/L were determined for samples collected during summer and fall (dry season). This suggests greater inflow of VOC-contaminated groundwater into NT-7 during seasonally high flow conditions.

4.4 GROSS ALPHA ACTIVITY

Five of the surface water samples (collected April 1997 through March 1999) were analyzed for gross alpha activity, and all of these results are less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Five of the surface water samples (collected April 1997 through March 1999) were analyzed for gross beta activity, and all of these results are less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface water station NT-07: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	TCE	12DCE (Total)	c12DCE	11DCE
04/03/97	99	71	300	NR	.
08/22/97	60	40	150	NR	6
02/18/98	24	15	71	NR	3 J
07/17/98	9	8	49	NR	.
02/02/99	17	13	60	60	2 J
03/02/99	28	21	82	82	3 J
07/29/99	.	.	.	.	.
01/25/00*	92	74	410	410	7 J
08/17/00	6	6	36	36	.
03/22/01	29	21	87	87	3
09/18/01	1 J	2 J	10	10	.
03/13/02	28	23	85	85	3
03/04/03	40	32	120	120	5
08/19/03	12	12	66	66	1 J
03/02/04	22	17	58	58	3 J
09/14/04	2 J	3 J	17	17	.
MCL	**5**	**5**	**NA**	**70**	**7**

Date Sampled	Concentration (µg/L)				
	VC	11DCA	111TCA	Chloroform	Other
04/03/97	.	22	.	.	.
08/22/97	7	15	10	4 J	.
02/18/98	6	7	3 J	2 J	.
07/17/98	.	3 J	1 J	.	.
02/02/99	3	5 J	2 J	1 J	.
03/02/99	3	7	3 J	.	.
07/29/99	.	.	.	.	.
01/25/00*	22	25	.	8 J	.
08/17/00	.	3 J	.	.	.
03/22/01	1 J	8	3 J	2 J	.
09/18/01	.	1 J	.	.	.
03/13/02	3	8	2 J	1 J	Chloromethane = 2 J
03/04/03	5	11	3 J	3 J	12DCA = 1 J
08/19/03	.	6	1 J	1 J	.
03/02/04	4	7	1 J	1 J	.
09/14/04	.	2 J	.	.	.
MCL	**2**	**NA**	**200**	**NA**	**.**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported; * = sample diluted (5X) before analysis

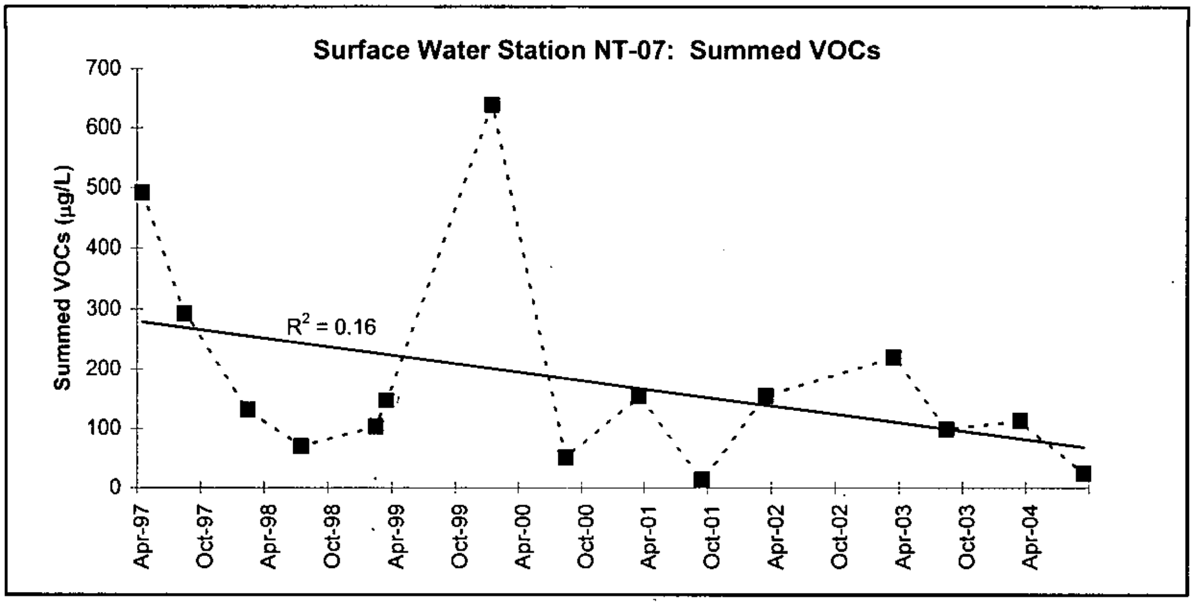

Surface Water Station NT-07: Summed VOCs
Summed VOCs (µg/L)
700
600
500
400
300
200
100
0
R^2 = 0.16
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04

Figure 1

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	0.3 - 3.0	50 - 500	.	.

NT-08

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: North Tributary 8, Bear Creek

Y-12 GRID EAST COORDINATE: 41,426.00

Y-12 GRID NORTH COORDINATE: 28,779.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 16

First Date	Last Date
04/03/97	09/14/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/02/04	.	09/14/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	10	0.442 mg/L	01/25/00	Decreasing
SUMMED VOCs (5 µg/L):	14	900 µg/L	07/17/98	Decreasing
GROSS ALPHA (15 pCi/L):	4	140 pCi/L	03/02/99	Indeterminate
GROSS BETA (50 pCi/L):	2	60.22 pCi/L	02/18/98	Indeterminate

SURFACE WATER SAMPLING STATION NT-08

1.0 LOCATION

This surface water sampling station is located immediately upstream of the confluence of the main channel of Bear Creek and a the northern tributary (NT) of the creek (NT-8). Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries trend northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). About 600 ft upstream of its confluence with Bear Creek, the main channel of NT-8 splits into eastern and western branches, both of which extend northeast toward the northwest section of the Bear Creek Burial Grounds (BCBG) waste management area (WMA).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Sixteen (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 1997 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 109 – 560 mg/L;
- pH of 6.3 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nine surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (5.4 mg/L in August 2000) being below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Ten surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all of these results exceed the drinking water MCL for uranium (0.03 mg/L). Wastes disposed at the BCBG are known sources of uranium and other inorganic (and organic) contaminants present in the surface water in the northern tributaries of Bear Creek (NT-6, NT-7, and NT-8) that drain the WMA (DOE 1997). Uranium leached from the wastes enters the shallow groundwater and is transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features. Because much of the main channel of NT-8 is more than 1,000 ft west of the waste disposal sites within the BCBG, the uranium probably enters the tributary via contaminated groundwater discharged into the headwaters of the tributary, which extend within a few hundred feet of the waste disposal areas within the northwest section of the BCBG. Moreover, the uranium concentrations reported for samples of surface water from the eastern branch of the tributary headwaters (sampling station NT-8-E) are higher than evident in samples of the surface water from the western branch of the tributary headwaters (sampling station NT-8-W). This suggests that inflow of uranium-contaminated groundwater into the eastern headwaters channel may be the principal source of the uranium evident downstream at the NT-08 surface water sampling station.

As shown by a time-series plot of available uranium concentrations (Figure 1), a generally decreasing concentration trend is indicated by the uranium results obtained to date. The uranium concentration reported for the sample collected in September 2004 (0.201 mg/L) is about 50 % lower than the concentration reported for the sample collected in January 2000 (0.442 mg/L; the historical maximum value).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs were detected in each of the groundwater samples: benzene, chloroform, PCE, TCE, 12DCE, 11DCE, VC, 111TCA, 12DCA, and 11DCA (Table 1). These compounds are all components of the groundwater contaminant plume emplaced during historical operation of the BCBG WMA. Dissolved VOCs in the shallow groundwater are transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features (e.g., NT-8). Thus, the presence of VOCs in the surface water at this sampling station is a result of the upstream inflow of VOC-contaminated groundwater into NT-8.

Based on the detection frequency and concentration levels, the primary VOCs in the surface water samples are PCE, TCE, 12DCE, and 11DCA (Table 2). These compounds were each detected in all but three of the samples, with respective historical maximum values of PCE (56 µg/L in July 1998), TCE (39 µg/L in July 1998), and c12DCE (200 µg/L in February 1999) exceeding respective drinking water MCLs. The most recent sampling results (September 2004) show concentrations of these compounds below their respective MCLs. Benzene, chloroform, 11DCE, VC, 11DCA, and 111TCA were detected less frequently, and the bulk of the results for these compounds are estimated values below 5 µg/L, with the highest concentration of 11DCE (7 µg/L) and VC (16 µg/L) exceeding respective MCLs (Table 2).

A time-series plot of the summed concentration of VOCs detected in surface water samples collected at NT-08 shows a generally decreasing long-term trend with a concentration "spike" (898 µg/L) in July 1998 and fairly steady concentrations since March 1999 (Figure 2).

4.4 GROSS ALPHA ACTIVITY

Five of the surface water samples (collected April 1997 through March 1999) were analyzed for gross alpha activity, and all but one of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L), including the historical maximum value (140 pCi/L in March 1999). In addition to or in lieu of gross alpha activity, thirteen of the samples were analyzed for uranium isotopes and these analytical results, summarized below, confirm that the elevated gross alpha activity is attributable to U-234 and U-238.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
04/03/97	7.1	31
08/22/97	19.49	50.22
02/18/98	15.77	91
07/17/98	1.54	6.59
02/02/99	16.75	137.6
07/29/99	19.48	73.32
01/25/00	32.16	154.9
08/17/00	34.45	109.3
03/22/01	17.35	99.46
09/18/01	9.41	29.36
03/13/02	17.83	90.59
03/04/03	32.46	121.3
08/18/03	26.05	71.68
03/02/04	14.61	101.6
09/14/04	14.67	50.83

As with uranium and VOCs in the surface water, the uranium isotopes are leached from sources within the BCBG WMA and are transported in the shallow groundwater toward discharge areas in nearby surface drainage features (e.g., NT-8). Thus, the presence of uranium isotopes in the surface water at this sampling station reflects the upstream inflow of contaminated groundwater into NT-8. Moreover, based on sampling results for surface water sampling stations located in the eastern and western headwaters channel of NT-8, higher levels of U-234 and U-238 in the easternmost channel (sampling station NT-8-E) compared to the westernmost channel (sampling station NT-8-W) suggest greater relative discharge of radiologically-contaminated groundwater into the easternmost channel, which borders the northwest side of the BCBG WMA.

4.5 GROSS BETA ACTIVITY

Five of the surface water samples (collected April 1997 through March 1999) were analyzed for gross beta activity, and two of these results exceed the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the MCL for gross beta activity): 52.9 pCi/L in August 1997 and 60.22 pCi/L in February 1998. As with gross alpha activity, the elevated levels of gross beta activity are attributable to uranium isotopes (and beta-particle emitting daughter products).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface water sampling station NT-08: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
04/03/97	.	.	26	18
08/22/97	.	.	54.09	52.9
02/18/98	.	.	88.61	60.22
07/17/98	.	.	5.84	7.04
03/02/99	0.54	0.35	140	44
01/25/00	2.5	0.442	.	.
08/17/00	5.4	0.238	.	.
03/22/01	2.3	0.315	.	.
09/18/01	0.063	0.271	.	.
03/13/02	0.045	0.361	.	.
03/04/03	<0.02	0.394	.	.
08/18/03	0.077	0.186	.	.
03/02/04	0.11	0.354	.	.
09/14/04	.035	0.201	.	.
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Surface water station NT-08: summary of VOC results

Date Sampled	Concentration (µg/L)					
	PCE	TCE	12DCE (Total)	c12DCE	11DCE	VC
04/03/97	31	18	29	NR	.	.
08/22/97	38	24	32	NR	9	16
02/18/98	18	11	16	NR	5 J	11
07/17/98	56	39	72	NR	14	14
02/02/99	23	15	200	200	5	11
03/02/99	11	7	83	83	2 J	3
07/29/99	4 J	3 J	48	48	.	.
01/25/00	12	8	100	100	2 J	5
08/17/00	.	.	4 J	4 J	.	.
03/22/01	9	6	79	79	2 J	.
09/18/01	.	.	2 J	2 J	.	.
03/13/02	11	6	66	66	1 J	1 J
03/04/03	15	9	82	82	2 J	3
08/18/03	4 J	2 J	29	29	.	.
03/02/04	8	5	46	46	1 J	.
09/14/04	1 J	1 J	9	9	.	.
MCL	**5**	**5**	**NA**	**70**	**7**	**2**

Date Sampled	Concentration (µg/L)				
	11DCA	111TCA	12DCA	Chloroform	Benzene
04/03/97	19	.	.	.	.
08/22/97	24	7	.	3 J	2 J
02/18/98	11	3 J	1 J	1 J	1 J
07/17/98	36	9	5 J	5	.
02/02/99	13	3 J	1 J	2 J	1 J
03/02/99	5	.	.	.	.
07/29/99	3 J	.	.	.	.
01/25/00	6	.	.	1 J	.
08/17/00	.	.	.	.	.
03/22/01	5	.	.	.	.
09/18/01	.	.	.	.	.
03/13/02	4 J	.	.	.	.
03/04/03	6	1 J	1 J	.	.
08/18/03	2 J	.	.	.	.
03/02/04	3 J	.	.	.	.
09/14/04	.	.	.	.	.
MCL	**NA**	**200**	**5**	**NA**	**5**

Note: "." = Not detected; J = Estimated value below the analytical reporting limit; NA = Not applicable; NR = Not reported

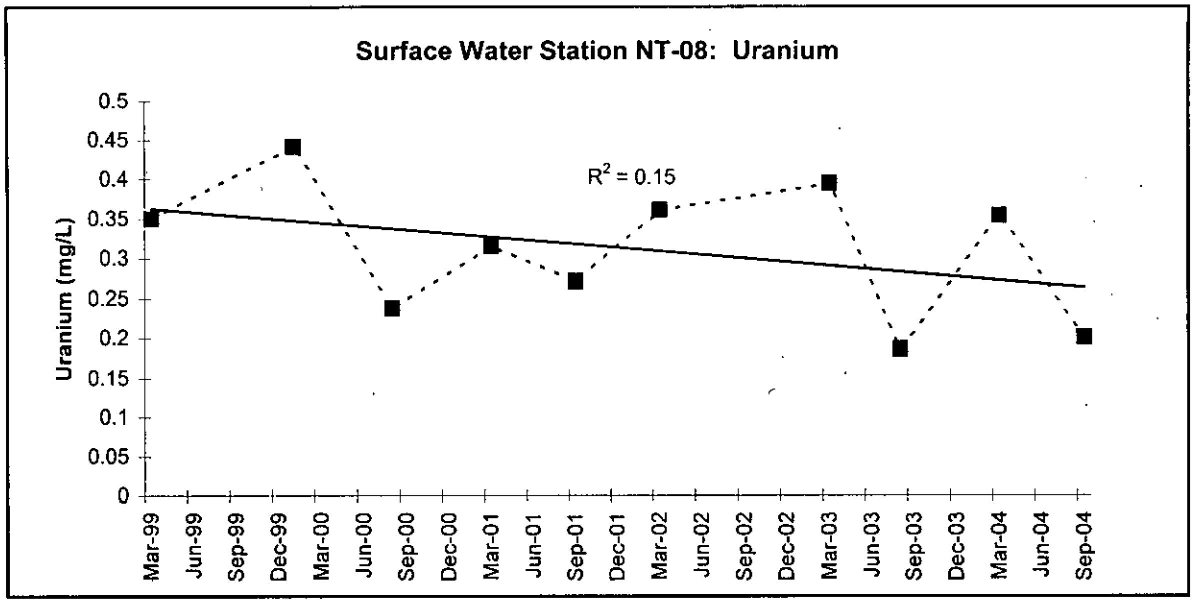


Figure 1

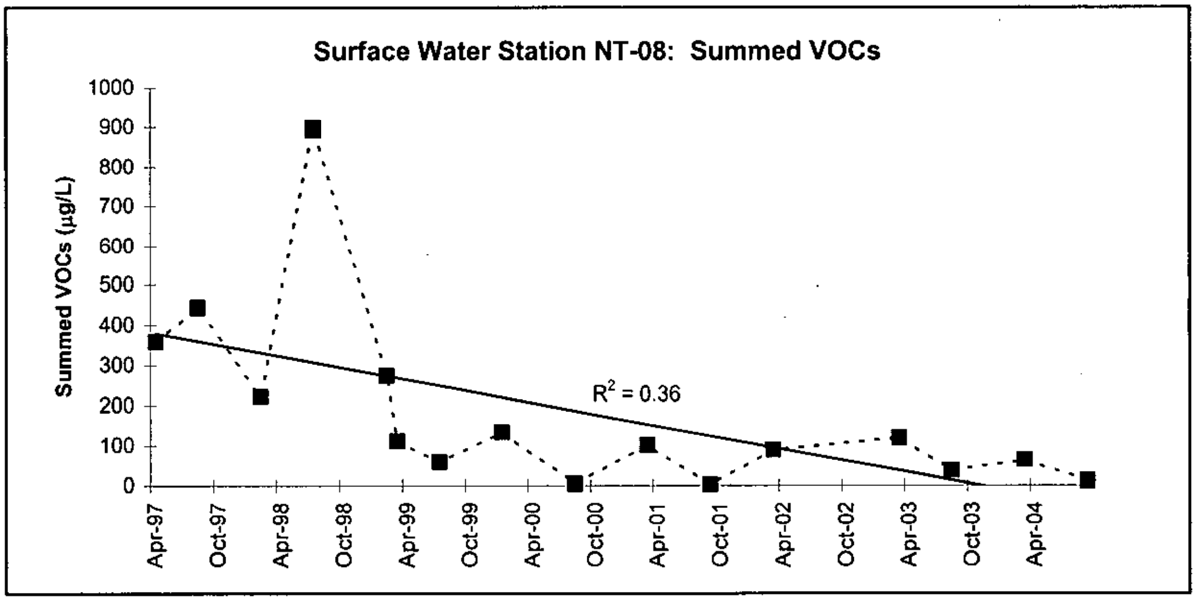


Figure 2

MAXIMUM CONCENTRATION: 2003

<5	0.3 - 3.0	ND	.	.
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

NT-8-E

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Eastern Headwaters of North Tributary 8
Y-12 GRID EAST COORDINATE: 42,154.00
Y-12 GRID NORTH COORDINATE: 29,798.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 5

First Date	**Last Date**
03/22/01	08/19/03

SAMPLING DATES FOR CALENDAR YEAR:		**1st Qtr**	**2nd Qtr**	**3rd Qtr**	**4th Qtr**
	2003	03/04/03	.	08/19/03	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	**Results (since 1991) > Screening Level** # Samp.	**Maximum**	**Max. Date**	**Long-Term Trend**
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	3	2.2 mg/L	03/04/03	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

SURFACE WATER SAMPLING STATION
NT-8-E

1.0 LOCATION

This surface water sampling station is located in the eastern headwaters channel of a northern tributary (NT) of Bear Creek (NT-8). Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries traverse northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). About 600 ft upstream of its confluence with Bear Creek, the main channel of NT-8 splits into eastern and western branches, both of which extend northeast toward the northwest section of the Bear Creek Burial Grounds (BCBG) waste management area (WMA), with sampling station NT-8-E being about 500 ft upstream of the confluence of the western and eastern branches.

