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LIST OF ACRONYMS AND ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
ASO	Analytical Services Organization
BCV	Bear Creek Valley
bgs	below ground surface
BNA	base, neutral, and acid (extractable organic compounds)
BQR	blank qualification result
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CY	calendar year
DOE	U.S. Department of Energy
DQO	data quality objective
Energy Systems	Lockheed Martin Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
ft	feet
ft/d	feet per day
GWPP	Groundwater Protection Program
GWQR	Groundwater Quality Report
HSEA	Health, Safety, Environment, and Accountability (Organization)
HSWA	Hazardous and Solid Waste Amendment
ICP	Inductively Coupled Plasma (spectroscopy)
MCL	maximum contaminant level (for drinking water)
MDA	minimum detection activity
MDL	method detection limit
μg/L	micrograms per liter
mg/L	milligrams per liter
msl	mean sea level
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OU	operable unit
pCi/L	picoCuries per liter
PCE	tetrachloroethane
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	record of decision
RPD	relative percent difference
SESD	Sampling and Environmental Support Department
SWDF	solid waste disposal facility (non-RCRA)
SWMU	solid waste management unit (RCRA)
TCE	trichloroethene

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

TDEC	Tennessee Department of Environment and Conservation
TDS	total dissolved solids
TSD	treatment, storage, and disposal (unit)
UTL	upper tolerance limit
VOC	volatile organic compound
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
1,1,2,2-TCA	1,1,2,2-tetrachloroethane
1,1,1-TCA	1,1,1-trichloroethane

1.0 INTRODUCTION

This groundwater quality report (GWQR) contains an evaluation of the groundwater quality data obtained during the 1994 calendar year (CY) at several hazardous and non-hazardous waste management facilities associated with the U.S. Department of Energy (DOE) Y-12 Plant located on the DOE Oak Ridge Reservation (ORR) southeast of Oak Ridge, Tennessee (Figure 1). These sites lie within the boundaries of the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge Regime), which is one of three hydrogeologic regimes defined for the purposes of groundwater quality monitoring at the Y-12 Plant (Figure 2). The Environmental Management Department of the Y-12 Plant Health, Safety, Environment, and Accountability (HSEA) Organization manages the groundwater monitoring activities in each regime under the auspices of the Y-12 Plant Groundwater Protection Program (GWPP). The purpose of the GWPP is to characterize the hydrogeology and to monitor groundwater quality at the Y-12 Plant and surrounding area to protect local groundwater resources in accordance with federal, state, and local regulations, DOE Orders, and Lockheed Martin Energy Systems, Inc. (Energy Systems) corporate policy.

The annual GWQR for the Chestnut Ridge Regime is completed in two parts. Part 1 consists primarily of data appendices and serves as a reference for the groundwater quality data obtained each CY under the lead of the Y-12 Plant GWPP. Because it contains information needed to comply with reporting requirements of Resource Conservation and Recovery Act (RCRA) interim status assessment monitoring, the Part 1 GWQR is submitted to the Tennessee Department of Environment and Conservation (TDEC) by the RCRA reporting deadline (March 1 of the following CY); Energy Systems submitted the 1994 Part 1 GWQR for the Chestnut Ridge Regime to the TDEC in February 1995 (HSW Environmental Consultants, Inc. 1995a). Part 2 (this report) contains an evaluation of the data with respect to regime-wide groundwater quality, presents the findings and status of ongoing hydrogeologic studies, describes changes in monitoring priorities, and presents planned modifications to the groundwater sampling and analysis activities.

2.0 BACKGROUND INFORMATION

The Chestnut Ridge regime is one of three hydrogeologic regimes defined for the purpose of groundwater and surface-water quality monitoring at the Y-12 Plant (Figure 2). The regime is flanked to the north by Bear Creek Valley (BCV) and to the south by Bethel Valley, and encompasses the section of Chestnut Ridge between Scarboro Road southeast of the eastern end of the Y-12 Plant and a drainage basin on the ridge located southwest of the western end of the Y-12 Plant (unless otherwise noted, all directions in this report are in reference to the Y-12 Plant grid system) (Figure 2). Groundwater quality monitoring activities at the waste-management sites in the Chestnut Ridge Regime have been in progress since the late 1970's and have evolved in response to regulatory changes and monitoring results. The following discussion provides brief descriptions of the regulatory framework under which the monitoring is currently performed.

2.1 Regulatory Framework

In 1984, the U.S. Environmental Protection Agency (EPA) and the TDEC determined that several of the waste management sites at the Y-12 Plant were hazardous waste treatment, storage, and disposal (TSD) units subject to regulation under RCRA. Several of these TSD units are located within the Chestnut Ridge Regime. Between CYs 1987 and 1989, several other waste managements sites in the regime were identified as solid waste management units (SWMUs) subject to regulation under section 3004(u) of RCRA. A RCRA Facility Investigation, as required under the Hazardous and Solid Waste Amendment (HSWA) permit issued for the ORR by the EPA in CY 1986, was planned for these sites to determine if contaminant releases to the environment had occurred.

In November 1989, the ORR was added to the National Priority List and in January 1992, the DOE, the EPA, and the TDEC negotiated a Federal Facility Agreement (FFA) regarding environmental restoration at the ORR under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Although this agreement superseded the HSWA permit and changed the regulatory status of RCRA-regulated TSD units and SWMUs to CERCLA operable units (OUs), the TDEC did not waive the RCRA permitting, post-closure care, corrective action, and groundwater monitoring requirements applicable to some of these sites. The DOE appeal of this regulatory interpretation was formally resolved with an Agreed Order signed in April 1994 by DOE, the TDEC, and Energy Systems regarding a RCRA post-closure permit for the S-3 Site, a RCRA site/CERCLA OU located in the Bear Creek Hydrogeologic Regime (Bear Creek Regime) west of the Y-12 Plant. The Agreed Order allowed DOE to proceed with CERCLA as the lead regulatory program, with RCRA applied as an appropriate, relevant, and applicable requirement to the extent that post-closure maintenance and care of former TSD facilities will comply with the terms of RCRA post-closure permits. Groundwater monitoring is to be integrated with the CERCLA remedial investigation/feasibility study (RI/FS), and data reporting will comply with RCRA post-closure permit conditions as well as RI/FS requirements. Three RCRA post-closure permits will be issued for the Y-12 Plant encompassing each of the hydrogeologic regimes. Specific requirements for interim status sites within each regime will be incorporated into the permits as separate modifications.

In addition to the hazardous waste facilities in the Chestnut Ridge Regime governed by RCRA and CERCLA regulations, there are several non-hazardous waste landfills in the regime. The landfills are classified as either Class II or Class IV facilities, as defined in the most recent (December 1993) *Rules of the Tennessee Department of Environment and Conservation, Division of Solid Waste Management, Chapter 1200-1-7, Solid Waste Processing and Disposal*. Groundwater monitoring at these landfills is performed in accordance with regulatory requirements and conditions of operating permits issued by the TDEC.

2.2 Site Descriptions

Groundwater quality monitoring in the Chestnut Ridge Regime during CY 1994 was performed at 13 sites representing three classes of waste-management facilities (Table 1): (1) sites comprising the CERCLA OUs defined in the FFA; (2) RCRA TSD facilities; and (3) non-hazardous waste Solid Waste Disposal Facilities (SWDFs). Locations of these sites are shown on Figure 3. General descriptions of each type of site are provided in the following sections; detailed site descriptions and discussions of the regulatory status and groundwater monitoring history of each site are included in Section 2.0 of the Part 1 GWQR.

2.2.1 CERCLA Operable Units

The FFA defined two types of CERCLA OUs for which an RI/FS would be performed: (1) source control OUs comprised of individual or groups of waste-management sites, and (2) integrator OUs that encompass groundwater and surface water, independent of the source control OUs that may contribute to the contamination of these media (U.S. Department of Energy 1994). The FFA established four source control OUs that lie within the Chestnut Ridge Regime (Table 1): one RCRA TSD unit, the Chestnut Ridge Security Pits (Security Pits), and three former RCRA SWMUs (Ash Disposal Basin, United Nuclear Corporation Site, and Rogers Quarry). However, because there was no evidence of intermingling contaminant plumes from different source areas, no integrator OU was established for the Chestnut Ridge Regime, and groundwater and surface water are included in the RI/FS for each source control OU.

2.2.2 RCRA Treatment, Storage, or Disposal Facilities

Four RCRA-regulated hazardous waste TSD facilities are in the Chestnut Ridge Regime (Table 1): the Security Pits, the Chestnut Ridge Sediment Disposal Basin (Sediment Disposal Basin), Kerr Hollow Quarry, and the East Chestnut Ridge Waste Pile. The Security Pits, Sediment Disposal Basin, and Kerr Hollow Quarry are closed facilities granted RCRA interim status in 1986. The East Chestnut Ridge Waste Pile is a storage facility built and operated in accordance with a RCRA operating permit issued by the TDEC in 1987.

The Sediment Disposal Basin, East Chestnut Ridge Waste Pile, and Kerr Hollow Quarry (and other sites at the Y-12 Plant) were designated in the FFA as Y-12 Study Areas. These sites are considered low priority units under CERCLA that may be investigated under preliminary assessments/site investigations. New OUs or additions to existing OUs may be necessary if results of the preliminary investigations indicate that a complete RI/FS is warranted.

2.2.3 Solid Waste Disposal and Storage Facilities

There are five non-hazardous waste landfills in the Chestnut Ridge Regime: Industrial Landfills II, IV, and V, and Construction/Demolition Landfills VI and VII (Table 1). Each of these sites has been issued an operating permit by the TDEC. These sites are currently used for disposal of combustible and decomposable solid waste and spoil material generated at the Y-12 Plant and elsewhere on the ORR. In addition to these sites, a temporary storage facility, the Chestnut Ridge Borrow Area Waste Pile, is located in the regime. This site is used for storage of soils removed from the Oak Ridge Civic Center properties and the Oak Ridge Sewer Beltway. Testing of these soils indicated that they do not exhibit the toxicity characteristic of a hazardous waste.

3.0 CY 1994 GROUNDWATER PROTECTION PROGRAM

The following sections describe the groundwater sampling activities performed during CY 1994 in the Chestnut Ridge Regime under the lead of the Y-12 Plant GWPP. Included are brief descriptions of the monitoring programs for which the sampling was performed, as well as details regarding the sampling locations, frequency, and procedures, analytical parameters, and results of quality assurance/quality control (QA/QC) sampling.

3.1 Sampling Locations

Groundwater monitoring during CY 1994 was performed for the purposes of five monitoring programs:

- RCRA interim status assessment monitoring;
- RCRA interim status detection monitoring;
- post-closure monitoring under conditions of a CERCLA record of decision (ROD);
- SWDF detection monitoring; and
- best-management practice monitoring.

Monitoring for the purposes of these programs involved quarterly and semiannual collection of groundwater samples from a total of 74 monitoring wells and one spring (Figure 4 and Table 2). Data regarding the monitored interval for each well are summarized in Table 3; detailed well construction information is contained in Appendix C of the Part 1 GWQR.

3.1.1 RCRA Interim Status Assessment Monitoring

Ten monitoring wells at the Security Pits were used for RCRA assessment monitoring (Figure 4 and Table 2). Assessment monitoring at the Security Pits has been in progress since CY 1988 and will be discontinued when a RCRA post-closure permit (which is expected to require RCRA corrective action monitoring) is issued for the site by the TDEC.

3.1.2 RCRA Interim Status Detection Monitoring

Fifteen monitoring wells were used for RCRA interim status detection monitoring: eight wells at the Sediment Disposal Basin and seven wells at Kerr Hollow Quarry (Figure 4 and Table 2). Statistical analyses of the results for selected indicator parameters (e.g., pH and specific conductance) were performed to identify any statistically significant changes in groundwater quality at each site. Results of these analyses were submitted by Energy Systems to the TDEC in July 1994 (Martin Marietta Energy Systems, Inc. 1994a and 1994b) and February 1995 (Martin Marietta Energy Systems, Inc. 1995a and 1995b). The annual RCRA detection monitoring reports for these facilities also were submitted in February 1995 (Martin Marietta Energy Systems, Inc. 1995c).

3.1.3 CERCLA ROD/RCRA Post-Closure Care Monitoring

Six monitoring wells at the United Nuclear Corporation Site were monitored during CY 1994 in accordance with an approved CERCLA ROD and the RCRA closure plan for the site. Groundwater samples are collected quarterly from these wells as part of the specified post-closure care and maintenance activities.

3.1.4 SWDF Detection/Background Monitoring

Detection monitoring is performed at each of the permitted SWDFs in the Chestnut Ridge Regime in accordance with the requirements contained in paragraph 1200-1-7-.02(7) of the

TDEC solid waste regulations. In CY 1994, 24 monitoring wells and one spring were sampled for SWDF detection monitoring purposes, including sampling to determine site-specific background (upgradient) water quality (Figure 4 and Table 2).

3.1.5 Best-Management Practice Monitoring

Groundwater samples were collected during CY 1994 from 19 monitoring wells as a best-management practice of the Y-12 Plant GWPP (Figure 4 and Table 2). Best-management practice monitoring was performed at sites where regulation-driven monitoring is not specified. For example, groundwater quality monitoring at the East Chestnut Ridge Waste Pile has been performed since CY 1987 even though it is a lined facility exempt from monitoring requirements.

3.2 Sampling Frequency

Groundwater samples were collected during each quarter of CY 1994. First through fourth quarter sampling events were performed January 5 - March 25, April 4 - June 29, July 6 - September 7, and October 3 - December 19, respectively. As summarized in the following table, 48 of the wells included in the previously described monitoring programs were scheduled for quarterly sampling, 22 wells were scheduled for semiannually sampling, and four wells were sampled once.

Site	Sampling Frequency (No. of Wells)		
	Quarterly	Semiannual	Annual
Chestnut Ridge Security Pits	10	.	.
Chestnut Ridge Sediment Disposal	8	.	.
Kerr Hollow Quarry	7	.	.
Industrial Landfill II	3	.	.
Industrial Landfill IV	5	.	.
Industrial Landfill V	4	.	.

Site	Sampling Frequency (No. of Wells)		
	Quarterly	Semiannual	Annual
Construction/Demolition Landfill VI	.	7	.
Construction/Demolition Landfill VII	5	.	.
Ash Disposal Basin	.	4	.
Chestnut Ridge Borrow Area Waste Pile	.	7	.
East Chestnut Ridge Waste Pile	.	4	.
Rogers Quarry	.	.	4
United Nuclear Corporation Site	6	.	.
Total	**48**	**22**	**4**

Monitoring wells sampled semiannually are located at sites where quarterly monitoring is not a TDEC or DOE requirement, or is deemed unnecessary as a best-management practice. Because the semiannual sampling schedule was phased into ongoing quarterly sampling during the second quarter (April) of CY 1994, some wells scheduled for semiannual sampling actually were sampled three times during CY 1994 (Table 2). Additionally, wells located at Rogers Quarry were scheduled for semiannual monitoring as a best-management practice, but were sampled only once during CY 1994 because of funding constraints. Semiannual sampling of spring CBS-1 was performed to obtain samples during seasonally high and low flow conditions.

3.3 Sample Collection

Personnel from the Oak Ridge K-25 Site Sampling and Environmental Support Department (SESD) collected groundwater samples from the monitoring wells, and personnel from the Y-12 HSEA Organization collected samples at spring CBS-1. Sampling was performed in accordance with the most recent version of the technical procedure for groundwater sampling (SESD-TP-8204) and surface water sampling approved by the Y-12 Plant GWPP Manager.

Filtered and unfiltered samples were collected from each location; filtering was performed in the field with an in-line 0.45 micron filter. To minimize the potential for cross-contamination, samples were generally collected in sequence from the least contaminated wells to the most contaminated wells at a site or in a sampling group (a series of monitoring wells grouped for sampling and data-tracking purposes). In areas where no groundwater contamination is present, samples were collected from the farthest upgradient wells first.

3.4 Laboratory Analysis

Groundwater samples were analyzed for a standard suite of analytes that included:

- principal cations and anions;
- trace metals (a term used to differentiate metals that are typically minor groundwater constituents, such as cobalt and nickel, from metals that occur as principal ionic constituents, such as magnesium and sodium);
- volatile organic compounds (VOCs);
- gross alpha activity and gross beta activity;
- total suspended solids, total dissolved solids (TDS), and turbidity;
- field and laboratory determinations of pH and specific conductance; and
- field determinations of temperature, dissolved oxygen, and oxidation-reduction potential.

Unfiltered groundwater samples were analyzed for the entire standard suite of constituents and parameters; filtered samples were analyzed only for metals. Analytical results for all groundwater samples are presented in Appendix E of the Part 1 GWQR.

In addition to the standard suite of analyses, groundwater samples collected from wells at some sites were analyzed for other compounds or parameters specified in the operating permit for the site, as required by TDEC regulations or otherwise requested by the TDEC, or as needed based on previous monitoring results. For example, samples collected from wells at Construction/Demolition Landfill VII were analyzed for additional organic compounds and other required parameters specified by the TDEC solid waste management regulations. Samples from other wells, such as well GW-295 at the Chestnut Ridge Borrow Area Waste Pile, were analyzed for isotopic uranium and beta-emitting radionuclides because of elevated gross alpha and gross beta activity reported for samples collected from the well in CY 1993. The specific analytes for each well are presented in the Part 1 GWQR and the *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant during Calendar Year 1994* (HSW Environmental Consultants, Inc. 1993).

Laboratory analyses of the bulk of the groundwater and surface water samples were performed by the K-25 Analytical Services Organization (ASO). EcoTek Laboratory Services, Inc. performed additional organic analyses required by the TDEC for selected SWDFs in the regime. Selected radiochemical analyses were performed by the Oak Ridge National Laboratory (ORNL) ASO.

3.5 Quality Assurance/Quality Control Sampling

Quality assurance/quality control samples included laboratory blanks, trip blanks, field blanks, equipment rinsates, and duplicate groundwater samples. A total of 102 laboratory blanks, 173 trip blanks, 9 field blanks, 49 equipment rinsate samples, and 40 duplicate samples were analyzed during CY 1994. Similar numbers of QA/QC samples were analyzed during each quarterly sampling event: 20 to 34 laboratory blanks, 37 to 54 trip blanks, 9 to 16 equipment rinsates, 2 to 3 field blanks, and 8 to 12 duplicate samples (approximately one per sampling group).

Laboratory blanks were samples of deionized water analyzed along with a specific number of associated groundwater samples. Trip blanks were samples of deionized water transported in each cooler containing groundwater samples scheduled for VOC analyses. Field blanks were samples of deionized water collected at the well head after samples were collected from selected wells at the Security Pits and the Sediment Disposal Basin. Equipment rinsates were samples of the deionized water that was used to decontaminate the groundwater sampling equipment, and were collected after a sampling team had completed sampling at a site or finished a sampling group. If more than one team collected groundwater samples at a site or within a sampling group, each collected an equipment rinsate sample.

Laboratory blanks, trip blanks, field blanks, and equipment rinsate samples were analyzed for VOCs; selected field blanks and equipment rinsates also were analyzed for metals, gross alpha and gross beta activity, and radionuclides. Analytical results are summarized in Appendix I of the Part 1 GWQR. Duplicate groundwater samples were analyzed for the constituents and parameters specified for the well from which the duplicate sample was collected. Analytical results for the duplicate groundwater samples are presented in Appendix F of the Part 1 GWQR.

Review of the CY 1994 data reported for the laboratory blanks, trip blanks, and equipment rinsates shows that the percent of samples that contained VOCs decreased to the lowest levels since the first quarter of 1992 (Figure 5). Overall, 12 VOCs were detected in the total QA/QC samples analyzed during the year, including 36% of the laboratory blanks, 28% of the trip blanks, 22% of the field blanks, and 16% of the equipment rinsate samples (Table 4). In contrast, a total of 26 VOCs were detected in 25% to 100% of the QA/QC samples analyzed during CYs 1992 and 1993 (excluding field blanks, which were not collected before CY 1994). In general, four groups of VOCs have been detected in the QA/QC samples analyzed each CY: (1) common laboratory reagents, (2) suspected source water contaminants, (3) VOC plume constituents, and (4) miscellaneous compounds.

Common Laboratory Reagents

The common laboratory reagents detected in the QA/QC samples are methylene chloride, acetone, 2-butanone, 4-methyl-2-pentanone, toluene, and 2-hexanone. Methylene chloride and acetone are the laboratory reagents most commonly detected in the QA/QC samples, particularly laboratory blanks; the fourth quarter of 1994 was the first time since the second quarter of 1992 that methylene chloride was detected in less than half of the laboratory blanks that contained VOCs (Figure 5). Overall, a significant reduction in the percentage of QA/QC samples containing common laboratory reagents occurred during CY 1994. For example, methylene chloride was detected in 16 (47%) of the laboratory blanks analyzed during the first quarter of the year, but only two (8%) of the laboratory blanks analyzed in the fourth quarter.

Source Water Contaminants

Two groups of compounds are suspected contaminants of the deionized water used to prepare the QA/QC samples: laboratory blank source water contaminants, and trip blank/equipment rinsate source water contaminants. Suspected contaminants of the deionized water used for laboratory blanks are 1,1,2,2-tetrachloroethane (1,1,2,2-TCA), bromoform, and 1,1,2-trichloroethane (these compounds have rarely been detected in trip blanks and equipment rinsate samples). Since CY 1991, at least one of these compounds (particularly 1,1,2,2-TCA) has been detected in about 13% of VOC contaminated laboratory blanks. However, the CY 1994 data reflect a continued reduction in the occurence of suspected source water contaminants in the laboratory blanks. For example, 1,1,2,2-TCA was detected in only one laboratory blank analyzed during CY 1994 and none of the laboratory blanks analyzed during CY 1993. In CY 1992, however, 1,1,2,2-TCA was detected in 10 to 30% of the laboratory blanks analyzed each quarter.

Chloroform, 1,2-dichloropropane, and cis-1,3-dichloropropene are the suspected contaminants of the deionized water used to prepare trip blanks and decontaminate sampling equipment. One or more of these compounds has been detected in 36% of the VOC-contaminated trip blanks and equipment rinsate samples collected since CY 1991, but less than 0.5% of the VOC-contaminated laboratory blanks.

Data obtained during CY 1994 reflect a continued reduction in the occurrence of QA/QC samples with suspected source water contaminants. For example, chloroform was often detected in 20% or more of the trip blanks and equipment rinsates analyzed each quarter of CYs 1991 and 1992, but was subsequently detected only in one trip blank analyzed in the third quarter of CY 1993 (Figure 5).

Results of Inductively Coupled Plasma (ICP) analyses reported for some inorganic compounds also indicate occasional problems with the deionized water used for field blanks and to rinse sampling equipment. As shown in the following table, calcium, magnesium, potassium, and sodium concentrations (in milligrams per liter [mg/L]) reported for one field blank and six equipment rinsate samples are uncharacteristic of deionized water:

Sample No.	Date	Concentration (mg/L)			
		Ca	Mg	K	Na
Equipment Rinsates					
ER CR 3	2/24/94	14	3.8	<0.6	2.0
ER CR 12	3/08/94	28	8.5	1.1	4.4
ER CR 12	3/08/94	30	8.8	1.3	4.9
ER CR 3	6/29/94	30	8.1	1.1	4.2
ER CR 3	8/14/94	31	8.4	1.4	3.9
ER CR 5	7/21/94	30	8.0	1.3	4.0
Field Blank					
FB CR 3	8/15/94	30	8.1	1.4	3.8

Except for the potassium concentration reported for ER CR 3 in February 1994, these results are at least an order-of-magnitude greater than the respective concentrations reported for the other field blanks and equipment rinsates that were analyzed for inorganic compounds.

VOC Plume Constituents

Two compounds that are known constituents of dissolved VOC plumes in groundwater in the Chestnut Ridge Regime were detected in QA/QC samples analyzed during CY 1994 (Table 4): 1,2-dichloroethane (1,2-DCA) in a first quarter trip blank, and trichloroethene (TCE) in four laboratory blanks, nine trip blanks, and two equipment rinsate samples analyzed in the third quarter. Review of the TCE data for these samples shows: (1) 12 of the associated groundwater samples contained TCE, although none were collected from wells with a prior history of TCE contamination; (2) these groundwater samples (and associated TCE-contaminated trip blanks) were transported in the same sample coolers (numbers 276 and 278); (3) the two equipment rinsate samples that contained TCE were collected by the same sampling personnel and transported in the same sample cooler (number 276); (4) all of the QA/QC samples and associated groundwater samples that contained TCE were analyzed by the K-25 ASO between

July 6 and July 12, 1994; and (5) similar TCE concentrations, ranging from 0.8 to 2 micrograms per liter (μg/L), were reported for the QA/QC and associated groundwater samples. These findings suggest that the TCE results for these QA/QC and groundwater samples are probable artifacts possibly related to the prior use of sample coolers 276 and 278 to transport K-25 Site waste characterization samples containing TCE.

Miscellaneous Compounds

Other compounds that have been detected in the QA/QC samples analyzed since CY 1991 are benzene, bromodichloromethane, carbon disulfide, chlorobenzene, chloromethane, ethylbenzene, styrene, vinyl acetate, and xylenes. Three of these compounds were detected in the CY 1994 QA/QC samples (Table 4): bromodichloromethane in a third quarter field blank, chloromethane in a fourth quarter trip blank, and vinyl acetate in a first quarter laboratory blank. Review of the historical data for the miscellaneous compounds indicates no clear pattern of occurrence, except that most of the samples that contained these compounds were analyzed during CY 1992, and that benzene, bromodichloromethane, and xylenes have been detected the most frequently.

4.0 INTERPRETIVE ASSUMPTIONS AND LIMITATIONS

Evaluation of groundwater quality in the Chestnut Ridge Regime was based primarily on data collected during CY 1994; however, historical data were used to corroborate results, identify trends, and define concentration distributions within contaminant plumes. The following sections contain a description of the interpretive assumptions used and the limitations that restrict evaluation of the groundwater quality data.

4.1 General Assumptions

Interpretive assumptions related to the evaluation of less-than-detection limit results and duplicate groundwater sample results are described in the following sections.

4.1.1 Less-than-Detection Limit Results

Less-than-detection limit results comprised a substantial proportion of the analytical data for many of the inorganic and organic analytes. There are several approaches described in the technical literature and EPA guidance documents regarding how these data should be treated in quantitative evaluations. Each approach basically involves replacing the less-than detection limit results with one of three types of surrogate values: zero, the analytical detection limit (or fraction thereof), or a missing value (i.e., no analytical result).

Organic Compounds

For the purposes of this report, zero was used as the surrogate value for less-than-detection limit results reported for organic compounds. Zero was selected as the surrogate value for VOCs because estimated concentrations below the specified analytical detection limit are often reported for these compounds. Estimated results (reported by the K-25 ASO with a "J" qualifier) represent discernable but unquantified responses from the analytical instrumentation and were, therefore, considered qualitative.

Inorganic Compounds

Zero was used as the surrogate value for the less-than-detection limit results reported for the principal cations and anions. Half the specified analytical detection limit was used as the surrogate value for the less-than-detection limit results reported for each trace metal. This type of surrogate value was used to ensure comparability with the reference concentrations used to evaluate the CY 1994 trace metal data (see Section 4.2.2.3).

Beginning in the second quarter of CY 1994, the detection limit reported for total and dissolved uranium analyses changed from 0.001 to 0.015 mg/L. The reported detection limit was increased in response to an assessment of the K-25 Uranium Fluorometry Laboratory performed by the K-25 ASO in January 1995. As part of this assessment, EPA contract laboratory program protocols were followed to recalculate the method detection limit (MDL) for total and dissolved uranium, which had been historically reported by the K-25 ASO as the instrument detection limit (0.001 mg/L), at three times the new instrument detection limit of 0.005 mg/L. Because the new MDL does not comply with the data quality objectives (DQOs) of the Y-12 Plant GWPP, missing values were used as surrogates for these data. An alternative analytical method (ICP mass spectroscopy; EPA Method 200.8) was implemented in the first quarter of CY 1995. This method has a standard reporting limit of 0.0005 mg/L.

Radioanalytes

The detection limit for radioanalytes (i.e., gross alpha activity, gross beta activity, and radionuclide activity) is expressed as the minimum detectable activity (MDA) in picoCuries per liter (pCi/L). Results for samples analyzed for radioanalytes during CY 1994 were evaluated with respect to the following method-specific MDAs provided by the K-25 and ORNL ASOs (Jago 1995).

Radioanalyte	MDA (pCi/L)	Radioanalyte	MDA (pCi/L)
Americium-241	17	Ruthenium-106	26
Cesium-137	3.9	Strontium (Total)	33
Iodine-129	35	Technetium-99	110

Radioanalyte	MDA (pCi/L)	Radioanalyte	MDA (pCi/L)
Iodine-131	35	Thorium-234	250
Neptunium-237	52	Tritium	950
Plutonium-238	84	Uranium-234	55
Plutonium-239	52	Uranium-235	14
Potassium-40	190	Uranium-238	22
Protactinium-234m	700	Gross Alpha Activity	4.7
Radium	1.5	Gross Beta Activity	11

For the purposes of this report, radioanalyte activities that were less than the specified MDA were considered unusable; missing values were used as surrogates for these results.

Results of recent inquires by the Y-12 Plant GWPP and other Energy Systems organizations indicate QA/QC deficiencies relating to MDAs associated with the radioanalytical results reported by the K-25 ASO (Jago 1995). The QA/QC concerns initially arose when it was determined that MDAs had neither been routinely reported by the K-25 ASO nor used on a consistent basis to qualify individual radiological results. Further inquiry determined that the method-specific MDAs currently obtained by the K-25 ASO for many parameters were too high to comply with: (1) the DQOs established for pending RI/FS-related risk assessments, (2) the DQOs needed for Y-12 Plant GWPP monitoring for compliance with existing regulatory requirements, operating or post-closure permit conditions, or (3) 4% of the DOE Order 5400.5 derived concentration guidelines. Actions intended to address these QA/QC problems, both at the Y-12 Plant and elsewhere on the ORR, are currently being formulated by the Y-12 Plant GWPP in conjunction with Energy Systems compliance and environmental restoration organizations from all three DOE facilities on the ORR, and central and site ASO staff. A set of guidelines will be published that describes a consistent process for projects to use to determine radiological data needs and document the quality of a set of radiological data. These guidelines will be incorporated into applicable Y-12 Plant GWPP procedures and plans. The end result of the process will be much lower MDAs and relevant QA/QC information will be reported along with individual results.