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Five (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 2001 and the most recent sample collected in August 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 148 – 288 mg/L;
- pH of 7.5 – 8.3 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Five surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (0.132 mg/L in March 2002) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Five surface water samples had (total) uranium concentrations above the applicable analytical reporting limit and three results exceed the drinking water MCL for uranium (0.03 mg/L): 1.16 mg/L in March 2002, 2.2 mg/L in March 2003, and 0.543 mg/L in August 2003. Waste disposal areas within the BCBG are known sources of uranium and other inorganic (and organic) contaminants present in the surface water in the northern tributaries of Bear Creek that drain this WMA (DOE 1997). Uranium leached from the wastes enters the shallow groundwater and is transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features. Because much of the main channel of NT-8 is more than 1,000 ft west of the waste disposal sites within the BCBG, the uranium probably enters the tributary via contaminated groundwater discharged into the headwaters of the tributary, which extend within a few hundred feet of the waste disposal areas within the northwest section of the BCBG. Moreover, the uranium concentrations reported for this sampling station are higher than reported for the samples of surface water collected from the western branch of the tributary headwaters (sampling station NT-8-W). This suggests greater inflow of uranium-contaminated groundwater into the eastern branch.

4.3 VOLATILE ORGANIC COMPOUNDS

Low concentrations of PCE (1 μg/L) and c12DCE (2 μg/L) were detected in the surface water sample collected in March 2001. Both VOCs are confirmed components of the groundwater contaminant plume emplaced during historical operation of the BCBG WMA. Dissolved VOCs in the shallow groundwater are transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features (e.g., NT-8).

4.4 GROSS ALPHA ACTIVITY

Instead of gross alpha activity, the surface water samples collected to date were analyzed for uranium isotopes; analytical results are summarized below.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
03/22/01	1.71	6.14
09/18/01	2.64	16.47
03/13/02	50.25	223.2
03/04/03	134.9	625.8
08/19/03	35.65	185.8

As with uranium and VOCs in the surface water, the uranium isotopes are leached from sources within the BCBG WMA and are transported in the shallow groundwater toward discharge areas in nearby surface drainage features (e.g., NT-8). Interestingly, these U-234 and U-238 concentrations are substantially higher than evident in surface water samples collected from the surface water station (NT-8-W) in the western headwaters channel of NT-8. This suggests greater relative discharge of radiologically-contaminated groundwater into the reach of the tributary channel upstream of NT-8-E.

4.5 GROSS BETA ACTIVITY

The surface water samples were not analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
ND	0.03 - 0.3	<5	.	.

NT-8-W

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Western Headwaters of North Tributary 8
Y-12 GRID EAST COORDINATE: 41,636.00
Y-12 GRID NORTH COORDINATE: 29,935.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 5

First Date	Last Date
03/22/01	08/19/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	03/04/03	.	08/19/03	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	2	0.0487 mg/L	03/04/03	Indeterminate
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

SURFACE WATER SAMPLING STATION
NT-8-W

1.0 LOCATION

This surface water sampling station is located in the western headwaters channel of a northern tributary (NT) of Bear Creek (NT-8). Numbered in ascending order downstream (west) of the Bear Creek headwaters near the west end of Y-12, the northern tributaries traverse northeast-southwest across the southern flank of Pine Ridge and are believed to be the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992). About 600 ft upstream of its confluence with Bear Creek, the main channel of NT-8 splits into eastern and western branches, both of which extend northeast toward the northwest section of the Bear Creek Burial Grounds (BCBG) waste management area (WMA), with sampling station NT-8-W being about 500 ft upstream of the confluence of the western and eastern branches.

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Five (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 2001 and the most recent sample collected in August 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 57 - 187;
- pH of 7.4 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Two surface water samples had nitrate concentrations above the applicable analytical reporting limit, and both results (0.033 mg/L in September 2001 and 0.029 mg/L in March 2002) are several orders-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Five surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, including two results that exceed the drinking water MCL for uranium (0.03 mg/L): 0.0465 mg/L in September 2001 and 0.487 mg/L in March 2003. Waste disposal areas within the Bear Creek Burial Grounds (BCBG) waste management area (WMA) are known sources of uranium and other inorganic (and organic) contaminants present in the surface water in the northern tributaries of Bear Creek that drain the WMA (DOE 1997). Uranium leached from the wastes enters the shallow groundwater and is transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features. Because much of the main channel of NT-8 is more than 1,000 ft west of the waste disposal sites within the BCBG, the uranium probably enters the tributary via contaminated groundwater discharged into the headwaters of the tributary, which extend within a few hundred feet of the waste disposal areas within the northwest section of the BCBG. Moreover, the uranium concentrations reported for this sampling station are lower than reported for the samples of surface water collected from the eastern branch of the tributary headwaters (sampling station NT-8-E). This suggests greater inflow of uranium-contaminated groundwater into the eastern branch.

4.3 VOLATILE ORGANIC COMPOUNDS

Low concentrations of c12DCE (2 μg/L) and 11DCE (1 μg/L) were detected in the surface water sample collected in March 2003. Both VOCs are confirmed components of the groundwater contaminant plume emplaced during historical operation of the BCBG WMA. As with uranium in the surface water; dissolved VOCs in the shallow groundwater are transported primarily in the direction of geologic strike toward discharge areas in nearby drainage features (e.g., NT-8).

4.4 GROSS ALPHA ACTIVITY

Instead of gross alpha activity, the surface water samples collected to date were analyzed for uranium isotopes; analytical results are summarized below.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
03/22/01	2.69	3.27
09/18/01	2.4	11.03
03/13/02	1.3	4.03
03/04/03	4.65	17.13
08/19/03	1.41	7.44

As with uranium and VOCs in the surface water, the uranium isotopes are leached from sources within the BCBG WMA and are transported in the shallow groundwater toward discharge areas in nearby surface drainage features (e.g., NT-8). Interestingly, these U-234 and U-238 concentrations are substantially lower than evident in surface water samples collected from the surface water station (NT-8-E) in the eastern headwaters channel of NT-8. This suggests substantially less discharge of radiologically-contaminated groundwater into the reach of the tributary channel upstream of NT-8-W.

4.5 GROSS BETA ACTIVITY

The surface water samples were not analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	5 - 50	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

OF 51

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Outfall 51
ADMIN. GRID EAST COORDINATE: 60,059.53
ADMIN. GRID NORTH COORDINATE: 29,210.23
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: . .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 12

First Date	Last Date
02/10/99	08/18/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/15/04	.	08/18/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	12	54 µg/L	09/03/02	Indeterminate
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

OUTFALL 51

1.0 LOCATION

Outfall 51 captures flow from a large spring (Big Spring) located the southeast corner of Bldg. 9201-2 and discharges into the exposed section of the main channel of Upper East Fork Poplar Creek (UEFPC) in south-central Y-12. The spring discharge was captured during construction of Bldg. 9201-2 in the early 1940's and measurements obtained over the past three years show average daily flow rates of 0.17 to 0.87 million gallons per day (mgd). Substantial sections of UEFPC also were modified during construction of other facilities at Y-12, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, being filled and replaced with an extensive network of underground storm drains. Also, the section of the creek near the eastern end of Y-12 was extensively modified by construction of New Hope Pond (NHP) in 1963 and the closure of NHP in 1988. An unlined surface impoundment, NHP was used to regulate the quantity and quality of surface water exiting Y-12 until it was closed and replace by Lake Reality, a lined surface impoundment built in 1988.

About 80% of dry-weather flow in UEFPC is attributable to once-through non-contact cooling water, condensate, and cooling tower blowdown, and the remaining 20% is from groundwater discharge (DOE 1998). In accordance with a flow management program initiated in July 1996, untreated water from the Clinch River intake lines to the DOE water treatment plant that supplies potable water to Y-12 is discharged into the exposed section of the main channel of UEFPC in the south-central section of Y-12 near Bldg. 9201-1. Augmentation of flow in UEFPC is necessary because reduced operations at Y-12 have decreased flow from 10-15 mgd to about 2.5 mgd. Flow augmentation also is needed to: (1) achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, which is located immediately upstream of where UEFPC exits the DOE Oak Ridge Reservation northeast of Y-12; (2) maintain compliance with NPDES toxicity requirements; and (3) lower the otherwise elevated water temperature in UEFPC.

Discharge from Outfall 51 accounts for about 10% of the total annual flow at Station 17. Beginning in August 2005, discharge from the outfall is captured and treated at the Big Spring Treatment Facility in accordance with the Phase I ROD for UEFPC (DOE 1997). This facility captures and treats Outfall 51 discharge and groundwater from basement dewatering sumps in Building 9201-2. It is unknown if any residual discharge from Outfall 51 persists as a result of groundwater infiltration.

2.0 SAMPLING HISTORY

Twelve (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 5400.5. Also, grab sampling and/or flow-proportionate composite sampling is performed for NPDES purposes and to meet the requirements of the Phase I ROD for UEFPC (DOE 1997).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 139 – 300 mg/L;
- pH of 6.8 – 8.6 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except mercury) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (5.5 mg/L in August 2001) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Ten surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.0116 mg/L in August 2001), being less than the drinking water MCL for uranium (0.03 mg/L).

4.3 MERCURY

Three surface water samples had (total) mercury concentrations above the applicable analytical reporting limit (Table 1), with the highest value (0.00096 mg/L in July 1999) being substantially below the drinking water MCL for mercury (0.002 mg/L). There are multiple sources of mercury within Y-12 upstream of this sampling station, including inflow of mercury-contaminated groundwater into UEFPC, and the remediation of these sources is the focus of the CERCLA Phase I ROD for mercury source areas in UEFPC (DOE 1997).

4.4 VOLATILE ORGANIC COMPOUNDS

Each surface water sample collected to date had low concentrations (most being estimated values below 5 μg/L) of one or more of the following VOCs (Table 2): bromodichloromethane (BDM), CTET, chloroform (CLF), PCE, TCE, c12DCE, 11DCA, and 111TCA. Based on concentration levels, the principal VOCs are PCE and TCE, with historical maximum concentrations that exceed the respective 5 μg/L drinking water MCL. The bulk of the results for the other compounds are estimated values below applicable analytical reporting limits. There are multiple sources of VOCs in Y-12 upstream of this sampling station, including the inflow of VOC-contaminated groundwater into UEFPC. Additionally, trihalomethanes (CLF and BDM) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency [EPA] 2001).

4.5 GROSS ALPHA ACTIVITY

Eleven surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (4.82 pCi/L in February 1999) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.6 GROSS BETA ACTIVITY

Ten surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with historical maximum value (4.89 pCi/L in September 2002) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1951&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

Table 1. Outfall 51: summary of results for nitrate, mercury, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Mercury (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
02/10/99	4.3	0.00096	.	4.82	1.77
08/17/99	4.8	0.00018	.	3.77	<MDA
04/10/00	5	0.00012	0.0068	2.79	2.03
09/19/00	4.9	.	0.011	3.4	3.52
02/27/01	5	.	0.00994	1.96	3.93
08/28/01	5.5	.	0.0116	3.96	2.83
02/14/02	4.4	.	0.00892	4.27	4.67
09/03/02	4.9	.	0.00881	3.74	4.89
03/10/03	4	.	0.00987	<MDA	3.81
08/12/03	3.8	.	0.00773	3.08	3.11
03/15/04	3.5	.	0.00883	4.22	<MDA
08/18/04	3.6	.	0.00714	3.95	4.37
MCL	**10**	**0.002**	**0.03**	**15**	**50***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Outfall 51: summary of results for VOCs

Date Sampled	Concentration (µg/L)							
	PCE	**TCE**	**c12DCE**	**111TCA**	**11DCA**	**CTET**	**CLF**	**BDM**
02/10/99	8	3 J	3 J	1 J	.	.	2 J	.
08/17/99	16	6	7	1 J	.	1 J	3 J	.
04/10/00	9	3 J	2 J	2 J	2 J	1 J	3 J	.
09/19/00	18	7	8	.	.	1 J	.	.
02/27/01	10	3 J	3 J	1 J	2 J	.	2 J	.
08/28/01	25	9	11	.	.	2 J	6	.
02/14/02	12	5	5	1 J	1 J	.	2 J	.
09/03/02	24	10	12	.	.	1 J	7	.
03/10/03	11	4 J	3 J	1 J	1 J	.	3 J	.
08/12/03	17	5	5	.	.	1 J	6	1 J
03/15/04	10	4 J	4	.	1	.	3 J	.
08/18/04	13	5	6	.	.	.	6	1 J
MCL	**5**	**5**	**70**	**200**	**7**	**5**	**80***	

Note: "." = Not detected; J = Estimated value; * MCL for total trihalomethanes (chloroform + bromoform + BDM + dibromochloromethane)

MAXIMUM CONCENTRATION: 2004

.	0.03 - 0.3	.	.	.
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

OF 200

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime

FUNCTIONAL AREA: Outfall 200

Y-12 GRID EAST COORDINATE: 57,700.00

Y-12 GRID NORTH COORDINATE: 29,400.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 21

First Date	Last Date
07/12/99	08/18/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	02/12/04	.	07/27/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	13	0.17 mg/L	03/20/00	Indeterminate
SUMMED VOCs (5 µg/L):	16	91 µg/L	08/28/01	Indeterminate
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

OUTFALL 200

1.0 LOCATION

This surface water sampling station is located at the outfall of the North-South Pipe, a subsurface drain that discharges into the exposed section of the main channel of Upper East Fork Poplar Creek (UEFPC) in south-central Y-12, directly southwest of Bldg. 9204-1. Construction of facilities at Y-12 substantially modified UEFPC, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, filled and replaced with an extensive network of underground storm drains. Also, the section of the creek near the eastern end of Y-12 was extensively modified by construction of New Hope Pond (NHP) in 1963 and the closure of NHP in 1988. An unlined surface impoundment, NHP was used to regulate the quantity and quality of surface water exiting Y-12 until it was closed and replace by Lake Reality, a lined surface impoundment built in 1988.

About 80% of dry-weather flow in UEFPC is attributable to once-through non-contact cooling water, condensate, cooling tower blowdown, and potable water treated and discharged from wastewater treatment facilities and the remaining 20% is from groundwater discharge (DOE 1998). In accordance with a flow management program initiated in July 1996, untreated water from the Clinch River intake lines to the DOE water treatment plant that supplies potable water to Y-12 is discharged near OF 200 to augment flow in UEFPC, which decreased from 10-15 million gallons per day (mgd) to about 2.5 mgd because of reduced operations at Y-12 in recent years. Flow management is needed to achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, which is located immediately upstream of where UEFPC exits the DOE Oak Ridge Reservation northeast of Y-12. Flow management also allows compliance with NPDES toxicity requirements and helps lower the otherwise elevated water temperature in UEFPC.

2.0 SAMPLING HISTORY

Twenty-one (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in July 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 5400.5. Also, grab sampling and/or flow-proportionate composite sampling is performed for NPDES purposes and to meet the requirements of the Phase I ROD for UEFPC (DOE 1997).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 120 – 316 mg/L;
- pH of 6.7 – 9.0 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except mercury and uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

The 17 surface water samples collected between July 1999 and August 2003 had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (8.7 mg/L in March 2000) being less than the drinking water MCL for nitrate (10 mg/L). Surface water samples collected from this station after August 2003 are not analyzed for nitrate.

4.2 URANIUM

Nineteen surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all but five of these results, including the historical maximum value (0.17 mg/L in March 2000), exceed the drinking water MCL for uranium (0.03 mg/L). There are multiple sources of uranium in the groundwater and surface water upgradient of Outfall 200.

4.3 MERCURY

Four surface water samples had (total) mercury concentrations above the applicable analytical reporting limit (Table 1), with the highest value (0.001 mg/L in March 2000) being less than the drinking water MCL for mercury (0.002 mg/L). There are multiple sources of mercury within Y-12 upstream of this sampling station, including inflow of mercury-contaminated groundwater into UEFPC, and the remediation of these sources is the focus of the Phase I ROD for mercury source areas in UEFPC (DOE 1997).

4.4 VOLATILE ORGANIC COMPOUNDS

Seventeen surface water samples collected between July 1999 and August 2003 had low concentrations of one or more of the following VOCs (Table 2): acetone, bromoform, bromodichloromethane (BDM), CTET, chloroform, dibromochloromethane (DBM), PCE, TCE, and c12DCE. Surface water samples collected from this station after August 2003 are not analyzed for VOCs. The bulk of the VOC results are estimated values below applicable analytical reporting limits; only results for acetone exceed 10 µg/L. There are multiple sources of VOCs in Y-12 upstream of this sampling station. Additionally, trihalomethanes (bromoform, BDM, chloroform, and DBM) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency 2001).

4.5 GROSS ALPHA ACTIVITY

The surface water samples collected to date were not analyzed for gross alpha activity.