4.1.2 Duplicate Sample Results

Duplicate groundwater samples were collected during at least one quarter of CY 1994 from each of the following monitoring wells:

1090	GW-181	GW-221	GW-299	GW-512	GW-560	GW-743
GW-141	GW-186	GW-292	GW-303	GW-513	GW-564	GW-757
GW-144	GW-203	GW-293	GW-321	GW-540	GW-732	GW-799

As part of the data verification process described in the Part 1 GWQR, the duplicate groundwater sample data for each well were reviewed to identify order-of-magnitude differences between corresponding analytical results, and the appropriate analytical laboratory was then contacted to determine if reporting errors were responsible for such differences. All the order-of-magnitude differences identified in the CY 1994 duplicate sample data, except those summarized below, were attributed to laboratory reporting errors (Paradigm Data Services, Inc. 1994a, 1994b, 1995a, and 1995b).

Well	Date Sampled	Analyte(s)
GW-757	1/07/94	Total Al, Fe, and Mg
GW-564	3/07/94	Cesium-137 activity
GW-540	4/14/94	Total Cu, Fe, Zn, dissolved Zn, and Uranium-234 activity
GW-732	7/09/94	Gross Alpha and Gross Beta activity
GW-299	7/21/94	Gross Alpha and Gross Beta activity
GW-799	10/10/94	Total Al, Fe, and Zn
GW-221	10/15/94	Radium (total) activity
GW-732	10/19/94	Dissolved Al and Fe

Because the order-of-magnitude differences for the compounds listed above could not be resolved, these results were assigned missing values as surrogates for the purposes of quantitative evaluation (e.g., calculation of mean annual gross alpha activity).

4.2 Specific Assumptions

The following sections describe the interpretive assumptions specific to the evaluation of CY 1994 data reported for VOCs, trace metals, major ions, and radiological parameters.

4.2.1 Volatile Organic Compounds

The extent of dissolved VOCs in groundwater was evaluated with respect to the summed annual average concentration of each VOC detected in samples from each monitoring well. In cases where elevated analytical detections limits were reported (i.e., diluted samples), the summed average VOC concentration was considered qualitative. If only estimated VOC concentrations were reported for the samples from a well, the highest reported concentration was used instead of the summed average concentration.

To determine the summed average VOC concentration for each well, the data were screened to identify probable artifacts of sampling or analysis (false positive results), and results that potentially reflect other extraneous factors unrelated to groundwater quality (anomalous results). False positive results were identified through evaluation of the VOC data reported for selected blanks associated with each groundwater sample. Anomalous results were identified from a review of CY 1991-1994 data for each well to quantify the frequency at which individual VOCs were detected (including estimated concentrations). Zero was used as the surrogate value for all false positive and most anomalous VOC results for the purposes of calculating average VOC concentrations.

4.2.1.1 False Positive Results

False positive results were identified using a procedure developed by the EPA that involves determining the blank qualification result (BQR) for each VOC detected in the laboratory and trip blanks, and comparing the BQRs to the VOC results reported for the associated groundwater samples. Blank qualification results were determined by multiplying the highest concentration of a VOC detected in either associated blank by a qualification factor. A factor of 5 was used to determine the BQR for most compounds, but a factor of 10 was used to determine the BQRs for the following common laboratory reagents: methylene chloride, acetone, 2-butanone, and toluene. The BQR determined for each compound was then compared to the corresponding result reported for the groundwater sample. If the compound was detected in the groundwater sample at a concentration less than or equal to the BQR, the result was screened as a false positive (U.S. Environmental Protection Agency 1988).

Thirteen VOCs were detected in the groundwater samples collected from monitoring wells in the Chestnut Ridge Regime during CY 1994, and false positive results were identified for six of these compounds (Table 5): methylene chloride, acetone, 2-butanone, toluene, TCE, and vinyl acetate. Of the 59 results for these compounds reported for the groundwater samples, 52 were screened as false positives. Seventy-five percent of the false positives were for common laboratory reagents (methylene chloride, acetone, 2-butanone, and toluene) that almost always were screened by BQRs determined from laboratory blank data (Table 5). All the false positive TCE results occurred in groundwater samples from monitoring wells with no prior history of TCE contamination (see discussion in Section 3.5). The only TCE results not identified as false positives were reported for samples collected from a well (GW-609) at the Security Pits with a long history of TCE contamination.

About 94% of the false positive VOC results were less than 10 μg/L. Only three of the false positive results exceeded 10 μg/L (the maximum screened concentration was 13 μg/L), and these were results for acetone and 2-butanone (common laboratory blank contaminants). Except for these three results, all other false positive results were less than the specified analytical detection limit (i.e., estimated values). Similar patterns also are evident in the false positive VOC data for CYs 1992 and 1993; more than 90% of the false positive results were less than 10 μg/L, false positive results greater than 10 μg/L were identified only for common laboratory reagents (methylene chloride, acetone, and 2-butanone), and most of the false positive results were less than analytical detection limits.

The number of false positive results identified in the groundwater data decreased from the first to the second quarter of CY 1994, then increased through the rest of the year (Figure 6). Similar trends also are evident in the number of false positive VOC results for groundwater samples collected during CYs 1991, 1992, and 1993. An explanation for this persistent increase through the end of each CY is not readily apparent. It is not directly related to the number of samples analyzed for VOCs (i.e., more samples analyzed, more false positives identified), because substantial increases in the number of false positives occur independent of the number of samples analyzed for VOCs. For instance, the total number of samples analyzed for VOCs decreased by 14% from the second to the third quarter of 1994, but the number of false positive results increased 117% during this period. Additionally, increases in the number of false positives do not appear directly related to the number of laboratory blank and trip blank samples that contained VOCs, including the common laboratory reagents. For example, the number of laboratory blanks in which at least one VOC was detected decreased from eight in the second quarter to five in the fourth quarter of CY 1994, but the number of false positive results screened by laboratory blanks increased from six in the second quarter to 14 in the fourth quarter.

4.2.1.2 Anomalous Results

One characteristic of the VOC data collected for the purposes of the Y-12 Plant GWPP is the sporadic occurrence of typically low (less than 5 μg/L) concentrations of various compounds in samples from wells with no history of VOC contamination. Such results occur for compounds, such as methylene chloride, that otherwise are typically identified as false positives, as well as compounds, such as tetrachloroethene (PCE), that are in the groundwater near known VOC source areas. A decision rule based on frequency of detection has been used to identify these results in previous GWQRs; results for compounds detected (including estimated concentrations below the detection limit) in only one out of four consecutive undiluted samples collected each CY from a particular sampling point were considered anomalous and assigned a surrogate value of zero (i.e., considered the same as less-than-detection limit VOC results). This approach has effectively reduced overly subjective interpretations of the VOC data and widely divergent annual assessments of the extent of VOC plumes.

Screening anomalous results from the VOC data has two primary drawbacks. First, it may negate evidence of groundwater contamination. For example, the apparently sporadic detection of a known plume constituent may be a sampling artifact; a compound present at very low concentrations in the groundwater may be occasionally volatilized during sample collection. Additionally, the infrequent detection of plume constituents may reflect transport during seasonal or episodic groundwater flow conditions. The second drawback is that a decreasing number of wells at the Y-12 Plant are being sampled at the quarterly frequency upon which the decision rule for identifying anomalous VOC results has historically been based.

To determine if evidence of VOC contamination or VOC plume migration has been negated in past GWQRs, and to accommodate the reduced sampling frequency of most monitoring wells at the Y-12 Plant, the VOC data reported for all wells in the Chestnut Ridge Regime sampled since CY 1991 were re-evaluated for anomalous results. For the purposes of this evaluation, anomalous results were defined as results (including estimated concentrations) for compounds detected in 25% or less of the undiluted samples from a particular location (i.e., 1 of 4 samples, 2 of 8 samples, 3 of 12 samples, etc.). Based on this decision rule, a total of 111 anomalous results have been reported for 21 compounds (Table 6): six laboratory reagents (43 results), four suspected blank source water contaminants (20 results), four miscellaneous compounds (7 results), and seven VOC plume constituents (41 results).

Laboratory reagents, suspected blank source water contaminants, and miscellaneous compounds account for 70 (63%) of the anomalous VOC results. About 75% of the anomalous results for these compounds were reported for samples collected during CYs 1991 and 1992 (Figure 6). The decrease in the number of anomalous results after CY 1992 generally corresponds with the decrease in the number of contaminated QA/QC samples during CYs 1993 and 1994. Additionally, the total number of anomalous results for all but four of these compounds show a direct 1:1 ratio with the number of wells for which they were reported (i.e., most were reported for only one sample from one well). These findings suggest that anomalous results for laboratory reagents, suspected blank source water contaminants, and miscellaneous compounds are probable sampling or analytical artifacts. Accordingly, for evaluation purposes in this report, anomalous results for these compounds identified in the CY 1994 VOC data were assigned zero as a surrogate value.

Forty-one anomalous results were identified for seven known VOC plume constituents, primarily PCE (14 results), TCE (seven results), and 1,1-dichloroethene (1,1-DCE) (seven results) (Table 6). Eighteen of the anomalous results for plume constituents were reported for samples from wells at the Security Pits in which other VOCs, such as 1,1,1-trichloroethane (1,1,1-TCA), have consistently been detected. Thus, screening these results as anomalous had no impact on the evaluation of the overall extent of the VOC plume in groundwater at the site. The remaining 23 anomalous results for VOC plume constituents were reported for samples collected from 14 wells, most of which are not located near known VOC source areas:

Well	Location
GW-142, GW-143, GW-144	Kerr Hollow Quarry
GW-161, GW-295	Chestnut Ridge Borrow Area Waste Pile
GW-293, GW-294	East Chestnut Ridge Waste Pile
GW-512	Ash Disposal Basin
1090, GW-205	United Nuclear Corporation Site
GW-798	Construction/Demolition Landfill VII
GW-187	Rogers Quarry
GW-607, GW-610	Chestnut Ridge Security Pits

The anomalous results identified for plume constituents in most of these wells were estimated values (usually ≤ 1 μg/L) reported for only one sample collected during CYs 1991 or 1992. Only the anomalous results reported for wells GW-142, GW-143, GW-144, and GW-610 potentially reflect groundwater contamination; the sporadic VOC results for these wells were not assigned zero as a surrogate value.

Anomalous results for PCE (six results), TCE (one result), and carbon tetrachloride (one result) were identified in the CY 1991 - CY 1994 data for wells at Kerr Hollow Quarry. The anomalous results for PCE were all reported for samples collected from wells GW-142 and GW-144 during CY 1991; anomalous results for TCE and carbon tetrachloride were reported for a sample collected from well GW-143 during the third quarter of CY 1993. Additionally, a total of six anomalous results for chloroform, a common blank contaminant but also a degradation product of carbon tetrachloride, were reported for the samples collected from these wells, primarily for samples collected after CY 1992 (i.e., after the K-25 ASO had effectively reduced chloroform contamination of QA/QC samples). In CY 1994, estimated concentrations of carbon tetrachloride (2 μg/L) and chloroform (0.5 μg/L) were reported for the second quarter sample from well GW-144 and the first quarter sample from well GW-143, respectively.

Four of the sixteen samples collected from well GW-610 since CY 1991 have contained low concentrations of PCE: 1.0 μg/L in the samples collected during the first and fourth quarters of CY 1991, 0.9 μg/L in the sample collected during the first quarter of CY 1992, and 1.0 μg/L in the sample collected during the fourth quarter of CY 1994. Well GW-610 is located directly downgradient of the PCE-dominated VOC plume at the Security Pits.

4.2.2 Trace Metals

As required by the TDEC, evaluation of groundwater quality with respect to trace metals was based on total concentrations reported for unfiltered groundwater samples. Evaluation of these data included: (1) consideration of analytical methods, (2) comparison to corresponding dissolved metal concentrations reported for filtered groundwater samples, (3) identification of median trace metal concentrations that exceeded appropriate reference values, and (4) review of the elevated median concentrations to identify those potentially biased from contamination during laboratory analysis.

4.2.2.1 Analytical Methods

Four analytical methods were used to determine trace metal concentrations in the filtered and unfiltered groundwater samples: (1) Atomic Absorption Spectroscopy (AAS) for cadmium, chromium, and lead; (2) Cold Vapor Atomic Absorption spectroscopy for mercury; (3) fluorometry for uranium; and (4) ICP spectroscopy for aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, strontium, thorium, vanadium, and zinc.

The AAS results for cadmium, chromium, and lead were evaluated in lieu of the ICP data because analytical interferences inherent to the ICP method can cause inaccurate results for these metals (U.S. Environmental Protection Agency 1986). However, the K-25 ASO reported that recent procedural improvements have generally eliminated analytical interferences that may be associated with ICP analyses for cadmium and chromium. This is supported by results of a statistical analysis of CY 1994 ICP and AAS data reported for these metals, which showed no statistically significant differences between data obtained by each respective analytical method (Paradigm Data Services, Inc. 1995c). Accordingly, continued AAS analyses for cadmium and chromium is not necessary for the purposes of the Y-12 Plant GWPP.

4.2.2.2 Total/Dissolved Concentrations

To qualitatively gauge the accuracy of the total metal concentrations reported for unfiltered groundwater samples from each well, they were compared to the corresponding dissolved metal concentrations reported for filtered groundwater samples. If the dissolved metal concentration exceeded the corresponding total concentration by an order-of-magnitude or more, both results were considered unusable. Order-of-magnitude differences were reported for total and dissolved concentrations of four metals reported for six monitoring wells and spring CBS-1:

Sampling Point	Date Sampled	Trace Metal	Concentration (mg/L)	
			Total	Dissolved
GW-562	03/07/94	Boron	0.007	0.61
GW-796	03/08/94	Zinc	<0.002	0.02
GW-540	04/14/94	Iron	0.026	0.33
GW-543	04/20/94	Zinc	0.0082	0.13
GW-221	07/27/94	Iron	<0.005	0.23
GW-175	08/13/94	Zinc	0.01	0.21
Spring CBS-1	09/07/94	Manganese	0.0066	0.13

These results were assigned missing values as surrogates for the purposes of quantitative evaluation.

4.2.2.3 Identification of Elevated Concentrations

Evaluation of groundwater quality with respect to trace metals was based on median total (unfiltered) concentrations determined from CY 1994 data for each well. The evaluation was based on median trace metal concentrations because, as described below, median values were used to calculate the reference concentrations used to evaluate the CY 1994 data for many of the trace metals. Medians were used to determine the reference concentrations because they are less sensitive to extreme values (outliers) and imply no assumptions regarding the distribution (i.e., normal or lognormal) of the data.

Reference concentrations used for comparison to the median trace metal concentrations were: (1) statistically-derived upper tolerance limits (UTLs) assumed to be representative of respective trace metal concentrations in uncontaminated groundwater, and (2) maximum contamination levels (MCLs) adopted by the TDEC for drinking water.

Elevated concentrations of aluminum, antimony, boron, cobalt, copper, iron, manganese, molybdenum, strontium, thorium, uranium, vanadium, and zinc were defined as median concentrations that exceeded respective UTLs determined from statistical evaluation of groundwater quality data obtained since CY 1986 from all monitoring wells at the Y-12 Plant (including wells monitoring contaminated groundwater). The technical approach used in the determination of UTLs for these metals involved:

- principal component analysis to identify the dominant sources of variation in the groundwater chemistry data;
- cluster analysis to identify subsets of similar geochemical data;
- classification modeling to assign monitoring wells to the identified clusters;
- review of cumulative probability graphs to identify potentially biased results (i.e., sampling or analytical artifacts) and results indicative of contamination that were excluded from determination of the UTLs; and

- statistical analysis of the data for the wells in each cluster using parametric and nonparametric techniques, as appropriate, to determine the UTL for each inorganic compound applicable only to the wells in the cluster.

The principal component analysis identified carbonate and bicarbonate alkalinity, magnesium, sodium, nitrate (as N), and specific conductance as the primary sources of variation in the groundwater geochemistry data. Classification modeling using median concentrations of these parameters identified ten separate groups of wells (i.e., clusters) characterized by similar geochemical data. Cluster 1 is represented by data from shallow wells located throughout BCV. Cluster 2 is represented primarily by the data for shallow wells that monitor groundwater with very low dissolved solids. Cluster 3 is similar in many respects to Cluster 1 in that it is represented by the data for shallow wells located throughout BCV, but the geochemical data for these wells is less variable. Cluster 4 is represented almost exclusively by the data for wells completed in the Copper Ridge Dolomite of the Knox Group. Clusters 5, 7, 8, and 9 are represented chiefly by the data for wells that monitor nitrate-contaminated groundwater in the ORR Aquitards near the west end of the Y-12 Plant. Clusters 6 and 10 are represented by data for groundwater at deeper zones in the ORR Aquitards; intermediate depth wells monitoring sodium-bicarbonate type groundwater (Cluster 6), and deep (>400 ft below ground surface [bgs]) wells monitoring sodium-chloride-bicarbonate type groundwater (Cluster 10). Reference concentrations for evaluating groundwater quality reported for wells classified as Cluster 1,2,3,4,6, or 10 were then determined using data for the wells in each cluster; details regarding the groundwater classification scheme and methods used to determine the UTLs for each cluster are included in a report to be issued in mid-1995 (HSW Environmental Consultants, Inc. et al. 1995).

The cluster designations for the wells in the Chestnut Ridge Regime that were sampled during CY 1994 are listed on Table 3; trace metal UTLs applicable to the wells in each cluster are listed in Table 7. These UTLs are generally more conservative than those used to evaluate trace metal data reported in previous GWQRs for the Chestnut Ridge Regime. The conservative bias may be attributable to using median values and differences in the data sets used to determine the reference levels. The UTLs used to evaluate the CY 1994 data were determined from median concentrations determined for a total of 430 monitoring wells located throughout the Y-12 Plant, whereas the UTLs presented in previous GWQRs were determined from data reported for 53 wells (only 15 in the Chestnut Ridge Regime) located hydraulically upgradient of known sources of groundwater contamination. Regardless of the cause, the net effect was a lower reference level for every non-drinking water metal except cobalt; the 0.019 mg/L UTL determined for cobalt is slightly higher than the 0.011 mg/L UTL used in the CY 1993 GWQR. The most significant differences are evident between the reference levels for boron, strontium, and vanadium. The lowest UTL for each of these metals (the UTL for vanadium is the same for each well cluster) is an order-of-magnitude or more less than the respective UTLs used as reference values for these metals in previous GWQRs.

Upper tolerance limits for the following metals were calculated as part of the study outlined above, but elevated concentrations of these metals were defined as median concentrations that exceeded the drinking water MCL specified below:

Trace Metal	MCL (mg/L)	Trace Metal	MCL (mg/L)
Arsenic	0.05	Lead	0.05
Beryllium	0.004	Mercury	0.002
Barium	2.0	Nickel	0.1
Cadmium	0.005	Selenium	0.05
Chromium	0.10	Silver	0.05

The MCLs for beryllium and nickel were recently approved by the TDEC. Elevated concentrations of these metals were identified in previous GWQRs based on a comparison to UTLs. The MCLs for the remaining metals listed above were used to identify elevated concentrations to maintain consistency with historical evaluations of the data for these metals.

4.2.2.4 Laboratory Biased Results

Individual trace metal concentrations that exceeded MCLs or background levels were reviewed to determine if they may have been biased from contamination during laboratory analysis. For example, boron concentrations may be biased by traces of borax, which is commonly used to clean laboratory glassware. Trace metal results that reflect potential laboratory contamination are reported by the K-25 ASO with a "c" qualifier. Results of this review show potentially biased concentrations of aluminum, boron, copper, iron, nickel, and zinc reported for samples collected during CY 1994 from 36 wells and spring CBS-1 (Table 8). These results were considered unusable and missing values were used as surrogates for quantitative evaluation purposes (e.g., calculation of median concentrations).

4.2.3 Principal Ions

Water is electrically neutral; therefore, the total charges on the principal anions (bicarbonate and carbonate alkalinity, chloride, fluoride, nitrate, and sulfate) and cations (calcium, magnesium, sodium, and potassium) should be equal. Total positive and negative charges were determined by summing the milliequivalents (i.e., molecular weight of the ion divided by the net ionic charge) of the dissolved (filtered samples) cation concentrations, which exclude digested cations that do not contribute charge to the groundwater, and the total (unfiltered sample) anion concentrations. The charge balance error was expressed as the relative percent difference (RPD) between the respective summed milliequivalent cation and anion concentrations. Charge balance errors for all groundwater and surface water samples collected in the Chestnut Ridge Regime during CY 1994 are included in Appendix G of the Part 1 GWQR.

Samples for which the calculated RPD exceeded ±10% were excluded from further evaluation. Based on this criterion, principal ion data reported for two groundwater samples were not evaluated: a sample collected during the third quarter from well GW-145 at Kerr Hollow Quarry, and a sample collected in the second quarter from well GW-562 at Construction/Demolition Landfill VII. The unusually low bicarbonate alkalinity (145 mg/L) reported for the sample from well GW-145, and the unusually high calcium (50 mg/L) and magnesium (27 mg/L) concentrations reported for the sample from well GW-562 are the suspected sources of the positive charge balance errors.

4.2.4 Radiochemical Parameters

The CY 1994 data reported for radioanalytes were evaluated with respect to: (1) negative values, (2) the respective MDAs reported by the K-25 and ORNL ASOs, and (3) the uncertainty associated with each result that exceeded the specified MDA. Radioanalyte activities reported by the ASOs are background corrected; i.e., each result represents the total activity minus the background activity associated with the analytical environment. If the activity in a sample is below the background level, the results is reported as a negative value. In addition, all non-negative radioanalyte activities reported for each groundwater sample were compared to their respective MDAs listed in Section 4.1.1. Furthermore, the degree of analytical uncertainty associated with quantifying gross alpha, gross beta, and radionuclide activity in a sample is expressed by the counting error reported for each result. The counting error is defined as two times the sample standard deviation. If the radioanalyte activity was less than background, the MDA, or the associated counting error, it was considered unusable; missing values were used as a surrogate for these results.

Only 8% of the CY 1994 radioanalyte data passed the evaluation criteria (Table 9). Of the data that failed the QA/QC criteria, 28% were negative values, 59% were less than the applicable MDA, and 13% were results that exceeded the MDA but were less than the associated counting errors.

The annual average gross alpha and gross beta activities were determined using data that passed the validation criteria and the applicable surrogate values noted in the preceding paragraphs. The associated average counting error (e) was calculated using the following formula from Evans (1955):

$$e=\sqrt{\frac{E_1^2}{n^2}+\frac{E_2^2}{n^2}\ldots}$$

where E_1, E_2, ... are the individual errors reported for each sample, and **n** is the number of samples that passed the validation criteria. This formula is appropriate for calculating the mean error of a series of errors.

4.3. Limitations

Groundwater quality data obtained during each quarter for most wells sampled during CY 1994 are generally not synchronous; sampling required 80, 87, 64, and 60 days during the first through fourth quarters of CY 1994, respectively (Figure 7). The fourth quarter data are generally the most concurrent; samples were collected during a 24-day time period, between October 3 and October 26, 1994, from 55 of the 65 wells included in the fourth quarter monitoring schedule. The time required to sample ten wells located at the Security Pits ranged from 6 to 10 days each quarter. Although samples from wells at a site may be considered relatively synchronous, comparison of quarterly data for most wells in the regime with regard to concurrent concentration changes may not be valid.

Continuous water-level monitoring performed as part of the RI for OU1 in the Bear Creek Regime show that water levels at shallow depths in the Conasauga Shales and throughout the Maynardville Limestone change significantly in response to precipitation events. Assuming similar responses in the Knox Group, groundwater flow conditions in the Chestnut Ridge Regime are generally dependent upon the amount of precipitation, which is variable during each quarterly sampling event and from quarter to quarter (Figure 7). For example, 44% of the 75 wells included in the first quarter sampling schedule were sampled within one day of a 0.5-in or greater rainfall; whereas, only 18% of the 65 wells included in the fourth quarter sampling schedule were sampled within one day of similar magnitude storms (Figure 7). Such relationships between rainfall and sampling activity indicate that groundwater samples may have been collected under more variable flow conditions during the first quarter, but similar (low) flow conditions during the fourth quarter.

5.0 HYDROGEOLOGIC FRAMEWORK

This section contains a general description of the complex hydrogeologic system in the Chestnut Ridge Regime. It provides sufficient descriptive detail needed for RCRA assessment monitoring reporting requirements regarding evaluation of groundwater flow directions. The description is based on the conceptual framework and associated nomenclature presented in: *Status Report - A Hydrologic Framework for the Oak Ridge Reservation* (Solomon et al. 1992). However, a revised conceptual model of the groundwater flow system at the Y-12 Plant is currently being developed and will incorporate the findings of several ongoing and recently completed hydrogeologic studies.

5.1 Geology

The geology in the area of the Y-12 Plant is generally characterized by sequences of south-dipping, fractured clastic (primarily shale and siltstone) and carbonate (limestone and dolostone) strata of Lower Cambrian to Lower Ordovician age (Figure 8). The primarily dolostone strata of the Knox Group form Chestnut Ridge, and the underlying interbedded limestone and shale formations of the Conasauga Group form BCV to the north. Strike and dip of bedding in the Chestnut Ridge Regime is generally N 55°E and 45°SE, respectively (not referenced to Y-12 Plant grid system).

With the exception of Kerr Hollow Quarry and Rogers Quarry, the sites in the Chestnut Ridge Regime are directly underlain by reddish-brown to yellow-orange residuum overlying the Knox Group. The residuum is characteristically slightly acidic, predominantly composed of clays and iron sesquioxides (Jennings 1985), and contains semi-continuous, relict beds of fractured chert and other lithologic inhomogeneities (such as silt bodies) that provide a weakly connected network through which saturated flow can occur (Solomon et al. 1992). The residuum is thin or non-existent near karst features such as dolines (sink holes), swallets (sinking streams), and solution pan features (Ketelle and Huff 1984). Depth to bedrock varies throughout the Chestnut Ridge Regime, but is usually less than 100 feet (ft).

The Knox Group consists of 2,500 to 3,000 ft of gray to blue-gray, thin- to thick-bedded cherty dolostone with interbeds of limestone (Figure 8). All but the southernmost portion of the Chestnut Ridge Regime is underlain by the Knox Group. The Chickamauga Group overlies the Knox Group disconformably and generally consists of thin- to medium-bedded argillaceous limestone and interbedded shale.

The most pervasive structural features in the Chestnut Ridge Regime are extensional, hybrid, and shear fractures (Solomon et al. 1992). Three major joint orientations are evident: one that roughly parallels bedding, one steeply dipping set that parallels geologic strike, and one steeply dipping set perpendicular to strike (Dreier et al. 1987). Fracture densities ranging from about 1 to 60 per foot have been observed in rock outcrops near the ORNL (Dreier et al. 1987; Sledz and Huff 1981). Most fractures are short, ranging from tenths of inches to a few feet in length (Solomon et al. 1992).

Dissolution of carbonates along fractures has produced many karst features in the Chestnut Ridge Regime. Smith et al. (1983) identified a series of sinkholes along the crest of the ridge that show a prominent alignment parallel to strike. This linear trend may result from dissolution along a bedding plane or joint set (Ketelle and Huff 1984; Smith et al. 1983).

5.2 Groundwater System

Solomon et al. (1992) divide the groundwater system underlying the ORR into two basic hydrogeologic units with fundamentally different hydrologic characteristics: the Knox Aquifer and the ORR Aquitards. The Knox Aquifer consists of the Knox Group and the underlying Maynardville Limestone formation of the Conasauga Group (Figure 8). The remaining formations of the Conasauga Group, the underlying Rome Formation, and the Chickamauga Group form the ORR Aquitards.

Both the Knox Aquifer and the ORR Aquitards are divided by Solomon et al. (1992) into four parts: (1) the stormflow zone, (2) the vadose zone, (3) the groundwater zone (subdivided into water table, intermediate, and deep intervals), and (4) the aquiclude (Figure 9). The divisions are based on the amount of water transmitted by each subsystem (i.e., groundwater flux), which decreases with depth. The flow system is vertically gradational with no discrete boundaries separating the subsystems. However, the bulk permeability of the Knox Aquifer is about ten times greater than that of the ORR Aquitards (Solomon et al. 1992).

The stormflow zone occurs in regolith as does much of the vadose zone, although in some areas the vadose zone includes weathered and fresh bedrock. In the bedrock, orthogonal sets of pervious, planar fractures form groundwater flow paths. Within a fracture, groundwater may flow either downdip, laterally, or in both directions. Changes in flow direction may occur at fracture splits and intersections, and groundwater flow paths may locally resemble stairsteps in both plan and sectional views (Moore 1989). Intersections of two or more fracture sets form permeable intervals or zones that transmit the bulk of the groundwater flux (Moore and Toran 1992). Fracture sets comprising the permeable zone in the water table interval are generally nonstratiform and groundwater generally flows in the direction of maximum hydraulic gradient along multiple, alternative flow paths (Moore and Toran 1992). Stratiform fracture sets are believed to form permeable zones at deeper intervals in the bedrock, and groundwater in these zones primarily flows in the direction of geologic strike (which may or may not correlate with the maximum hydraulic gradient) toward cross-cutting tributary streams (Moore and Toran 1992). Additionally, the vertical spacing between permeable zones increases with depth, and these zones are poorly connected in three dimensions (Solomon et al. 1992).

Results of a detailed evaluation of specific geochemical characteristics and well construction information for wells completed in the Knox Aquifer show evidence (in some cases) for rapid groundwater flow conditions (Shevenell 1994). Variables selected for evaluation as potential indicators of "quickflow" in the Knox Aquifer included hardness variation, dolomite and calcite saturation indices, partial pressure of carbon dioxide, and monitored interval characteristics (i.e., presence of fractures and cavities). Numerous wells completed in the Copper Ridge Dolomite exhibit one or more of these assumed quickflow indicators (Table 10). Shevenell (1994) used these indicators to prepare maps illustrating two-dimensional trends of potentially interconnected quickflow pathways interpolated between monitoring wells and springs. The extent of contamination in the Chestnut Ridge Regime was evaluated with regard to these inferred migration pathways (see Section 6.0).

Recharge on Chestnut Ridge is via vertical percolation through the regolith and direct input via sinkholes. Annual recharge has been estimated to be about 2.6 inches, some portion of which possibly results from delayed unsaturated flow (Solomon et al. 1992). Groundwater discharge pathways from the ridge have not been completely established, but based on knowledge of flow in similar karst systems and the results of dye-tracer tests in the Chestnut Ridge Regime, springs and seeps located along or across strike (particularly to the southeast) are the probable discharge points.

5.2.1 Stormflow Zone

Investigations in Bethel Valley and Melton Valley near ORNL show that groundwater occurs intermittently above the water table in a shallow "stormflow zone" that extends from ground surface to a depth of about 6 ft (Moore 1989). Channels for lateral flow in the stormflow zone include macropores and mesopores, which are connected voids created by various processes, including biochanneling, cracking, and soil particle aggregation (Moore 1989). This zone is thicker and more permeable in forested areas than in grassy or brushy areas, and is more permeable near the land surface than at deeper levels (Moore 1989). However, a stormflow zone may not exist in areas that have undergone substantial modification, such as capped portions of waste-management areas. Additionally, most investigations of the stormflow zone have been performed in valleys underlain by ORR Aquitards. The hydrologic significance of the stormflow zone in residuum overlying the Knox Group on Chestnut Ridge has not been determined and may be less than indicated for ORR Aquitard formations in Bethel Valley and Melton Valley.

Water is present in the stormflow zone during, and for short periods after, significant rainfall events; most of the water is lost to evapotranspiration and much of the remaining water discharges at nearby seeps, springs, and streams (Figure 10). Analysis of infiltrometer test results from Bethel Valley and Melton Valley suggest that the hydraulic conductivity of the stormflow zone averages about 29 feet per day (ft/d) near the top and 0.1 ft/d near the base (Moore 1989). Lateral flow in the stormflow zone is intermittent, lasting a few days to a few weeks after precipitation. Flow is fairly rapid when the zone is full of water but relatively slow when nearly drained (Moore 1989).

5.2.2 Vadose Zone

The vadose zone occurs between the stormflow zone and the water table. The geometric mean depth to the water table in the Knox Aquifer is about 100 ft. Water is added to the vadose zone by percolation through the regolith and is removed by transpiration and recharge to the water table. The vadose zone is unsaturated except in the capillary fringe above the water table and within wetting fronts during periods of vertical percolation; most recharge is episodic and occurs along discrete permeable fractures that become saturated, even though surrounding micropores remain unsaturated (Solomon et al. 1992).

The hydraulic conductivity of the unsaturated regolith on Chestnut Ridge has been determined from slug tests in wells located at the United Nuclear Corporation Site (Mishu 1982), and in areas several miles west of the Chestnut Ridge Regime (Woodward-Clyde Consultants, Inc. 1984). Little variation was observed with depth, but conductivities determined by field and laboratory tests varied by approximately two orders-of-magnitude for comparable depth intervals. Mean field conductivities ranged from 0.0057 to 0.49 ft/d and mean laboratory conductivities ranged from 2.8×10^{-5} to 9.1×10^{-3} ft/d. Results of the slug tests are similar to those obtained from infiltrometer tests. Moore (1988) reported a geometric mean hydraulic conductivity of about 0.006 ft/d for residuum on Chestnut Ridge based on results of infiltrometer studies near ORNL reported by Watson and Luxmoore (1986) and Wilson and Luxmoore (1988).

The hydraulic conductivity of the residuum overlying the Knox Aquifer varies with the degree of saturation (Luxmoore 1982; Daniels and Broderick 1983). Luxmoore (1982) demonstrated that hydraulic conductivity decreases by approximately one order-of-magnitude with a volumetric water content decrease to 90% of saturation, and two orders-of-magnitude with a volumetric water content decrease to 75% of saturation. Daniels and Broderick (1983), as summarized in Ketelle and Huff (1984), reported that hydraulic conductivity decreases by roughly one order-of-magnitude relative to maximum when saturation is 90%, and three orders-of-magnitude relative to maximum when saturation is 75%. Ketelle and Huff (1984) also noted that wide variations in soil permeability occur over short lateral distances. These findings are consistent with observations of permeability variation in residual soils found in other karst areas (Quinlan and Aley 1987).

5.2.3 Groundwater Zone

Solomon et al. (1992) divide the saturated zone in the Knox Aquifer and ORR Aquitards into water table, intermediate, and deep intervals based on observed changes in hydrologic characteristics and groundwater geochemistry with depth (Figure 9).

5.2.3.1 Water Table Interval

A permeable interval 3 to 15 ft thick usually occurs in the transitional horizon between regolith and unweathered bedrock. The water table often occurs within this permeable interval (Solomon et al. 1992). The saturated thickness of this interval changes with cyclic fluctuations in the water table elevation and the interval may be nearly drained during seasonal water table declines. Moore (1989) estimates an average effective porosity of 0.0042 near the water table.

Results of geochemical dating studies of the ORR Aquitards in Melton Valley generally support the concept of a groundwater zone that is most active near the water table and becomes increasingly sluggish with depth (Solomon et al. 1992). Analyses of ^{3}H:^{3}He ratios in groundwater samples collected from 1 to 6 ft below the water table showed ages ranging from 0.09 to 7.23 years, and the presence of large amounts of ^{4}He in groundwater samples from greater depths (45 to 165 ft below ground surface) suggested much greater residence times (Poreda et al. 1988).

5.2.3.2 Intermediate Interval

Groundwater in the intermediate bedrock interval occurs in relatively permeable fractures in a relatively impermeable matrix, but permeable fractures are poorly connected (Solomon et al. 1992). Enlarged fractures and cavities are the primary water-producing features and solute transport pathways, and are supplied by seepage through fractures in the rock matrix, which outnumber the enlarged fractures and cavities, are interconnected, and provide the continuity for groundwater flow paths (Moore 1989).

Estimates of the hydraulic conductivity of the intermediate interval in the Knox Aquifer are provided by results of straddle packer tests performed in three core holes in the Chestnut Ridge Regime: two at the east end of the regime near the Sediment Disposal Basin and one at the west end of the regime near Industrial Landfill IV. The tested intervals were in the Copper Ridge Dolomite of the Knox Group and were generally less than 600 ft below the ground surface (bgs). Calculated hydraulic conductivities ranged from 0.0002 to 3.1 ft/d (King and Haase 1988) and averaged about 0.6 ft/d. The upper population represents more permeable water-producing intervals and the lower population represents less permeable matrix intervals.

The hydraulic conductivity of some water-producing intervals in the Knox Aquifer is much greater than indicated by the straddle packer tests owing to an interconnected network of solution cavities and solutionally-enlarged fractures. For instance, groundwater flow rates determined from a tracer test performed by Ketelle and Huff (1984) ranged from about 490 to 1,250 ft/d. Preliminary results of a dye-tracer test performed by Geraghty & Miller, Inc. (1990) at the Security Pits indicated flow rates of about 100 to 300 ft/d, although findings of the test were not confirmed by a second test performed at the site (Science Applications International Corporation 1993). However, results of the Ketelle and Huff (1984) and the Geraghty & Miller, Inc. (1990) tracer tests are within the range of conduit-flow rates typical in karst terrains (Quinlan and Ewers 1985).

5.2.3.3 Deep Interval

Identification of the deep interval is based on hydraulic and geochemical data for several deep (greater than 500 ft) monitoring wells and coreholes. Solomon et al. (1992) report that the boundary between the intermediate interval and the deep interval in BCV occurs at depths of about 325 ft in the ORR Aquitards and 650 ft in the Knox Aquifer. The boundary is based on lower hydraulic conductivity, although use of hydraulic conductivity may not always be a reliable indicator (Solomon et al. 1992).

Evaluation of data obtained from straddle packer tests and slug tests, and slow-recovery analyses, indicates that the geometric mean hydraulic conductivity of the deep interval is about

0.001 ft/d (Solomon et al. 1992). The low conductivities may reflect reduced fracture apertures or increased fracture spacings (Solomon et al. 1992).

5.2.4 Aquiclude

The aquiclude occurs below the deep groundwater interval and is generally marked by the presence of saline water with TDS concentrations of 40,000 to 300,000 mg/L (Solomon et al. 1992). Information obtained southeast of the Chestnut Ridge Regime in Melton Valley indicates that the saline water typically occurs at depths of about 600 to 700 ft bgs (Solomon et al. 1992). The water in the aquiclude is a sodium-, calcium-, and chloride-rich brine that is chemically similar to brines associated with major sedimentary basins (Solomon et al. 1992).

Saline groundwater has not been encountered at depth in the Chestnut Ridge Regime. However, several wells completed at depths of about 500 to 1,000 ft bgs in BCV monitor groundwater with TDS concentrations of several thousand mg/L to several tens of thousand mg/L, suggesting that the aquiclude may be present at greater depth near the Y-12 Plant than in Melton Valley (Solomon et al. 1992).

5.3 Groundwater Flow Directions

Directions of groundwater flow in the Chestnut Ridge Regime were evaluated from static water level measurements obtained in January and August 1994. Water levels were determined in 82 monitoring wells during January 1994 (the seasonally high water table) and in 87 wells in August 1994 (the seasonally low water table); depth-to-water measurements and water-level elevations for each well are presented in Appendix L of the Part 1 GWQR. Groundwater elevations show that the water table in the Chestnut Ridge Regime generally reflects surface topography and radial groundwater flow directions (Figure 11). Strike-parallel hydraulic gradients range from 0.02 to 0.05 and strike-normal gradients range from 0.06 to 0.09. Static water levels decreased an average of about 8 ft in most of the wells from January to August. The similar pattern of water level decrease in all wells indicate that significant changes in groundwater flow directions (i.e., no significant deviation of horizontal hydraulic gradients) did not occur during the year.

Average water level elevations for selected upgradient and downgradient sites in the regime, determined from depth-to-water measurements obtained during sampling events from CYs 1991 to 1994, show generally uniform and concurrent seasonal water level fluctuations (Figure 12). The fluctuation range is much higher (about 16 to 33 ft) at sites located along the crest of Chestnut Ridge (Industrial Landfill IV, United Nuclear Corporation Site, and Security Pits) than at Rogers Quarry (3.5 ft) and Kerr Hollow Quarry (7 ft) located in Bethel Valley. Data from well GW-146 was excluded from the average water level determined for Kerr Hollow Quarry because the water levels for the well were much lower (up to 140 ft) than the site average level, and the fluctuation range was about 98 ft (693.2 to 790.9 ft msl).

5.4 Groundwater Geochemistry

Groundwater geochemistry in the Chestnut Ridge Regime was evaluated from a review of trilinear plots (i.e., Piper diagrams) prepared using the mean annual concentration of each major ion (excluding results for samples with positive or negative charge balance errors that exceeded 10%) determined for each well and spring sampled during CY 1994. Results of this evaluation indicate that calcium-magnesium bicarbonate type groundwater occurs throughout the Chestnut Ridge Regime (Figure 13). Additionally, groundwater samples from most of the wells exhibit a chemical composition typical of water in contact with dolomite, having characteristically equivalent molar concentrations of calcium and magnesium. Moreover, a major change in groundwater geochemistry did not occur with depth in the Knox Aquifer; calcium-magnesium-bicarbonate or calcium-sulfate groundwater occurs to depths of 1,000 ft bgs (Dreier et al. 1993).

Variations from the calcium-magnesium-bicarbonate type groundwater typical of the Knox Aquifer are evident for several wells. The atypical geochemistry of the groundwater samples from these wells probably reflects artifacts of well installation in some cases, and natural differences in groundwater chemistry in others.

The atypical groundwater geochemistry of the samples collected during CY 1994 from wells GW-295, GW-545, and GW-731 probably reflects grout contamination. For example, the geochemistry of the samples obtained from well GW-295 is dominated by chloride; concentrations averaged 41.5 mg/L in the two samples collected from the well in CY 1994, which is substantially higher than the concentrations reported for other wells at the Chestnut Ridge Borrow Area Waste Pile. Calcium chloride-based additives that were used to accelerate grout hardening during installation of well GW-295 and nearby deeper well GW-160, both of which intercept a solution cavity at a depth of 137 to 140 ft bgs, may be the source of the elevated chloride concentrations in samples from the well (HSW Environmental Consultants, Inc. 1994). Similarly atypical pH levels (>10) and carbonate alkalinity concentrations reported for the samples from wells GW-545 and GW-731 likewise probably reflect the chemical effects of localized grout contamination resulting from well installation and/or nearby plugging and abandonment activities.

Groundwater samples from well GW-539, the upgradient well at Industrial Landfill II, exhibit atypical chloride concentrations possibly representative of the groundwater in less active portions of the Knox Aquifer. The average chloride concentrations determined for the samples from this well steadily increased from 14 mg/L in CY 1991 to 28 mg/L in CY 1993, then decreased to 23.5 mg/L in CY 1994. The reason for the elevated chloride concentrations in samples from this well has not been identified, but may be related to groundwater flow conditions in the aquifer zone monitored by the well. The monitored interval for well GW-539 is about 136 to 156 ft bgs and intercepts an apparently sluggish water-bearing zone at 155 ft bgs. Data obtained during sampling consistently show that the well is purged to dryness and requires about two or three hours to recover sufficient water volume for sample collection. The slow water-level recovery rate (about 0.8 gallons per hour, determined from measurements during the third quarter of 1994) suggests that the well is completed in a low permeability zone within the Knox Group. Elevated chloride concentrations reported for the well may reflect a longer groundwater residence time than typical of more hydraulically active parts of the aquifer.

The chemistry of the groundwater samples collected during CY 1994 from wells GW-143 and GW-146 at Kerr Hollow Quarry also probably reflects the composition of groundwater in less permeable zones within the Knox Aquifer (Figure 13). Samples from each of these wells have higher average sodium, potassium, and sulfate concentrations than the samples collected from the wells with which they are paired (GW-144 and GW-145, respectively). The midpoint of the monitored interval for well GW-143 (about 229 ft bgs) is about 60 ft deeper than the midpoint in well GW-144 (about 171 ft bgs). Well GW-144, which intercepts a fracture at 170 ft bgs that yields over 20 gallons per minute (Jones et al. 1994), yields about three well volumes when purged and recovers relatively quickly. In contrast, well GW-143 yields only about one well volume before going dry and recovers more slowly. Similarly, well GW-146, which is completed with a deeper monitored interval (190 to 220 ft bgs) than well GW-145 (86 to 110 ft bgs), yields about one well volume before going dry and recovers very slowly, whereas GW-145 also yields about one well volume but recovers more rapidly. Furthermore, the depth to water in well GW-146 exhibits a direct relationship with the length of time between sampling events (water levels are higher after longer intervals between sampling), indicating that sampling is rarely performed when the groundwater water level in the well is at hydrostatic equilibrium. These relationships suggest that the higher average sodium, potassium, and sulfate concentrations in the groundwater monitored by wells GW-143 and GW-146 are a function of longer residence times in deeper aquifer zones with less direct hydraulic communication to shallower and more permeable zones in the Knox Aquifer.

The chemistry of groundwater samples collected during CY 1994 from wells at Rogers Quarry suggest that the chemical composition of groundwater in the Chickamauga Group differs from that typical of the Knox Aquifer (Figure 13). The sodium, potassium, and sulfate concentrations reported for these wells are usually higher than respective concentrations reported for wells completed in the Knox Aquifer, and the range of calcium:magnesium ratios (6.1:1 to 0.8:1) differs from the consistently equal (or nearly equal) proportions common to most Knox Aquifer wells.

6.0 GROUNDWATER QUALITY EVALUATION

Groundwater quality data obtained during CY 1994 are generally consistent with historical findings: VOCs are the primary groundwater contaminants in the Chestnut Ridge Regime, and generally occur only in groundwater near the Security Pits. The interpretive assumptions and limitations described in Section 4.0 were taken into consideration to evaluate the CY 1994 data. Results of the evaluation of the data for the major groups of groundwater contaminants (VOCs, trace metals, and radionuclides) are described in the following sections.

6.1 Volatile Organic Compounds

Results for VOCs reported for CY 1994 are consistent with historical data for wells in the regime. Most of the wells that contained VOCs are located at the Security Pits. Low levels of some VOCs also occur in wells located at the Ash Disposal Basin and Industrial Landfill V, Industrial Landfill IV, and Kerr Hollow Quarry.

Chestnut Ridge Security Pits

The horizontal dimensions of the plume at the Security Pits are approximately 3,000 ft (east-west) by approximately 1,000 ft (north-south) (Figure 14). Orientation of the plume axis along the crest of Chestnut Ridge suggests preferential transport along strike toward the east. As noted in Section 5.3, water level isopleths indicate a radial groundwater flow pattern at the site, with the higher hydraulic gradients towards the flanks of the ridge north and south of the site. However, the discontinuity between the apparent direction of plume movement and the direction of maximum hydraulic gradient supports strike-parallel transport in the Knox Group. Additionally, VOCs typical of the Security Pits (1,1,1-TCA and PCE) were detected in samples from three springs located about 7,000 ft east of the site in Union Valley, potentially reflecting farther transport from the Security Pits (CDM Federal Programs Corporation 1995).

The maximum depth of the VOC plume downdip of the Security Pits is defined by monitoring wells GW-742 and GW-743, located south of the area where groundwater contains the highest summed average VOC concentrations (Figure 15). Aside from false positive results for common laboratory reagents (acetone, 4-methyl-2-pentanone, toluene, and methylene chloride) reported in CYs 1992 and 1994, no other VOCs have been detected in samples collected from these wells since they were installed in CY 1991. However, data for wells GW-173 and GW-609 suggest that movement of the VOCs along strike to the east may be occurring at deep intervals in the aquifer below the shallower wells adjacent to the disposal trenches (Figure 15). The elevation of the screened interval in well GW-173, which is located about 200 ft east of the site, is between 948 and 959 ft above msl; GW-609 is screened between 840 and 853 ft msl and is located about 600 ft farther to the east. The summed average VOC concentrations in samples from well GW-609 were significantly greater than in samples from well GW-173 during CYs 1990, 1991, and 1992 (well GW-173 was not sampled during CYs 1993 and 1994). In addition, PCE and 1,2-dichloroethene (1,2-DCE) concentrations in samples from well GW-609, although lower in CY 1994 than in CY 1990, have generally increased since the second quarter of CY 1993 (Figure 16). Tetrachloroethane is the primary compound detected in the samples from both wells, suggesting that the wells intercept VOCs migrating from the eastern disposal trenches at the site. Except for the second quarter of 1994, concentration fluctuations in samples from well GW-609 have generally corresponded with seasonal water level fluctuations (Figure 16).

Evaluation of average concentrations, frequency of detection, and areal distribution indicates the primary components of the VOC plume at the Security Pits are 1,1,1-TCA, PCE, 1,1-dichloroethane (1,1-DCA), and 1,1-DCE. Secondary VOCs at the site are 1,2-DCE, TCE, and 1,2-DCA. The distribution of these VOCs shows that 1,1,1-TCA, 1,1-DCA, and 1,1-DCE are the principal compounds in the VOC plume in the western part of the site and that PCE and 1,2-DCE are the major components of the plume in the eastern part of the site (Figure 17). This distinct difference in the composition of the VOC plume may be directly related to differences in the types of wastes disposed of in the eastern and western disposal trenches at the site, and/or differences between the solubilities of these compounds.

In general, summed VOC concentrations in groundwater at the Security Pits have decreased by about one third since 1989 (Table 11). However, except for well GW-177, summed VOC concentrations increased in groundwater monitored by all wells sampled during CY 1994. Annual summed average VOC concentrations determined for samples from well

GW-177 decreased from 66.7 μg/L in CY 1989 to 18.8 μg/L in CY 1990, but have since fluctuated between a high of 33 μg/L in CY 1993 and a low of 25.5 μg/L in CY 1992. Review of 1987-1994 1,1,1-TCA and 1,1-DCA data reported for well GW-177 shows: (1) substantial decreases in the concentrations of both compounds after closure of the site in 1988 and construction of the multilayer cap in 1989; (2) a corresponding increase in the depth to the static water level in the well; and (3) distinctive cyclic fluctuations in 1,1,1-TCA and 1,1-DCA concentrations that generally show an inverse correlation with static water level fluctuations in the well (i.e., higher concentration with lower water level) (Figure 18).

Ash Disposal Basin and Industrial Landfill V

The primary component of the VOC plume at the western end of the Security Pits, 1,1,1-TCA, has consistently been detected in groundwater samples collected from two hydraulically downgradient wells: GW-514 at the Ash Disposal Basin and GW-796 at Industrial Landfill V (Table 12). Low 1,1,1-TCA concentrations (less than 2 μg/L) have been reported for samples collected from well GW-514 since CY 1991; however, 1,1,1-TCA has not been detected in samples collected from shallower wells (GW-512 and GW-513) clustered with well GW-514. All three wells are hydraulically upgradient of the Ash Disposal Basin which suggests that this site is not the source of the 1,1,1-TCA in the well. Well GW-514 is located about 900 ft south of the western disposal trench at the Security Pits. Similarly, samples collected from GW-796, located about 400 ft south of the western disposal trenches, have had 1,1,1-TCA concentrations of 1 to 2 μg/L since the second quarter of 1993.

The repeated occurrence of low concentrations of 1,1,1-TCA in the groundwater samples collected from these two wells is considered to represent transport in the direction of maximum hydraulic gradient, possibly along preferred pathways oriented perpendicular to geologic strike. Analyses of selected geochemical parameters for wells near the Security Pits indicate the occurrence of numerous pathways with quickflow (high conductivity) characteristics (Shevenell 1994) that also would influence migration of VOCs (Figure 19). The known extent and geometry of the VOC plume at the Security Pits is consistent with the interpreted pathway network; however, there are some notable exceptions. Shevenell (1994) interprets wells GW-181, GW-511, and GW-514 to be interconnected by strike-normal pathways that follow the trend of the VOC plume at the Security Pits. Given this pathway orientation, it is unusual that the 1,1,1-TCA consistently detected in samples from well GW-514 has never been detected in samples from wells GW-181 and GW-511 (both of which are used to define the horizontal plume boundary south of the Security Pits). Although Shevenell (1994) notes that both of these wells exhibit geochemical indicators of quickflow, the absence of 1,1,1-TCA in samples from these wells implies minimal or no hydraulic connection with groundwater in well GW-514. Alternatively, a separate strike-normal pathway that bypasses these wells may connect well GW-514 with groundwater near the Security Pits (Figure 19). Additionally, a strike-normal pathway, such as the one shown to connect wells GW-175 and GW-179, may also connect well GW-796 with the groundwater near the Security Pits (Figure 19).

Industrial Landfill IV

The primary component of the VOC plume at the western end of the Security Pits, 1,1,1-TCA, has consistently been detected in groundwater samples collected from well GW-305 located on the east side of Industrial Landfill IV (Figure 14). Concentrations of 1,1,1-TCA reported for samples collected from well GW-305 have consistently increased from 0.6 μg/L during the first quarter of CY 1992 to 6 μg/L in the fourth quarter of CY 1994 (Figure 16). However, neither 1,1,1-TCA nor any other VOC (excluding false positive results) have been detected in samples from the other wells at Industrial Landfill IV, and the only confirmed source of 1,1,1-TCA is the western end of the Security Pits. Well GW-305 may be connected with groundwater near Security Pits. The screened interval for well GW-177 (1,010 - 1,023 ft msl) at the western end of the Security Pits is similar to that of well GW-305 (1,001 - 1,015 ft msl). However, Industrial Landfill IV lies about 4,500 ft west of the Security Pits (Figure 14) and average water-level elevations in wells at the site are more than 20 ft higher during seasonally high and low water-level conditions (Figure 11).

Kerr Hollow Quarry

Carbon tetrachloride has been detected at low concentrations (1 to 6 μg/L) in 61% of the groundwater samples collected from well GW-144 at Kerr Hollow Quarry since the third quarter of CY 1990, but was only detected once in CY 1994 (second quarter). Chloroform, a potential degradation product of carbon tetrachloride, was detected in samples collected from GW-142 in the second (4 μg/L) and third (1 μg/L) quarters of 1993, but was not detected in any of the samples collected in CY 1994. Low chloroform concentrations (all less than 1 μg/L) also were reported for samples collected from well GW-143 in the third quarter of 1993 and first quarter of 1994, and well GW-144 in the third quarter of 1993. Although the concentrations of carbon tetrachloride and chloroform are typically less than their respective analytical detection limits, the recurring detection of these compounds suggests that Kerr Hollow Quarry may be the source of these VOCs. Furthermore, because these VOCs have been detected with some regularity, sporadic results below the detection limit may reflect occasional volatilization during sample collection, and not the absence of the compound in the groundwater. The greater frequency of occurrence during CYs 1990 through 1993 suggests that the source of VOCs may be related to disturbance of waste materials during closure activities performed during that time.

6.2 Semi-Volatile and Other Organic Compounds

Groundwater samples collected during CY 1994 from 12 wells at the Sediment Disposal Basin and Rogers Quarry were analyzed for base, neutral, and acid (BNA) extractable organic compounds; analytical results are provided in Appendix E of the Part 1 GWQR. Only two compounds were detected, di-n-butylphthalate in samples from wells at both sites, and bis(2-ethylhexyl)phthalate in samples from two wells at Rogers Quarry (Table 13). However, compounds detected in nine of these samples also were detected in the associated laboratory blank samples (Table 13). The occurrence of these compounds in the associated laboratory blanks indicates that these results are probably analytical artifacts (QA/QC sample data needed to identify false positive BNA results were not available). The remaining five results were reported for samples collected from five wells and were estimated concentrations below the respective analytical detection limits. Except for di-n-butylphthalate detected in well GW-158 during the third quarter of CY 1993, the CY 1994 results represent the only occurrence of these compounds in these wells during the last eight consecutive quarterly sampling events.

Samples from selected monitoring wells at Industrial Landfills II, IV, and V, Construction/Demolition Landfill VII, and the Chestnut Ridge Borrow Area Waste Pile were analyzed for additional organic compounds, some of which were required by the TDEC; analytical results for each well are provided in Appendix E of the Part I GWQR. Trichlorofluoromethane was detected in the sample collected during the third quarter from well GW-298 (44 μg/L) at the Chestnut Ridge Borrow Area Waste Pile, and the sample collected during the fourth quarter from well GW-796 (2 μg/L) at Industrial Landfill V. This compound has not been detected in previous samples collected from either well, and the respective CY 1994 results reported for each well were considered analytical artifacts.

6.3 Trace Metals

As described in Section 4.2.2.3, median CY 1994 metal concentrations for each well were evaluated with respect to one of two reference concentrations: UTLs or MCLs. The median concentration of 12 metals determined for samples from 37 wells in the regime exceeded the applicable reference concentration. As shown in the following table, elevated boron concentrations were widespread, and elevated concentrations of other metals were determined for six or less wells.

Metal	Number of Wells	Metal	Number of Wells
Boron	30	Uranium (fluor)	2
Strontium	6	Aluminum	1
Vanadium	5	Chromium (AAS)	1
Zinc	5	Iron	1
Nickel	4	Manganese	1
Beryllium	2	Molybdenum	1

Review of the data for these metals suggests few of the elevated median concentrations potentially reflect groundwater contamination. For example, the apparent widespread occurrence of elevated boron concentrations is probably a combined function of the high frequency of detection (boron was detected in 98% of the unfiltered samples analyzed during CY 1994) and an overly conservative reference concentration (the 0.028 mg/L UTL for Cluster 4) applicable to most of the wells in the regime. Additionally, the elevated median concentrations determined for most of the other metals listed above reflect probable sampling or analytical artifacts relating to: (1) preservation (acidification) of turbid groundwater samples (aluminum, chromium, iron, manganese, and zinc), (2) potential analytical interferences (beryllium and vanadium), (3) corrosion of stainless steel well screen (chromium, nickel, manganese, and iron), and (4) contamination during well installation (molybdenum). Review of the CY 1994 data with regard to these potential sources of bias suggests that elevated median concentrations of boron, strontium, and uranium may be representative of concentrations in the groundwater monitored by some of the wells located at Kerr Hollow Quarry, Rogers Quarry, and Industrial Landfill IV.

Boron

The highest CY 1994 median boron concentrations were determined for wells GW-143, GW-145, and GW-146 at Kerr Hollow Quarry; wells GW-186 and GW-187 at Rogers Quarry; and well GW-217 at Industrial Landfill IV (Table 14). Median boron concentrations for wells at Kerr Hollow Quarry and Rogers Quarry are about an order-of-magnitude higher than most other wells in the regime. Review of historical data for these wells indicates that boron concentrations have consistently exceeded the 0.12 mg/L UTL since the first quarter CY 1990 (Figure 20). Interestingly, four of the five wells with the highest median boron concentrations (GW-143, GW-146, GW-186, and GW-187) monitor groundwater with a substantially different geochemistry than typically monitored by most wells in the Chestnut Ridge Regime. For example, the sodium- and sulfate-dominated geochemistry of groundwater samples collected from wells GW-143 and GW-146 may, as discussed in Section 5.4, represent groundwater quality in less permeable intervals within the Knox Aquifer. Boron concentrations reported for these wells likewise may reflect natural concentrations in the aquifer zones monitored by the wells.

Samples from well GW-217 at Industrial Landfill IV had the highest median boron concentration (0.21 mg/L) reported for Cluster 4 wells (Table 14). Boron concentrations reported for well GW-217 show a steadily increasing trend following a concentration peak (or "spike") in the second quarter of CY 1992 (Figure 20). Median concentrations from two other wells at the site (GW-141 and GW-522) also slightly exceeded the UTL, but the concentrations reported for these wells do not show a similar increasing trend.

Strontium

Median strontium concentrations determined for wells at Kerr Hollow Quarry (GW-142, GW-144, GW-145, GW-146, and GW-147) and well GW-732 at the Sediment Disposal Basin exceeded the UTL (Table 14). The highest median strontium concentrations were determined for the wells at Kerr Hollow Quarry, particularly wells GW-145 (7.5 mg/L), GW-146 (6.95 mg/L), and GW-147 (1.15 mg/L). The CY 1994 data are consistent with the historical data for each of these wells. For example, total strontium concentrations ranging from 6.3 to 18 mg/L have been reported for samples collected from well GW-145 and GW-146 since the first quarter of 1990 (Figure 21). The strontium concentrations reported for these wells may have resulted from waste disposal at Kerr Hollow Quarry, but the results for each well have remained extremely consistent and, unlike the occurrence of VOCs in the groundwater at the site, generally did not show a corresponding response to disturbance of these wastes during closure of the site. Alternatively, the total strontium concentrations in the groundwater monitored by these wells may reflect strontium locally dissolved from the carbonate bedrock.

Strontium concentrations reported for well GW-732 at the Sediment Disposal Basin show a general increasing trend since the well was installed in CY 1991 (Figure 21). During CY 1994, total strontium concentrations exceeded the Cluster 4 UTL (0.079 mg/L) in two of the four quarterly samples, and increased from 0.047 mg/L to 0.21 mg/L. Strontium concentration in samples from this well may similarly reflect natural concentrations in the carbonate bedrock.