4.6 GROSS BETA ACTIVITY

Surface water samples collected to date were not analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1951&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

Table 1. Outfall 200: summary of results for nitrate, mercury, and uranium

Date Sampled	Nitrate (mg/L)	Mercury (mg/L)	Uranium (mg/L)
07/12/99	2.3	0.00065	.
07/15/99	5.7	0.0007	.
03/20/00	8.7	0.001	0.17
04/10/00	6	0.00069	0.0589
09/19/00	3.6	.	0.0102
02/14/01	7	.	0.142
02/27/01	5.8	.	0.134
08/28/01	3.1	.	0.00775
09/04/01	6.4	.	0.0824
02/01/02	7.2	.	0.12
02/14/02	7.7	.	0.073
08/20/02	5.8	.	0.0344
09/03/02	4.3	.	0.00761
01/29/03	4.5	.	0.0382
03/10/03	4.8	.	0.0427
07/23/03	7.8	.	0.0453
08/12/03	6.1	.	0.0236
02/12/04	.	.	0.055
03/15/04	.	.	0.0354
07/27/04	.	.	0.0266
08/18/04	.	.	0.0131
MCL	**10**	**0.002**	**0.03**
Note: "." = Not analyzed			

Table 2. Outfall 200: summary of VOC results

Date Sampled	Concentration (µg/L)			
	PCE	TCE	c12DCE	Acetone
07/12/99	3 J	.	.	.
07/15/99	3 J	.	.	.
03/20/00	7	2 J	2 J	.
04/10/00	4 J	.	1 J	.
09/19/00	.	.	.	.
02/14/01	5	1 J	2 J	.
02/27/01	3 J	.	.	.
08/28/01	1 J	.	.	78
09/04/01	4 J	1 J	1 J	.
02/01/02	.	.	.	.
02/14/02	4 J	1 J	1 J	.
08/20/02	2 J	.	.	.
09/03/02	1 J	.	.	.
01/29/03	3 J	.	.	.
03/10/03	3 J	.	1 J	.
07/23/03	3 J	.	1 J	11
08/12/03	3 J	.	.	10
MCL	**5**	**5**	**70**	**NA**
Date Sampled	**Concentration (µg/L)**			
	Chloroform	**Bromoform**	**BDM**	**DBM**
07/12/99	.	.	.	.
07/15/99	5	.	.	.
03/20/00	5	.	.	.
04/10/00	10	.	1 J	.
09/19/00	5	.	1 J	.
02/14/01	4 J	.	.	.
02/27/01	3 J	.	.	.
08/28/01	5	7	3 J	3 J
09/04/01	5	1 J	2 J	.
02/01/02	5	1 J	2 J	.
02/14/02	4 J	1 J	1 J	.
08/20/02	8	4 J	2 J	1 J
09/03/02	8	3 J	2 J	1 J
01/29/03	3 J	.	.	.
03/10/03	5	1 J	1 J	.
07/23/03	6	2 J	2 J	.
08/12/03	5	3 J	2 J	2 J
MCL	**80***			

Note: "." = Not detected; J = Estimated value; NA = Not applicable; * MCL for total trihalomethanes (chloroform + bromoform + BDM + dibromochloromethane); samples collected after 08/12/03 are not analyzed for VOCs.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
100 - 1,000	ND	.	.	.

S07

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: North Tributary 2, Bear Creek

ADMIN. GRID EAST COORDINATE: 49,411.15

ADMIN. GRID NORTH COORDINATE: 29,494.59

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 6

First Date	Last Date
09/17/01	09/13/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/01/04	.	09/13/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	6	276 mg/L	09/17/01	Indeterminate
URANIUM (0.03 mg/L):	0	. mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

SURFACE WATER SAMPLING STATION
S07

1.0 LOCATION

Samples of surface water in the channel of a northern tributary (NT) of Bear Creek (NT-2), which are numbered in ascending order downstream of the creek headwaters near the west end of Y-12, are obtained from this sampling station. The channel of NT-2 trends northeast-southwest across the southern flank of Pine Ridge about midway between the former S-3 Ponds and the Oil Landfarm waste management area (WMA), with sampling station S07 located just upstream of the confluence with the main channel of Bear Creek. The similar trend and pattern of the northern tributaries of Bear Creek suggest that they are the surface expression of large-scale fracture zones (or small faults) in the bedrock (Conasauga Group) underlying Bear Creek Valley (BCV) (Solomon et. al. 1992).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Six (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in September 2001 and the most recent sample collected in September 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives of the Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 5400.5. Also, grab sampling and/or flow-proportionate composite sampling is performed for NPDES purposes and to meet the requirements of the Phase I ROD for the Bear Creek watershed (DOE 2000).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- pH of 7.3 – 8.4 (field measurements) and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Six of the surface water samples had nitrate concentrations above the applicable analytical reporting limit, and all of these results, including the historical maximum value (276 mg/L in September 2001), substantially exceed the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds. Located at the headwaters of Bear Creek near the west end of Y-12, the S-3 Ponds were four contiguous, unlined surface impoundments used from 1951 to 1984 for the infiltration/evaporation of several million gallons of nitric acid wastes generated at Y-12. Now covered with a multilayer low-permeability cap constructed in 1988, the former S-3 Ponds emplaced a heterogeneous mixture of inorganic, organic, and radiological contamination in the underlying Nolichucky Shale. Nitrate is a primary component of the plume and is transported in the shallow groundwater system south toward Bear Creek and to the west, parallel with geologic strike, toward discharge areas in NT-1 and NT-2 (DOE 1997). Additionally, nitrate in the deeper (>150 ft bgs) groundwater flow/transport pathways in the Nolichucky Shale moves westward along strike and, under vertically upward hydraulic gradients, enters the shallow flow system and ultimately discharges into NT-1 and NT-2. Thus, elevated nitrate concentrations in the surface water at this sampling station result from the upstream discharge of nitrate-contaminated groundwater into NT-2.

4.2 URANIUM

The surface water samples were not analyzed for (total) uranium.

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

None of the surface water samples were analyzed for gross alpha activity; however, the samples collected between September 2001 and August 2003 were analyzed for uranium isotopes. The analytical results, summarized below, do not indicate the presence of uranium isotopes above background levels in BCV.

Sampling Date	Concentration (pCi/L)	
	U-234	U-238
09/17/01	1.53	0.61
03/11/02	0.36	0.36
03/03/03	0.91	0.66
08/18/03	0.57	0.31

4.5 GROSS BETA ACTIVITY

None of the surface water samples were analyzed for gross beta activity however, the samples collected between September 2001 and August 2003 were analyzed for Tc-99. The analytical results, summarized below, show that Tc-99 is present in the surface water at this sampling location.

Sampling Date	Tc-99 (pCi/L)
09/17/01	487.22
03/11/02	94.14
03/03/03	36.94
08/18/03	47.15

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes that contained Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Nolichucky Shale closely mirrors that of nitrate. Accordingly, Tc-99 in the shallow groundwater system is transported westward, parallel with geologic strike, toward discharge areas in NT-1 and NT-2 (DOE 1997). Thus, the repeated detection of Tc-99 in the surface water samples indicate the discharge of nitrate-contaminated groundwater into NT-2 upstream of this sampling station.

5.0 REFERENCES

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation,* ORNL/TM-12053, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	ND	ND

S17

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: South Chestnut Ridge Tributary 5
ADMIN. GRID EAST COORDINATE: 62,954.07
ADMIN. GRID NORTH COORDINATE: 23,678.06
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 4

First Date	Last Date
02/19/03	07/19/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/29/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
S17

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This surface water sampling station is located in the main channel of SCR5 north of and adjacent to Bethel Valley Road. Flow in SCR5 includes discharge from the outfall for Kerr Hollow Quarry (KHQ), which is an abandoned water-filled quarry formerly used for the disposal of hazardous wastes from Y-12 and elsewhere on the DOE Oak Ridge Reservation. KHQ was closed in accordance with a RCRA closure plan in 1989. Requirements for RCRA post-closure care of the site, including groundwater quality monitoring, are specified in the RCRA post-closure permit for the Chestnut Ridge Hydrogeologic Regime (TDEC 1995).

2.0 SAMPLING HISTORY

Four (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 2003 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 5400.5. Also, grab sampling and/or flow-proportionate composite sampling is performed for NPDES purposes.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 130 – 199 mg/L;
- pH of 7.1 – 7.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the highest result (2.99 in January 2004) being substantially below the drinking water MCL for nitrate (10 mg/L). The nitrate results are higher than background levels of nitrate in groundwater and surface water on Chestnut Ridge, which are typically less than 1 mg/L. The source of the nitrate in surface water at this location (as in the groundwater at wells located at Kerr Hollow Quarry) may be municipal sewage sludge that was applied to the land surface at nearby upgradient areas, the closest of which is located west of SCR5 about 600 ft upgradient of S17.

4.2 URANIUM

All of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, with the highest result (0.00106 mg/L in August 2003) being substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the surface water samples.

4.4 GROSS ALPHA ACTIVITY

One surface water sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (3.5 pCi/L in August 2003) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

None of the surface water samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Tennessee Department of Environment and Conservation (TDEC). 1995. Resource Conservation and Recovery Act Post-Closure Permit for the U.S. Department of Energy Y-12 Chestnut Ridge Hydrogeologic Regime, Permit No. TNHW-088, TDEC Division of Solid Waste Management, Nashville, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	<7.5	<25

SCR1.25SP

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime

FUNCTIONAL AREA: Spring Sampling Location, South Chestnut Ridge

ADMIN. GRID EAST COORDINATE: 52,720.00

ADMIN. GRID NORTH COORDINATE: 25,170.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 13

First Date	Last Date
02/16/99	08/17/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/11/04	.	08/17/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	33.27 pCi/L	02/22/01	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR1.25SP

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This spring discharges groundwater into the main channel of Dunaway Branch, hydraulically downgradient (south) of Industrial Landfill II.

2.0 SAMPLING HISTORY

Thirteen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 120 – 231 mg/L;
- pH of 5.6 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Five of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest value (0.088 mg/L in January and August 2003) being several orders-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

None of the groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the groundwater samples.

4.4 GROSS ALPHA ACTIVITY

Eleven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum value (33.27 pCi/L in February 2001) exceeding the drinking water MCL for gross alpha activity (15 pCi/L). However, this result is an outlier compared to the other results for gross alpha activity, which are all less than 5 pCi/L, and is probably a sampling or analytical artifact.

4.5 GROSS BETA ACTIVITY

Ten groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the historical maximum value (4.62 pCi/L in January 2003) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	ND	ND

SCR1.5SW

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: South Chestnut Ridge Tributary 1
Y-12 GRID EAST COORDINATE: 52,149.58
Y-12 GRID NORTH COORDINATE: 23,251.03
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 8

First Date	Last Date
02/19/01	07/19/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/29/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	0	< μg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
SCR1.5SW

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This surface water sampling station is located on the main channel of Dunaway Branch, immediately upstream (north) of Bethel Valley Road. This sampling station is hydraulically downgradient (southeast) of Industrial Landfill II and Industrial Landfill VI.

2.0 SAMPLING HISTORY

Eight (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 2001 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 94 – 190 mg/L;
- pH of 7.0 – 7.6 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the highest value (0.152 mg/L in February 2003) being an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Six surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, with the higher value (0.00161 mg/L in August 2002) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the any of the surface water samples.

4.4 GROSS ALPHA ACTIVITY

Two surface water samples had gross alpha activity above the applicable MDA and corresponding CE, and both results (3.7 pCi/L in August 2002 and 2 pCi/L in August 2003) are substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

None of the surface water samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	<7.5	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (μg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

SCR2.1SP

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Spring Sampling Location, South Chestnut Ridge
ADMIN. GRID EAST COORDINATE: 53,881.17
ADMIN. GRID NORTH COORDINATE: 25,141.97
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 12

First Date	Last Date
01/13/98	07/19/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	01/29/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 μg/L):	1	10 μg/L	02/02/99	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR2.1SP

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This spring discharges groundwater into the main channel of SCR2 and is hydraulically downgradient (southeast) of Industrial Landfill II, Industrial Landfill IV, and Construction/Demolition Landfill VI.

2.0 SAMPLING HISTORY

Twelve (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in January 1998 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 85 – 221 mg/L;
- pH of 6.9 – 7.8 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (0.32 mg/L in February 1999) being an order-of-magnitude below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

All of the groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit, with the historical maximum value (0.0092 mg/L in July 1998) being an order-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, low concentrations of VOCs were detected in two groundwater samples: carbon disulfide (2 µg/L) in July 1998 and acetone (10 µg/L) in February 1999. These results may be sampling or analytical artifacts and are considered to be outliers.

4.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (9.7 pCi/L in July 1998) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	<0.015	ND	ND	ND
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

SCR2.2SP

LOCATION

HYDROGEOLOGIC REGIME:	Chestnut Ridge Regime
FUNCTIONAL AREA:	Spring Sampling Location, South Chestnut Ridge
Y-12 GRID EAST COORDINATE:	53,869.00
Y-12 GRID NORTH COORDINATE:	23,472.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	DOE Order
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 15

First Date	Last Date
03/15/95	07/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/29/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR2.2SP

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. This spring discharges groundwater into the main channel of SCR2. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River).

2.0 SAMPLING HISTORY

Fifteen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 1995 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 163 – 224 mg/L;
- pH of 6.7 – 7.4 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (2.67 in February 2001) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Nine groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit, with the historical maximum value (0.00099 mg/L in July 1997) being several orders-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected the groundwater samples.

4.4 GROSS ALPHA ACTIVITY

One groundwater sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (3.7 pCi/L in August 2003) is substantially less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

None of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	<25
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

SCR3.5SP

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Spring Sampling Location, South Chestnut Ridge
Y-12 GRID EAST COORDINATE: 56,467.40
Y-12 GRID NORTH COORDINATE: 24,338.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 14

First Date	Last Date
02/16/99	08/17/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/11/04	.	08/17/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR3.5SP

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River).

This spring discharges groundwater into the main channel of McCoy Branch downstream of the Filled Coal Ash Pond (FCAP) and immediately upstream of Rogers Quarry. The FCAP is a former settling basin formed by the construction of an earthen dam across the upper reach of McCoy Branch. Beginning in 1955, the basin received coal ash from the Y-12 Steam Plant that was pumped as slurry over the crest of Chestnut Ridge and gravity-drained into the basin. By 1967, the basin had filled with ash and the slurry was allowed to overtop the dam and flow down McCoy Branch into Rogers Quarry until 1989. Remedial action at the FCAP was completed in April 1997 in accordance with a CERCLA ROD approved in February 1996 (DOE 1996). As described in the remedial action report, CERCLA remedial actions at the FCAP included: (1) raising the crest of the dam, (2) reinforcing the fact of the dam and removing large trees from the face of the dam; (3) installing a subsurface drain; (4) repairing the emergency spillway for the dam; (5) constructing a settling basin and oxygenation weir at the foot of the dam; and (6) replacing a small wetland area in McCoy Branch immediately downstream of the settling basin (DOE 1997). These remedial actions are intended to minimize the migration of contaminants into surface water, minimize direct contact of humans and animals with the ash, reduce the potential for failure of the dam, and preserve the local habitat over the long term (DOE 1996).

2.0 SAMPLING HISTORY

Fourteen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 78 – 307 mg/L;
- pH of 5.9 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Six groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the highest value (0.51 mg/L in January 2003) being an order-of-magnitude below the drinking water MCL for nitrate (10 mg./L).

4.2 URANIUM

One groundwater sample had a (total) uranium concentration above the applicable analytical reporting limit, and this result (0.00523 mg/L in February 2003) is orders-of-magnitude below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were not detected the groundwater samples.

4.4 GROSS ALPHA ACTIVITY

Seven groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (14.06 pCi/L in January 2003) being slightly below the drinking water MCL for gross alpha activity (15 pCi/L). However, this result is an outlier compared to the other results for gross alpha activity, none of which exceed 3 pCi/L.

4.5 GROSS BETA ACTIVITY

Nine groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (6.75 pCi/L in January 2003) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/02-1410&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/01-1596&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	ND	ND

SCR3.5SW

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: South Chestnut Ridge Tributary 3
Y-12 GRID EAST COORDINATE: 56,618.00
Y-12 GRID NORTH COORDINATE: 24,138.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 3

First Date	Last Date
08/18/03	07/19/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	01/29/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SURFACE WATER SAMPLING STATION
SCR3.5SW

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. This surface water sampling station is located on the main channel of McCoy Branch. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River).

This sampling station is in the main channel of McCoy Branch downstream of the Filled Coal Ash Pond (FCAP) and immediately upstream of Rogers Quarry. The FCAP is a former settling basin formed by the construction of an earthen dam across the upper reach of McCoy Branch. Beginning in 1955, the basin received coal ash from the Y-12 Steam Plant that was pumped as slurry over the crest of Chestnut Ridge and gravity-drained into the basin. By 1967, the basin had filled with ash and the slurry was allowed to overtop the dam and flow down McCoy Branch into Rogers Quarry until 1989. Remedial action at the FCAP was completed in April 1997 in accordance with a CERCLA ROD approved in February 1996 (DOE 1996). As described in the remedial action report, CERCLA remedial actions at the FCAP included: (1) raising the crest of the dam, (2) reinforcing the fact of the dam and removing large trees from the face of the dam; (3) installing a subsurface drain; (4) repairing the emergency spillway for the dam; (5) constructing a settling basin and oxygenation weir at the foot of the dam; and (6) replacing a small wetland area in McCoy Branch immediately downstream of the settling basin (DOE 1997). These remedial actions are intended to minimize the migration of contaminants into surface water, minimize direct contact of humans and animals with the ash, reduce the potential for failure of the dam, and preserve the local habitat over the long term (DOE 1996).

2.0 SAMPLING HISTORY

Three (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 2003 and the most recent sample collected in July 2004. The grab sampling method was used to collect the sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Analytical results for the surface water sample show:

- TDS of 168 – 221 mg/L;
- pH of 7.1 – 7.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the surface water samples had nitrate concentrations above the applicable analytical reporting limit, with the highest result (0.459 mg/L in January 2004) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

All of the surface water samples had (total) uranium concentrations above the applicable analytical reporting limit, with the highest result (0.000601 in January 2004) being substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the surface water sample.

4.4 GROSS ALPHA ACTIVITY

One surface water sample had gross alpha activity above the applicable MDA and corresponding CE, and this result (1.8 pCi/L in August 2003) is substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

None of the surface water samples had gross beta activity above the applicable MDA and corresponding CE.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/02-1410&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1997. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond Vicinity) Oak Ridge, Tennessee*, DOE/OR/01-1596&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	ND	ND

SCR4.3SP

LOCATION

HYDROGEOLOGIC REGIME: Chestnut Ridge Regime
FUNCTIONAL AREA: Spring Sampling Location, South Chestnut Ridge
Y-12 GRID EAST COORDINATE: 61,264.00
Y-12 GRID NORTH COORDINATE: 24,773.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: SWDF
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 22

First Date	Last Date
02/14/94	07/22/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	01/13/04	.	07/22/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum		Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level				
NITRATE (10 mg/L):	0	<	mg/L		
URANIUM (0.03 mg/L):	0	<	mg/L		
SUMMED VOCs (5 μg/L):	2	12	μg/L	07/14/98	Indeterminate
GROSS ALPHA (15 pCi/L):	0	<	pCi/L		
GROSS BETA (50 pCi/L):	0	<	pCi/L		

SPRING SCR4.3SP

1.0 LOCATION

There are five primary tributary drainage basins on south Chestnut Ridge (SCR), informally numbered from west to east (SCR1 through SCR5): Dunaway Branch (SCR1) and SCR2 southwest of Y-12, McCoy Branch (SCR3) directly south of Y-12; and SCR4 and SCR5 in southeast of Y-12. Flow in each tributary is mainly intermittent at elevations higher than 900 ft above msl. Surface runoff, stormflow discharge, and groundwater baseflow contribute flow to each tributary, which increases with distance downstream and includes substantial contributions from springs. Each tributary conveys surface water south toward Bethel Valley and discharges into Melton Hill Reservoir (Clinch River). This spring discharges groundwater into the main channel of SCR4 and is hydraulically downgradient of Industrial Landfill V and Construction/Demolition Landfill VII.