Uranium

The median uranium concentration determined wells GW-142 and GW-145 at Kerr Hollow Quarry exceeded the applicable UTLs of 0.005 mg/L, and 0.012 mg/L, respectively (Table 14). Historically, total uranium concentrations reported for well GW-145 have consistently been higher than reported for other wells at the site, ranging from 0.008 to 0.016 mg/L, while uranium concentrations in samples from well GW-142 were less consistent, ranging from below the detection limit (<0.001 mg/L) to 0.032 mg/L (Figure 21). Annual average gross alpha activity in these samples was low (less than 15 pCi/L), which suggests the total uranium concentrations reported for these wells reflect natural concentration variations in the Knox Aquifer.

6.4 Radioactivity

As noted in Section 4.2.4, only 8% of the CY 1994 radioanalyte data reported for wells in the Chestnut Ridge Regime passed the QA/QC screening criteria. None of these results suggest groundwater contamination (Table 15). The highest individual gross alpha activity (15.5 ± 4 pCi/L) and gross beta activity (33.4 ± 5.3 pCi/L) were reported for the fourth quarter samples collected from wells GW-145 and GW-143, respectively (results for both wells reflect a slightly increasing trend throughout the year).

No identifiable patterns or trends were evident among the results reported for radionuclide activities that passed the QA/QC screening criteria (Table 16). Each of these results were characterized by counting errors that typically exceeded 50% of the reported radionuclide activity. Moreover, radionuclide activities that passed the QA/QC screening criteria: (1) could not be qualitatively verified because the gross alpha or gross beta activities reported for most of these samples did not pass the QA/QC screening criteria, and (2) did not exhibit the expected parent/daughter isotopic relationships.

7.0 CONCLUSIONS

- Several of the interpretive assumptions used in evaluation of the CY 1994 data differed from those used in pervious GWQRs. The changes primarily involved: (1) modification of the decision rule used to identify anomalous results for VOCs, (2) use of more conservative reference values for identification of elevated trace metal concentrations, and (3) application of updated QA/QC screening criteria relating to background corrected values, counting uncertainty, and MDAs for radioanalyte results. These modifications had no significant impact on the evaluation of the data reported for VOCs or trace metals. However, only about 8% of the CY 1994 results for radioanalytes were suitable for evaluation based on the revised interpretive assumptions.

- A variety of VOCs, primarily methylene chloride and acetone, were detected in 36% of the laboratory blanks, 28% of the trip blanks, 22% of the field blanks, and 16% of the equipment rinsate samples analyzed during CY 1994. These results reflect a continued reduction in the percentage of VOC-contaminated QA/QC samples evident since the fourth quarter of CY 1992. The results reported for laboratory and trip blanks were used to identify a total of 52 false positive VOC results in the CY 1994 groundwater samples. Most of the false positives were for common laboratory reagents (methylene chloride, acetone, toluene, and 2-butanone) frequently detected in laboratory blanks.

- The CY 1994 results reported for major cations and anions show that calcium-magnesium-bicarbonate type groundwater occurs in the Knox Aquifer throughout most of the Chestnut Ridge Regime. Wells completed in some water-producing zones monitor a sulfate-dominated groundwater probably resulting from dissolution of locally disseminated sulfides. The atypical geochemistry of the groundwater samples from some wells is a probable artifact of grout contamination relating to well installation and/or plugging and abandonment of nearby wells.

- Data obtained during CY 1994 indicate no significant changes in the characteristics of the dissolved VOC plume in groundwater at the Security Pits. The plume is about 3,000 ft long, 1,000 ft wide, and extends to a depth of at least 250 ft bgs. The axis of the plume is generally oriented parallel with the crest of the ridge, indicating preferred along-strike migration (despite the strong strike-normal flow directions inferred from water level isopleths). Principal components of the plume are PCE and 1,1,1-TCA, each associated with sources in the eastern and western disposal trenches, respectively. Summed concentrations of these and other compounds remained generally stable or slightly increased in most wells during CY 1994; the highest summed average VOC concentrations were determined for wells GW-177 (28.3 μg/L) and GW-609 (54.5 μg/L).

- The principal component of the VOC plume originating from the western disposal trenches at the Security Pits (1,1,1-TCA) was detected at low (qualitative) concentrations in the samples collected during CY 1994 from well GW-514 at the Ash Disposal Basin and well GW-796 at Industrial Landfill V. These wells are located hydraulically downgradient of the Security Pits, suggesting that the monitored interval for each well intercepts one or more groundwater flowpaths hydraulically connected to the 1,1,1-TCA-dominated plume. Low concentrations of 1,1,1-TCA also were reported for the samples collected from well GW-305 at Industrial Landfill IV located more than 4,000 ft west of the Security Pits. The western disposal trenches at the Security Pits are the only confirmed source of 1,1,1-TCA in the regime, but water level elevations at Industrial Landfill IV during seasonal high and low groundwater flow conditions are typically more than 20 ft higher than those at the Security Pits. Volatile organic compounds similar to those at the Security Pits, particularly 1,1,1-TCA, have been observed in a spring located about 7,000 ft east of the site near Illinois Ave. These VOCs may or may not be from the Security Pits.

- Carbon tetrachloride was detected at an estimated (qualitative) concentration of 2 μg/L in the sample collected from well GW-144 at Kerr Hollow Quarry during the second quarter of the year. Chloroform, a degradation product of carbon tetrachloride, also has been sporadically detected in samples collected from several wells at the site, and was detected in the sample collected from well GW-143 (0.5 μg/L) during the first quarter of 1994. Historical data shows that PCE also has been sporadically detected in samples from several wells at the site. It is possible that the consistently low concentration of these compounds and their sporadic detection frequency are sampling artifacts; the compounds may be present at low concentrations in the groundwater at Kerr Hollow Quarry, but are completely or partially volatilized during well purging and sampling.

- Groundwater quality with respect to trace metal concentrations was evaluated through comparison with one of two types of reference concentrations: available MCLs for drinking water, or UTLs determined from statistical analysis of groundwater quality data obtained since CY 1986. Median concentrations determined from the CY 1994 data for aluminum, beryllium, boron, chromium, iron, manganese, molybdenum, nickel, strontium, uranium, vanadium, and zinc exceeded the applicable reference concentration. Elevated median concentrations for most of these metals were probably biased by sampling or analytical artifacts. Additionally, the UTL for some of the metals, particularly boron, appears to be too conservative for the purposes of the Y-12 Plant GWPP. Evaluation of the CY 1994 data based on these considerations showed consistently elevated concentrations of boron, strontium, and uranium in samples from wells at Kerr Hollow Quarry, Rogers Quarry, and Industrial Landfill IV. However, the elevated concentrations of these metals could not be conclusively attributed to groundwater contamination originating from any of these sites.

- Review of the useable radioanalyte results reported for wells sampled during CY 1994 show that annual average gross alpha and gross beta activities were below the Safe Drinking Water Act screening levels of 15 and 50 pCi/L, respectively. The small percentage of acceptable results reported for specific radionuclides were considered unreliable because of high proportional counting uncertainties and incompatible results for parent/daughter isotopes.

8.0 PLANNED AND PROPOSED MONITORING CHANGES

Changes to the groundwater monitoring program in the Chestnut Ridge Regime are currently planned by the Y-12 Plant GWPP for implementation in CY 1996. Other modifications also are proposed based on the monitoring results obtained during CY 1994.

8.1 Sampling Locations, Frequency, and Analytical Parameters

Requirements of the groundwater monitoring programs for sites in the Chestnut Ridge Regime have not changed, and thus few changes to the monitoring well network are planned for CY 1996 (Figure 22). A total of 74 monitoring wells and one spring will be sampled for the purposes of the following programs (Table 17):

- 11 wells for RCRA interim status assessment monitoring at the Security Pits;
- 15 wells for RCRA detection monitoring programs at Kerr Hollow Quarry and the Sediment Disposal Basin;
- 6 wells for post-closure monitoring at the United Nuclear Corporation Site in accordance with a CERCLA ROD;
- 24 wells and spring CBS-1 for detection monitoring at Industrial Landfills II, IV, and V, and at Construction/Demolition Landfills VI and VII; and
- 18 wells for best-management practice monitoring at the East Chestnut Ridge Waste Pile, the Ash Disposal Basin, Rogers Quarry, and Chestnut Ridge Borrow Area Waste Pile.

Spring CBS-1 will be sampled semiannually; wells included in the above listed monitoring programs will be sampled at the frequencies summarized below.

Site	Sampling Frequency (No. of Wells)	
	Quarterly	Semiannual
Chestnut Ridge Security Pits	11	.
Chestnut Ridge Sediment Disposal Basin	8	.
Kerr Hollow Quarry	7	.
Industrial Landfill II	.	3
Industrial Landfill IV	.	5
Industrial Landfill V	.	6
Construction/Demolition Landfill VI	.	6
Construction/Demolition Landfill VII	.	4
Ash Disposal Basin	.	4
Chestnut Ridge Borrow Area Waste Pile	.	6
East Chestnut Ridge Waste Pile	.	4
Rogers Quarry	.	4
United Nuclear Corporation Site	.	6
Total	**26**	**48**

Wells included in each sampling event will be sampled in the sequence shown on Table 17. Groundwater samples collected from each well and spring will be analyzed for the parameters and constituents specified in the *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant During Calendar Year 1996* (HSW Environmental Consultants, Inc. 1995b).

8.2 Proposed Modifications

Proposed modifications to the monitoring programs implemented in CY 1994 involve assessment monitoring at the Security Pits, data management, metals analyses, and equipment rinsate samples. The following items describe the proposed changes:

- Continued quarterly sampling of wells GW-181 and GW-511, located south of the Security Pits, may not be necessary. These wells exhibit "quick-flow" characteristics, but apparently are not in a flowpath hydraulically connected to the Security Pits. The VOC plume constituents have never been detected in samples from either of these wells. Additionally, wells GW-181 and GW-511 are not specified in the RCRA post-closure permit application submitted to the TDEC for the site.

- A special sampling event should be performed to collect groundwater samples for VOC analyses from wells GW-612 and GW-174 at the Security Pits. These wells have not been sampled since July 1992. Results for these wells will provide more current data regarding concentration trends (1,1,1-TCA and PCE) within the VOC plume.

- Fewer rinsate samples should be collected. Established guidance requires one equipment rinsate to be collected for at least 10 % of the monitoring wells sampled; rinsate samples were collected for nearly 20 % of the wells sampled during CY 1994.

- Dissolved iron and manganese concentrations should be included in charge balance determinations. The charge contributed by these cations is negligible in most samples, but omitting these cations in some instances causes consistently negative charge balance errors greater than 10%.

- The boron reference value determined for Cluster 4 wells is too conservative and should be re-evaluated.

- Analyses for cadmium and chromium by AAS should be discontinued if not a site-specific or well-specific requirement. Statistical evaluation of the CY 1994 data showed no significant difference between results obtained by ICP and AAS methods for these metals.

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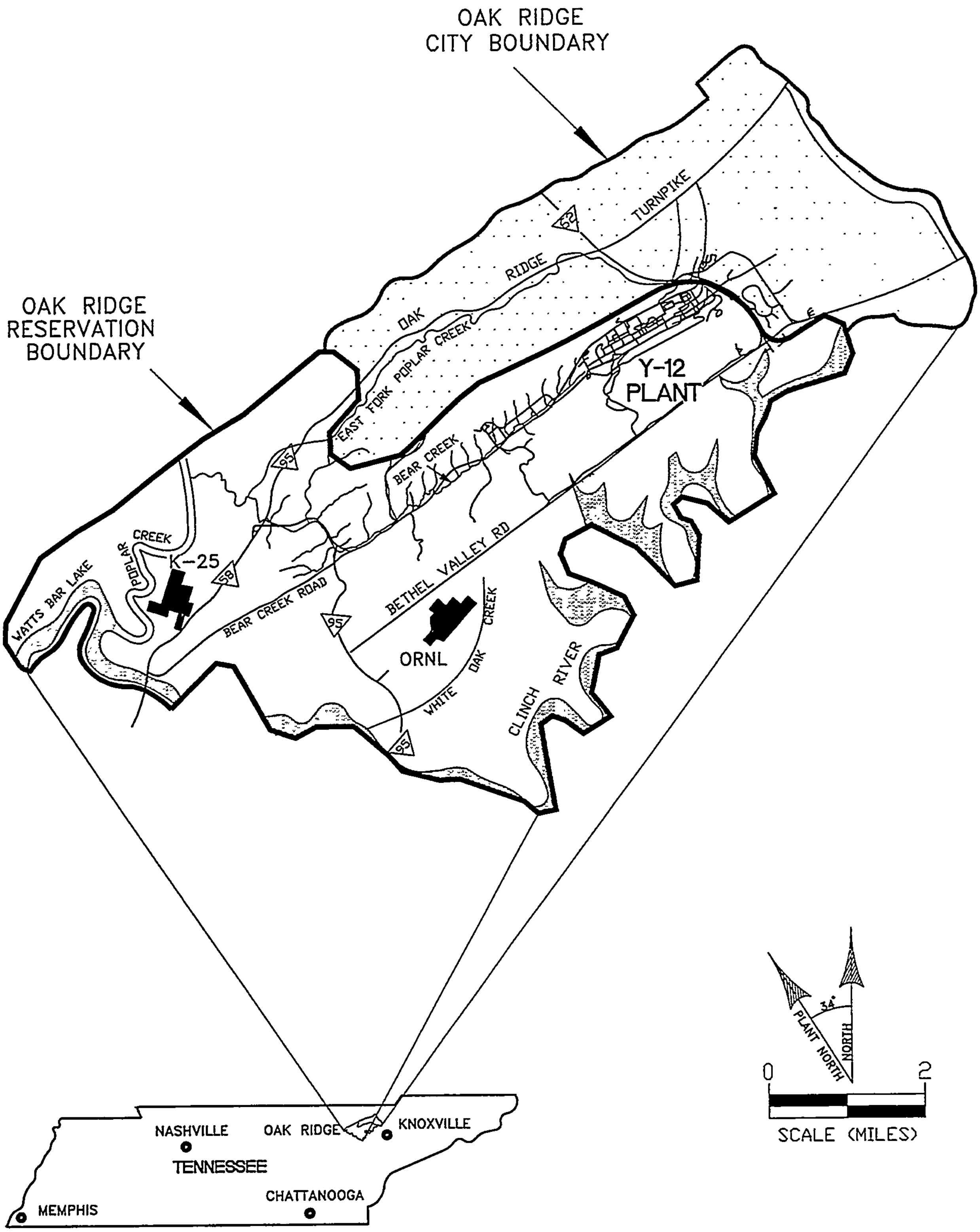
APPENDIX A

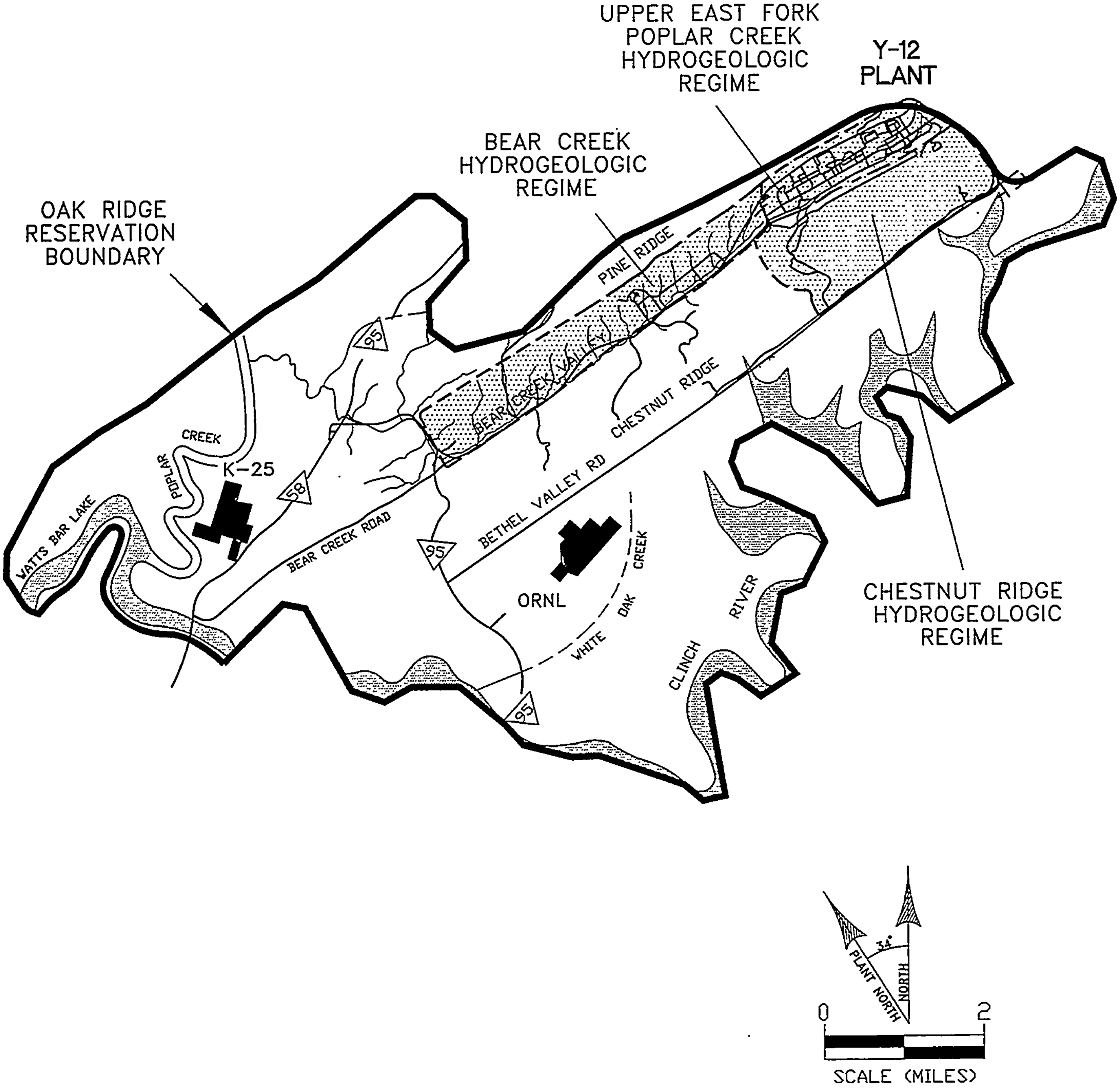
FIGURES

FIGURES

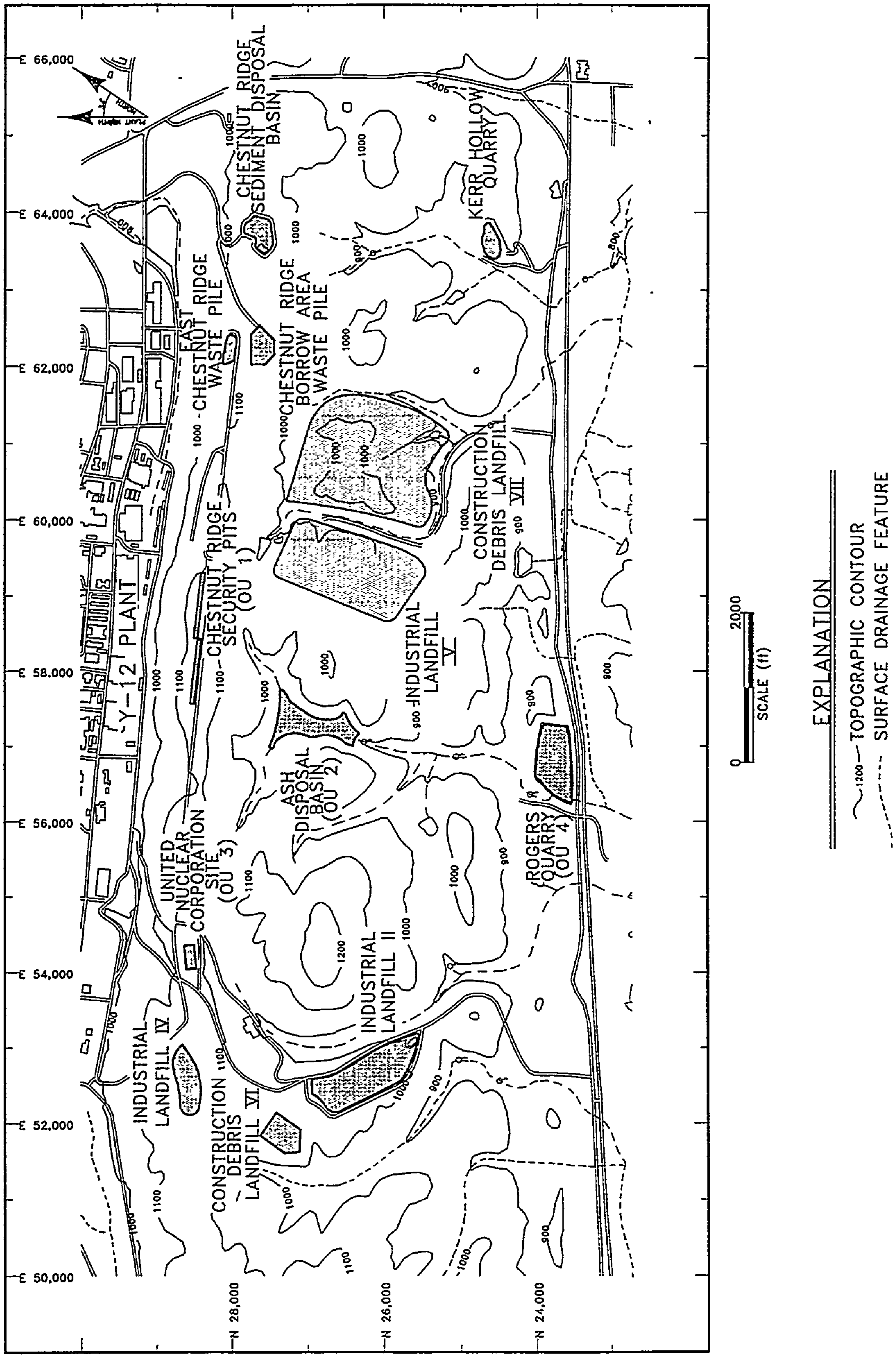
FIGURES (cont'd)



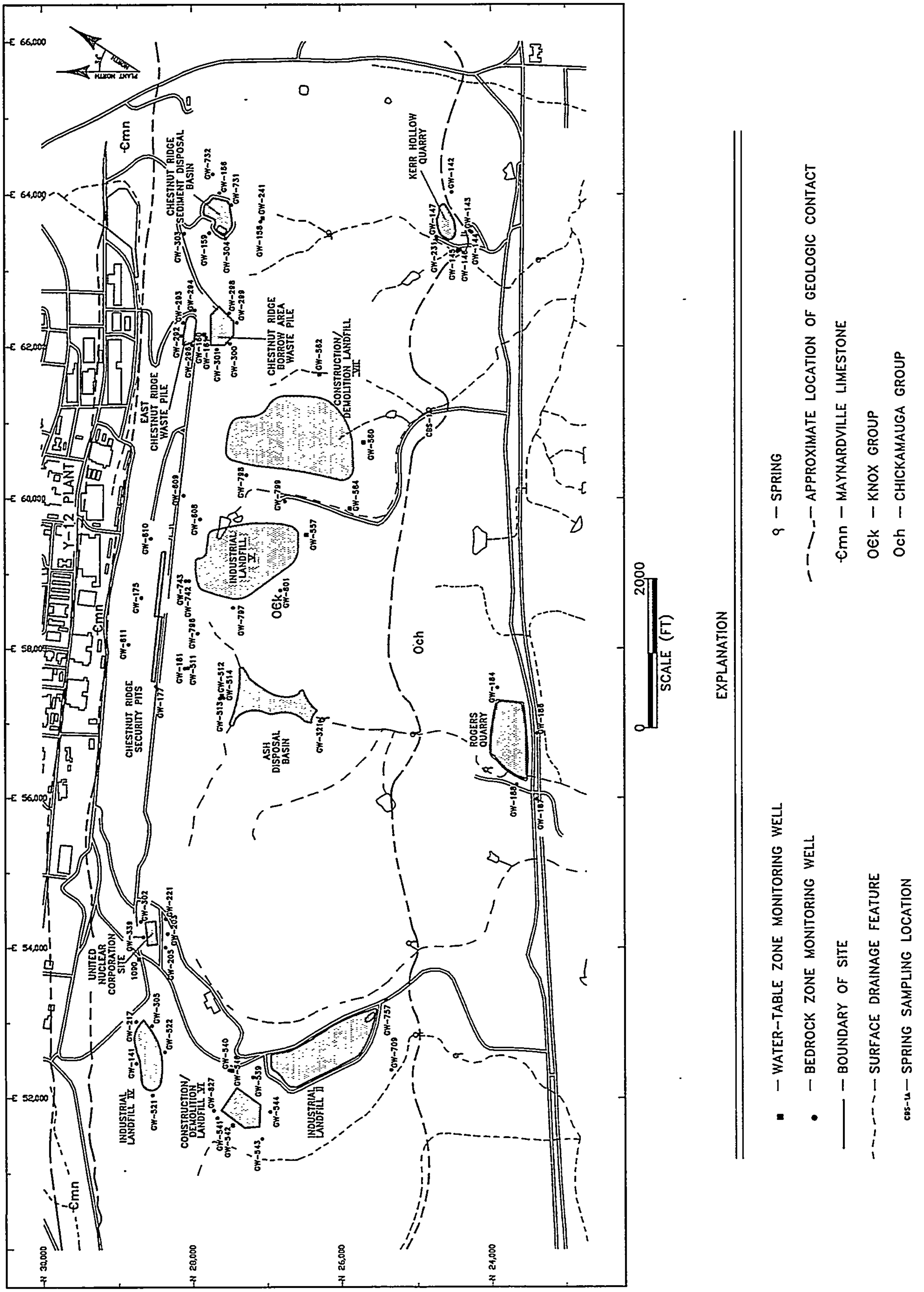
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 1
DATE:	9-8-95	REGIONAL LOCATION OF THE Y-12 PLANT
DWG ID.:	OR250-HC	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 2
DATE:	9-8-95	HYDROGEOLOGIC REGIMES AT THE Y-12 PLANT
DWG ID.:	OR321-HC	

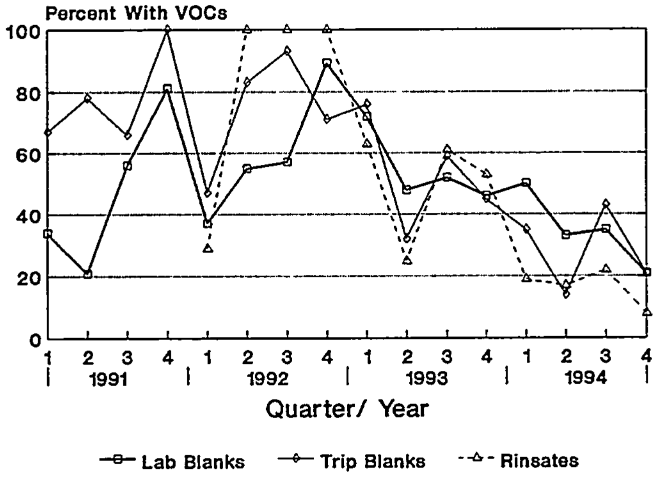


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 3
DATE:	2-13-95	WASTE-MANAGEMENT SITES AND CERCLA OPERABLE UNITS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR210-HC	



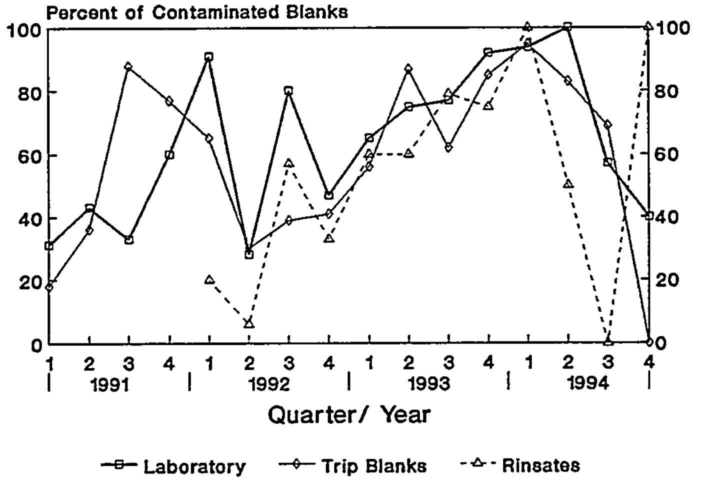
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 4
DATE:	6-8-95	SAMPLING LOCATIONS FOR GROUNDWATER AND SURFACE WATER MONITORING DURING CY 1994
DWG ID.:	OR307-HC	