2.0 SAMPLING HISTORY

Twenty-two (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1994 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 118 – 216 mg/L;
- pH of 6.4 – 7.15 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (2.3 mg/L in January 2001) being less than the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

None of the groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, VOCs were detected in the groundwater samples collected in July 1998 (acetone = 12 μg/L), February 2000 (acetone = 8.5 μg/L), July 2000 (methylene chloride = 1.5 μg/L), and January 2002 (carbon disulfide = 0.39 μg/L). These sporadic detections are suspected sampling or analytical artifacts.

4.4 GROSS ALPHA ACTIVITY

Three groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (4.4 pCi/L in July 1999) being substantially below the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Three groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (3.31 pCi/L in July 2001) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

SCR7.1SP

LOCATION

HYDROGEOLOGIC REGIME:	East Fork Regime
FUNCTIONAL AREA:	Spring Sampling Location, Union Valley
Y-12 GRID EAST COORDINATE:	67,970.00
Y-12 GRID NORTH COORDINATE:	28,440.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	CERCLA
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

		First Date	Last Date
TOTAL SAMPLING EVENTS:	18	03/11/96	07/19/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/02/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	Results (since 1991) > Screening Level: # Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	4	9 µg/L	08/27/98	Decreasing
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR7.1SP

1.0 LOCATION

This spring discharges groundwater into the main channel of the western branch of Scarboro Creek in Union Valley east of Y-12, about 2,500 ft east of the boundary of the DOE Oak Ridge Reservation (ORR).

2.0 SAMPLING HISTORY

Eighteen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 1996 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 238 – 340 mg/L;
- pH of 6.6 – 8.9 (field measurements); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Eleven groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (1.03 mg/L in March 1996) being substantially below the drinking water MCL for nitrate (10 mg/L). Groundwater samples collected after July 2003 were not analyzed for nitrate.

4.2 URANIUM

Only two groundwater samples were analyzed for (total) uranium, and neither sample (collected in March and June 1996) had a concentration above the applicable analytical reporting limit.

4.3 VOLATILE ORGANIC COMPOUNDS

As shown in the following data summary, low concentrations of CTET, chloroethane, PCE, and TCE were detected in eleven groundwater samples, with CTET and TCE detected the most frequently.

Date Sampled	Concentration (µg/L)			
	PCE	TCE	CTET	Chloroethane
03/11/96	1 J	2 J	3 J	.
06/20/96	.	2 J	4 J	.
08/25/97	.	1 J	4 J	.
03/03/98	.	3 J	1 J	.
08/27/98	1 J	3 J	5	.
08/30/99	.	.	3 J	4 J
05/30/00	.	.	1 J	.
09/06/00	.	1 J	1 J	.
01/29/01	.	2 J	.	.
02/11/03	.	2 J	.	.
07/22/03	.	1 J	.	.
MCL	**5**	**5**	**5**	**NA**
Note: "." = Not detected; J = Estimated value; NA = Not applicable; only sampling dates with at least one VOC detected are shown (none detected since July 2003).				

These compounds are components of the plume of dissolved VOCs in the Maynardville Limestone that extends from the eastern end of Y-12 into Union Valley east of the ORR boundary.

4.4 GROSS ALPHA ACTIVITY

Five groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, with the highest value (3.68 pCi/L in August 1998) being less than the drinking water MCL for gross alpha activity (15 pCi/L). Groundwater samples collected after July 2003 were not analyzed for gross alpha activity.

4.5 GROSS BETA ACTIVITY

Nine groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (5.68 pCi/L in February 2003) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). Groundwater samples collected after July 2003 were not analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	.	ND	.	.

SCR7.8SP

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime

FUNCTIONAL AREA: Spring Sampling Location, Union Valley

Y-12 GRID EAST COORDINATE: 68,300.00

Y-12 GRID NORTH COORDINATE: 27,915.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 17

First Date	Last Date
04/09/97	07/19/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/02/04	.	07/19/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	.	. mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SCR7.8SP

1.0 LOCATION

This spring discharges groundwater into the main channel of the western branch of Scarboro Creek in Union Valley east of Y-12, about 3,000 ft east of the boundary of the DOE Oak Ridge Reservation (ORR).

2.0 SAMPLING HISTORY

Seventeen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 1997 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 170 – 289 mg/L;
- pH of 6.1 – 9.2 (field measurements); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nine groundwater samples had nitrate concentrations above the applicable analytical reporting limit, with the historical maximum value (1.8 mg/L in January 2001) being substantially below the drinking water MCL for nitrate (10 mg/L). Groundwater samples collected after July 2003 were not analyzed for nitrate.

4.2 URANIUM

The groundwater samples were not analyzed for (total) uranium.

4.3 VOLATILE ORGANIC COMPOUNDS

As shown in the following data summary, low concentrations of PCE, toluene, 12DCE, 111TCA, and 11DCA were detected in five groundwater samples collected to date, with PCE and 12DCE detected the most frequently.

Date Sampled	Concentration (µg/L)				
	PCE	12DCE	111TCA	11DCA	Toluene
08/25/97	2 J	1 J	.	.	.
03/03/98	2 J	1 J	.	.	.
08/27/98	2 J	2 J	.	.	.
02/04/99	1 J	1 J	1 J	1 J	.
08/13/01	.	.	.	.	1 J
MCL	**5**	**5**	**5**	**NA**	
Note: "." = Not detected; J = Estimated value; NA = Not applicable					

The source of the VOCs in the groundwater samples from this spring has not been determined. However, each compound except toluene is a confirmed component of the plume of dissolved VOCs in the Maynardville Limestone that extends from the eastern end of Y-12 into Union Valley east of the ORR boundary. Additionally, the spring is located hydraulically downgradient (east) of a former municipal landfill, which also is a likely source of VOCs.

4.4 GROSS ALPHA ACTIVITY

None of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE. Groundwater samples collected after July 2003 were not analyzed for gross alpha activity.

4.5 GROSS BETA ACTIVITY

Seven groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (3.53 pCi/L in July 2002) being substantially below the SDWA screening level (50 pCi/L) for a 4 millirem dose equivalent (the drinking water MCL for gross beta activity). Groundwater samples collected after July 2003 were not analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	ND
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

SPR14.0SP

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Pine Ridge
Y-12 GRID EAST COORDINATE: 54,168.52
Y-12 GRID NORTH COORDINATE: 31,638.58
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

GROUNDWATER SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 1

First Date	Last Date
02/19/04	02/19/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/19/04	.	.	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SPR14.0SP

1.0 LOCATION

This spring discharges groundwater from the southern flank of Pine Ridge, about 300 ft north of Bear Creek Road at the western end of the Y-12 Complex. The spring is hydraulically upgradient of all waste-management activities.

2.0 SAMPLING HISTORY

One (unfiltered) groundwater sample has been collected to date to meet the surveillance monitoring objectives of the Y-12 GWPP (February 19, 2004). This sample was collected to evaluate groundwater quality before commencement of the Hollow Fill Construction Project. The grab sampling method was used to collect the sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on available data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 49 mg/L;
- pH of 6.24 (field measurement); and
- total concentrations of trace metals (except iron) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. The sample was analyzed for all of these constituents and for uranium isotopes (U-234, U-235, U-236, & U-238). None of these contaminants are present at elevated concentrations; only nitrate (0.0316 mg/L) and gross alpha activity (2.6 ± 1.8 pCi/L) were detected in the sample from this spring.

Although not typical groundwater or surface water contaminants in the East Fork Regime, the concentrations of iron (4.14 mg/L) and sulfate (4.87 mg/L) are elevated considering the low level of TDS in the sample (see Section 3.0).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

MAXIMUM CONCENTRATION: 2004

10 - 100	0.015 - 0.03	ND	7.5 - 15	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

SS-1

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spring Sampling Location, Bear Creek
ADMIN. GRID EAST COORDINATE: 50,440.00
ADMIN. GRID NORTH COORDINATE: 29,670.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: DOE Order
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 37

First Date	Last Date
08/30/90	07/20/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	01/27/04	.	07/20/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	33	142 mg/L	05/03/93	Decreasing
URANIUM (0.03 mg/L):	26	0.058 mg/L	08/05/98	Indeterminate
SUMMED VOCs (5 μg/L):	2	11 μg/L	03/09/95	Outlier
GROSS ALPHA (15 pCi/L):	23	29 pCi/L	07/15/02	Indeterminate
GROSS BETA (50 pCi/L):	17	178 pCi/L	05/03/93	Decreasing

SPRING SS-1

1.0 LOCATION

This spring discharges contaminated groundwater into the main channel of Bear Creek near the confluence of a northern tributary of the creek (NT-1) about 1,800 ft downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area., Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-seven (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

In addition to sampling performed to meet the surveillance monitoring objectives of the Y-12 GWPP, numerous samples have been collected to date for the purposes of other monitoring programs.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 586 -1,174 mg/L;
- pH of 6.8 – 8.2 (field measurements);
- elevated concentrations of chloride (>100 mg/L), sodium (>30 mg/L), and sulfate (>50 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results obtained since January 1991 that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

All of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical minimum value (8.22 mg/L in February 1998) being the only result below the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 1,750 ft east-northeast of spring SS-1, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells (and springs), the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek. Sampling results for spring SS-1 are representative of nitrate concentrations within the shallow karst network.

Five of the groundwater samples had nitrate concentrations above 50 mg/L (Table 1) and all of these results, including the historical maximum value (142 mg/L in May 1993), were reported for sample collected during the early 1990s. Nitrate concentrations below 25 mg/L were reported for each sample collected since September 1995. This illustrates the decreasing long-term concentration trend indicated by a time-series plot of the nitrate results (Figure 1). The reduced levels of nitrate in the shallow karst network in the Maynardville Limestone, as indicated by the sampling results for spring SS-1, reflect the substantial reduction in the relative flux of nitrate following the closure of the S-3 Ponds in 1984 and the installation of the low permeability cap in 1988 (DOE 1997).

4.2 URANIUM

All of the groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with 26 of these results exceeding the drinking water MCL for uranium (0.03 mg/L). The contaminant plume emplaced during historical operation of the former S-3 Ponds is the source of the uranium in the groundwater from this spring (DOE 1997).

Considering the slightly acidic to slightly basic pH of the samples from the spring (see Section 3.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). A time-series plot of uranium concentrations shows an indeterminate long-term trend, with generally decreasing concentrations since the historical maximum value (0.058 mg/L) in August 1998 (Figure 2).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs were detected in 16 of the groundwater samples: acetone, chloroform, PCE, TCE, and 12DCE (Table 2). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Sampling results for spring SS-1 are representative of VOC concentrations in the shallow karst network in the upper (easternmost) part of BCV, where the primary components of the VOC plume are PCE, TCE, and 12DCE (isomers) and the principal source areas include Spoil Area I and the contaminant plume emplaced during historical operation of former S-3 Ponds (DOE 1997).

Based on the detection frequency, the primary VOCs in the groundwater samples are PCE and TCE, with one or both compounds detected in each sample (Table 2). Aside from an anomalous result for acetone (9 µg/L), which is not a primary component of the contaminant plume in the Maynardville Limestone, all of the results for each VOC are estimated values of 3 µg/L or less and are less than the drinking water MCL for each applicable compound (Table 2).

4.4 GROSS ALPHA ACTIVITY

All but one of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with 23 of these results, including the historical maximum value (29 pCi/L in August 1998 and July 2002) exceed the drinking water MCL for gross alpha activity (15 pCi/L). A time-series plot of the gross alpha activity in samples from this location shows an indeterminate long-term trend (Figure 3).

Available radiological data, summarized below, indicate that uranium isotopes are the likely source of the elevated gross alpha activity in the groundwater from the spring.

Sampling Date	U-234 (pCi/L)	U-238 (pCi/L)
08/20/98	19.32	23.57
01/10/01	13	12
07/12/01	12	11

The contaminant plume emplaced during operation of the former S-3 Ponds is the source of the uranium isotopes (DOE 1997). As with total uranium, the uranium isotopes probably occur in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993).

4.5 GROSS BETA ACTIVITY

All of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with 16 of the results, including the historical maximum value (178 pCi/L in May 1993), exceeding the SDWA screening level (50 pCi/L) equivalent to a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). Although uranium isotopes (and beta particle-emitting daughter products) may contribute to the elevated levels of gross beta activity, the primary source is Tc-99. As shown by the data summarized blow, Tc-99 was detected (i.e., >MDA and CE) in all six samples analyzed for this radionuclide, although the results reflect concentrations that are substantially below the SDWA screening level (3,470 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99.

Sampling Date	Tc-99 (pCi/L)
03/09/95	50.8
09/22/95	95.5
03/18/96	67
08/13/96	48
01/10/01	64
07/12/01	61

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate. A time-series plot of the gross beta activity in samples from this location shows a generally decreasing long-term trend (Figure 4) that is similar to the trend of nitrate concentrations (Figure 1).

5.0 REFERENCES

Fetter, C.W. 1993. *Contaminant Hydrogeology*. Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-1: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	45	0.029	24.62	101.96
04/10/91	43	0.029	13.86	112.65
07/29/91	57	0.04	11.74	121.77
12/04/91	41	0.047	24.4	89.1
03/10/92	31	0.039	27.3	92.7
06/01/92	53.5	0.044	21.7	105
09/08/92	56	0.043	7.84	73.1
12/16/92	41	0.033	24.8	23.1
03/09/93	31	0.031	12.9	27.1
05/03/93	142	0.016	15.1	178
08/16/93	44.2	0.045	18.9	52.6
11/08/93	54.9	0.04	18.2	63.6
02/14/94	17.77	0.044	21.9	43.5
09/07/94	30	0.032	13.1	65
03/09/95	23	0.025	13.5	46.8
09/22/95	28	0.036	15.1	62.8
03/18/96	19.8	0.028	16.3	32.4
08/13/96	11.7	0.041	12.5	28.1
02/03/97	12.4	0.047	20	20
10/13/97	14.6	0.039	14	42
02/19/98	8.22	0.05	14	16
08/05/98	11.6	0.058	29	30
02/25/99	18.5	0.0436	23	37
08/11/99	18.03	0.0443	19	42
02/10/00	17.2	0.0444	19	44
08/02/00	19.8	0.0408	16	56
01/10/01	17.4	0.0436	18	64
07/12/01	23.5	0.0425	24	67
01/09/02	18.5	0.0415	21	60
07/15/02	17.4	0.0373	29	51
01/30/03	11.3	0.0326	23	33
07/29/03	13.4	0.0288	23	42
01/27/04	12.1	0.0247	<MDA	29
07/20/04	13.7	0.0247	14	47
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Spring SS-1: summary of VOC results

Date Sampled	Concentration (µg/L)				
	PCE	**TCE**	**12DCE**	**Acetone**	**Chloroform**
01/18/91	2 J	1 J	.	.	.
04/10/91	2 J	0.6 J	.	.	.
07/29/91	2 J	0.6 J	0.7 J	.	.
12/04/91	.	3 J	3 J	.	.
06/01/92	1 J	.	.	9	.
09/08/92	1 J	.	.	.	.
03/09/93	2 J	.	.	.	0.7
05/03/93	3 J	.	.	.	.
11/08/93	1 J	.	.	.	.
02/14/94	2 J	2 J	.	.	.
03/09/95	1 J	1 J	.	.	.
03/18/96	.	3 J	.	.	.
08/13/96	2 J	1 J	.	.	.
02/03/97	2 J	.	.	.	.
02/19/98	1 J	.	.	.	.
08/05/98	1 J	.	.	.	.
MCL	**10**	**0.03**	**70***	**NA**	**80****

Note: "." = Not detected; J = Estimated value; NA = Not applicable; *MCL is for c12DCE; ** MCL for total trihalomethanes (chloroform + bromoform + BDM + dibromochloromethane)

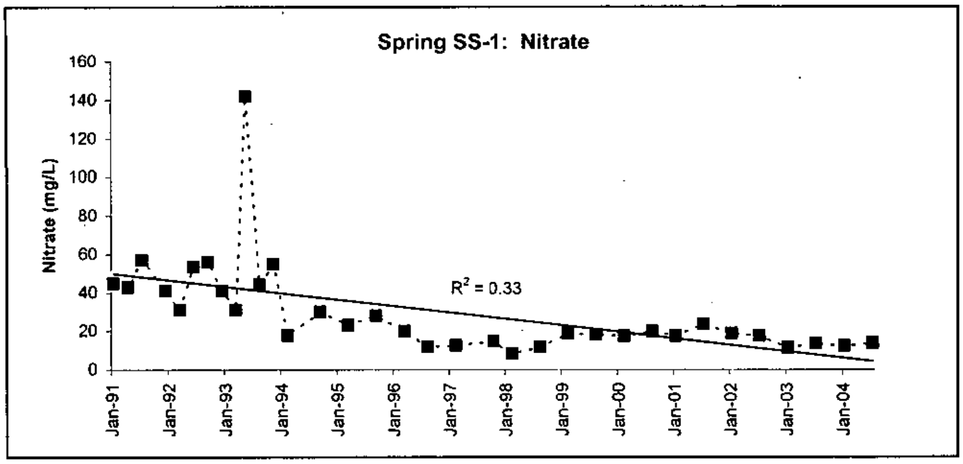


Figure 1

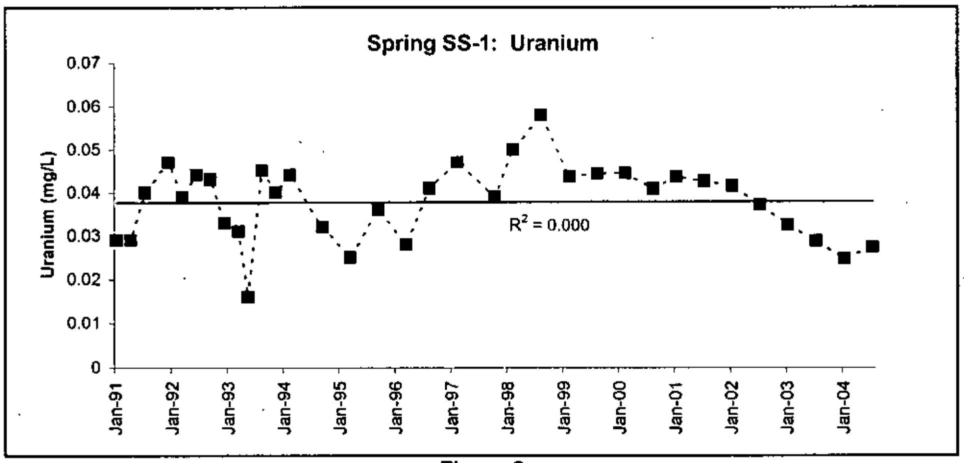


Figure 2

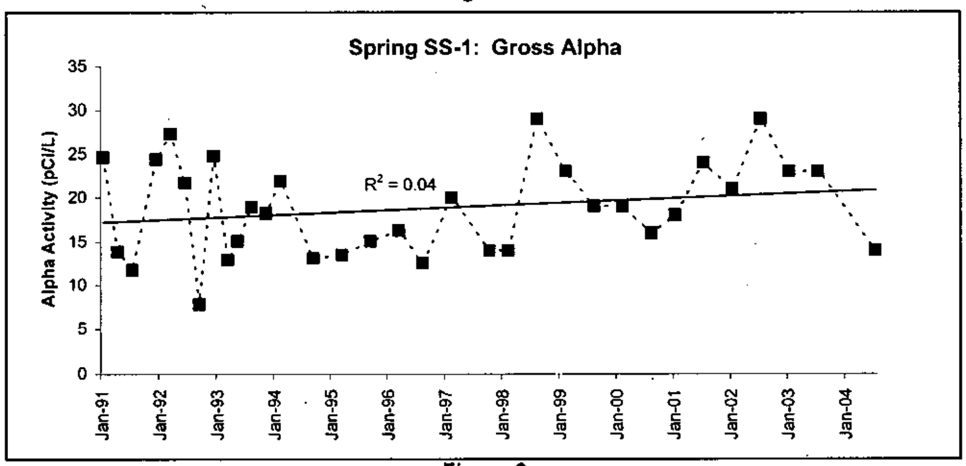


Figure 3

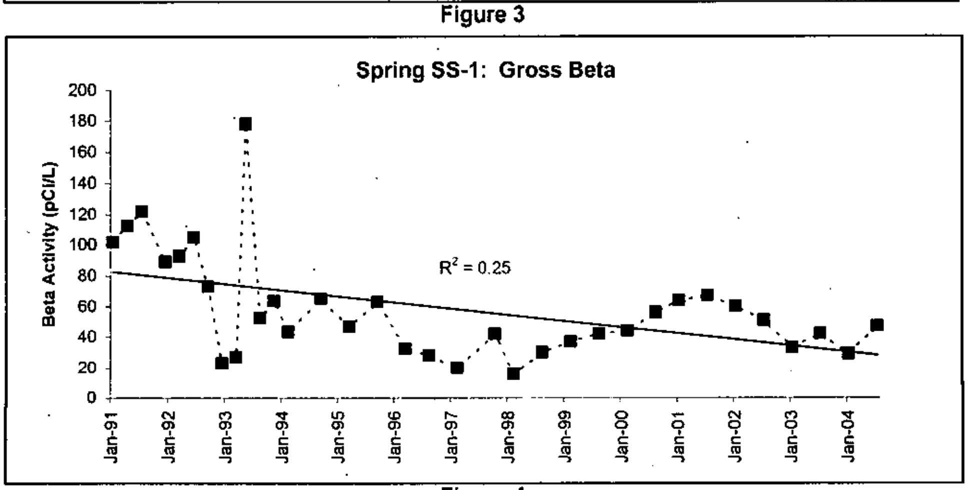


Figure 4

MAXIMUM CONCENTRATION: 2004

10 - 100	0.03 - 0.3	5 - 50	15 - 150	50 - 500
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

SS-4

LOCATION

HYDROGEOLOGIC REGIME:	Bear Creek Regime
FUNCTIONAL AREA:	Spring Sampling Location, Bear Creek
Y-12 GRID EAST COORDINATE:	44,213.00
Y-12 GRID NORTH COORDINATE:	28,831.00
SURFACE ELEVATION:	. ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING:	CERCLA
HYDROLOGIC MONITORING:	.
OTHER:	.

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 40

First Date	Last Date
08/30/90	07/20/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	01/27/04	.	07/20/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	27	67.6 mg/L	11/08/93	Indeterminate
URANIUM (0.03 mg/L):	34	0.332 mg/L	02/09/00	Indeterminate
SUMMED VOCs (5 µg/L):	28	39 µg/L	07/10/02	Increasing
GROSS ALPHA (15 pCi/L):	34	130 pCi/L	02/09/00	Indeterminate
GROSS BETA (50 pCi/L):	23	180 pCi/L	07/11/01	Indeterminate

SPRING SS-4

1.0 LOCATION

This spring discharges contaminated groundwater into the main channel of Bear Creek downstream of the confluence of a northern tributary of the creek (NT-6) about 8,000 ft downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Groundwater discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek. Discharge of (contaminated) groundwater from springs SS-4 and SS-5 sustains flow in the main creek channel during seasonally low flow periods (summer and fall). Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Forty (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample. Also, samples collected from the spring since January 1996 have been obtained from the mouth of the spring, whereas previous samples were obtained from the point where groundwater from the spring flows into Bear Creek.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 112 – 788 mg/L;
- pH of 6.5 – 7.8 (field measurements);
- elevated concentrations of chloride (>35 mg/L) and sulfate (>25 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results obtained since January 1991 that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Thirty-four of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with all but six of the results exceeding the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 8,000 ft east-northeast of spring SS-4, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells (and springs), the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek. Sampling results for spring SS-4 are representative of nitrate concentrations within the shallow karst network.

Nitrate concentrations reported for the groundwater samples range between the historical minimum value of 3.12 mg/L in February 1994 and the historical maximum value of 67.6 mg/L in November 1993 (Table 1). A time-series plot of the nitrate concentrations in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 1). Note that these nitrate levels are higher than indicated by sampling results for spring SS-1, which discharges into the main channel of Bear Creek upstream of spring SS-4 and about a mile closer to the former S-3 Ponds. Higher nitrate concentrations in the groundwater discharged from spring SS-4 probably reflects the transfer of contaminants from Bear Creek into the Maynardville Limestone via the losing reach of the creek south of the Oil Landfarm (DOE 1997).

4.2 URANIUM

Thirty-four of the groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and all of these results exceed the drinking water MCL for uranium (0.03 mg/L). Considering the slightly acidic to slightly basic pH of the samples from the spring (see Section 3.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). Located about 4,500 ft upstream of spring SS-4, the Boneyard/Burnyard, where large volumes of uranium-bearing wastes were below the saturated zone, was identified as the principal source of elemental uranium (and alpha radioactivity) in BCV (DOE 1997). In March 2003, a CERCLA remedial action at the site was completed, which involved the construction of an upgradient subsurface drain to hydraulically isolate the buried wastes; the excavation, consolidation, and disposal of about 64,000 yd^3 of wastes that were in contact with groundwater; and the reconstruction of a section of NT-3 that drains the site (BJC 2003).

Uranium concentrations reported for the groundwater samples range between the historical minimum value of 0.031 mg/L in July 1996 and the historical maximum value of 0.332 mg/L in February 2000. A time-series plot of the uranium concentrations in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 2). Note that these uranium levels are substantially higher than indicated by sampling results for spring SS-1, which discharges into Bear Creek upstream of the former Boneyard/Burnyard. Higher uranium concentrations in the groundwater discharged from spring SS-4 is a direct result of the transfer of uranium from Bear Creek into the Maynardville Limestone via the losing reach of the creek downstream of the Boneyard/Burnyard (DOE 1997).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs were detected in at least one of the groundwater samples: CTET, TCE, 11DCE, and 12DCE (Table 2). These compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousand feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Sampling results for spring SS-4 are representative of concentrations within the TCE-dominated VOC plume in the shallow karst network downgradient of several known or suspected sources of VOCs, including (listed in sequence from downgradient to upgradient) Sanitary Landfill I, the Hazardous Chemical Disposal Area (located at the former Boneyard/Burnyard, the Rust Spoil Area, the former S-3 Ponds, and Spoil Area I (DOE 1997).

Based on the detection frequency, the primary VOCs in the groundwater samples are TCE and 12DCE (c12DCE), with one or both compounds detected in all but five of the samples (Table 2). The concentrations of both compounds are relatively low, with respective historical maximum values of 20 µg/L and 17 µg/L reported for the sample collected in July 2002. Also, the most recent sampling result (July 2004) shows that TCE concentrations remain slightly above the drinking water MCL for TCE (5 µg/L). In contrast, CTET was detected in only one sample and 11DCE was detected in only two samples. Nevertheless, the summed concentrations of VOCs detected in the samples are typically much higher than summed VOC concentrations in sample from spring SS-1 as a result of the transfer of VOCs from Bear Creek into the Maynardville Limestone via the losing reach of the creek upstream of spring SS-4 (DOE 1997). A time-series plot of the summed concentrations of VOCs in samples from this location show a generally increasing trend (Figure 3) that appears to begin after the location was moved to the spring headwaters in January 1996 (see Section 2.0).

4.4 GROSS ALPHA ACTIVITY

Thirty-four of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE, and all of these results exceed the drinking water MCL for gross alpha activity (15 pCi/L). A time-series plot of the gross alpha activity in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 4). Available radiological data, summarized below, indicate that uranium isotopes are the likely source of the elevated gross alpha activity in the groundwater from the spring.

Sampling Date	U-234 (pCi/L)	U-238 (pCi/L)
01/18/91	5.62	9.08
04/10/91	1.74	6.1
07/29/91	14.4	20.9
12/04/91	13.2	10.5
03/10/92	5.19	12.5
06/01/92	15.3	32.3
09/08/92	31.9	27.4
12/16/92	50.2	63.9
02/13/98	19.84	39.75
07/14/98	7.2	14.86
02/02/99	23.39	45.31
08/11/99	19.46	43.31
02/09/00	73.55	137.9
08/03/00	11.52	19.1
01/11/01	28.37	52.1
07/11/01	19.09	39.2
01/08/02	28.11	53.34
07/10/02	18.65	31.07
01/29/03	14.76	22.49
07/28/03	15.3	25.34
01/27/04	7.23	14.43
07/20/04	14.58	28.75

The former Boneyard/Burnyard is the primary source of the uranium isotopes observed in samples from spring SS-4 (DOE 1997). As with total uranium, the uranium isotopes probably occur in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993).

4.5 GROSS BETA ACTIVITY

Thirty-four of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE, with 23 of the results exceeding the SDWA screening level (50 pCi/L) equivalent to a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). A time-series plot of the gross beta activity in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 4).

Although uranium isotopes (and beta particle-emitting daughter products) may contribute to the elevated levels of gross beta activity, the primary source is Tc-99. As shown by the following data summary, Tc-99 was detected (i.e., >MDA and CE) in seven of the ten samples analyzed for this radionuclide, and all but one of these results show Tc-99 concentrations that are substantially below the SDWA screening level (3,470 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99.

Sampling Date	Tc-99 (pCi/L)
03/10/92	7.19
06/01/92	<CE
09/08/92	4,550
12/16/92	<CE
02/14/94	137
09/06/94	156
03/09/95	<CE
07/25/95	87.6
03/16/96	52
07/30/96	48

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee,* Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-4: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	10	0.04	21.7	30.4
04/10/91	12	0.041	18.23	49.55
07/29/91	37	0.09	26.28	123.86
12/04/91	4.77	0.067	32.4	36.2
03/10/92	15.15	0.13	35.1	54.9
06/01/92	40.6	0.16	55	132
09/08/92	59	0.224	49.1	118
12/16/92	47	0.285	34.3	30.3
03/09/93	9.3	0.084	25.8	37.1
05/03/93	15	0.112	29.6	44.3
08/16/93	41.3	0.181	57	118
11/08/93	67.6	0.24	55.1	143
02/14/94	3.12	0.046	15.3	20.6
09/06/94	37	0.198	67.4	111
03/09/95	3.7	0.049	19.8	28.1
07/25/95	23	0.14	48	84.5
03/16/96	13.9	0.12	51	53.2
07/30/96	14.2	0.031	68.4	64.4
02/03/97	11.3	0.1	43	32
08/29/97	42	0.13	50	100
02/19/98	6.95	0.073	27	31
08/04/98	34.8	0.0971	38	110
02/24/99	18.2	0.239	110	60
08/11/99	18.27	0.109	34	56
02/09/00	40	0.332	130	170
08/01/00	42.6	0.108	41	160
01/11/01	45.2	0.152	56	140
07/11/01	40.9	0.101	60	180
01/08/02	43.7	0.182	73	180
07/10/02	8.53	0.0945	43	53
01/29/03	38.4	0.0812	42	130
07/28/03	24.9	0.0731	26	110
01/27/04	12	0.0361	24	48
07/20/04	17.1	0.0693	29	51
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

Table 2. Spring SS-4: summary of VOC results

Date Sampled	Concentration (µg/L)				
	TCE	12DCE	c12DCE	11DCE	CT
01/18/91	6	.	NR	.	.
04/10/91	13	.	NR	.	.
07/29/91	4 J	1 J	NR	.	.
12/04/91	4 J	.	NR	.	.
03/10/92	4 J	4 J	NR	.	.
06/01/92	4 J	4 J	NR	.	.
09/08/92	5	6	NR	.	.
12/16/92	5	3 J	NR	.	.
03/09/93	4 J	2 J	NR	.	.
05/03/93	4 J	4 J	NR	.	.
08/16/93	4 J	7	NR	.	.
11/08/93	4 J	3 J	NR	.	.
02/14/94	3 J	.	NR	.	.
09/06/94	4 J	5	NR	.	.
03/09/95	2 J	.	NR	.	.
07/25/95	3 J	5	NR	.	.
03/16/96	6	7	NR	.	.
07/30/96	6	3 J	NR	.	.
02/03/97	4 J	.	NR	.	.
08/29/97	10	5	5	.	.
02/19/98	5	1 J	1 J	.	6
08/04/98	14	11	11	2 J	.
02/24/99	7	2 J	2 J	.	.
08/11/99	11	6	6	.	.
02/09/00	10	3 J	3 J	.	.
08/01/00	7	3 J	3 J	.	.
01/11/01	12	8	8	.	.
07/11/01	15	9	9	.	.
01/08/02	8	4 J	4 J	.	.
07/10/02	20	17	17	2 J	.
01/29/03	4 J	2 J	2 J	.	.
07/28/03	9	5	5	.	.
01/27/04	3 J	.	.	.	.
07/20/04	6	.	4 J	.	.
MCL	**5**	**NA**	**70**	**7**	**5**
Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported					

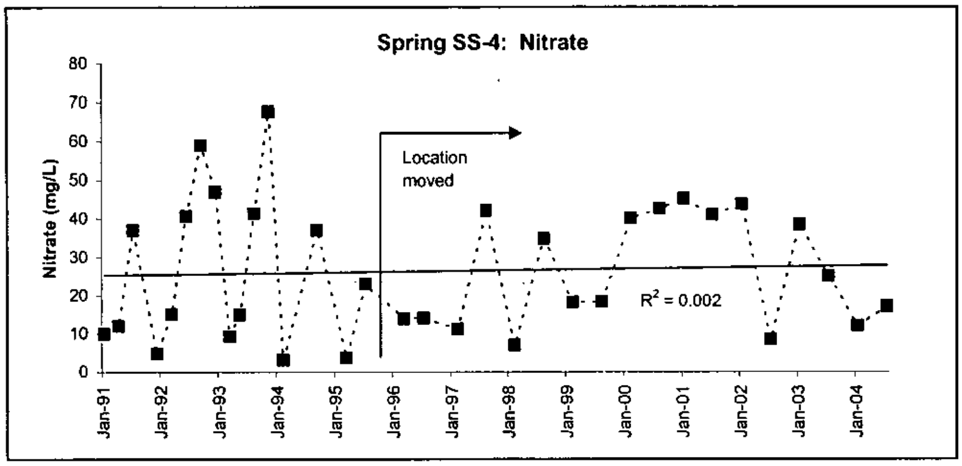


Figure 1

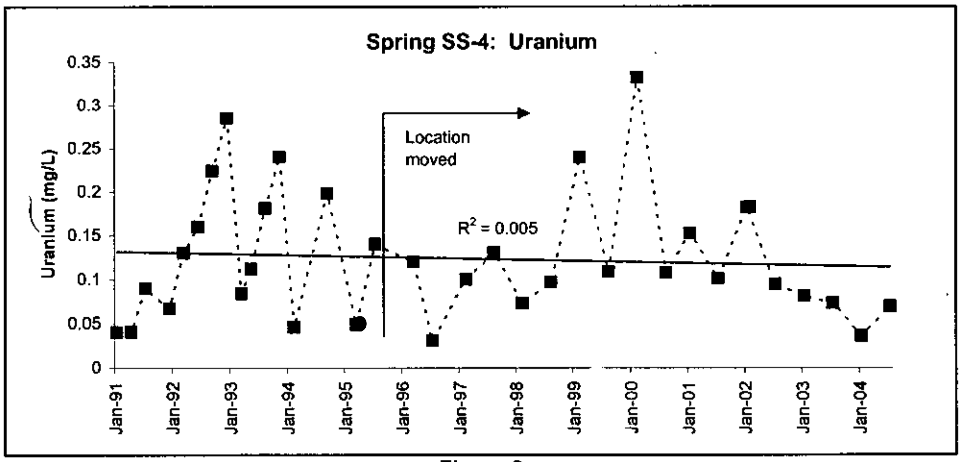


Figure 2

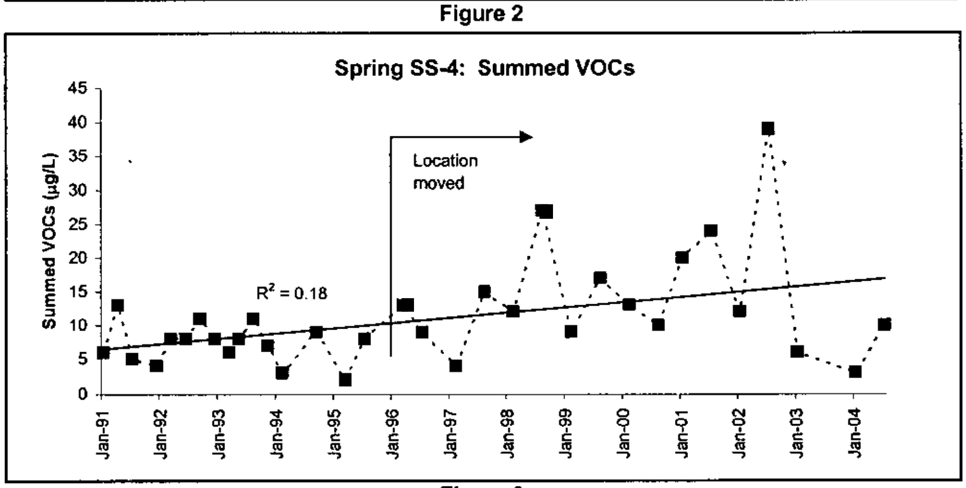


Figure 3

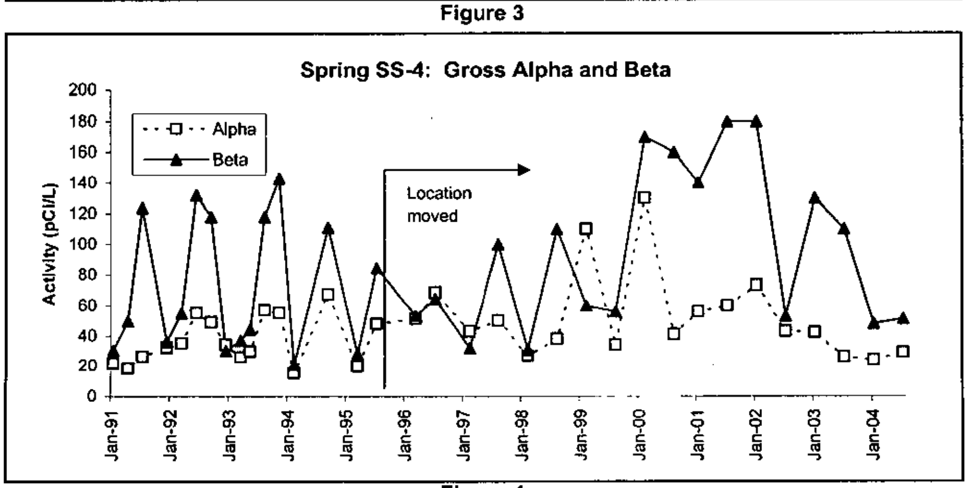


Figure 4

MAXIMUM CONCENTRATION: 2004

5 - 10	0.03 - 0.3	ND	15 - 150	25 - 50
Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (μg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)

SS-5

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spring Sampling Location, Bear Creek
Y-12 GRID EAST COORDINATE: 41,208.00
Y-12 GRID NORTH COORDINATE: 28,650.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 65

First Date	Last Date
08/30/90	07/20/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	01/27/04	.	07/20/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	20	988 mg/L	02/03/98	Decreasing
URANIUM (0.03 mg/L):	26	0.132 mg/L	02/09/00	Indeterminate
SUMMED VOCs (5 μg/L):	3	21 μg/L	08/03/98	Indeterminate
GROSS ALPHA (15 pCi/L):	26	57 pCi/L	02/09/00	Indeterminate
GROSS BETA (50 pCi/L):	13	81.75 pCi/L	07/29/91	Indeterminate

SPRING SS-5

1.0 LOCATION

This spring discharges contaminated groundwater into the main channel of Bear Creek immediately downstream of the confluence of a northern tributary of the creek (NT-8) that borders the western side of the Bear Creek Burial Grounds waste management area (WMA) about 11,000 ft downstream of the Bear Creek headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-5).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Groundwater discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek. Discharge of (contaminated) groundwater from springs SS-4 and SS-5 sustains flow in the main creek channel during seasonally low flow periods (summer and fall). Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Sixty-five (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP and the remedial investigation of Bear Creek Valley (DOE 1997), with the first sample collected in August 1990 and the most recent sample collected in July 2004. The 28 samples collected for the remedial investigation (April 1997 – February 1999) were analyzed only for nitrate and/or radioanalytes. The grab sampling method was used to collect each sample.