All Compounds



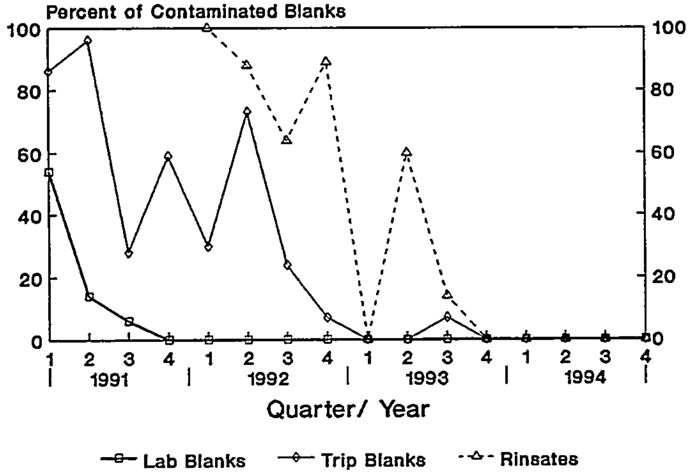
Laboratory Reagent

Methylene Chloride

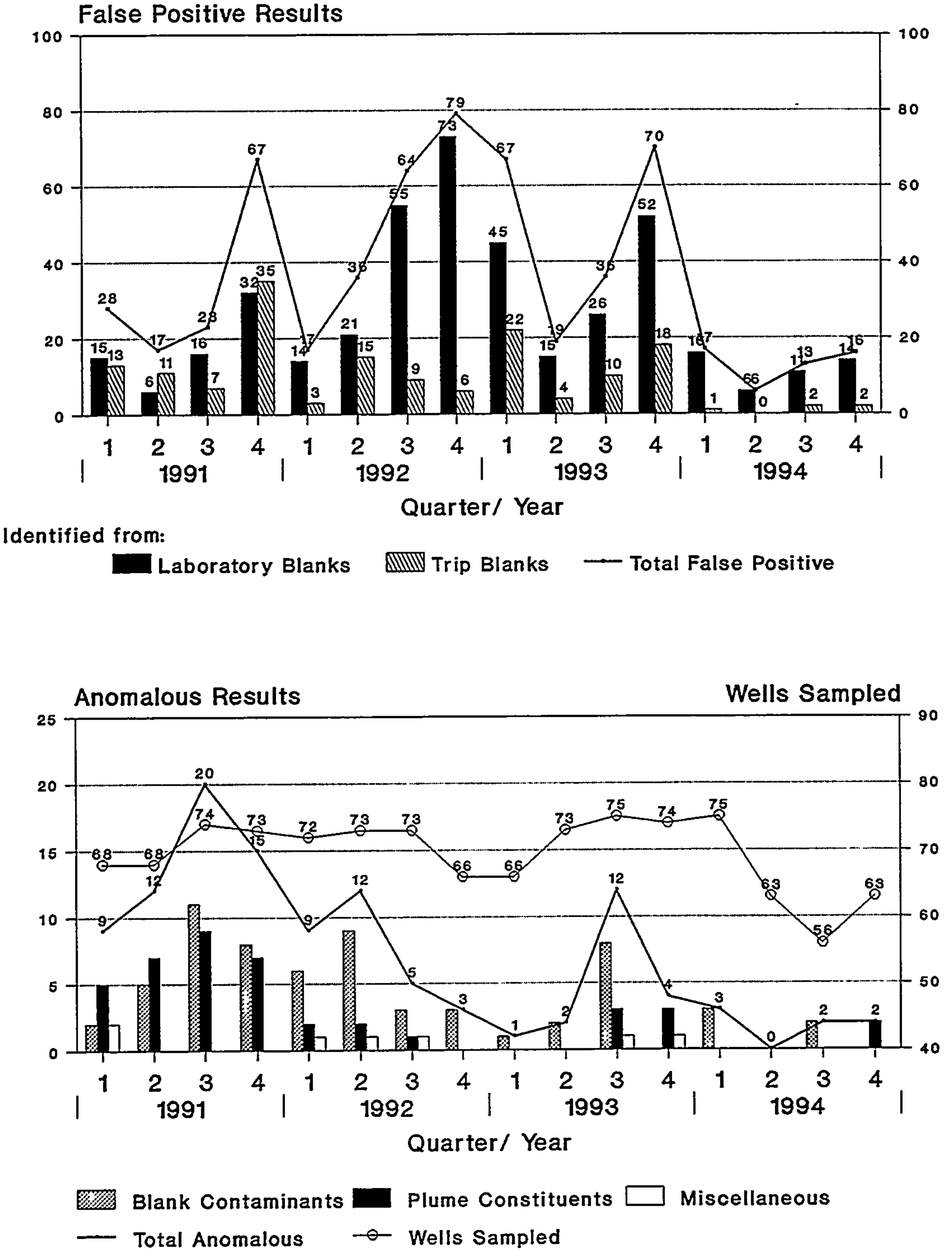


Source Water Contaminant

Chloroform



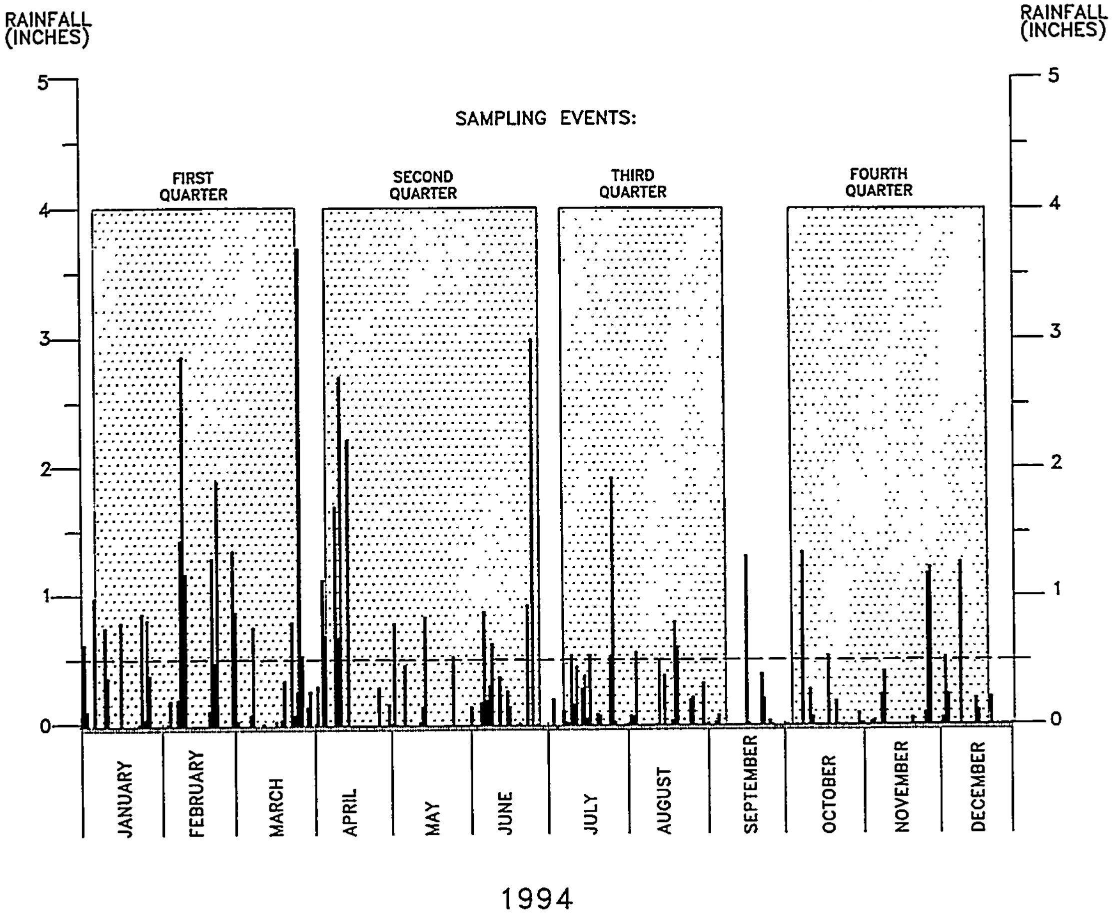
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 5
DATE:	8-6-95	VOCs IN QA/QC SAMPLES, 1991 - 1994
DWG ID.:	HG7	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DATE:	8-6-95
DWG ID.:	HG7

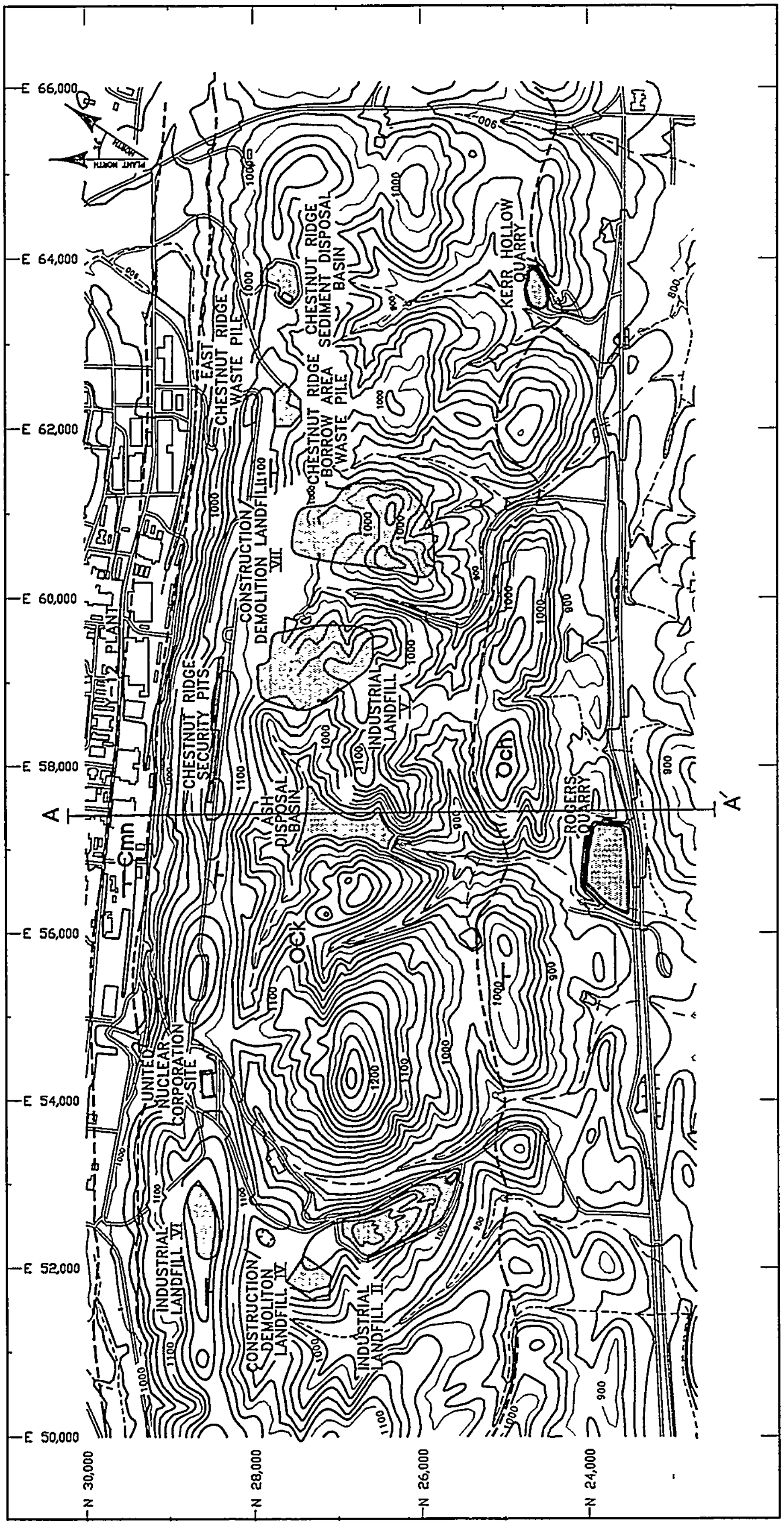
FIGURE 6

FASLE POSITIVE AND ANOMALOUS VOC RESULTS, 1991-1994



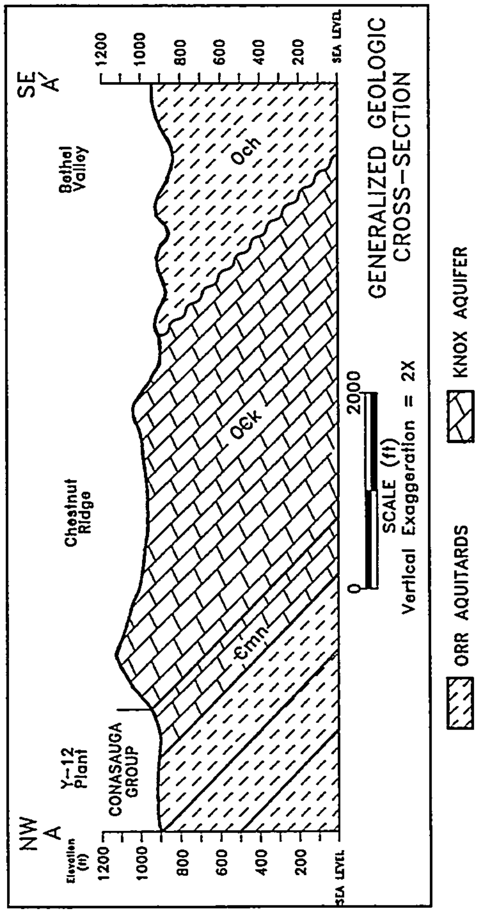
SOURCE: National Oceanic and Atmospheric Administration

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 7
DATE:	9-8-95	RAINFALL DURING SAMPLING EVENTS IN CY 1994
DWG ID.:	RAIN2	



SOURCE: King and Haase, 1987

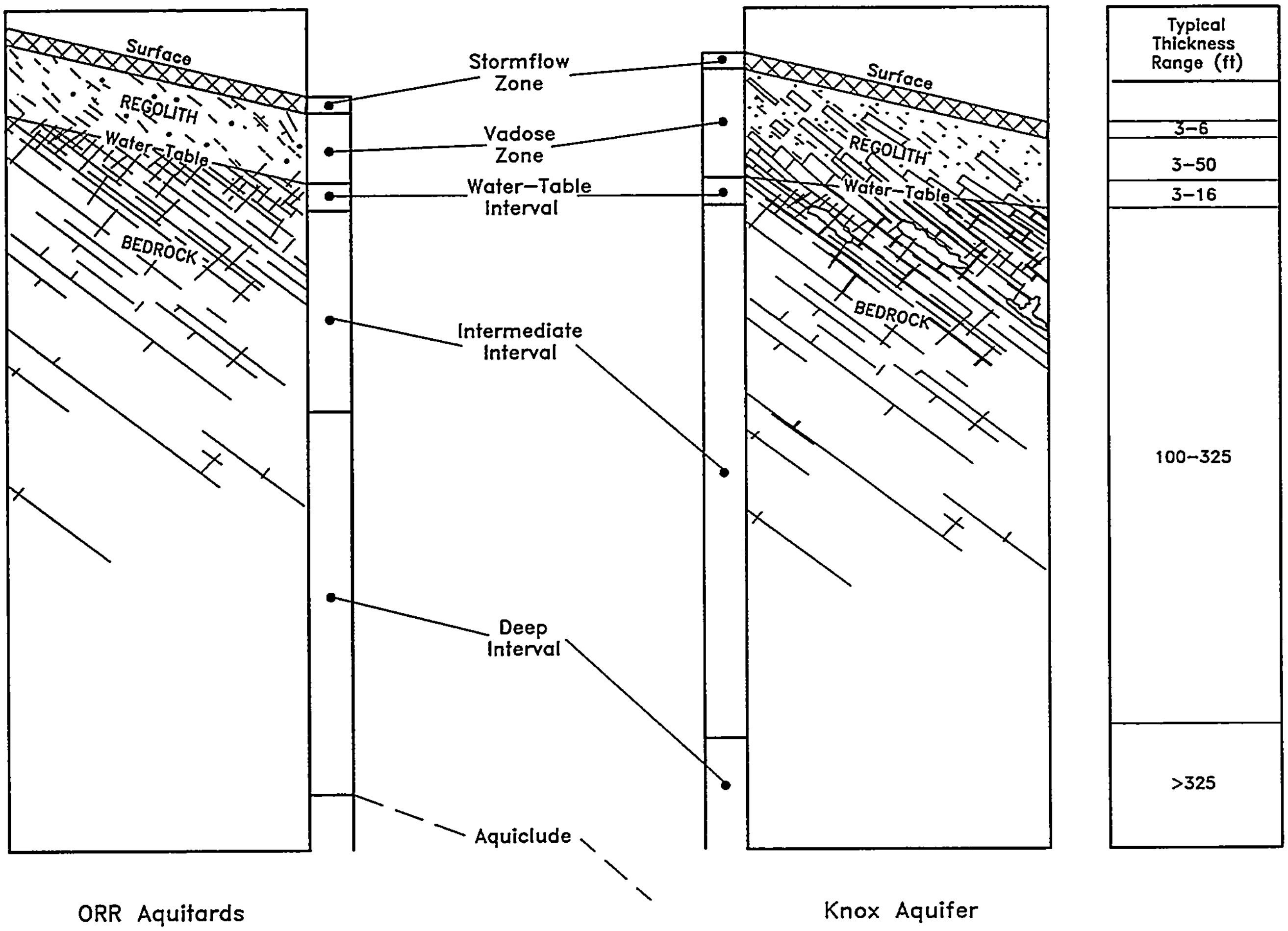
SYSTEM		GROUP (Formation)	HYDRO UNIT	MAP SYMBOL	THICKNESS (FT)
ORDOVICIAN	UPPER	CHICKAMAUGA (Undifferentiated)	ORR AQUITARDS	Och	1500 TO 2000
	MIDDLE	MISSING SECTION (Subaerial Erosion)			
	LOWER	KNOX (Undifferentiated)	KNOX AQUIFER	O€k	2500 TO 3000
CAMBRIAN	UPPER	CONASAUGA (Maynardville Limestone)		€mn	418 TO 450



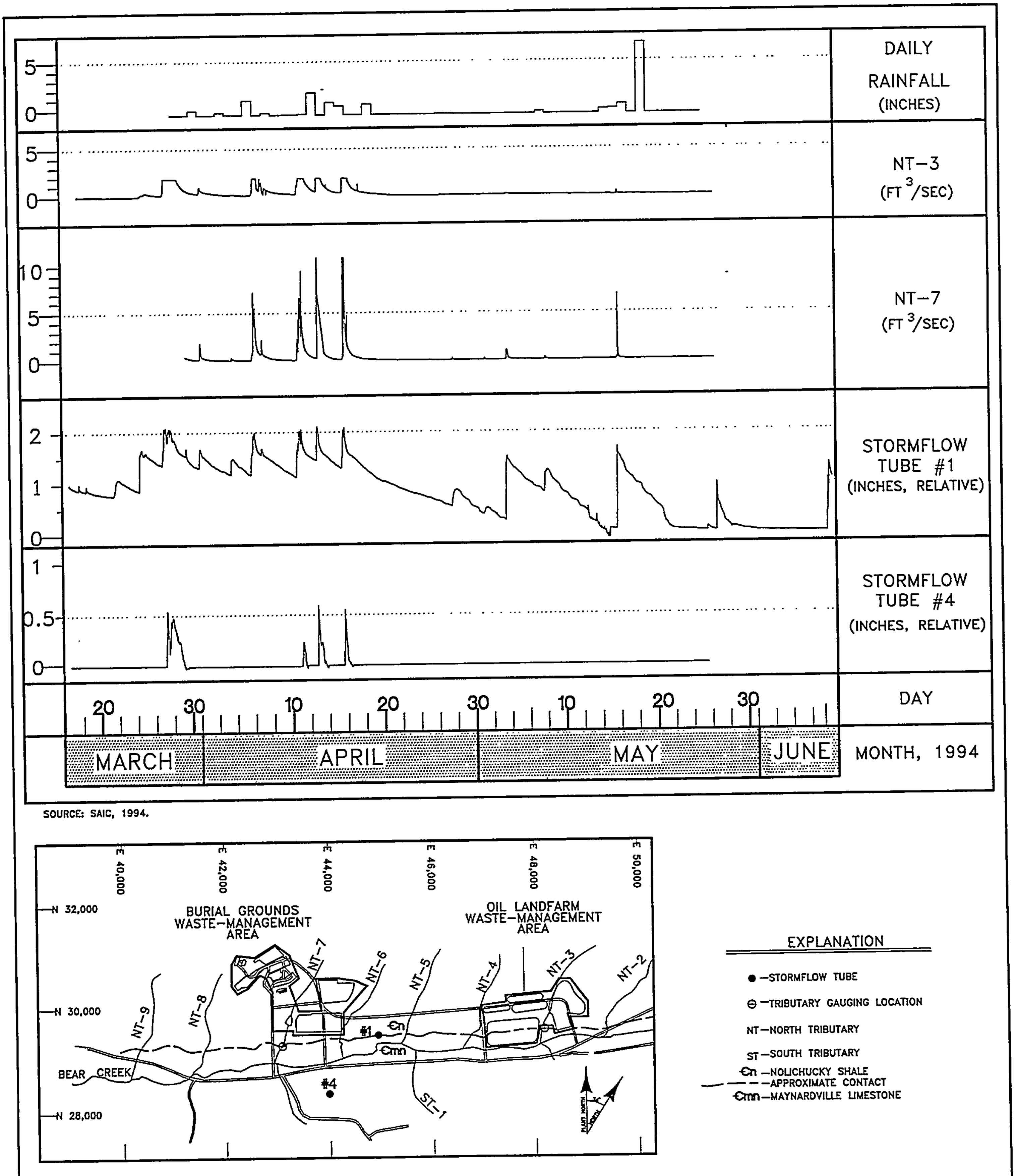
GENERALIZED GEOLOGIC CROSS-SECTION

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 8
DATE:	5-9-95	TOPOGRAPHY AND BEDROCK GEOLOGY IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR456-HC	

HYDROSTRATIGRAPHIC UNITS
PROPOSED BY SOLOMON *et al*. (1992)

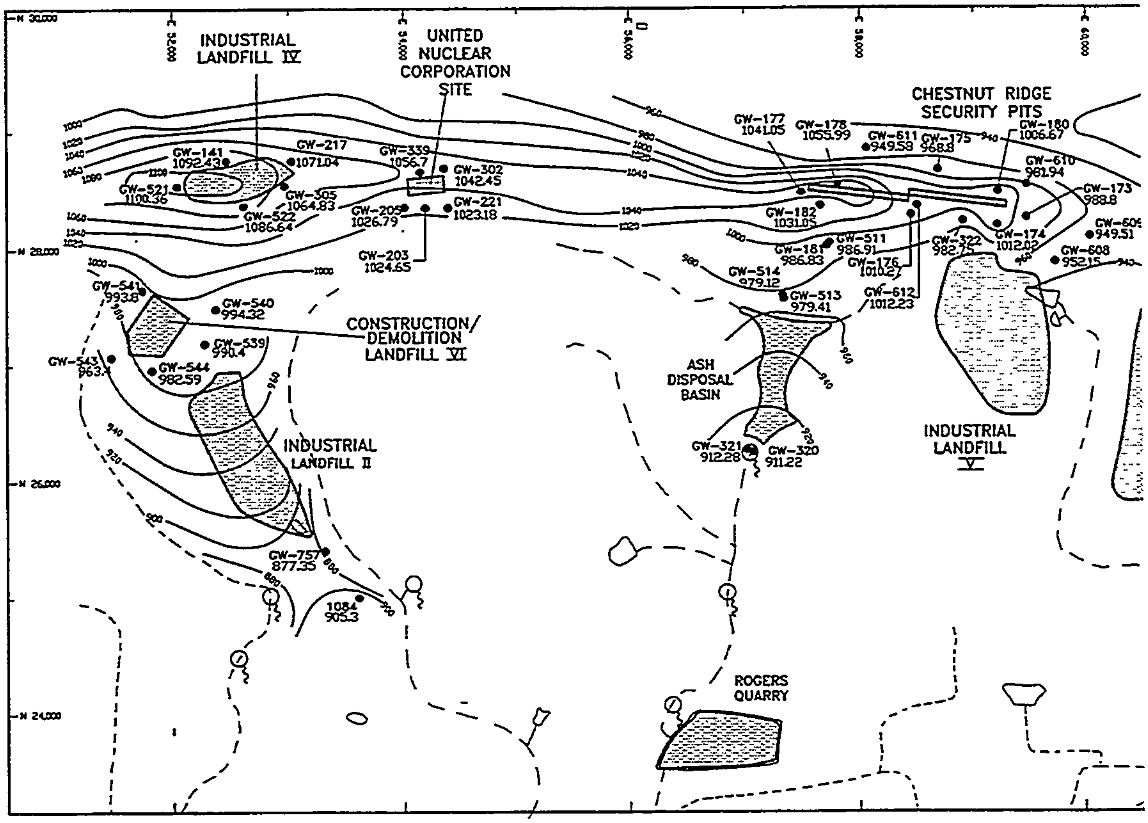


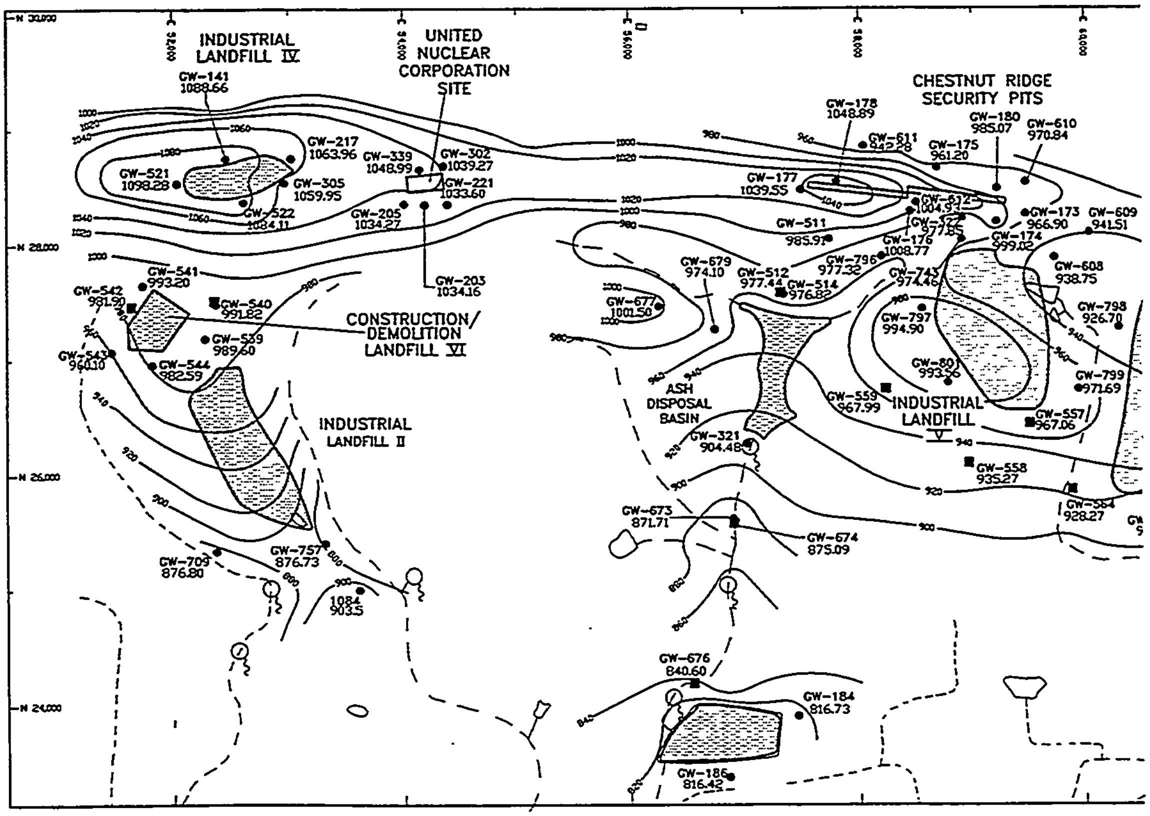
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 9 SCHEMATIC PROFILE OF HYDROSTRATIGRAPHIC UNITS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DATE:	5-9-94	
DWG ID.:	OR213-HC	

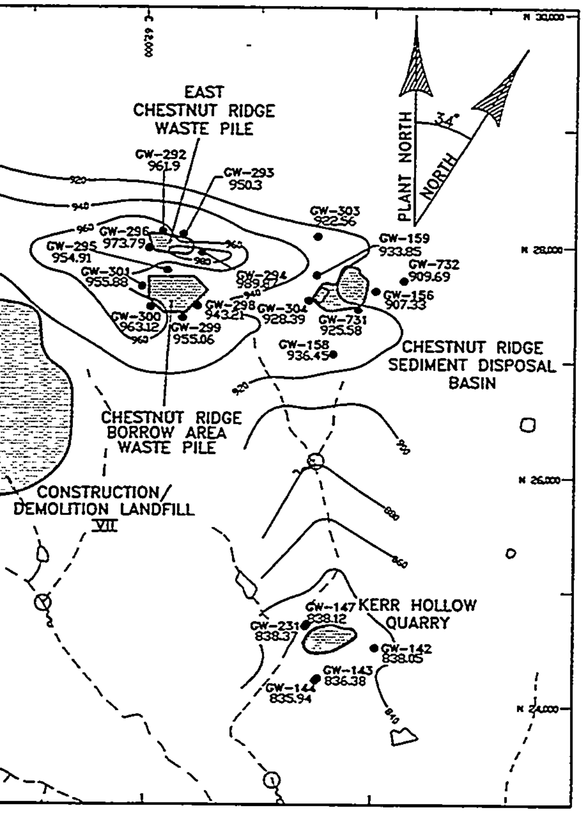


SOURCE: SAIC, 1994.