In addition to sampling performed for the purposes described above, numerous samples have been collected to date for the purposes of other monitoring programs.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 110 – 494 mg/L;
- pH of 6.5 – 7.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Forty-nine of the groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with results for 20 samples exceeding the drinking water MCL for nitrate (10 mg/L). The source of the nitrate is the former S-3 Ponds, which are unlined surface impoundments that were filled and covered with a multilayer low-permeability cap during RCRA closure of the site in 1988. Located about 8,000 ft east-northeast of spring SS-4, the former S-3 Ponds were used for the evaporation/infiltration of several million gallons of nitric acid wastes generated at Y-12 between 1951 and 1984. The groundwater contaminant plume originating from the site contains a heterogeneous mixture of inorganic, organic, and radiological contaminants. Nitrate, a principal component of the plume, enters the Maynardville Limestone via direct inflow of nitrate-contaminated groundwater from the Nolichucky Shale and recharge of nitrate-contaminated surface water in Bear Creek (DOE 1997). Nitrate is chemically stable and highly mobile in groundwater and effectively traces the primary groundwater flow/transport pathways followed by other similarly mobile contaminants originating from the former S-3 Ponds (and elsewhere in BCV). Based on the existing network of monitoring wells (and springs), the extent of nitrate contamination in the Maynardville Limestone in BCV west of Y-12, as defined by concentrations above 10 mg/L, is generally characterized by: (1) a relatively contiguous plume of nitrate in the fracture-dominated groundwater flow/transport pathways at depth (>100 ft bgs) in the bedrock that extends from south (down-dip) of the former S-3 Ponds westward for about 10,000 ft along geologic strike (i.e., bedding plan fractures) and (2) a more discontinuous plume of nitrate in the shallow karst network, which receives substantially greater recharge (i.e., dilution) and is significantly influenced by hydrologic interactions with surface water in Bear Creek. Sampling results for spring SS-5 are representative of nitrate concentrations within the shallow karst network.

Nitrate concentrations reported for the groundwater samples range between the historical minimum value (0.24 mg/L in May 1998) and the historical maximum value (988 mg/L in February 1998). However, the historical maximum value is an outlier compared to the nitrate results reported for the other samples, which are all less than 30 mg/L (Table 1). Excluding this suspected outlier, a time-series plot of the nitrate results shows a generally decreasing long-term concentration trend dominated by wide seasonal concentration fluctuations (Figure 1). Also, the highest concentrations have been reported for samples collected during seasonally low groundwater flow conditions. This suggests that nitrate-contaminated groundwater provides the bulk of the baseflow discharge from the spring, with lower concentrations in samples obtained during seasonally high flow conditions reflecting dilution from uncontaminated (or less contaminated) recharge.

4.2 URANIUM

Thirty-four groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), and 26 of these results exceed the drinking water MCL for uranium (0.03 mg/L). The uranium concentrations range between the historical minimum value of 0.005 mg/L in February 1994 and the historical maximum value of 0.132 mg/L in February 2000. A time-series plot of the uranium concentrations in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 2).

Considering the slightly acidic to slightly basic pH of the samples from the spring (see Section 3.0), uranium probably occurs in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993). The sources of uranium in the groundwater discharging from this spring include the Boneyard/Burnyard, which was identified as the principal source of elemental uranium (and alpha radioactivity) in BCV, but also may include uranium transported from sources within the BCBG WMA (DOE 1997) and the S-3 Site.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, at least one of the following VOCs were detected in fifteen of the groundwater samples: acetone, 4-methyl-2-pentanone, TCE, and 12DCE (Table 2). The latter two compounds are components of an essentially contiguous plume of dissolved VOCs that occurs in the Maynardville Limestone on either side of the topographic and hydrologic divide between the Bear Creek and Upper East Fork Poplar Creek watersheds. In the Bear Creek watershed west of the flow divide, the VOC plume in the Maynardville Limestone appears to originate near Spoil Area I and to extend several thousands of feet westward (parallel with geologic strike) down the axis of BCV, with influx of various VOCs from several different downgradient source areas. The distribution of VOCs within the plume reflects the relative contributions from the source areas and commingling during downgradient transport. Sampling results for spring SS-5 are representative of concentrations within the TCE-dominated VOC plume in the shallow karst network downgradient of several sources of VOCs, including the BCBG WMA (DOE 1997).

Based on the detection frequency, the primary VOCs in the groundwater samples are TCE and 12DCE (Table 2). The bulk of the results for each compound are estimated values below 5 μg/L, with the highest concentration (9 μg/L) reported for c12DCE in the sample collected in February 2000. Also, the most recent sampling results show TCE concentrations slightly above the drinking water MCL for TCE (Table 2). In contrast, 4-methyl-2-pentanone was detected in one sample and acetone was detected in only two samples (excluding false positive results).

4.4 GROSS ALPHA ACTIVITY

Forty groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 3), and results for 26 samples exceed the drinking water MCL for gross alpha activity (15 pCi/L). The results for gross alpha activity range between the historical minimum value of 4.45 pCi/L in December 1991 and the historical maximum value of 57 pCi/L in February 2000. A time-series plot of the gross alpha activity in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 3). Uranium isotopes are the source of the elevated gross alpha activity in the groundwater from the spring (Table 3).

As with the elemental uranium in the groundwater from this spring, the former Boneyard/Burnyard and the BCBG WMA are the likely sources of the uranium isotopes (DOE 1997). Similarly, the uranium isotopes probably occur in the groundwater as uranyl cations, which are prone to pH-sensitive sorption reactions and tend to form soluble complexes with a variety of inorganic anions in the groundwater, such as carbonate (Fetter 1993).

4.5 GROSS BETA ACTIVITY

Forty groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 3), with 13 of the results exceeding the SDWA screening level (50 pCi/L) equivalent for a 4 millirem per year (mrem/yr) dose equivalent (the drinking water MCL for gross beta activity). A time-series plot of the gross beta activity in the samples from this location shows a widely fluctuating, indeterminate long-term trend (Figure 4).

In addition to uranium isotopes (and beta particle-emitting daughter products), the elevated levels of gross beta activity are attributable to Tc-99. As shown by the following data summary, Tc-99 was detected (i.e., >MDA and CE) in twelve of the 16 samples analyzed for this radionuclide, and all but one of these results show Tc-99 concentrations that are substantially below the SDWA screening level (3,470 pCi/L) for a 4 mrem/yr dose equivalent from Tc-99

Sampling Date	Tc-99 (pCi/L)
03/10/92	7.25
06/01/92	<CE
09/08/92	4,800
12/16/92	<CE
02/02/99	18.42
08/11/99	26.45
02/90/00	55.74
08/03/00	48.25
01/11/01	111.97
07/11/01	119.67
01/08/02	78.57
07/10/02	16.17
01/29/03	35.94
07/28/03	32.18
01/27/04	8.85
07/20/04	36.29

This man-made radionuclide is a "signature" component of the contaminant plume emplaced during historical operation of the former S-3 Ponds, which is the only site at Y-12 that received wastes containing Tc-99 (DOE 1997). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-), which is soluble and highly mobile in groundwater (Gee et al. 1983). Based on the existing network of monitoring wells (and springs) in BCV west of Y-12, the distribution of elevated gross beta activity suggests that the transport of Tc-99 in the Maynardville Limestone closely mirrors that of nitrate.

5.0 REFERENCES

Bechtel Jacobs Company LLC (BJC). 2003. *Calendar Year 2002, Resource Conservation and Recovery Act Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 National Security Complex Oak Ridge, Tennessee,* BJC/OR-1334, Bechtel Jacobs Company LLC, Oak Ridge, TN.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* Macmillan Publishing Co., New York, NY.

Gee, G.W., D. Rai, and R.J. Serne. 1983. *Mobility of Radionuclides in Soil.* In: Chemical Mobility and Reactivity in Soil Systems. Soil Science Society of America, Inc. Madison, WI (pp 203-227).

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-5: summary of results for nitrate and uranium

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)
01/18/91	5	0.032
04/10/91	8	0.039
07/29/91	27	0.061
12/04/91	1.36	0.007
03/10/92	6.14	0.035
06/01/92	13.9	0.075
09/08/92	24	0.106
12/16/92	20	0.117
03/09/93	2.5	0.018
05/03/93	4.5	0.025
08/16/93	15.2	0.098
11/08/93	24.8	0.1
02/14/94	0.65	0.005
09/06/94	17	0.095
03/09/95	1.2	0.0054
07/25/95	7.5	0.075
03/16/96	3.92	0.031
07/29/96	8.6	0.086
02/03/97	2.09	0.019
04/04/97	4.5	.
08/22/97	7.5	.
08/29/97	11.4	0.07
10/31/97	16.6	.
01/02/98	13.8	.
02/03/98	[988]	.
02/13/98	4.4	.
02/18/98	3.14	0.023
02/27/98	2.5	.
04/01/98	0.63	.
05/18/98	0.24	.
06/03/98	2.4	.
06/30/98	7	.
07/14/98	10.2	.
07/31/98	20.7	.
08/03/98	14	0.0551
08/31/98	28.6	.
09/30/98	28.5	.
02/23/99	6.03	0.0606
08/11/99	7.109	0.0746
02/09/00	10.5	0.132
08/01/00	6.95	0.0614
01/11/01	20.8	0.107
07/11/01	14.9	0.0607
01/08/02	16.6	0.109
07/10/02	4.48	0.0476

Table 1. (Continued)

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)
01/29/03	9.2	0.0412
07/28/03	0.98	0.0393
01/27/04	2.79	0.0152
07/20/04	9.22	0.0421
MCL	**10**	**0.03**
Note: "." = Not analyzed; [ ] = Suspected outlier		

Table 2. Spring SS-5: summary of VOC results

Date Sampled	Concentration (µg/L)				
	TCE	12DCE	c12DCE	Acetone	4-Methyl-2-Pentanone
07/29/91	0.9 J	0.9 J	NR	.	.
03/10/92	.	.	NR	FP	4 J
06/01/92	2 J	2 J	NR	.	.
09/08/92	2 J	2 J	NR	FP	FP
05/03/93	.	.	NR	2 J	FP
08/16/93	2 J	2 J	NR	.	.
11/08/93	1 J	.	NR	.	.
07/25/95	2 J	3 J	NR	.	.
08/29/97	3 J	.	.	.	.
08/03/98	2 J	3 J	3 J	16	.
02/09/00	.	9	9	.	.
01/11/01	.	2 J	2 J	.	.
01/08/02	.	2 J	2 J	.	.
07/10/02	2 J	3 J	3 J	.	.
01/29/03	.	2 J	2 J	.	.
07/28/03	.	.	.	.	.
01/27/04	.	.	.	.	.
07/20/04	.	.	.	.	.
MCL	**5**	**NA**	**70**	**NA**	**NA**

Note: "." = Not detected; J = Estimated value; NA = Not applicable; NR = Not reported; FP = False positive result

Table 3. Spring SS-5: summary of results for gross alpha activity, gross beta activity, and uranium isotopes

Date Sampled	Concentration (pCi/L)			
	Gross Alpha Activity	Gross Beta Activity	U-234	U-238
01/18/91	15.1	14.12	3.49	3.49
04/10/91	14.33	33.87	2.28	10
07/29/91	31.8	81.75	8.54	14.7
12/04/91	4.45	7.58	2.59	2.59
03/10/92	10.6	18.4	3.49	4.36
06/01/92	30.2	52.4	5.47	7.3
09/08/92	23.2	73	<CE	21.8
12/16/92	43.9	44	17.4	39.2
03/09/93	8.69	12.5	.	.
05/03/93	6.11	15.7	.	.
08/16/93	30.6	65.2	.	.
11/08/93	32.8	73.3	.	.
02/14/94	4.6	4.04	.	.
09/06/94	28.8	50.3	.	.
03/09/95	5.19	4.1	.	.
07/25/95	26.4	29.9	.	.
03/16/96	12.9	16.6	.	.
07/29/96	32.1	29.8	.	.
02/03/97	9.3	11	.	.
04/04/97	11	13	9.5	8.8
08/22/97	14.57	27.38	6.64	11.54
08/29/97	18	34	.	.
10/31/97	37.34	68.43	15.76	28.86
12/03/97	38.52	70.92	19.97	35.83
01/02/98	.	.	19.9	31.88
02/03/98	.	.	6.44	13.6
02/13/98	13.71	18.44	7.44	12.18
02/18/98	9.5	13	.	.
02/27/98	.	.	5.06	9
04/01/98	.	.	4.89	8.6
05/18/98	.	.	2.49	4.33
06/03/98	.	.	4.52	8.02
06/30/98	.	.	8.6	12.14
07/14/98	34.79	58.08	17.91	31.48
07/31/98	.	.	21.54	61.8
08/03/98	31	46	.	.
08/31/98	.	.	12.7	21.04
09/30/98	.	.	14.39	28.37
10/21/98	.	.	13.23	23.35
10/28/98	.	.	12.03	25.65
11/04/98	.	.	9.97	20.16
11/11/98	.	.	12.28	24.01
11/18/98	.	.	12.9	27.63
11/25/98	.	.	16.89	30.9
12/02/98	.	.	15.33	25.85
12/09/98	.	.	11.74	21.94

Table 3. (Continued)

Date Sampled	Concentration (pCi/L)			
	Gross Alpha Activity	Gross Beta Activity	U-234	U-238
12/16/98	.	.	10.91	19.32
12/28/98	.	.	23.54	46.3
12/30/98	.	.	21.17	45.14
02/02/98	.	.	8.1	15.06
02/23/99	29	25	.	.
08/11/99	24	29	14.91	28.61
02/09/00	57	58	39.15	69.69
08/01/00	29	25	.	.
08/03/00	.	.	12.71	23.23
01/11/01	41	68	21.24	38.09
07/11/01	31	69	11.69	19.69
01/08/02	48	81	20.69	36.72
07/10/02	31	37	8.54	15.18
01/29/03	21	42	11.88	16.92
07/28/03	18	39	5.02	10.66
01/27/04	7.3	17	2.7	4.41
07/20/04	17	29	7.9	17
MCL	**15**	**50***	**Not Applicable**	