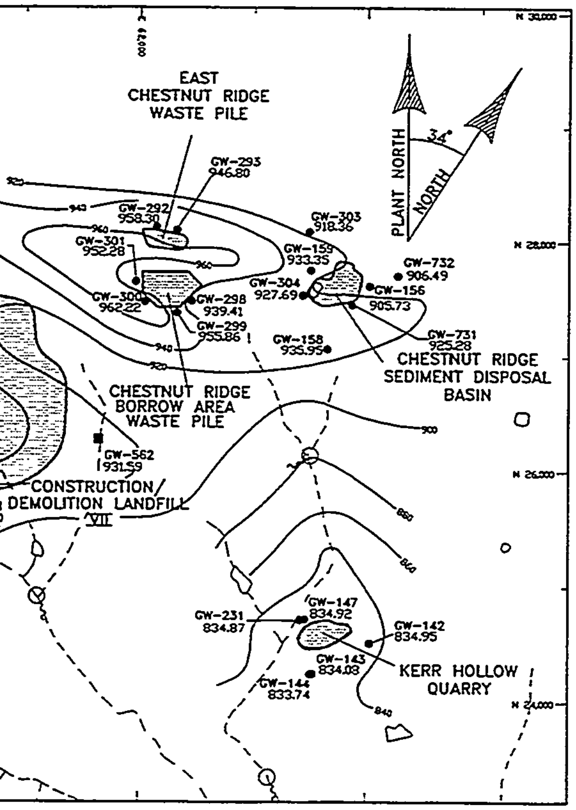
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 10 RAINFALL RESPONSES IN THE STORMFLOW ZONE
DATE:	5-9-95	
DWG ID.:	OR427-HC	


N 30,000
N 28,000
N 26,000
N 24,000
E 32,000
E 34,000
E 36,000
E 38,000
E 40,000
INDUSTRIAL LANDFILL IV
UNITED NUCLEAR CORPORATION SITE
CHESTNUT RIDGE SECURITY PITS
GW-141 1092.43
GW-217 1071.04
GW-339 1056.7
GW-302 1042.45
GW-521 1100.36
GW-305 1064.83
GW-522 1086.64
GW-205 1026.79
GW-221 1023.18
GW-203 1024.65
GW-177 1041.05
GW-178 1055.99
GW-611 949.58
GW-175 968.8
GW-180 1006.67
GW-610 981.94
GW-173 988.8
GW-609 949.51
GW-182 1031.05
GW-181 986.83
GW-511 986.91
GW-176 1010.2
GW-322 982.75
GW-174 1012.02
GW-608 952.15
GW-514 979.12
GW-513 979.41
GW-612 1012.23
GW-541 993.8
GW-540 994.32
GW-539 990.4
GW-543 963.7
GW-544 982.59
CONSTRUCTION/ DEMOLITION LANDFILL VI
ASH DISPOSAL BASIN
INDUSTRIAL LANDFILL II
INDUSTRIAL LANDFILL V
GW-321 912.28
GW-320 911.22
GW-757 877.35
1084 905.3
ROGERS QUARRY


N 30,000
N 28,000
N 26,000
N 24,000
E 32,000
E 34,000
E 36,000
E 38,000
E 40,000
INDUSTRIAL LANDFILL IV
UNITED NUCLEAR CORPORATION SITE
CHESTNUT RIDGE SECURITY PITS
GW-141 1088.66
GW-217 1063.96
GW-339 1048.99
GW-302 1039.27
GW-221 1033.60
GW-521 1098.28
GW-305 1059.95
GW-522 1084.11
GW-205 1034.27
GW-203 1034.16
GW-178 1048.89
GW-611 942.28
GW-175 961.20
GW-180 985.07
GW-610 970.84
GW-177 1039.55
GW-612 1004.9
GW-173 966.90
GW-609 941.51
GW-511 985.91
GW-322 977.85
GW-176 1008.77
GW-174 999.02
GW-608 938.75
GW-679 974.10
GW-512 977.44
GW-796 977.32
GW-514 976.82
GW-743 974.46
GW-677 1001.50
GW-798 926.70
GW-797 994.90
GW-801 993.56
GW-799 971.69
GW-541 993.20
GW-542 981.90
GW-540 991.82
GW-539 989.60
GW-543 960.10
GW-544 982.59
CONSTRUCTION/ DEMOLITION LANDFILL VI
ASH DISPOSAL BASIN
INDUSTRIAL LANDFILL II
INDUSTRIAL LANDFILL V
GW-559 967.99
GW-557 967.06
GW-321 904.48
GW-558 935.27
GW-564 928.27
GW-673 871.71
GW-674 875.09
GW-709 876.80
GW-757 876.73
1084 903.5
GW-676 840.60
GW-184 816.73
GW-186 816.42



Groundwater Elevations
January 11–24, 1994



Groundwater Elevations
August 22–31, 1994

EXPLANATION

GW-558 935.27 ■ Water Table Monitoring Well

GW-156 905.73 ● Bedrock Monitoring Well

—920— Approximate Water-Level Isopleth (ft msl)

- - - - Surface Drainage Feature

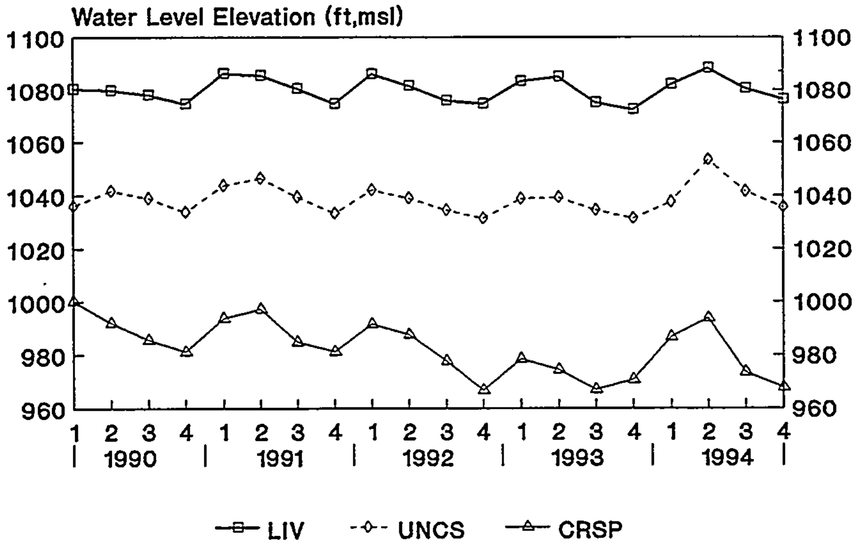
♀ Spring

0 2000
SCALE (ft)

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 11 GROUNDWATER ELEVATIONS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DATE:	6-19-95	
DWG ID.:	OR454-HC	

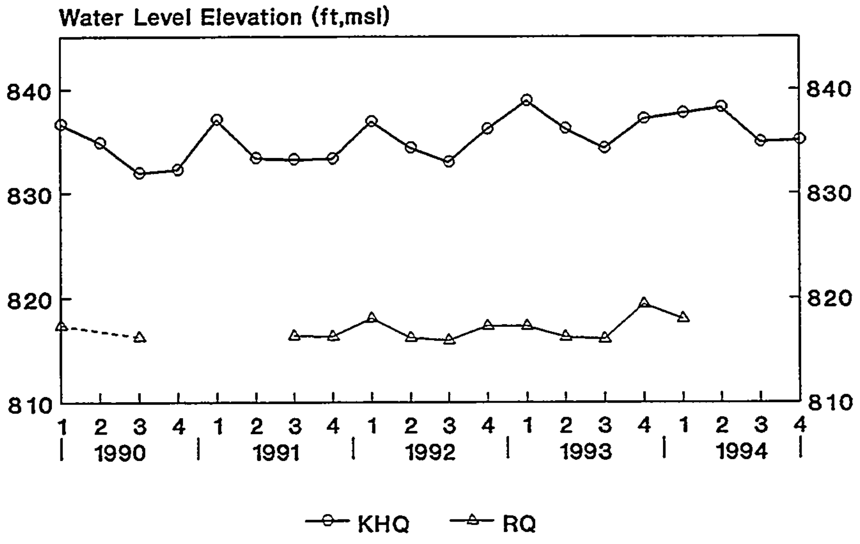
Upgradient Sites

Recharge



Downgradient Sites

Discharge



EXPLANATION

Depth to water measurements obtained during sampling events were averaged for all wells at each site and converted to elevations in feet above mean sea level (ft, msl).

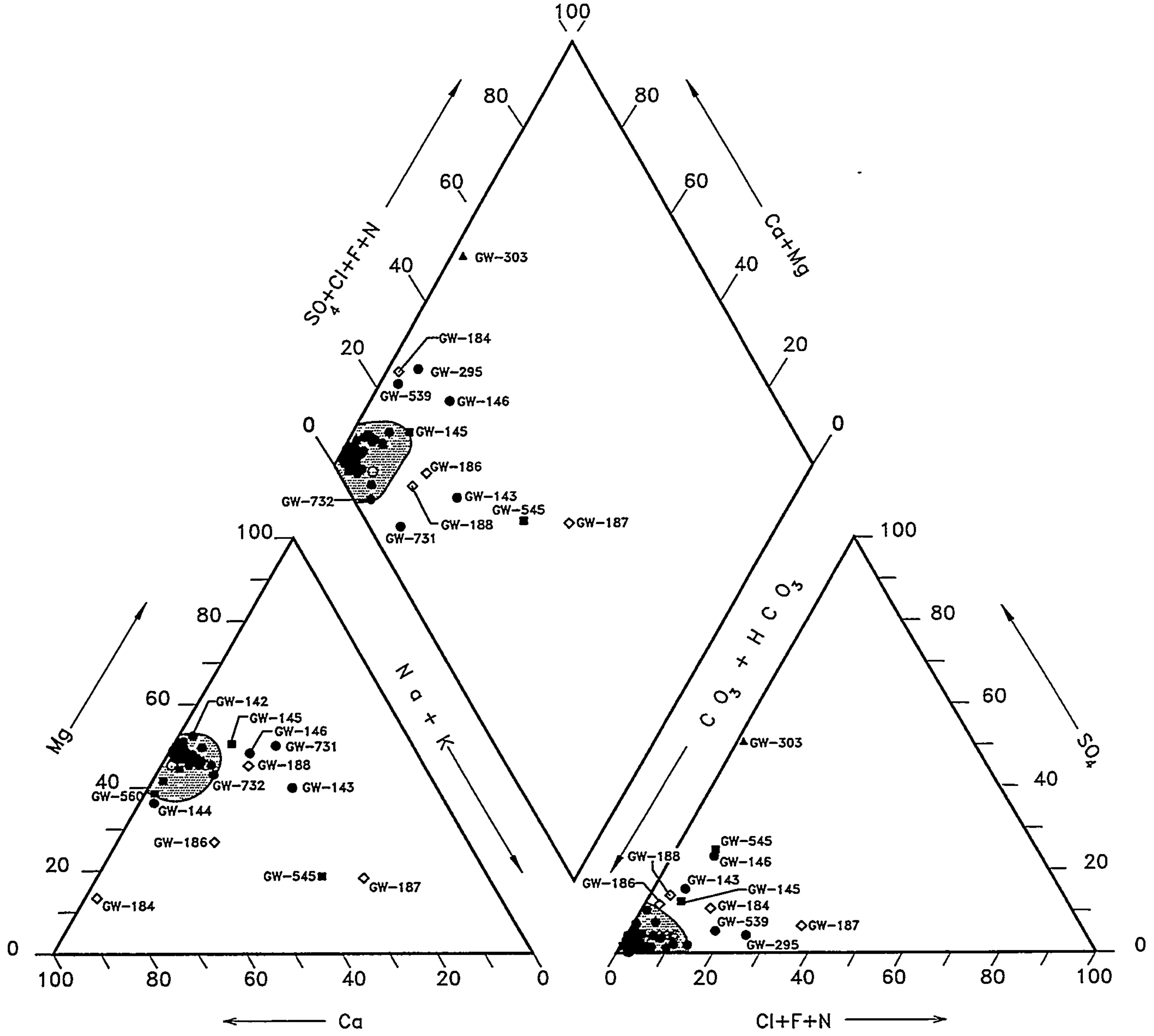
UPGRADIENT SITES

CRSP — Chestnut Ridge Security Pits
LIV — Industrial Landfill IV
UNCS — United Nuclear Corporation Site

DOWNGRADIENT SITES

KHQ — Kerr Hollow Quarry
RQ — Rogers Quarry

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 12
DATE:	6-19-95	WATER LEVEL HYDROGRAPHS FOR SELECTED SITES IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR458-HC	

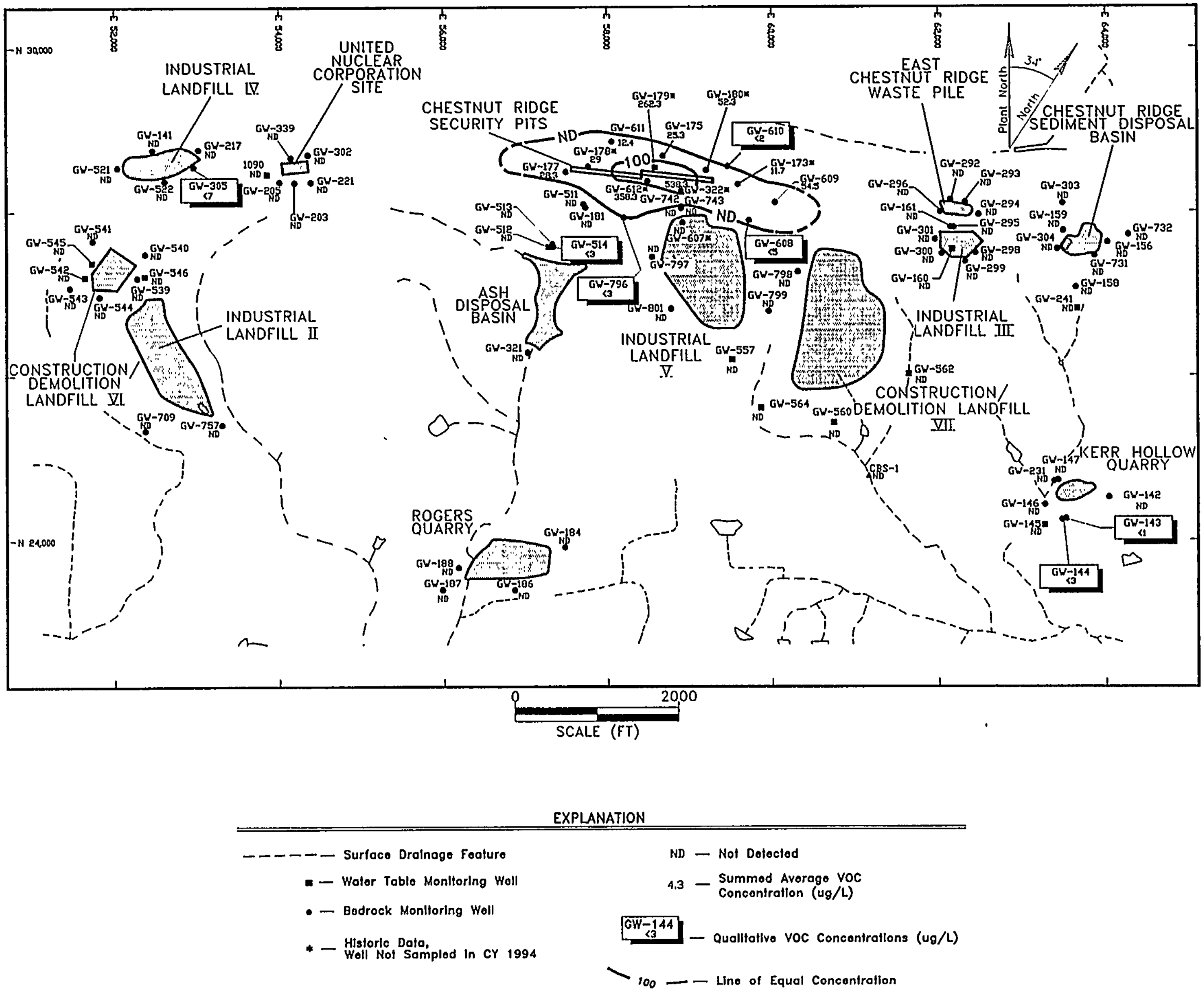


EXPLANATION

▨ — GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS, 74 WELLS ARE PLOTTED ON THIS DIAGRAM

GW-545 ■ — WATER TABLE MONITORING WELL	Knox Group
GW-755 ○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP	
GW-143 ● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP	
GW-303 ▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP	
GW-188 ◇ — BEDROCK MONITORING WELL	Chickamauga Group

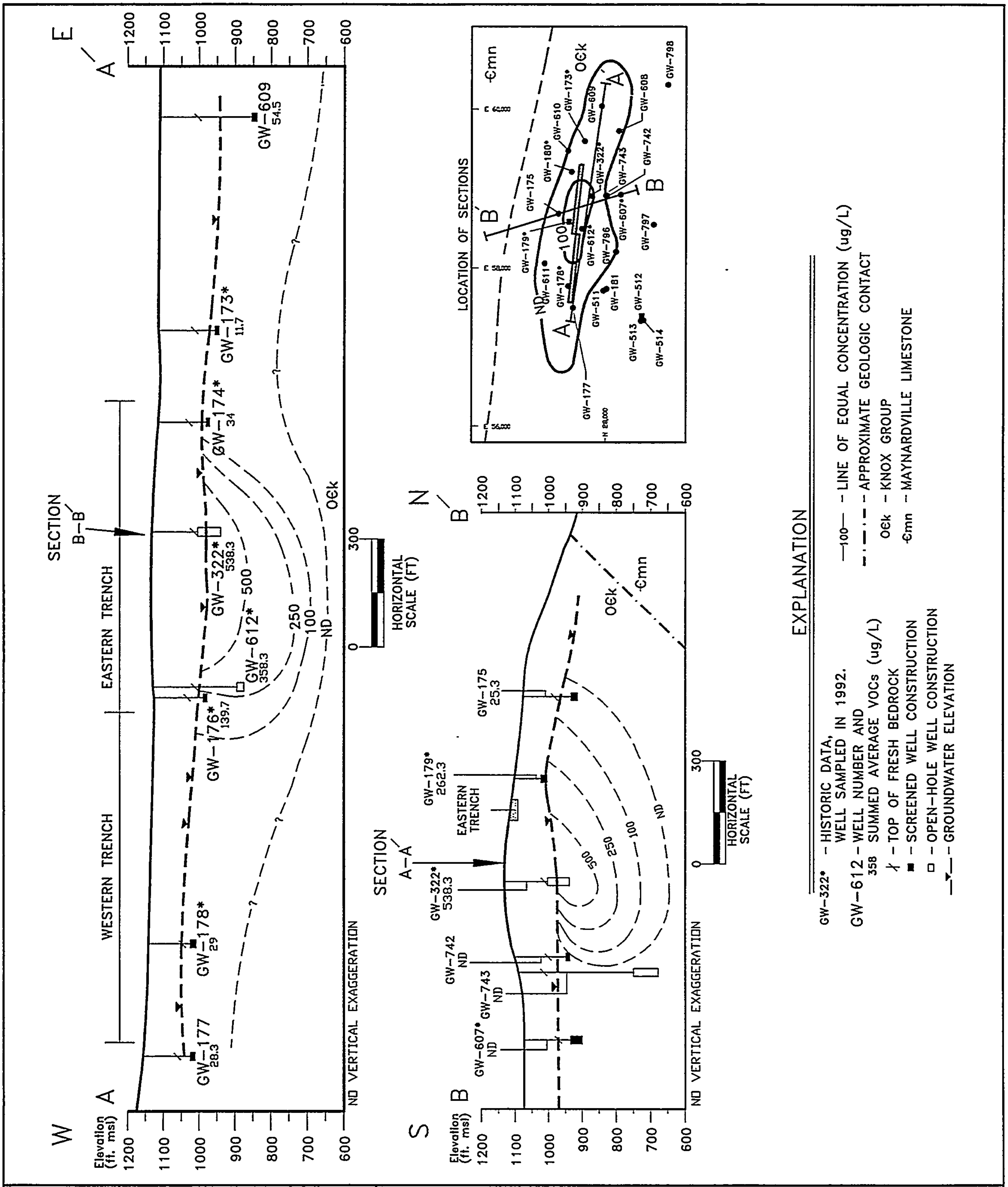
LOCATION:	Y-12 PLANT OAK RIDGE, TN	FIGURE 13
DATE:	9-8-95	GROUNDWATER GEOCHEMISTRY IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR480-HC	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DATE:	9-8-95
DWG ID.:	OR374B-HC

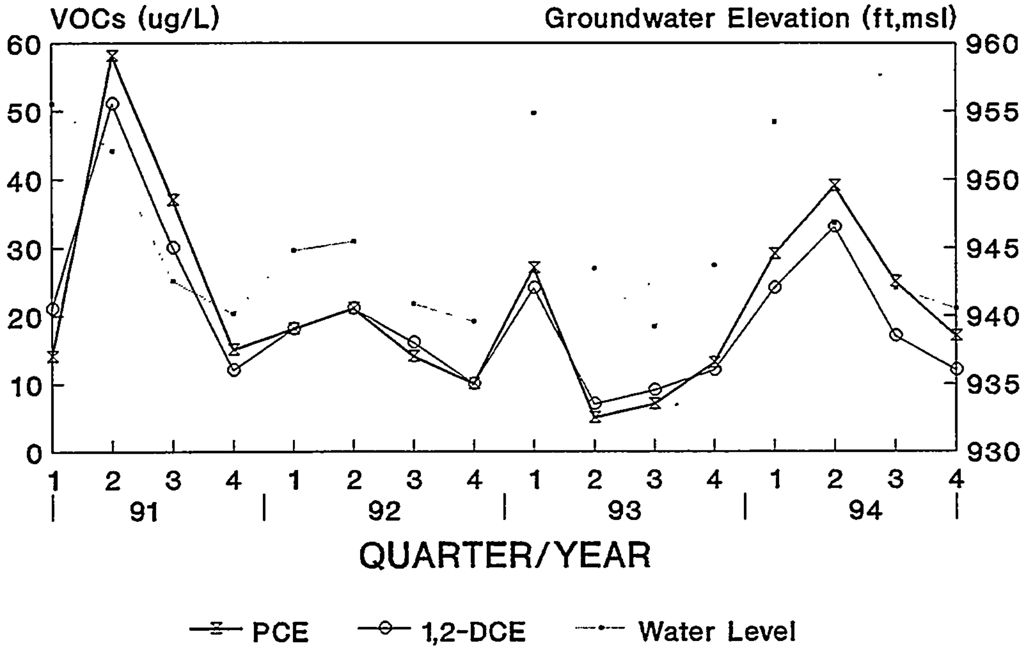
FIGURE 14

HORIZONTAL EXTENT OF VOCs IN GROUNDWATER IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME

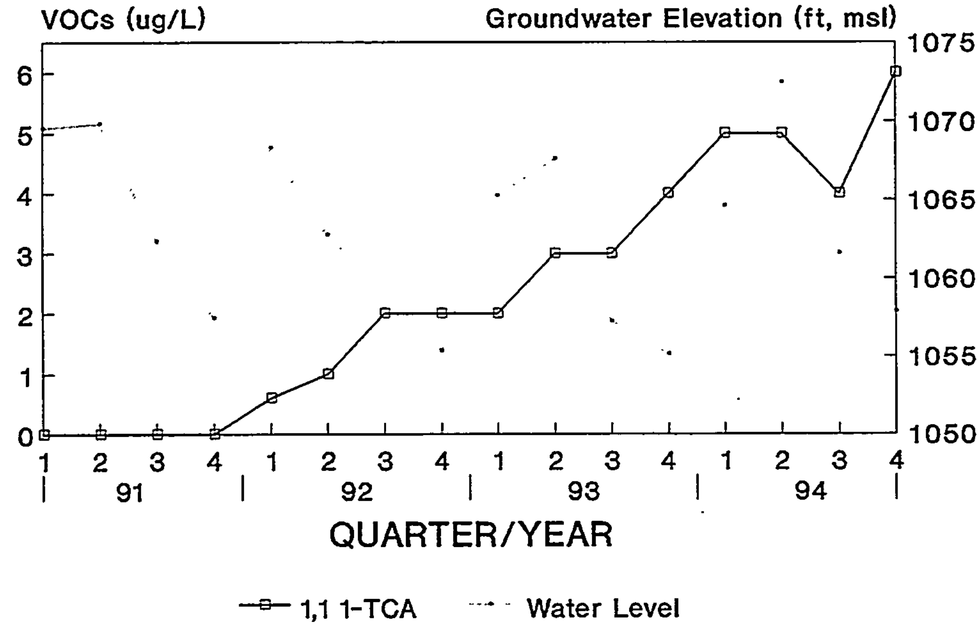


LOCATION:	Y–12 PLANT OAK RIDGE, TN	FIGURE 15
DATE:	6–20–95	VERTICAL EXTENT OF VOCs IN GROUNDWATER AT THE CHESTNUT RIDGE SECURITY PITS
DWG ID.:	OR375–HC	

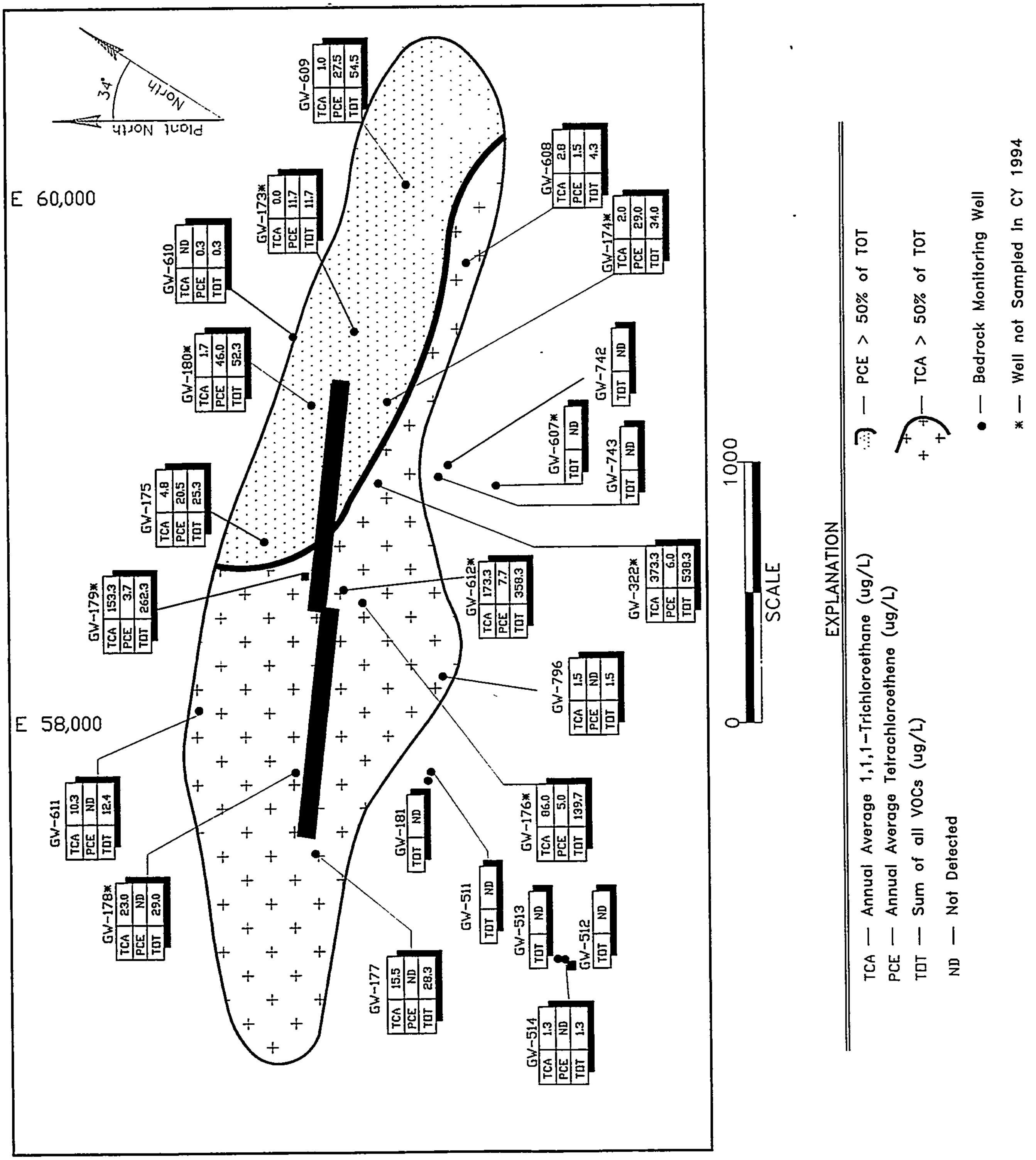
GW-609
Security Pits



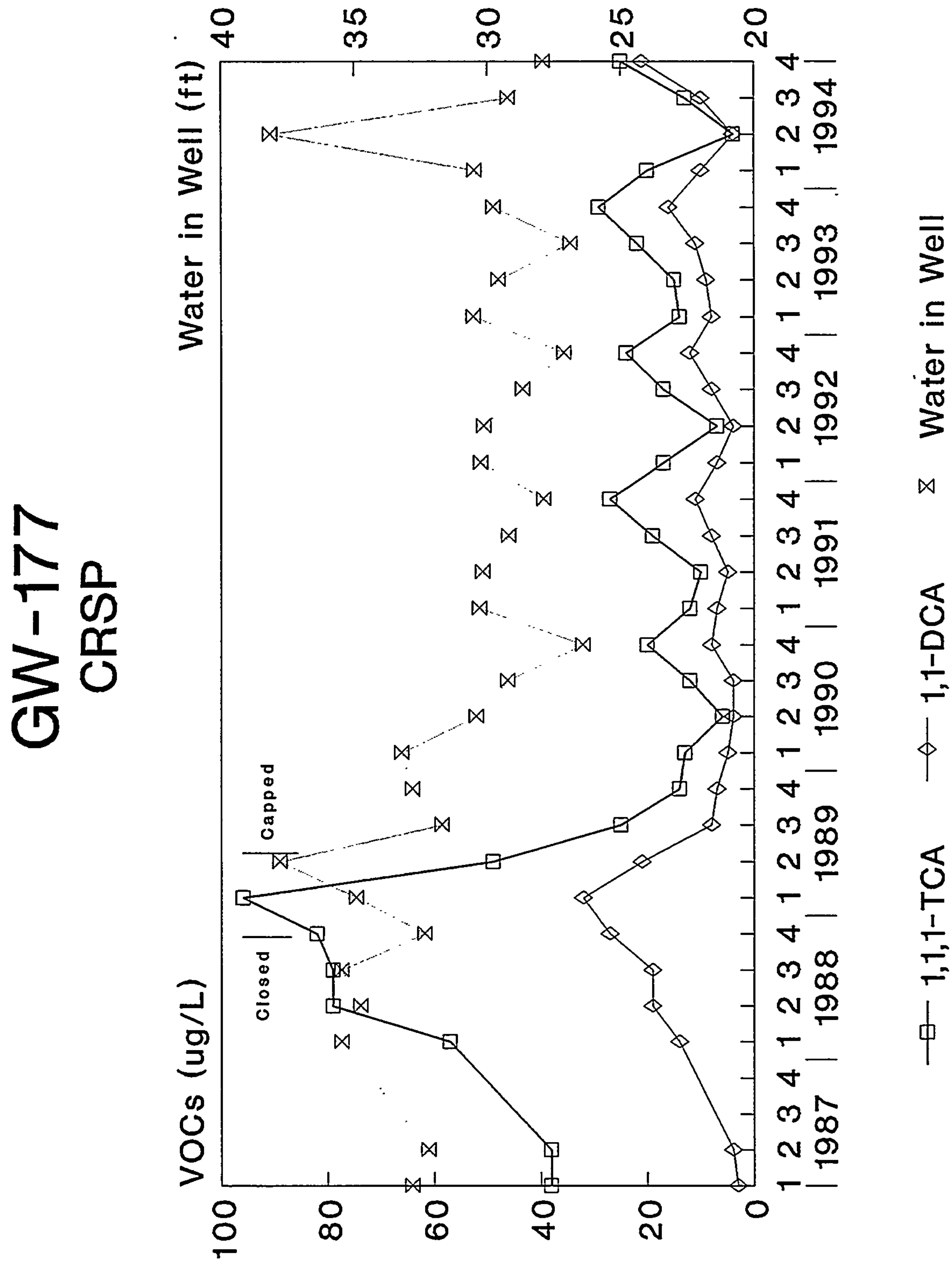
GW-305
UNCS



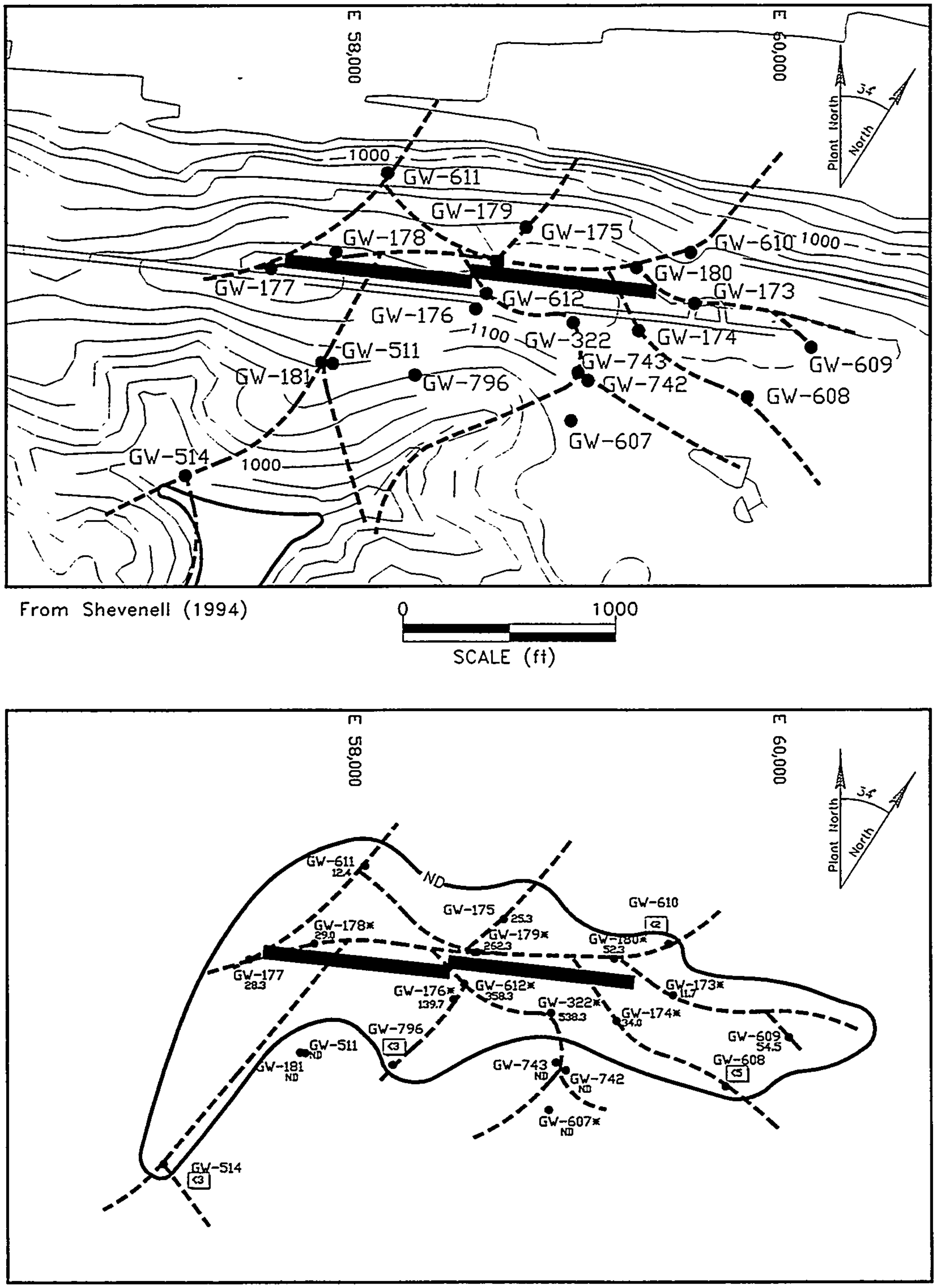
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 16
DATE:	6-14-95	CONCENTRATIONS OF SELECTED VOCs IN WELLS GW-609 AND GW-305, 1991-1994
DWG ID.:	HG	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 17
DATE:	9-8-95	DISTRIBUTION OF VOCs IN GROUNDWATER AT THE CHESTNUT RIDGE SECURITY PITS
DWG ID.:	OR374-HC	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 18
DATE:	6-19-95	CONCENTRATIONS OF 1,1,1-TCA AND 1,1-DCA IN SAMPLES COLLECTED FROM WELL GW-177, 1987-1994
DWG ID.:	H18	