Note: "." = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

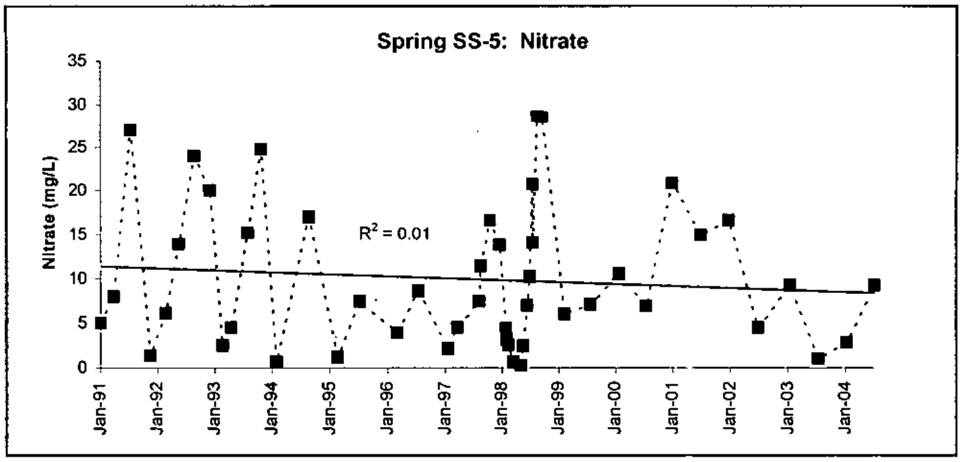


Figure 1

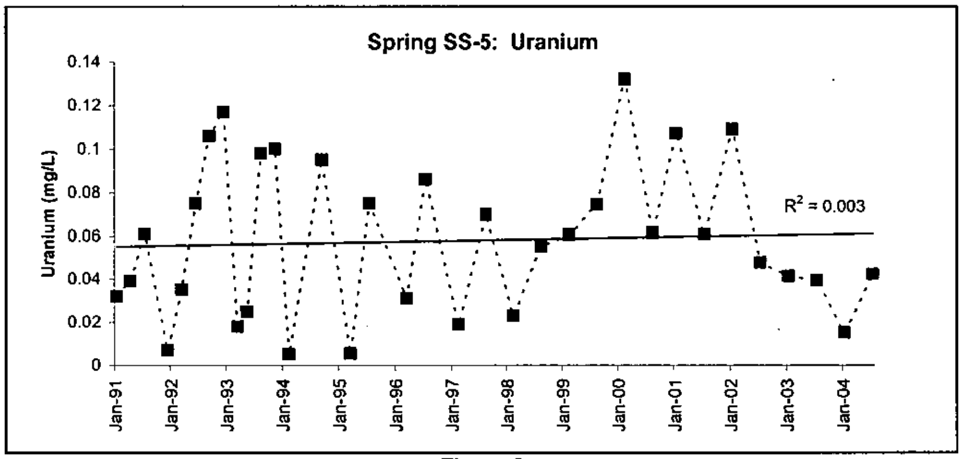


Figure 2

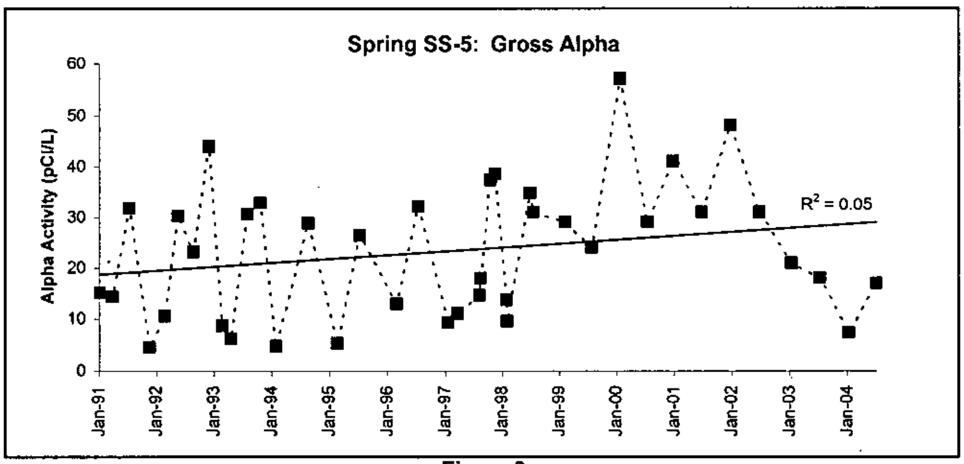


Figure 3

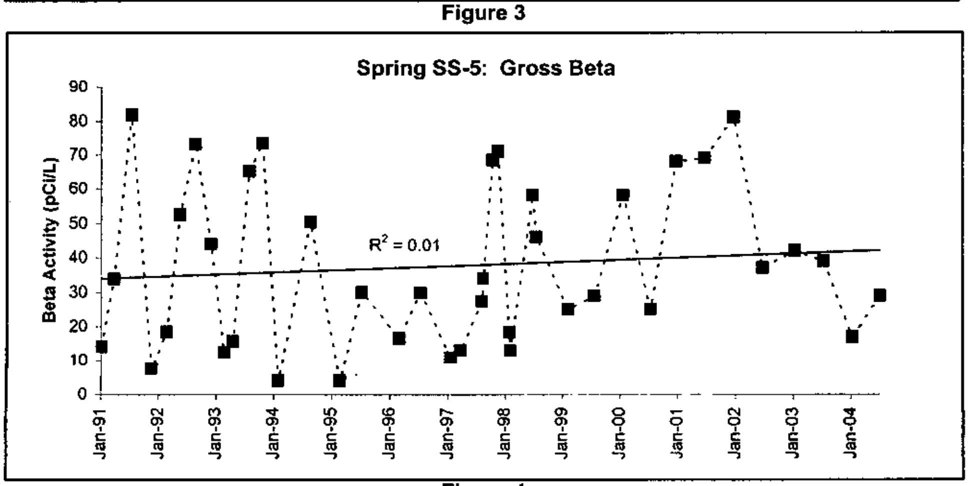


Figure 4

MAXIMUM CONCENTRATION: 2004

<5	ND	ND	<7.5	<25
Nitrate (mg/L)	**Uranium (mg/L)**	**Summed VOCs (µg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**

SS-6

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spring Sampling Location, Bear Creek
Y-12 GRID EAST COORDINATE: 35,186.00
Y-12 GRID NORTH COORDINATE: 28,462.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: RCRA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 36

First Date	Last Date
08/30/90	07/07/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	03/02/04	.	07/07/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	1	37.8 mg/L	11/08/93	Outlier
URANIUM (0.03 mg/L):	2	0.15 mg/L	11/08/93	Indeterminate
SUMMED VOCs (5 µg/L):	1	9 µg/L	11/08/93	Outlier
GROSS ALPHA (15 pCi/L):	1	54.3 pCi/L	11/08/93	Outlier
GROSS BETA (50 pCi/L):	1	126 pCi/L	11/08/93	Outlier

SPRING SS-6

1.0 LOCATION

This spring discharges groundwater into the main channel of Bear Creek about three miles downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Thirty-six (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample. Note that the sample collected on November 1993 may have been inadvertently misidentified as a sample that was collected the same day from surface water sampling station BCK-09.40, and vice versa. Misidentification of these samples in the field is suspected because the analytical results reported for the sample from spring SS-6 are more consistent with the historical data for BCK-09.40 and the analytical results reported for the sample from BCK-09.40 are more consistent with the historical data for spring SS-6. However, there are not any available records that prove the misidentification of these samples; consequently, the analytical results for both samples are considered unusable to meet the surveillance monitoring objectives of the Y-12 GWPP.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 76 – 272 mg/L, excluding an outlier (580 mg/L) in November 1993 (see Section 2.0);
- pH of 6.5 – 8.6 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and

- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Excluding the groundwater sample collected in November 1993 (see Section 2.0), 14 of the samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (2.33 mg/L in February 2000) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Excluding the groundwater sample collected in November 1993 (see Section 2.0), seven of the samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.034 mg/L in February 1998) being the only result above the drinking water MCL.

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results and the groundwater sample collected in November 1993 (see Section 2.0), c12DCE was detected in one sample (1 μg/L in February 1998) from this spring.

4.4 GROSS ALPHA ACTIVITY

Excluding the groundwater sample collected in November 1993 (see Section 2.0), nine of the samples had gross alpha activity above the applicable MDA and corresponding CE, with the historical maximum value (10 pCi/L in February 1998) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Excluding the groundwater sample collected in November 1993 (see Section 2.0), nine of the samples had gross beta activity above the applicable MDA and corresponding CE, with the highest value (47 pCi/L in August 1997) being slightly below the SDWA screening level (50 pCi/L) equivalent to a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). This elevated result is an outlier when compared to the other results, all of which are 12 pCi/L or less.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-6: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	.	.	< CE	< CE
04/10/91	.	.	< CE	< CE
07/29/91	.	.	< CE	< CE
12/04/91	.	.	< CE	< CE
03/10/92	.	.	< CE	< CE
06/01/92	.	.	< CE	< CE
09/08/92	.	.	< CE	< CE
12/16/92	.	.	< CE	< CE
03/09/93	.	.	< CE	< CE
05/03/93	.	.	< CE	< CE
08/16/93	.	.	< CE	< CE
11/08/93	[37.8]	[0.15]	[54.3]	[126]
03/09/95	0.68	.	2.17	< CE
07/25/95	0.45	.	< CE	< CE
04/03/97	0.29	.	<MDA	4.6
08/26/97	1.6	.	2.43	47.66
02/18/98	2.29	0.034	10	12
07/30/98	1.55	0.0102	4.8	<MDA
02/23/99	0.68	0.00625	3	<MDA
08/10/99	0.9259	0.0109	5.5	<MDA
02/09/00	2.33	0.0212	7.6	10
08/01/00	1.6	0.00863	4.9	9.2
03/04/03	0.096	.	NA	3.63
08/19/03	0.8	0.00665	NA	5.01
03/02/04	0.15	.	NA	1.9
07/07/04	0.5	.	3.33	5.66
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; [ ] unusable analytical result (see Section 2.0); NA = Not analyzed;
* = SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	.	<25

SS-6.6

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spring Sampling Location, Bear Creek
Y-12 GRID EAST COORDINATE: 30,365.00
Y-12 GRID NORTH COORDINATE: 28,554.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 12

First Date	Last Date
04/03/97	03/02/04

SAMPLING DATES FOR CALENDAR YEAR:		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
	2004	03/02/04	.	.	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	16.32 pCi/L	08/16/00	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SS-6.6

1.0 LOCATION

This spring discharges groundwater into the main channel of Bear Creek about four miles downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-6.6).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Twelve (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in April 1997 and the most recent sample collected in March 2004. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 81 – 240 mg/L;
- pH of 6.3 – 8.0 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in

UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Twelve groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.97 mg/L in January 2000) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Four groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.0155 mg/L in August 1997) less than the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Traces of benzene (1 μg/L) and toluene (1 μg/L) were detected in the groundwater sample collected in August 1998; both results are probably sampling or analytical artifacts.

4.4 GROSS ALPHA ACTIVITY

Six groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (16.32 pCi/L in August 2000) being slightly above the drinking water MCL for gross alpha activity (15 pCi/L). However, the historical maximum value appears to be an outlier when compared to the other results for gross alpha activity, which are all less than 5 pCi/L.

4.5 GROSS BETA ACTIVITY

Ten groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (48.9 pCi/L in August 2003) being slightly below the SDWA screening level (50 pCi/L) equivalent to a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). However, the historical maximum value appears to be an outlier when compared to the other results for gross beta activity, which are all less than 20 pCi/L.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-6.6: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
04/03/97	0.4	.	<MDA	5.2
08/25/97	0.55	0.0155	4.9	16.18
02/19/98	0.6	.	2.2	2.32
08/28/98	0.38	.	4.86	5.74
02/03/99	0.6	.	.	<MDA
07/29/99	0.03	.	1.33	<MDA
01/25/00	0.97	0.00793	.	3.89
08/16/00	0.62	0.00503	16.32	16
03/22/01	0.49	.	4.1	2.73
03/04/03	0.32	.	.	3.31
08/19/03	0.2	0.0127	.	48.9
03/02/04	0.38	.	.	8.71
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	<0.015	ND	.	<25

SS-7

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime
FUNCTIONAL AREA: Spring Sampling Location, Bear Creek
Y-12 GRID EAST COORDINATE: 27,918.00
Y-12 GRID NORTH COORDINATE: 28,760.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 15

First Date	Last Date
05/23/95	08/19/03

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2003	03/04/03	.	08/19/03	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	2	0.036 mg/L	10/26/95	Outlier
SUMMED VOCs (5 µg/L):	0	< µg/L		
GROSS ALPHA (15 pCi/L):	1	16.4 pCi/L	10/26/95	Outlier
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SS-7

1.0 LOCATION

This spring discharges groundwater into the main channel of Bear Creek about 4.5 miles downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-7).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Fifteen (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in May 1995 and the most recent sample collected in August 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 119 – 228 mg/L;
- pH of 6.2 – 8.9 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in

UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Fifteen groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (4.74 mg/L in October 1995) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Seven groundwater samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), including two results (0.036 mg/L in October 1995 and 0.0316 mg/L in September 2001) being slightly above the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

VOCs were not detected in the groundwater samples.

4.4 GROSS ALPHA ACTIVITY

Nine of the groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (16.4 pCi/L in October 1995) being slightly above the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Five of the groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (23.7 pCi/L in October 1995) being substantially below the SDWA screening level for gross beta activity (50 pCi/L) equivalent to a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-7: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
05/23/95	0.24	.	< CE	< CE
10/26/95	4.74	0.036	16.4	23.7
04/04/97	0.34	.	<MDA	<MDA
08/25/97	1.5	.	5.8	10.1
02/17/98	0.24	.	1.53	<MDA
07/16/98	0.31	0.0096	<MDA	2.17
02/02/99	0.13	.	NA	<MDA
07/29/99	0.58	.	4.62	4.42
01/25/00	1.3	0.0168	NA	5.24
08/16/00	1.7	0.0136	7.11	9.5
03/22/01	0.16	.	1.41	<MDA
09/18/01	1.7	0.0316	NA	8.59
03/12/02	1.9	0.0161	NA	9.29
03/04/03	0.057	.	NA	<MDA
08/19/03	0.27	0.00453	NA	11.17
MCL	**10**	**0.03**	**15**	**50***

Note: "." = Not detected; NA = Not analyzed; * SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

MAXIMUM CONCENTRATION: 2003

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
<5	ND	ND	.	<25

SS-8

LOCATION

HYDROGEOLOGIC REGIME: Bear Creek Regime

FUNCTIONAL AREA: Spring Sampling Location, Bear Creek

Y-12 GRID EAST COORDINATE: 27,552.00

Y-12 GRID NORTH COORDINATE: 28,887.00

SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA

HYDROLOGIC MONITORING: .

OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 28

First Date	Last Date
08/30/90	08/19/03

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2003	03/04/03	.	08/19/03	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	0	< mg/L		
SUMMED VOCs (5 µg/L):	1	7 µg/L	06/01/92	Outlier
GROSS ALPHA (15 pCi/L):	0	< pCi/L		
GROSS BETA (50 pCi/L):	0	< pCi/L		

SPRING SS-8

1.0 LOCATION

This spring discharges groundwater into the main channel of Bear Creek about 4.5 miles downstream of the headwaters near the west end of Y-12. From its headwaters, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. In Bear Creek Valley (BCV), the major springs along the south side (SS) of Bear Creek are numbered in ascending order downstream from the headwaters (e.g., SS-8).

Approximately half of the annual precipitation in Bear Creek Valley (BCV) exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring, with the remainder of the annual precipitation lost to evapotranspiration and recharge to the groundwater system (DOE 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally return to pre-precipitation levels within one or two days.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone, which directly underlies the creek throughout much of BCV (DOE 1997). Discharge from springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during seasonally dry periods when spring discharge and groundwater baseflow provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major groundwater discharge area. Losing reaches in upper and middle Bear Creek, play an important role in transferring contaminants from Bear Creek into the Maynardville Limestone.

2.0 SAMPLING HISTORY

Twenty-eight (unfiltered) groundwater samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in August 1990 and the most recent sample collected in August 2003. The grab sampling method was used to collect each sample.

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the groundwater samples is characterized by:

- TDS of 100 – 280 mg/L;
- pH of 6.0 – 8.5 (field measurements);
- calcium-magnesium-bicarbonate dominated major ion chemistry, with low molar proportions of chloride, potassium, sodium, and sulfate (<10% of total anions/cations); and
- total concentrations of trace metals that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in

UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Twenty-one groundwater samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (358 mg/L in February 1998) substantially exceeding the drinking water MCL for nitrate (10 mg/L). However, this result is an outlier when compared to the nitrate concentrations reported for the other samples, all of which are less than 1.5 mg/L.

4.2 URANIUM

One groundwater sample had (total) uranium concentrations above the applicable analytical reporting limit (two samples were not analyzed for uranium; Table 1), and this result (0.001 mg/L in November 1993) is substantially below the drinking water MCL for uranium (0.03 mg/L).

4.3 VOLATILE ORGANIC COMPOUNDS

Excluding false positive results, acetone was detected in the groundwater sample collected in June 1992 (7 µg/L).

4.4 GROSS ALPHA ACTIVITY

Four groundwater samples had gross alpha activity above the applicable MDA and corresponding CE (five samples were not analyzed for gross alpha activity; Table 1), with the historical maximum value (6.91 pCi/L in August 1993) being less than the drinking water MCL for gross alpha activity (15 pCi/L).

4.5 GROSS BETA ACTIVITY

Six groundwater samples had gross beta activity above the applicable MDA and corresponding CE (Table 1), with the historical maximum value (4.82 pCi/L in September 2001) being substantially below the SDWA screening level (50 pCi/L) equivalent to a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Volume 1, DOE/OR/02-1545&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Spring SS-8: summary of results for nitrate, uranium, gross alpha activity, and gross beta activity

Date Sampled	Nitrate (mg/L)	Uranium (mg/L)	Gross Alpha Activity (pCi/L)	Gross Beta Activity (pCi/L)
01/18/91	.	.	< CE	< CE
04/10/91	0.4	.	< CE	< CE
07/29/91	0.3	.	< CE	< CE
12/04/91	.	.	< CE	< CE
03/10/92	0.31	.	< CE	< CE
06/01/92	.	.	< CE	< CE
09/08/92	.	.	< CE	< CE
12/16/92	0.31	.	< CE	3.12
03/09/93	0.36	.	< CE	< CE
05/03/93	0.32	.	< CE	< CE
08/16/93	1.2	.	6.91	< CE
11/08/93	0.3	0.001	< CE	< CE
04/04/97	0.32	.	<MDA	<MDA
08/25/97	0.33	.	1.31	2.38
02/17/98	0.42	.	<MDA	<MDA
07/16/98	0.28	.	<MDA	<MDA
02/03/99	[358]	NA	1.02	<MDA
07/29/99	0.43	NA	1.9	<MDA
01/25/00	0.29	.	NA	<MDA
08/16/00	.	.	<MDA	<MDA
03/22/01	0.3	.	<MDA	1.78
09/18/01	0.4	.	NA	4.82
03/12/02	0.29	.	NA	2.71
09/09/02	0.24	.	NA	<MDA
03/04/03	0.16	.	NA	<MDA
08/19/03	0.2	.	NA	3.32
MCL	**10**	**0.03**	**15**	**50 ***

Note: "." = Not detected; NA = Not analyzed; [ ] = Qualitative, ion charge balance error (-84.4%);
* SDWA screening level for a 4 millirem dose equivalent (the MCL for gross beta activity)

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	0.015 - 0.03	.	7.5 - 15	<25

STATION 8

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Upper East Fork Poplar Creek
ADMIN. GRID EAST COORDINATE: 59,505.00
ADMIN. GRID NORTH COORDINATE: 29,188.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 23

First Date	Last Date
02/12/99	08/18/04

		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SAMPLING DATES FOR CALENDAR YEAR:	2004	02/12/04	.	07/27/04	.

PRINCIPAL CONTAMINANTS

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
	Results (since 1991) > Screening Level			
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	4	0.0558 mg/L	02/14/01	Indeterminate
SUMMED VOCs (5 µg/L):	13	17 µg/L	07/23/03	Indeterminate
GROSS ALPHA (15 pCi/L):	5	54.97 pCi/L	07/12/99	Indeterminate
GROSS BETA (50 pCi/L):	0	< pCi/L	.	