From Shevenell (1994)

EXPLANATION

4.3 — Summed Average VOC Concentrations (ug/L)

* — Not Sampled in CY 1994

<3 — Qualitative VOC Concentration (ug/L)

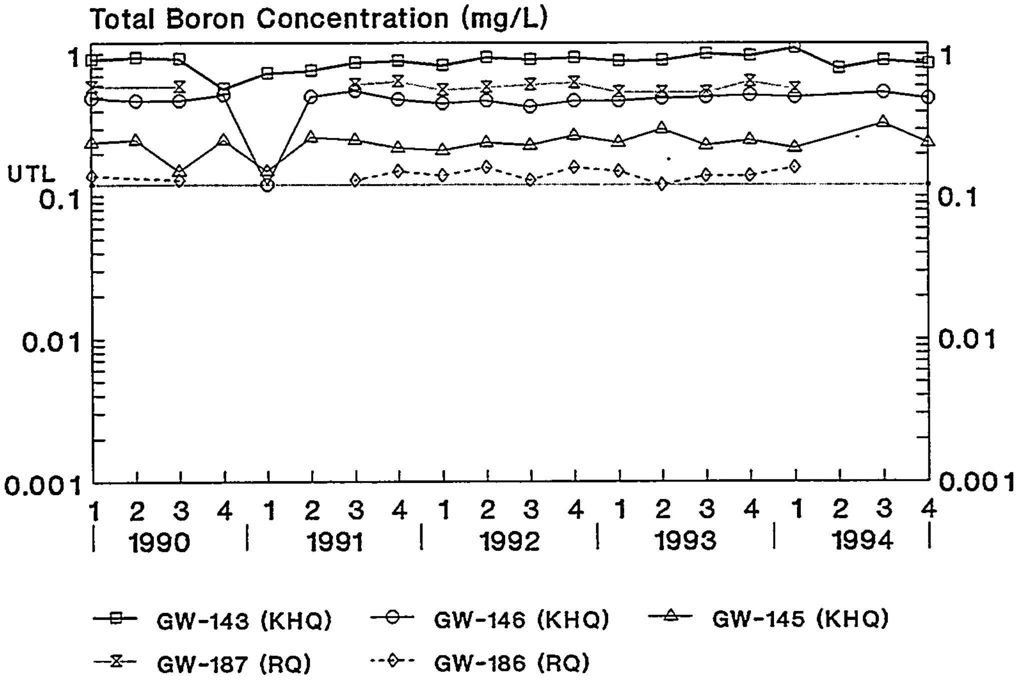
ND — Not Detected

– – – – — Interpolated Pathways

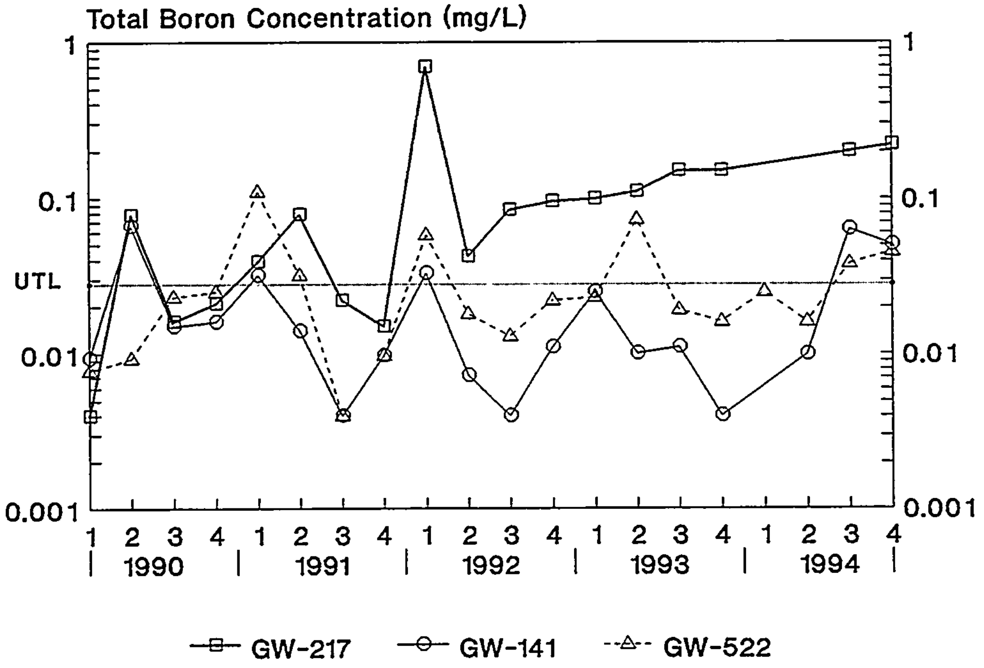
ND — Line of Equal Concentration

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 19
DATE:	9-8-95	POSSIBLE EFFECT OF PREFERRED PATHWAY FLOW ON THE VOC PLUME AT THE CHESTNUT RIDGE SECURITY PITS
DWG ID.:	OR374-HC	

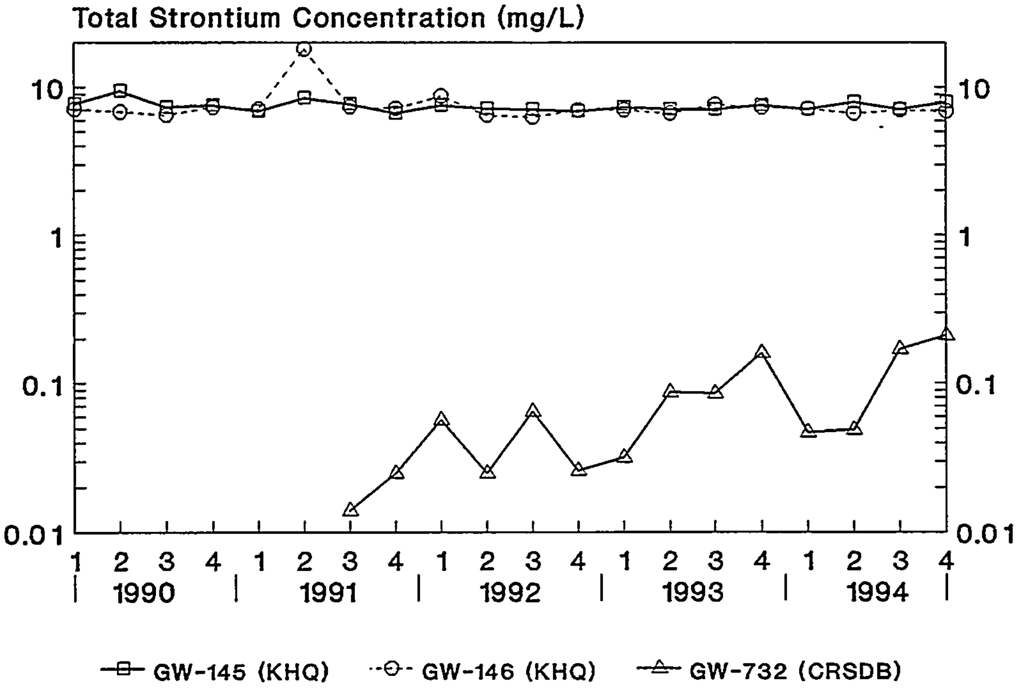
Cluster 1

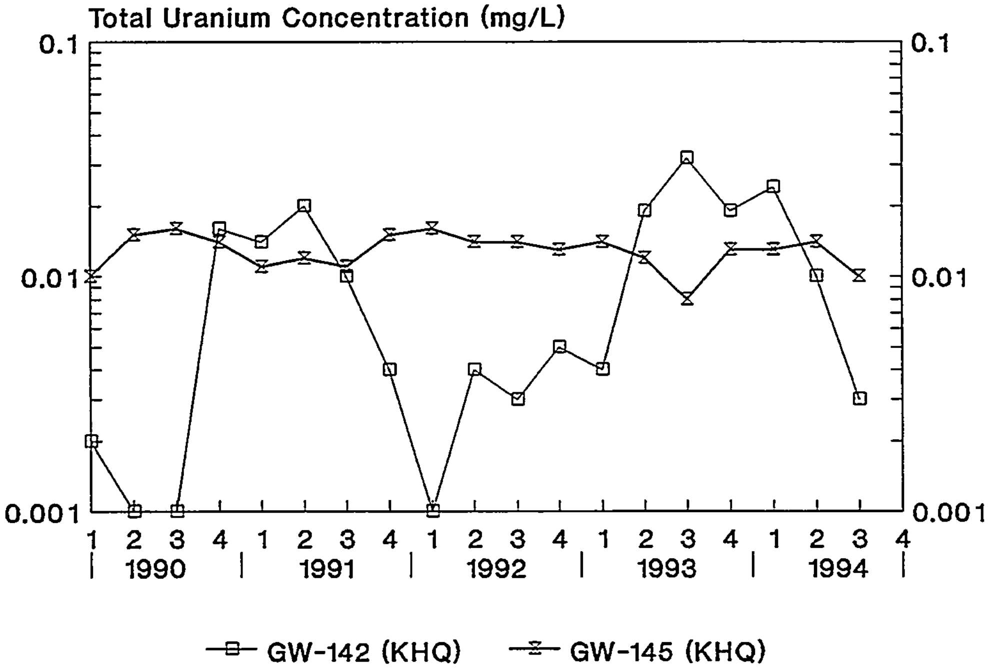


Cluster 4

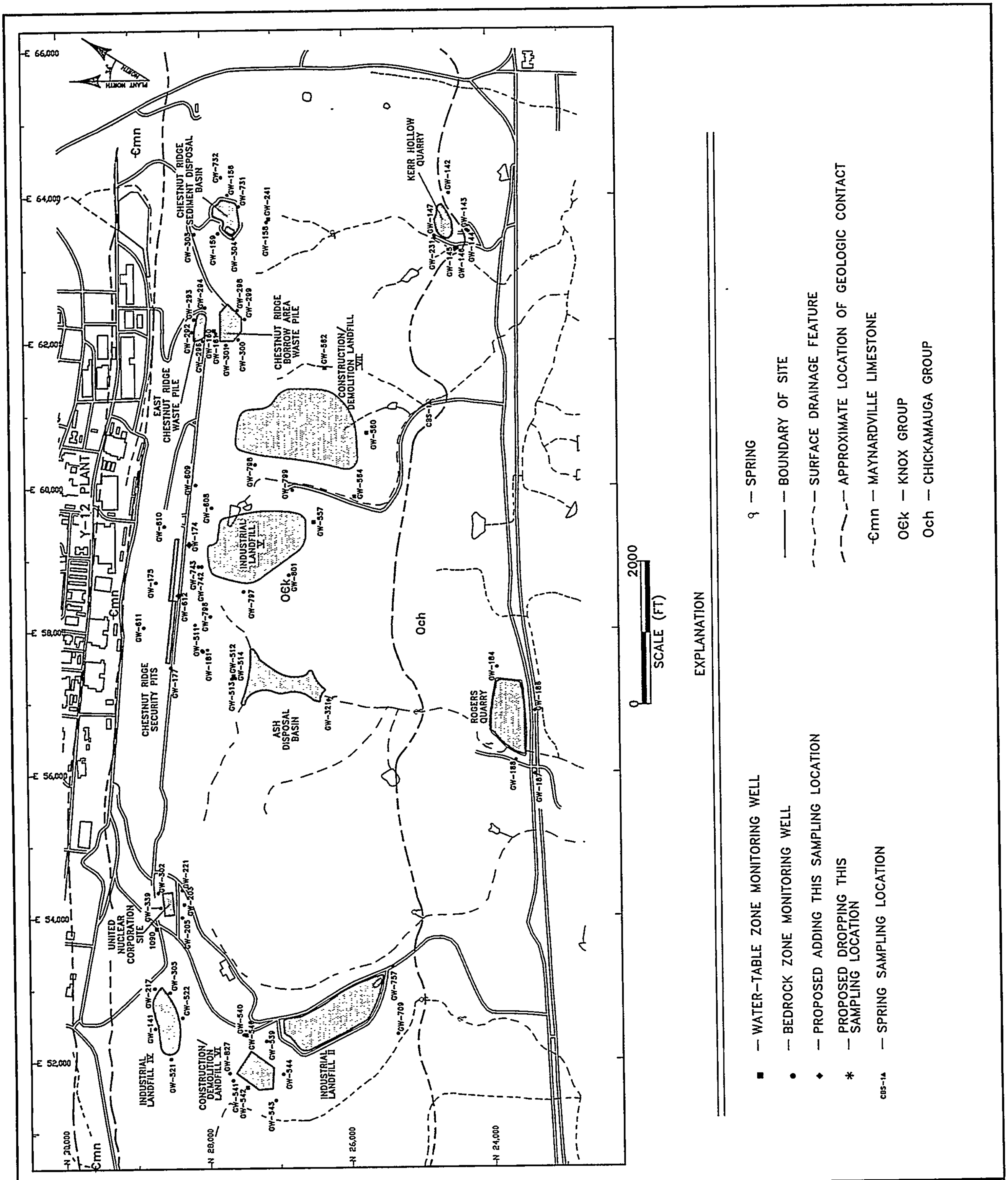


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 20
DATE:	6-19-95	BORON CONCENTRATIONS IN SAMPLES FROM SELECTED WELLS, 1991-1994
DWG ID.:	HG20	





LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 21
DATE:	6-19-95	STRONTIUM AND URANIUM CONCENTRATIONS IN SAMPLES FROM SELECTED WELLS, 1991-1994
DWG ID.:	HG21	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 22
DATE:	9-8-95	SAMPLING LOCATIONS PLANNED FOR GROUNDWATER MONITORING DURING CY 1996
DWG ID.:	OR307-HC	

APPENDIX B

TABLES

Table 1. Waste-Management Sites and CERCLA Operable Units in the Chestnut Ridge Hydrogeologic Regime

Site	Regulatory Classification	
	Historical[1]	Current[2]
Chestnut Ridge Sediment Disposal Basin	TSD Unit	Study Area/TSD Unit
East Chestnut Ridge Waste Pile	TSD Unit	Study Area/TSD Unit
Kerr Hollow Quarry	TSD Unit	Study Area/TSD Unit
Chestnut Ridge Security Pits	TSD Unit	CR OU 01/TSD Unit
Ash Disposal Basin	SWMU	CR OU 02
United Nuclear Corporation Site	SWMU	CR OU 03
Rogers Quarry	SWMU	CR OU 04
Industrial Landfill II	SWDF	SWDF
Industrial Landfill IV	SWDF	SWDF
Industrial Landfill V	N/A	SWDF
Construction/Demolition Landfill VI	N/A	SWDF
Construction/Demolition Landfill VII	N/A	SWDF
Chestnut Ridge Borrow Area Waste Pile	NR	Study Area

Notes:

1 Regulatory classification before the 1992 Federal Facility Agreement.

TSD Unit - RCRA-regulated land-based Treatment, Storage, or Disposal Facility.
SWMU - RCRA-regulated Solid Waste Management Unit
SWDF - Solid Waste Disposal Facility (non-hazardous waste)
N/A - Not applicable (new facility)
NR - Not regulated

2 Modified from: *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (U.S. Department of Energy 1994)

CR OU 01 - Chestnut Ridge Operable Unit 01 (Source Control and Groundwater OU)
CR OU 02 - Chestnut Ridge Operable Unit 02 (Source Control and Groundwater OU)
CR OU 03 - Chestnut Ridge Operable Unit 03 (Source Control and Groundwater OU)
CR OU 04 - Chestnut Ridge Operable Unit 04 (Source Control and Groundwater OU)

Table 2. Monitoring Programs Implemented During CY 1994

Monitoring Program	Sampling Point	Location[1]	Quarters Sampled[2]			
			1st	2nd	3rd	4th
RCRA Interim Status Assessment Monitoring						
	GW-175	CRSP	■	■	■	■
	GW-177	CRSP	■	■	■	■
	GW-181	CRSP	■	■	■	■
	GW-511	CRSP	■	■	■	■
	GW-608	CRSP	■	■	■	■
	GW-609	CRSP	■	■	■	■
	GW-610	CRSP	■	■	■	■
	GW-611	CRSP	■	■	■	■
	GW-742	CRSP	■	■	■	■
	GW-743	CRSP	■	■	■	■
RCRA Interim Status Detection Monitoring						
	GW-142	KHQ	■	■	■	■
	GW-143	KHQ	■	■	■	■
	GW-144	KHQ	■	■	■	■
	GW-145[a]	KHQ	■	■	■	■
	GW-146	KHQ	■	■	■	■
	GW-147	KHQ	■	■	■	■
	GW-156	CRSDB	■	■	■	■
	GW-158	CRSDB	■	■	■	■
	GW-159[a]	CRSDB	■	■	■	■
	GW-231	KHQ	■	■	■	■
	GW-241	CRSDB	■	■	■	■
	GW-303	CRSDB	■	■	■	■
	GW-304	CRSDB	■	■	■	■

Table 2 (cont'd)

Monitoring Program	Sampling Point	Location[1]	Quarters Sampled[2]			
			1st	2nd	3rd	4th
RCRA	**Interim Status Detection Monitoring (cont'd)**					
	GW-731	CRSDB	■	■	■	■
	GW-732	CRSDB	■	■	■	■
CERCLA ROD/RCRA Post-Closure Care Monitoring						
	1090	UNCS	■	■	■	■
	GW-203	UNCS	■	■	■	■
	GW-205	UNCS	■	■	■	■
	GW-221	UNCS	■	■	■	■
	GW-302	UNCS	■	■	■	■
	GW-339	UNCS	■	■	■	■
SWDF Detection and Background Monitoring						
	GW-141	LIV	■	■	■	■
	GW-217	LIV	■	■	■	■
	GW-305	LIV	■	■	■	■
	GW-521[a]	LIV	■	■	■	■
	GW-522	LIV	■	■	■	■
	GW-539[a]	LII	■	■	■	■
	GW-540	CDLVI	■	■	.	■
	GW-541[a]	CDLVI	■	■	.	■
	GW-542	CDLVI	■	■	.	■
	GW-543	CDLVI	■	■	.	■
	GW-544	CDLVI	■	■	.	■
	GW-545[a]	CDLVI	■	■	.	■
	GW-546	CDLVI	■	■	.	■
	GW-557	LV	■	■	■	■
	GW-560	CDLVII	■	■	■	■
	GW-562	CDLVII	■	■	■	■

Table 2 (cont'd)

Monitoring Program	Sampling Point	Location[1]	Quarters Sampled[2]			
			1st	2nd	3rd	4th
SWDF Detection and Background Monitoring (cont'd)						
	GW-564	CDLVII	■	■	■	■
	GW-709	LII	■	■	■	■
	GW-757	LII	■	■	■	■
	GW-796[a]	LV	■	■	■	■
	GW-797[a]	LV	■	■	■	■
	GW-798[a]	CDLVII	■	■	■	■
	GW-799	CDLVII	■	■	■	■
	GW-801	LV	■	■	■	■
	CBS-1[b]	CDLVII	■	.	■	.
Best Management Practice Monitoring						
	GW-160	CRBAWP	■	.	■	.
	GW-161	CRBAWP	■	.	■	.
	GW-184	RQ	■	.	.	.
	GW-186	RQ	■	.	.	.
	GW-187	RQ	■	.	.	.
	GW-188	RQ	■	.	.	.
	GW-292	ECRWP	■	■	.	■
	GW-293	ECRWP	■	■	.	■
	GW-294	ECRWP	■	■	.	■
	GW-295	CRBAWP	■	.	■	.
	GW-296	ECRWP	■	■	.	■
	GW-298	CRBAWP	■	.	■	.
	GW-299	CRBAWP	■	.	■	.
	GW-300[a]	CRBAWP	■	.	■	.
	GW-301	CRBAWP	■	.	■	.
	GW-321	ADB	■	■	.	■

Table 2 (cont'd)

Monitoring Program	Sampling Point	Location[1]	Quarters Sampled[2]			
			1st	2nd	3rd	4th
Best Management Practice Monitoring (cont'd)						
	GW-512	ADB	■	■	.	■
	GW-513	ADB	■	■	.	■
	GW-514	ADB	■	■	.	■

Notes:

1 ADB - Ash Disposal Basin
CDLVI - Construction/Demolition Landfill VI
CDLVII - Construction/Demolition Landfill VII
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
ECRWP - East Chestnut Ridge Waste Pile
KHQ - Kerr Hollow Quarry
LII - Industrial Landfill II
LIV - Industrial Landfill IV
LV - Industrial Landfill V
RQ - Rogers Quarry
UNCS - United Nuclear Corporation Site

2 ■ - sample collected during specified quarter of CY 1994
. - sample not collected

Quarterly Sampling Events:

First Quarter: January 5 - March 25, 1994
Second Quarter: April 4 - June 29, 1994
Third Quarter: July 6 - September 7, 1994
Fourth Quarter: October 3 - December 19, 1994

a Upgradient monitoring well

b Spring Sampling Station

Table 3. Construction Information for Monitoring Wells Sampled During CY 1994[1]

Well No.	Location[2]	Cluster Designation[3]	Aquifer[4]		Monitored Interval Depths[5]		
			Interval	Form.	Top		Bottom
1090	UNCS	4	WT	OCk	unknown	-	96.7
GW-141	LIV	4	BDR	OCk	141.0	-	156.0
GW-142[a]	KHQ	4	BDR	OCk	248.5	-	295.0
GW-143[a]	KHQ	1	BDR	OCk	205.0	-	253.0
GW-144	KHQ	4	BDR	Och/OCk	148.0	-	195.0
GW-145	KHQ	1	WT	OCk	86.0	-	110.0
GW-146[a]	KHQ	1	BDR	OCk	190.0	-	220.0
GW-147	KHQ	4	BDR	OCk	52.0	-	69.0
GW-156	CRSDB	4	BDR	OCk	146.0	-	157.0
GW-158[a]	CRSDB	4	BDR	OCk	356.0	-	441.0
GW-159	CRSDB	4	BDR	OCk	146.0	-	157.0
GW-160[a]	CRBAWP	4	WT	OCk	205.0	-	235.0
GW-161[a]	CRBAWP	4	BDR	OCk	350.0	-	400.0
GW-175	CRSP	4	BDR	OCk	148.3	-	166.7
GW-177	CRSP	4	BDR	OCk	132.0	-	145.0
GW-181[a]	CRSP	4	BDR	OCk	155.0	-	168.0
GW-184	RQ	3	BDR	Och	101.5	-	130.0
GW-186	RQ	1	BDR	Och	142.0	-	171.0
GW-187	RQ	1	BDR	Och	139.0	-	162.0
GW-188	RQ	1	BDR	Och	49.0	-	68.0
GW-203	UNCS	4	BDR	OCk	144.0	-	156.0
GW-205	UNCS	4	BDR	OCk	154.0	-	164.0
GW-217	LIV	4	BDR	OCk	165.2	-	180.0
GW-221	UNCS	4	BDR	OCk	147.0	-	158.0
GW-231	KHQ	4	BDR	OCk	22.8	-	35.0
GW-241	CRSDB	4	WT	OCk	78.0	-	103.0

Table 3 (cont'd)

Well No.	Location[2]	Cluster Designation[3]	Aquifer[4]		Monitored Interval Depths[5]		
			Interval	Form.	Top		Bottom
GW-292	ECRWP	4	BDR	OCk	172.1	-	186.0
GW-293[a]	ECRWP	4	BDR	OCk	197.0	-	214.0
GW-294	ECRWP	4	BDR	OCk	113.0	-	128.0
GW-295	CRBAWP	1	BDR	OCk	130.4	-	146.0
GW-296	ECRWP	4	BDR	OCk	134.4	-	147.0
GW-298	CRBAWP	4	BDR	OCk	171.1	-	190.0
GW-299	CRBAWP	4	BDR	OCk	153.0	-	168.0
GW-300	CRBAWP	4	BDR	OCk	132.0	-	147.0
GW-301	CRBAWP	4	BDR	OCk	148.5	-	163.5
GW-302	UNCS	4	BDR	OCk	121.5	-	134.8
GW-303[a]	CRSDB	1	BDR	OCk	300.0	-	321.0
GW-304	CRSDB	3	BDR	OCk	148.5	-	167.0
GW-305	LIV	4	BDR	OCk	165.3	-	179.6
GW-321	ADB	4	BDR	OCk	84.0	-	98.6
GW-339	UNCS	4	BDR	OCk	101.0	-	114.0
GW-511	CRSP	4	BDR	OCk	140.0	-	153.7
GW-512	ADB	4	WT	OCk	48.0	-	61.0
GW-513	ADB	4	BDR	OCk	111.0	-	125.3
GW-514[a]	ADB	4	BDR	OCk	174.0	-	195.0
GW-521	LIV	4	BDR	OCk	123.2	-	136.0
GW-522	LIV	4	BDR	OCk	183.0	-	195.3
GW-539	LII	4	BDR	OCk	136.4	-	156.0
GW-540	CDLVI	4	BDR	OCk	158.5	-	171.5
GW-541	CDLVI	4	BDR	OCk	86.7	-	104.5
GW-542	CDLVI	4	WT	OCk	59.0	-	76.5
GW-543	CDLVI	4	BDR	OCk	76.2	-	93.6

Table 3 (cont'd)

Well No.	Location[2]	Cluster Designation[3]	Aquifer[4]		Monitored Interval Depths[5]		
			Interval	Form.	Top		Bottom
GW-544	CDLVI	4	BDR	OCk	91.0	-	109.3
GW-545	CDLVI	10	WT	OCk	55.2	-	67.0
GW-546	CDLVI	4	WT	OCk	66.2	-	84.4
GW-557	LV	4	WT	OCk	112.9	-	138.0
GW-560	CDLVII	4	WT	OCk	45.2	-	69.0
GW-562	CDLVII	4	WT	OCk	36.0	-	60.0
GW-564	CDLVII	4	WT	OCk	52.0	-	81.0
GW-608[a]	CRSP	4	BDR	OCk	148.0	-	220.0
GW-609	CRSP	4	BDR	OCk	256.4	-	269.0
GW-610	CRSP	4	BDR	OCk	105.1	-	117.4
GW-611	CRSP	4	BDR	OCk	101.5	-	121.6
GW-709	LII	4	BDR	OCk	68.7	-	80.6
GW-731	CRSDB	4	BDR	OCk	164.0	-	178.7
GW-732	CRSDB	4	BDR	OCk	178.3	-	190.0
GW-742[a]	CRSP	4	BDR	OCk	350.0	-	420.0
GW-743	CRSP	4	BDR	OCk	150.1	-	161.1
GW-757	LII	3	BDR	OCk	134.0	-	166.7
GW-796	LV	4	BDR	OCk	122.9	-	136.5
GW-797	LV	4	BDR	OCk	118.0	-	134.1
GW-798	CDLVII	4	BDR	OCk	122.0	-	135.4
GW-799	CDLVII	4	BDR	OCk	78.7	-	92.0
GW-801	LV	4	BDR	OCk	175.8	-	188.9

Table 3 (cont'd)

Notes:

1 Well construction information compiled from: *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* (Jones et al. 1994).