SURFACE WATER SAMPLING STATION
Station 8

1.0 LOCATION

This surface water sampling station is located on the exposed section of the main channel of Upper East Fork Poplar Creek (UEFPC) in south-central Y-12, directly southeast of Bldg. 9201-1. Construction of facilities at Y-12 has substantially modified UEFPC, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, filled and replaced with an extensive network of underground storm drains. Also, the section of the creek near the eastern end of Y-12 was extensively modified by construction of New Hope Pond (NHP) in 1963 and the closure of NHP in 1988. An unlined surface impoundment, NHP was used to regulate the quantity and quality of surface water exiting Y-12 until it was closed and replace by Lake Reality, a lined surface impoundment built in 1988.

About 80% of dry-weather flow in UEFPC is attributable to once-through non-contact cooling water, condensate, cooling tower blowdown, and potable water treated and discharged from wastewater treatment facilities and the remaining 20% is from groundwater discharge (DOE 1998). In accordance with a flow management program initiated in July 1996, untreated water from the Clinch River intake lines to the DOE water treatment plant that supplies potable water to Y-12 is discharged into the exposed section of the main channel of UEFPC in the south-central section of Y-12 near Bldg. 9201-1. Augmentation of flow in UEFPC is necessary because reduced operations at Y-12 have decreased flow from 10-15 million gallons per day (mgd) to about 2.5 mgd. Flow augmentation also is needed to: (1) achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, which is located immediately upstream of where UEFPC exits the DOE Oak Ridge Reservation northeast of Y-12; (2) maintain compliance with NPDES toxicity requirements; and (3) lower the otherwise elevated water temperature in UEFPC.

2.0 SAMPLING HISTORY

Twenty-three (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in February 1999 and the most recent sample collected in July 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs as a best management practice and to meet the requirements of DOE Order 450.1. Also, grab sampling and/or flow-proportionate composite sampling is performed to meet the requirements of the Phase I ROD for UEFPC (DOE 1997).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 150 – 350 mg/L;
- pH of 6.7 – 8.4 (field measurements);
- elevated concentrations of sulfate (>25 mg/L); and

- total concentrations of trace metals (except mercury and uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, the surface-water quality data obtained by the Y-12 GWPP are not flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Nineteen surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (3.9 mg/L in April 1999) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Fifteen surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), including four results that exceed the drinking water MCL for uranium (0.03 mg/L): 0.05 mg/L in March 2000; 0.0558 mg/L and 0.0367 mg/L in February 2001; and 0.04 mg/L in February 2002. Note that all of the elevated uranium results are for samples collected during winter and spring, suggesting higher contaminant flux during seasonally high flow conditions. There are numerous sources of uranium within Y-12 upstream of this sampling station, including inflow of uranium-contaminated groundwater into UEFPC.

4.3 MERCURY

Six surface water samples had (total) mercury concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (0.00081 mg/L in July 1999) being substantially below the drinking water MCL for mercury (0.002 mg/L). There are multiple sources of mercury within Y-12 upstream of this sampling station, including inflow of mercury-contaminated groundwater into UEFPC, and the remediation of these sources is the focus of the CERCLA Phase I ROD for mercury source areas in UEFPC (DOE 1997).

4.4 VOLATILE ORGANIC COMPOUNDS

Nineteen surface water samples collected between February 1999 and August 2003 had low concentrations of one or more of the following VOCs (Table 2): bromoform (BFM), bromodichloromethane (BDM), chloroform (CLF), dibromochloromethane (DBM), TCE, and c12DCE. Most of these results are estimated values below 5 μg/L, and none of the concentrations exceed applicable MCLs for drinking water. There are multiple sources of VOCs in Y-12 upstream of this sampling station, including the inflow of VOC-contaminated groundwater into UEFPC. Additionally, trihalomethanes (CLF, BMF, BDM, and DBM) are included in a class of drinking water disinfection byproducts (DBPs) that form through chemical interactions between chlorine and natural organic matter (U.S. Environmental Protection Agency [EPA] 2001). Thus, chlorinated water discharged into UEFPC is a likely source of the DBPs detected in the surface water samples from this sampling station.

4.5 GROSS ALPHA ACTIVITY

Twenty-one surface water samples had gross alpha activity above the applicable MDA and corresponding CE (Table 3), with results reported for five samples, including the historical maximum value (54.97 pCi/L in July 1999), exceeding the drinking water MCL for gross alpha activity (15 pCi/L). Uranium isotopes (U-234 and U-238) are the likely source of the elevated gross alpha activity, with the highest values for each isotope also being reported for the sample collected in July 1999 (Table 3).

4.6 GROSS BETA ACTIVITY

Twenty-two surface water samples had gross beta activity above the applicable MDA and corresponding CE (Table 3), with historical maximum value (36.22 pCi/L in July 1999) being less than the SDWA screening level (50 pCi/L) for a 4 millirem per year dose equivalent (the drinking water MCL for gross beta activity). As with the gross alpha activity, uranium isotopes are the likely source of the gross beta activity; the highest values for each isotope are reported for the same sample as the historical maximum gross beta result (July 1999).

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1951&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

U. S. Environmental Protection Agency (EPA). 2001. *Controlling Disinfection By-Products and Microbial Contamination in Drinking Water*, EPA/600/R-01/110, U. S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

Table 1. Surface Water Sampling Station 8: summary of results for nitrate, mercury, and uranium

Sampling Date	Concentration (mg/L)		
	Nitrate	Total Uranium	Mercury
02/12/99	2.4	NA	0.00026
04/29/99	3.9	NA	0.00058
07/12/99	1.8	NA	0.00081
07/15/99	2.1	NA	0.00045
03/20/00	3.4	0.05	0.0005
04/10/00	2	0.0171	0.0004
09/19/00	1.4	.	NA
02/14/01	3.6	0.0558	NA
02/27/01	1.8	0.0367	NA
08/28/01	1.4	.	NA
09/04/01	2.3	0.026	NA
02/01/02	2.7	0.04	NA
02/14/02	2.5	0.0185	NA
08/20/02	2.1	0.00958	NA
09/03/02	1.4	.	NA
01/29/03	2.2	0.0189	NA
03/10/03	1.9	0.0134	NA
07/23/03	2.1	0.012	NA
08/12/03	1.9	0.00797	NA
02/12/04	NA	0.017	NA
03/15/04	NA	0.0122	NA
07/27/04	NA	0.00731	NA
08/18/04	NA	.	NA
MCL	**10**	**0.03**	**0.002**
Note: NA = Not analyzed; "." = Not detected			

Table 2. Surface Water Sampling Station 8: summary of VOC results

Date Sampled	Concentration (µg/L)					
	CLF	BDM	BMF	DBM	TCE	c12DCE
02/12/99	4 J	.	.	.	1 J	.
04/29/99	2 J	.	.	.	2 J	.
07/12/99	2 J	.	.	.	2 J	.
07/15/99	5	.	.	.	.	.
03/20/00	7	.	.	.	2 J	.
04/10/00	11	1 J	.	.	1 J	.
09/19/00	4 J	1 J	.	.	.	.
02/14/01	4 J	1 J	.	.	3 J	1 J
02/27/01	4 J	1 J	.	.	1 J	.
08/28/01	6	3 J	3 J	2 J	.	.
09/04/01	4 J	1 J	.	.	1 J	.
02/01/02	5	2 J	.	.	.	.
02/14/02	5	2 J	.	.	.	.
08/20/02	9	2 J	.	.	.	.
09/03/02	9	2 J	.	.	.	.
01/29/03	2	.	.	.	2 J	.
03/10/03	5	2 J	.	.	.	.
07/23/03	7	2 J	.	.	1 J	.
08/12/03	7	2 J	.	.	.	.
MCL	**80***				**5**	**70**

Note: "." = Not detected; J = Estimated value; * MCL for total trihalomethanes (chloroform + bromoform + BDM + dibromochloromethane); samples collected after 08/12/03 were not analyzed for VOCs

Table 3. Surface Water Sampling Station 8: summary of results for gross alpha activity, gross beta activity, U-234, and U-238

Sampling Date	Concentration (pCi/L)			
	Gross Alpha Activity	Gross Beta Activity	U-234	U-238
02/12/99	7.99	6.41	2.59	4.07
04/29/99	NA	NA	NA	12.97
07/12/99	54.97	36.22	11.17	60.83
07/15/99	11.07	7.12	2.93	11.59
03/20/00	15.91	10.96	<MDA	15.07
04/10/00	7.23	5.86	1.77	6.4
09/19/00	<MDA	3.85	1.8	1.49
02/14/01	16.92	10.67	7.13	14.74
02/27/01	13.26	9.32	2.46	8.28
08/28/01	3.91	4.26	0.99	1.19
09/04/01	8.64	6.42	3.39	5.08
02/01/02	16.72	8.96	3.49	8.97
02/14/02	7.6	7.31	1.17	4.44
08/20/02	3.56	5.43	1.43	2.54
09/03/02	2.35	4.28	1.37	1.79
01/29/03	18.85	12.12	4.18	6.89
03/10/03	6.3	4.95	1.82	3.23
07/23/03	5.99	8.89	2.28	4.38
08/12/03	4.22	7.58	0.75	2.59
02/12/04	12.99	8.43	2.23	5.37
03/15/04	4.84	3.82	1.47	3.79
07/27/04	6.64	8.19	2.58	2.43
08/18/04	3.53	3.79	1.93	1.61

Note: NA = Not analyzed

MAXIMUM CONCENTRATION: 2004

Nitrate (mg/L)	Uranium (mg/L)	Summed VOCs (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
.	0.015 - 0.03	.	.	.

STATION 17

LOCATION

HYDROGEOLOGIC REGIME: East Fork Regime
FUNCTIONAL AREA: Upper East Fork Poplar Creek
Y-12 GRID EAST COORDINATE: 64,100.00
Y-12 GRID NORTH COORDINATE: 30,500.00
SURFACE ELEVATION: . ft above mean sea level (msl)

MONITORING PURPOSE

SAMPLING: CERCLA
HYDROLOGIC MONITORING: .
OTHER: .

SAMPLING HISTORY

TOTAL SAMPLING EVENTS: 25

First Date	Last Date
03/11/96	08/18/04

SAMPLING DATES FOR CALENDAR YEAR:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
2004	02/12/04	.	07/27/04	.

PRINCIPAL CONTAMINANTS

Results (since 1991) > Screening Level

Contaminant (screening level)	# Samp.	Maximum	Max. Date	Long-Term Trend
NITRATE (10 mg/L):	0	< mg/L		
URANIUM (0.03 mg/L):	3	0.04 mg/L	03/20/00	Indeterminate
SUMMED VOCs (5 µg/L):	2	6 µg/L	03/20/00	Indeterminate
GROSS ALPHA (15 pCi/L):	.	. pCi/L		
GROSS BETA (50 pCi/L):	.	. pCi/L		

SURFACE WATER SAMPLING STATION
Station 17

1.0 LOCATION

This surface water sampling station is located on the main channel of Upper East Fork Poplar Creek (UEFPC), just upstream of where UEFPC exits the DOE Oak Ridge Reservation (ORR) northeast of Y-12. Construction of facilities at Y-12 has substantially modified UEFPC, with the headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central sections of Y-12, filled and replaced with an extensive network of underground storm drains. Also, the section of the creek near the eastern end of Y-12 was extensively modified by construction of New Hope Pond (NHP) in 1963 and the closure of NHP in 1988. An unlined surface impoundment, NHP was used to regulate the quantity and quality of surface water exiting Y-12 until it was closed and replace by Lake Reality, a lined surface impoundment built in 1988.

During normal operations, flow in UEFPC is directed through a concrete-lined distribution channel located around the south and east side of Lake Reality. Also, a gravel and perforated pipe underdrain beneath portions of the distribution channel captures shallow groundwater. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was diverted through the Lake Reality spillway (LRSPW), which discharges into the mainstream of UEFPC directly north of Lake Reality. Bypassing Lake Reality reduces mercury contributions to dry-weather flow in UEFPC. Station 17 monitors surface water quality in UEFPC approximately 800 ft downstream of LRSPW.

About 80% of dry-weather flow in UEFPC is attributable to once-through non-contact cooling water, condensate, cooling tower blowdown, and potable water treated and discharged from wastewater treatment facilities and the remaining 20% is from groundwater discharge (DOE 1998). In accordance with a flow management program initiated in July 1996, untreated water from the Clinch River intake lines to the DOE water treatment plant that supplies potable water to Y-12 is discharged into the exposed section of the main channel of UEFPC in the south-central section of Y-12 near Bldg. 9201-1. Augmentation of flow in UEFPC is necessary because reduced operations at Y-12 have decreased flow from 10-15 million gallons per day (mgd) to about 2.5 mgd. Flow augmentation also is needed to: (1) achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17; (2) maintain compliance with NPDES toxicity requirements; and (3) lower the otherwise elevated water temperature in UEFPC.

2.0 SAMPLING HISTORY

Twenty-five (unfiltered) surface water samples collected to date meet the surveillance monitoring objectives of the Y-12 GWPP, with the first sample collected in March 1996 and the most recent sample collected in August 2004. The grab sampling method was used to collect each sample.

In addition to the sampling performed to meet the surveillance monitoring objectives Y-12 GWPP, surface water samples also have been collected to meet other monitoring requirements, including sampling that the Y-12 Surface Water Program performs to comply with the Y-12 NPDES permit, as a best management practice, and to meet the requirements of DOE Order 450.1. Also, grab sampling and/or flow-proportionate composite sampling is performed to meet the requirements of the Phase I ROD for UEFPC (DOE 1997).

3.0 GEOCHEMICAL CHARACTERISTICS

Based on data that meet the surveillance monitoring objectives of the Y-12 GWPP, the geochemistry of the surface water samples is characterized by:

- TDS of 93 – 380 mg/L;
- pH of 6.0 – 8.8 (field measurements);
- elevated concentrations of chloride (>50 mg/L) and sulfate (>25 mg/L); and
- total concentrations of trace metals (except uranium) that are either below respective analytical reporting limits or are within the range of background levels in groundwater (and surface water) at Y-12, as defined by the respective upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW 1995).

4.0 CONTAMINATION

This section describes analytical results that meet the surveillance monitoring objectives of the Y-12 GWPP for the following surface water contaminants: nitrate, uranium, mercury, VOCs, gross alpha activity, and gross beta activity. One or more of these contaminants may be present in the surface waters as a legacy of historical operations at Y-12, although nitrate is a primary contaminant only in Bear Creek and some of its northern tributaries; mercury is a primary contaminant only in UEFPC; and none of these contaminants are typically present at elevated concentrations in surface waters on Chestnut Ridge south of Y-12. Also, none of the surface-water quality data obtained for any monitoring locations by the Y-12 GWPP are flow-proportionate and, therefore, are not optimal for evaluating contaminant flux (mass transport) at the sampling station.

4.1 NITRATE

Eighteen surface water samples had nitrate concentrations above the applicable analytical reporting limit (Table 1), with the historical maximum value (3 mg/L in April 1999 and March 2000) being substantially below the drinking water MCL for nitrate (10 mg/L).

4.2 URANIUM

Sixteen surface water samples had (total) uranium concentrations above the applicable analytical reporting limit (Table 1), including four results that equal or exceed the drinking water MCL for uranium (0.03 mg/L). There are numerous sources of uranium within Y-12 upstream of this sampling station, including inflow of uranium-contaminated groundwater into UEFPC.

4.3 MERCURY

Six surface water samples had (total) mercury concentrations above the applicable analytical reporting limit (Table 1), with the maximum value (0.001 mg/L in July 1999) being less than the drinking water MCL for mercury (0.002 mg/L). There are multiple sources of mercury within Y-12 upstream of this sampling station, including inflow of mercury-contaminated groundwater into UEFPC, and the remediation of these sources is the focus of the Phase I ROD for UEFPC (DOE 1997).

4.4 VOLATILE ORGANIC COMPOUNDS

Low concentrations of bromodichloromethane (BDM), CTET, chloroform, and PCE were detected in the 18 surface water samples collected from February 1999 to August 2003, with chloroform and PCE detected the most frequently (Table 2). There are multiple sources of VOCs in Y-12 upstream of this sampling station, including the inflow of VOC-contaminated groundwater into UEFPC.

4.5 GROSS ALPHA ACTIVITY

None of the surface water samples were analyzed for gross alpha activity.

4.6 GROSS BETA ACTIVITY

None of the surface water samples were analyzed for gross beta activity.

5.0 REFERENCES

HSW Environmental Consultants, Inc. (HSW) and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-234, Prepared for Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

U.S. Department of Energy (DOE). 1997. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1951&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE. 1998. *Report on the Remedial Investigation of Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1641/V3&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Table 1. Surface Water Sampling Station 17: summary of results for nitrate, mercury, and uranium

Sampling Date	Concentration (mg/L)		
	Nitrate	Total Uranium	Mercury
02/12/99	2.1	NA	NA
04/28/99	NA	NA	0.00033
04/29/99	3	NA	0.00069
07/12/99	1.2	NA	0.001
07/15/99	2.1	NA	0.00045
03/20/00	3	0.04	0.00049
04/10/00	.	0.0145	0.00039
09/19/00	1.3	.	NA
02/14/01	2.7	0.0379	NA
02/27/01	1.8	0.0332	NA
08/28/01	1.4	0.00453	NA
09/04/01	2.2	0.0265	NA
02/01/02	2.5	0.0281	NA
02/14/02	1.5	0.0172	NA
08/20/02	2.1	0.00877	NA
09/03/02	1.4	.	NA
01/29/03	1.1	0.03	NA
03/10/03	1.9	0.0138	NA
07/23/03	2.3	0.0132	NA
08/12/03	1.8	0.00755	NA
02/12/04	NA	0.0155	NA
03/15/04	NA	0.0118	NA
07/27/04	NA	0.00764	NA
08/18/04	NA	.	NA
MCL	**10**	**0.03**	**0.002**
Note: NA = Not analyzed; "." = Not detected			

Table 2. Stations 17: summary of VOC results

Date Sampled	Concentration (µg/L)			
	BDM	CTET	Chloroform	PCE
02/12/99	.	.	2 J	.
04/29/99	.	.	1 J	1 J
07/15/99	.	.	3 J	.
03/20/00	.	.	4 J	2 J
04/10/00	.	1 J	5	.
09/19/00	.	.	3 J	.
12/14/01	.	.	2 J	2 J
02/27/01	.	.	2 J	1 J
08/28/01	1 J	.	4 J	.
09/04/01	.	.	2 J	.
02/01/02	.	.	2 J	.
02/14/02	.	.	2 J	.
08/20/02	.	.	5 J	.
09/03/02	.	.	5 J	.
01/29/03	.	.	1 J	1 J
03/10/03	.	.	3 J	.
07/23/03	.	.	4 J	.
08/12/03	.	.	5 J	.
MCL	**80***	**5**	**80***	**5**
Note: "." = Not detected; J = Estimated value; NA = Not applicable; * MCL for total trihalomethanes (chloroform + bromoform + BDM + dibromochloromethane); samples collected after 08/12/03 were not analyzed for VOCs				