2 ADB - Ash Disposal Basin
CDLVI - Construction/Demolition Landfill VI
CDLVII - Construction/Demolition Landfill VII
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
ECRWP - East Chestnut Ridge Waste Pile
KHQ - Kerr Hollow Quarry
LII - Industrial Landfill II
LIV - Industrial Landfill IV
LV - Industrial Landfill V
RQ - Rogers Quarry
UNCS - United Nuclear Corporation Site

3 Cluster designation for trace metal data evaluation purposes (see Table 8).
Spring CBS-1 was assigned to cluster 4.

4 Interval:
WT - Water Table Interval
BDR - Bedrock Interval

Form.: Geologic Formation
Och - Chickamauga Group (ORR Aquitard)
OCk - Knox Group (Knox Aquifer)

5 Depth in feet from the ground surface.

a Open borehole well construction.

Table 4. VOCs Detected in QA/QC Samples During CY 1994

Compound	Number of QA/QC Samples Containing Specified Compound (by Sample Type)				
	Laboratory Blanks	Trip Blanks	Field Blanks	Equipment Rinsates	Total
Total Samples	102	173	9	49	333
Laboratory Reagents					
Methylene Chloride	30	34	1	5	70
Acetone	4	11	1	.	16
Toluene	5	4	.	1	10
2-Butanone	3	1	.	.	4
Source Water Contaminants					
Chloroform	.	.	1	.	1
1,2-Dichloropropane	.	.	1	.	1
1,1,2,2-Tetrachloroethane	1	.		.	1
VOC Plume Constituents					
Trichloroethene	4	9	.	2	15
1,2-Dichloroethane	.	1	.	.	1
Miscellaneous Compounds					
Bromodichloromethane	.	.	1	.	1
Chloromethane	.	1	.	.	1
Vinyl Acetate	1	.	.	.	1
Total Number of Contaminated Samples:	**37**	**49**	**2**	**8**	**96**
Percent of Total Samples:	**36%**	**28%**	**22%**	**16%**	**29%**

Table 5. Summary of False Positive VOC Results for 1994 Groundwater Samples

Compound	Groundwater Sample Results[1]	False Positive Results Identified From[2]		Total False Positive Results	Percent of Groundwater Sample Results
		Laboratory Blanks	Trip Blanks		
Laboratory Reagents					
Methylene Chloride	26	23 (12)	1 (1)	24	92
Toluene	6	4 (3)	1 (1)	5	83
Acetone	5	3 (2)	2 (1)	5	100
2-Butanone	5	5 (3)	0	5	100
Source Water Contaminants					
Chloroform	2	0	0	0	0
VOC Plume Constituents					
Trichloroethene	16	11 (4)	1 (1)	12	75
1,1,1-Trichloroethane	30	0	0	0	0
Tetrachloroethane	13	0	0	0	0
1,1-Dichloroethane	10	0	0	0	0
1,1-Dichloroethene	4	0	0	0	0
1,2-Dichloroethene	4	0	0	0	0
Carbon tetrachloride	1	0	0	0	0
Miscellaneous Compounds					
Vinyl acetate	1	1 (1)	0	1	100
Total Results:	**123**	**47**	**5**	**52**	**42**

Notes:

1 The number of samples in which the compound was detected (including estimated results below the respective detection limit).

2 The number of false positive results in groundwater samples identified by each type of blank. The number in parentheses indicates number of blank samples from which false positive results were identified.

Table 6. Anomalous VOC Results, CY 1991 to CY 1994

Compound	No. of Anomalous Results[1]	No. of Wells	Maximum Concentration[2] (µg/L)
Laboratory Reagents			
Acetone	14	13	77.0
Methylene Chloride	13	12	1.0
4-methyl-2-pentanone	6	6	5.0
Toluene	6	5	2.0
2-Butanone	3	3	13.0
2-Hexanone	1	1	3.0
Source Water Contaminants			
Chloroform	16	6	4.0
1,1,2,2-Tetrachloroethane	2	2	1.0
Bromoform	1	1	1.0
1,2-Dichloropropane	1	1	3.0
Miscellaneous Compounds			
Carbon Disulfide	3	3	3.0
Ethylbenzene	2	2	2.0
Benzene	1	1	7.0
Xylenes	1	1	3.0
VOC Plume Constituents			
Trichloroethene	7	7	9.0
Tetrachloroethene	14	7	2.0
1,1-Dichloroethene	7	3	3.0
1,1-Dichloroethane	4	2	3.0
Carbon Tetrachloride	3	3	2.0
1,2-Dichloroethene	3	3	2.0
1,1,1-Trichloroethane	3	3	0.7

Notes:

[1] Total samples analyzed: 1,112
Samples with anomalous results: 89 (8% of total)
Total anomalous results: 111

[2] Concentration in micrograms per liter (µg/L)

Table 7. Upper Tolerance Limits for Selected Trace Metals

Trace Metal	Upper Tolerance Limit[1] (mg/L)			
	Cluster 1 Sampling Point	Cluster 3 Sampling Point	Cluster 4 Sampling Point	Cluster 10 Sampling Point
Aluminum	2.4	2.4	2.4	2.4
Antimony	0.05[a]	0.05[a]	0.05[a]	0.05[a]
Boron	0.12	0.041	0.028	3.1
Cobalt	0.019	0.019	0.019	0.019
Copper	0.012	0.012	0.012	0.012
Iron	8.7	8.7	4.6	6.9
Manganese	1.7	1.7	0.13	0.13
Molybdenum	0.018	0.018	0.018	0.018
Strontium	4.4	0.92	0.079	0.92
Thorium	0.2[a]	0.2[a]	0.2[a]	0.2[a]
Uranium	0.012	0.005	0.005	0.005
Vanadium	0.0044	0.0044	0.0044	0.0044
Zinc	0.041	0.041	0.041	0.040

Note:

1 - Concentration, in milligrams per liter assumed to be representative of uncontaminated groundwater at the Y-12 Plant.

a - Analytical detection limit.

Table 8. Trace Metal Concentrations Potentially Biased by Laboratory Contamination

Well No.	Qtr. Sampled	Trace Metal Concentration[1] (mg/L)					
		Aluminum	Boron	Copper	Iron	Nickel	Zinc
1090	1st	.	.	.	.	0.04	.
GW-141	1st	.	0.033	.	.	.	.
GW-141	2nd	.	.	0.17	.	.	.
GW-142	1st	.	0.071	.	.	.	.
GW-142	2nd	.	0.068	0.029	6.1	.	.
GW-144	2nd	.	0.031	.	.	.	.
GW-145	2nd	.	0.25	.	.	.	.
GW-146	2nd	.	0.47	.	.	.	.
GW-147	1st	.	0.068	.	.	.	.
GW-147	2nd	.	0.053	.	.	.	.
GW-160	1st	7.8	0.062	.	9.9	.	0.077
GW-177	1st	.	0.058	.	.	.	.
GW-184	1st	.	0.049	.	.	.	.
GW-203	1st	.	0.029	.	.	.	.
GW-205	1st	.	0.056	.	.	.	.
GW-217	1st	.	0.15	.	.	.	.
GW-217	2nd	.	0.16	.	.	.	.
GW-221	2nd	.	.	0.015	.	.	.
GW-292	2nd	.	0.05	.	.	.	.
GW-293	2nd	.	0.042	.	.	.	.
GW-294	2nd	.	0.033	.	.	.	.
GW-295	1st	.	.	0.014	.	0.074	0.075
GW-296	2nd	.	0.11	.	.	.	.
GW-299	1st	.	0.056	.	.	.	.
GW-302	1st	.	0.031	.	.	0.13	.

Table 8 (cont'd)

Well No.	Qtr. Sampled	Trace Metal Concentration[1] (mg/L)					
		Aluminum	Boron	Copper	Iron	Nickel	Zinc
GW-302	2nd	.	.	.	.	0.057	.
GW-321	1st	.	0.029	.	.	.	.
GW-339	1st	.	.	.	.	0.06	.
GW-339	2nd	.	.	.	.	0.053	.
GW-511	1st	.	0.041	.	.	.	.
GW-513	1st	.	0.11	.	.	.	.
GW-522	2nd	.	.	.	.	.	0.052
GW-539	2nd	4.6	.	0.099	29	0.65	0.31
GW-542	1st	.	0.038	.	.	.	0.048
GW-543	1st	.	.	.	.	.	0.053
GW-544	1st	.	0.032	.	.	.	0.14
GW-545	1st	.	.	.	.	.	0.059
GW-564	1st	.	0.27	.	.	.	.
GW-709	2nd	.	0.041	0.013	.	.	.
GW-731	1st	.	0.03	.	.	.	.
GW-732	1st	.	0.029	.	.	.	.
GW-757	2nd	.	0.062	0.023	.	.	0.076
CBS-1	1st	.	0.037	.	.	.	.

<u>Notes</u>:

1 Results, in milligrams per liter, reported by the K-25 ASO with a "c" qualifier.

Table 9. Summary of CY 1994 Radioanalyte Data

Radioanalyte	No. of Reported Results for CY 1994			% Passing
	Total	Failed QA/QC Criteria	Passed QA/QC Criteria	
Iodine-135	1	0	1	100
Technetium-99	11	3	8	73
Potassium-40	17	7	10	59
Radium (Total)	28	16	12	43
Strontium (Total)	11	7	4	36
Tritium	4	3	1	25
Gross Beta Activity	257	235	22	9
Gross Alpha Activity	257	236	21	8
Protactinium-243m	83	77	6	7
Thorium-234	83	80	3	4
Cesium-137	83	81	2	2
Uranium-235	98	97	1	1
Americium-241	4	4	0	0
Iodine-129	4	4	0	0
Iodine-131	2	2	0	0
Iodine-133	1	1	0	0
Neptunium-237	4	4	0	0
Plutonium-238	4	4	0	0
Plutonium-239	4	4	0	0
Uranium-234	98	98	0	0
Uranium-238	98	98	0	0
Ruthenium-106	2	2	0	0
Total	**1,154**	**1,063**	**91**	**8**

Table 10. Monitoring Wells with Geochemical Indicator Parameters Indicative of Rapid Groundwater Flow

Well Number	Geochemical Indicator[2]				
	Dolomite SI	PCO_2	Calcite SI	Hardness Variation	Cavity
1090[a]	■		■	■	
GW-099	■				
GW-141[a]	■				■
GW-155	■		■	■	
GW-156	■			■	
GW-173	■	■			
GW-174	■	■		■	■
GW-179	■			■	
GW-181[a]	■			■	
GW-221[a]	■	■			
GW-241[a]	■	■			■
GW-293[a]	■				
GW-298[a]	■				
GW-299[a]	■		■		
GW-300[a]	■			■	
GW-322	■				
GW-323	■				
GW-511[a]				■	■
GW-513[a]	■	■			
GW-521[a]			■		
GW-683	■		■	■	■
GW-710				■	

Table 10 (cont'd)

Notes:

1 Modified from: *Chemical Characteristics of Waters in Karst Formations at the Oak Ridge Y-12 Plant*, Table 8, pg 41 - 42 (Shevenell 1994).

2 Probable indicators of rapid groundwater flow conditions:

Dolomite SI: Dolomite saturation index (SI). Samples from well exhibit SI fluctuations between super- and under-saturation indicative of rapidly changing flow conditions.

PCO_2: Partial pressure of carbon dioxide. Samples of CO_2 from well exhibit near atmospheric pressure indicating limited groundwater residence times and rapid recharge.

Calcite SI: Calcite saturation index. Samples from well exhibit consistent undersaturation with respect to calcite, suggesting relatively young, quick-flowing groundwater.

Hardness Variation: Variation in equivalent $CaCO_3$ hardness. Coefficients of variation greater than 0.10 considered indicative of or influenced by quickflow component.

Cavity: Well completed in a solution cavity.

a Well sampled during CY 1994.

Table 11. Annual Average Summed VOC Concentrations in Groundwater at the Chestnut Ridge Security Pits, 1989-1994

Well Number	Summed Average VOC Concentration[1] (μg/L)					
	1989	1990	1991	1992	1993	1994
GW-173	17.0	13.5	11.8	11.7	NS	NS
GW-174	47.8	48.5	43.7	34.0	NS	NS
GW-175	31.8	38.5	31.0	29.5	17.0	25.3
GW-176	285.3	233.5	170.5	139.7	NS	NS
GW-177	66.7	18.8	26.3	25.5	33.0	28.3
GW-178	43.4	40.0	34.0	29.0	NS	NS
GW-179	838.0	455.0	328.3	262.3	NS	NS
GW-180	145.8	99.5	74.2	52.3	NS	NS
GW-322	696.0	730.3	633.0	538.3	NS	NS
GW-607	NS	16.9	ND	ND	ND	NS
GW-608	NS	14.8	15.5	(4.5)	(4.0)	(4.3)
GW-609	NS	78.0	67.5	35.5	28.4	54.5
GW-610	NS	(1.0)	(0.5)	ND	ND	(0.3)
GW-611	NS	16.0	9.0	13.5	10.5	12.4
GW-612	NS	505.8	451.3	358.3	NS	NS

Note:

1 All results in micrograms per liter.

NS - Not Sampled
ND - Not Detected

( ) - Qualitative results; summed average determined exclusively from estimated concentrations

Table 12. Annual Average VOC Concentrations in CY 1994 Groundwater Samples

	Average VOC Concentration[2] (μg/L)										
Sampling Point	**GW-143**	**GW-144**	**GW-175**	**GW-177**	**GW-305**	**GW-514**	**GW-608**	**GW-609**	**GW-610**	**GW-611**	**GW-796**
Location[1]	**KHQ**	**KHQ**	**CRSP**	**CRSP**	**LIV**	**ADB**	**CRSP**	**CRSP**	**CRSP**	**CRSP**	**LV**
Carbon Tetrachloride	0	0.5	0	0	0	0	0	0	0	0	0
Chloroform	0.1	0	0	0	0	0	0	0	0	0	0
1,1-Dichloroethane	0	0	0	11.3	0	0	0	2.0	0	1.3	0
1,1-Dichloroethene	0	0	0	1.5	0	0	0	0	0	0.8	0
1,2-Dichloroethene	0	0	0	0	0	0	0	21.5	0	0	0
Tetrachloroethene	0	0	20.5	0	0	0	1.5	27.5	0.3	0	0
1,1,1-Trichloroethane	0	0	4.8	15.5	5.0	1.3	2.8	1.0	0	10.3	1.5
Trichloroethene	0	0	0	0	0	0	0	2.5	0	0	0
Summed Average VOCs	**(0.1)**	**(0.5)**	**25.3**	**28.3**	**(5.0)**	**(1.3)**	**(4.3)**	**54.5**	**(0.3)**	**12.4**	**(1.5)**

Notes:

1 ADB - Ash Disposal Basin
CRSP - Chestnut Ridge Security Pits
KHQ - Kerr Hollow Quarry
LIV - Industrial Landfill IV
LV - Industrial Landfill V

2 All results in micrograms per liter (μg/L).
0 - False Positive, anomalous, or not detected

( ) - Qualitative results; summed average determined exclusively from estimated concentrations (including anomalous results reported for GW-143, GW-144, and GW-610)

Table 13. Base, Neutral, and Acid Extractable Organic Compounds in CY 1994 Groundwater Samples

Compound	Sampling Point	Location[1]	Concentration[2] (μg/L) 1st	2nd	3rd	4th
di-n-butylphthalate	GW-156	CRSDB	[17]	<10	<10	2
	GW-158	CRSDB	[12]	2	<10	[6]
	GW-186	RQ	[15]	NS	NS	NS
	GW-241	CRSDB	[5]	<10	[2]	1
	GW-303	CRSDB	<10	<10	[4]	2
	GW-731	CRSDB	[18]	<10	<10	-
bis(2-ethylhexyl)phthalate	GW-184	RQ	1	NS	NS	NS
	GW-186	RQ	[2]	NS	NS	NS

Notes:

1 CRSDB - Chestnut Ridge Sediment Disposal Basin
RQ - Rogers Quarry

2 μg/L - Micrograms per liter
NS - Not Sampled
[ ] - Compound detected in the associated laboratory blank sample

Table 14. CY 1994 Median Trace Metal Concentrations that Exceed UTLs or MCLs

Metal[1]	Sampling Point	Location[2]	Cluster[3]	UTL/ MCL (mg/L)	CY 1994 Median Concentration[4] (mg/L)	Number of Samples[5]
Aluminum						
	GW-160	CRBAWP	4	2.4	11	1
Boron						
	GW-141	LIV	4	0.028	0.050	3
	GW-142	KHQ	4	0.028	0.094	2
	GW-143	KHQ	1	0.12	0.875	4
	GW-145	KHQ	1	0.12	0.240	3
	GW-146	KHQ	1	0.12	0.500	3
	GW-147	KHQ	4	0.028	0.044	2
	GW-160	CRBAWP	4	0.028	0.033	1
	GW-161	CRBAWP	4	0.028	0.039	2
	GW-177	CRSP	4	0.028	0.094	3
	GW-181	CRSP	4	0.028	0.033	4
	GW-186	RQ	1	0.12	0.160	1
	GW-187	RQ	1	0.12	0.570	1
	GW-205	UNCS	4	0.028	0.032	3
	GW-217	LIV	4	0.028	0.210	2
	GW-241	CRSDB	4	0.028	0.038	4
	GW-294	ECRWP	4	0.028	0.029	2
	GW-298	CRBAWP	4	0.028	0.036	2
	GW-299	CRBAWP	4	0.028	0.079	1
	GW-300	CRBAWP	4	0.028	0.058	2
	GW-301	CRBAWP	4	0.028	0.051	2
	GW-302	UNCS	4	0.028	0.035	3
	GW-321	ADB	4	0.028	0.060	2

Table 14 (cont'd)

Metal[1]	Sampling Point	Location[2]	Cluster[3]	UTL/ MCL (mg/L)	CY 1994 Median Concentration[4] (mg/L)	Number of Samples[5]
Boron (cont'd)						
	GW-513	ADB	4	0.028	0.043	2
	GW-522	LIV	4	0.028	0.032	4
	GW-542	CDLVI	4	0.028	0.032	2
	GW-544	CDLVI	4	0.028	0.032	2
	GW-610	CRSP	4	0.028	0.035	4
	GW-709	LII	4	0.028	0.054	3
	GW-732	CRSDB	4	0.028	0.054	3
	GW-796	LV	4	0.028	0.029	4
Chromium (AAS)						
	GW-295	CRBAWP	N/A	0.1	0.285	2
Iron						
	GW-160	CRBAWP	4	4.6	6.4	1
Manganese						
	GW-160	CRBAWP	4	0.13	0.195	2
Molybdenum						
	GW-541	CDLVI	4	0.018	0.032	3
Nickel						
	GW-295	CRBAWP	N/A	0.06	0.17	1
Strontium						
	GW-142	KHQ	4	0.079	0.495	4
	GW-144	KHQ	4	0.079	0.085	4
	GW-145	KHQ	1	4.4	7.5	4
	GW-146	KHQ	1	4.4	6.95	4
	GW-147	KHQ	4	0.079	1.15	4

Table 14 (cont'd)

Metal[1]	Sampling Point	Location[2]	Cluster[3]	UTL/ MCL (mg/L)	CY 1994 Median Concentration[4] (mg/L)	Number of Samples[5]
Strontium (cont'd)						
	GW-732	CRSDB	4	0.079	0.1095	4
Uranium (Fluor)						
	GW-142	KHQ	4	0.005	0.01	4
	GW-145	KHQ	1	0.012	0.013	4
Vanadium						
	GW-160	CRBAWP	4	0.0044	0.0215	2
	GW-241	CRSDB	4	0.0044	0.0054	4
	GW-295	CRBAWP	1	0.0044	0.00505	2
	GW-301	CRBAWP	4	0.0044	0.0048	2
	GW-545	CDLVI	4	0.0044	0.014	3
Zinc						
	GW-160	CRBAWP	4	0.041	0.063	1
	GW-177	CRSP	4	0.041	0.052	4
	GW-542	CDLVI	4	0.041	0.052	2
	GW-544	CDLVI	4	0.041	0.066	2
	GW-545	CDLVI	4	0.041	0.103	2

Table 14 (cont'd)

Notes:

1 Results obtained by ICP spectroscopy unless otherwise noted.

2 ADB - Ash Disposal Basin
CDLVI - Construction/Demolition Landfill VI
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
ECRWP - East Chestnut Ridge Waste Pile
KHQ - Kerr Hollow Quarry
LII - Industrial Landfill II
LIV - Industrial Landfill IV
LV - Industrial Landfill V
RQ - Rogers Quarry
UNCS - United Nuclear Corporation Site

3 Cluster designation for trace metal data evaluation purposes (see Section 4.2.2.4).
N/A - Not applicable for metal concentrations compared to MCLs.

4 Concentrations in milligrams per liter.

5 The number of samples used to determine median concentrations, excluding samples potentially contaminated in the laboratory (see Section 4.2.2.3).

Table 15. Gross Alpha and Gross Beta Activities That Meet QA/QC Criteria

Sampling Point	Location[1]	Date Sampled	Activity[2] (pCi/L)	
			Gross Alpha	Gross Beta
GW-142	KHQ	2/16/94	14.7 ± 3.4	.
GW-143	KHQ	3/3/94	.	19.4 ± 4
GW-143	KHQ	4/18/94	.	16.6 ± 3.6
GW-143	KHQ	7/24/94	.	13.4 ± 3.3
GW-143	KHQ	10/24/94	12 ± 3.5	33.4 ± 5.3
GW-144	KHQ	10/25/94	8.43 ± 2.8	.
GW-145	KHQ	3/11/94	9.46 ± 3.6	17.6 ± 3.8
GW-145	KHQ	4/20/94	11.7 ± 3.2	14.3 ± 3.4
GW-145	KHQ	7/26/94	10.1 ± 3.7	15.5 ± 3.5
GW-145	KHQ	10/26/94	15.5 ± 4	23.5 ± 4.4
GW-146	KHQ	3/3/94	.	20 ± 4
GW-146	KHQ	4/18/94	.	19.1 ± 3.8
GW-146	KHQ	7/25/94	6.33 ± 2.9	28.8 ± 4.7
GW-146	KHQ	10/28/94	7.33 ± 2.8	20.1 ± 4.1
GW-156	CRSDB	4/7/94	.	13.7 ± 3.7
GW-158	CRSDB	10/26/94	9.55 ± 3	.
GW-160	CRBAWP	7/20/94	6.62 ± 5.5	.

Table 15 (cont'd)

Sampling Point	Location[1]	Date Sampled	Activity[2] (pCi/L)	
			Gross Alpha	Gross Beta
GW-205	UNCS	10/12/94	.	13.7 ± 3.4
GW-295	CRBAWP	2/15/94	.	14.5 ± 3.4
GW-302	UNCS	10/15/94	6.65 ± 4.1	19.6 ± 6.2
GW-305	LIV	7/7/94	12.4 ± 3.2	12.2 ± 3.3
GW-339	UNCS	10/15/94	7.91 ± 4.5	15 ± 5.8
GW-539	LII	4/4/94	6.76 ± 2.8	.
GW-545	CDLVI	3/25/94	.	23.3 ± 4.2
GW-545	CDLVI	4/19/94	.	17.4 ± 3.9
GW-731	CRSDB	7/9/94	.	21 ± 4
GW-731	CRSDB	10/18/94	.	12.9 ± 3.5
GW-732	CRSDB	2/12/94	7.38 ± 2.6	.
GW-732	CRSDB	10/19/94	7.1 ± 2.4	.
GW-742	CRSP	2/20/94	9.09 ± 3.1	.
GW-742	CRSP	11/17/94	5.9 ± 2.1	.
GW-757	LII	1/7/94	6.73 ± 2.7	.
GW-757	LII	10/7/94	5.44 ± 3	.

Table 15 (cont'd)

Notes:

1	CDLVI	-	Construction/Demolition Landfill VI
	CRBAWP	-	Chestnut Ridge Borrow Area Waste Pile
	CRSDB	-	Chestnut Ridge Sediment Disposal Basin
	KHQ	-	Kerr Hollow Quarry
	LII	-	Industrial Landfill II
	LIV	-	Industrial Landfill IV
	UNCS	-	United Nuclear Corporation Site

2 Activity reported in picoCuries per liter.

. - results did not meet evaluation criteria

Table 16. Radioisotope Activities That Meet QA/QC Criteria

Isotope	Sampling Point	Location[1]	Date Sampled	Activity[2]
Cesium-137				
	GW-562	CDLVII	4/19/94	34.1 ± 28
	GW-564	CDLVII	3/7/94	39.1 ± 27
Iodine-135				
(Bq/L)	GW-521	LIV	1/6/94	0.7 ± 0.27
Potassium-40				
	GW-205	UNCS	4/7/94	9,410 ± 1,100
	GW-339	UNCS	7/27/94	665 ± 260
	GW-521	LIV	4/5/94	1,620 ± 550
	GW-560	CDLVII	7/12/94	614 ± 230
	GW-564	CDLVII	7/14/94	517 ± 240
	GW-796	LV	4/25/94	494 ± 350
			7/20/94	374 ± 360
	GW-799	CDLVII	7/18/94	443 ± 290
	GW-801	LV	4/27/94	1,040 ± 660
			7/21/94	416 ± 300
Protactinium (total)				
	GW-203	UNCS	7/26/94	32,000 ± 25,000
	GW-562	CDLVII	3/7/94	3,090 ± 2,800
			4/19/94	4,990 ± 4,400
	GW-796	LV	10/11/94	3,170 ± 2,000
	GW-797	LV	4/25/94	6,750 ± 5,900
	GW-798	CDLVII	3/8/94	3,970 ± 2,800

Table 16 (cont'd)

Isotope	Sampling Point	Location[1]	Date Sampled	Activity[2]		
Radium (total)						
(Bq/L)	1090	UNCS	4/12/94	0.15	±	0.1
			10/16/94	0.087	±	0.076
	GW-203	UNCS	1/6/94	0.083	±	0.049
	GW-205	UNCS	1/7/94	0.061	±	0.047
			7/26/94	0.09	±	0.078
			10/12/94	0.14	±	0.09
	GW-221	UNCS	10/15/94	0.089	±	0.074
	GW-302	UNCS	7/28/94	0.099	±	0.082
	GW-339	UNCS	7/27/94	0.11	±	0.08
			10/15/94	0.07	±	0.068
	GW-521	LIV	1/6/94	0.072	±	0.052
			4/5/94	0.056	±	0.043
Strontium (total)						
	GW-298	CRBAWP	2/14/94	55.3	±	25
	GW-299	CRBAWP	2/13/94	41.5	±	23
	GW-301	CRBAWP	2/13/94	41.5	±	23
	GW-521	LIV	4/5/94	37.8	±	22
Technetium-99						
	GW-160	CRBAWP	2/12/94	192	±	65
	GW-295	CRBAWP	2/15/94	205	±	65
	GW-298	CRBAWP	2/14/94	302	±	68
	GW-299	CRBAWP	2/13/94	155	±	64
	GW-300	CRBAWP	2/13/94	160	±	64

Table 16 (cont'd)

Isotope	Sampling Point	Location[1]	Date Sampled	Activity[2]
Technetium-99 (cont'd)				
	GW-301	CRBAWP	2/13/94	157 ± 64
	GW-521	LIV	1/6/94	148 ± 63
			7/7/94	121 ± 62
Thorium-234				
	GW-203	UNCS	7/26/94	1,640 ± 810
	GW-521	LIV	4/5/94	1,480 ± 470
	GW-798	CDLVII	7/19/94	638 ± 390
Tritium				
(Bq/L)	GW-521	LIV	10/4/94	100 ± 20
Uranium-235				
	GW-521	LIV	1/6/94	101 ± 68

Notes:

1
CDLVII - Construction/Demolition Landfill VII
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
LIV - Industrial Landfill IV
LV - Industrial Landfill V
UNCS - United Nuclear Corporation Site

2
Activity reported in picoCuries per liter unless noted otherwise:
Bq/L - Becquerels per liter (one picoCurie equals about 27 becquerels)

Table 17. Sampling Frequency and Well Sampling Sequence Planned for CY 1996

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-1	LIV	GW-217	SDM
(Q1,Q3)	LIV	GW-141	SDM
	LIV	GW-521	SDM
	LIV	GW-522	SDM
	LIV	GW-305	SDM
CR-2	UNCS	GW-203	ROD
(Q2,Q4)	UNCS	GW-205	ROD
	UNCS	GW-221	ROD
	UNCS	GW-339	ROD
	UNCS	GW-302	ROD
	UNCS	1090	ROD
CR-3	CRSP	GW-181	AMP
	CRSP	GW-511	AMP
	CRSP	GW-742	AMP
	CRSP	GW-743	AMP
	CRSP	GW-610	AMP
	CRSP	GW-608	AMP
	CRSP	GW-177	AMP
	CRSP	GW-611	AMP
	CRSP	GW-175	AMP
	CRSP	GW-609	AMP
CR-4	ECRWP	GW-296	BMP
(Q2,Q4)	ECRWP	GW-294	BMP
	ECRWP	GW-293	BMP
	ECRWP	GW-292	BMP

Table 17 (cont'd)

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-5	CRBAWP	GW-161	BMP
(Q2,Q4)	CRBAWP	GW-160	BMP
	CRBAWP	GW-301	BMP
	CRBAWP	GW-300	BMP
	CRBAWP	GW-299	BMP
	CRBAWP	GW-298	BMP
CR-6	CRSDB	GW-159	RDM
	CRSDB	GW-304	RDM
	CRSDB	GW-731	RDM
	CRSDB	GW-732	RDM
	CRSDB	GW-156	RDM
	CRSDB	GW-303	RDM
	CRSDB	GW-241	RDM
	CRSDB	GW-158	RDM
CR-7	KHQ	GW-142	RDM
	KHQ	GW-147	RDM
	KHQ	GW-231	RDM
	KHQ	GW-146	RDM
	KHQ	GW-143	RDM
	KHQ	GW-144	RDM
	KHQ	GW-145	RDM
CR-8	ADB	GW-321	BMP
(Q2,Q4)	ADB	GW-513	BMP
	ADB	GW-512	BMP
	ADB	GW-514	BMP

Table 17 (cont'd)

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-9	RQ	GW-184	BMP
(Q2,Q4)	RQ	GW-188	BMP
	RQ	GW-187	BMP
	RQ	GW-186	BMP
CR-10	LII	GW-539	SDM
(Q2,Q4)	LII	GW-709	SDM
	LII	GW-757	SDM
CR-11	CDLVI	GW-540	SDM
(Q2,Q4)	CDLVI	GW-546	SDM
	CDLVI	GW-541	SDM
	CDLVI	GW-827	SDM
	CDLVI	GW-542	SDM
	CDLVI	GW-543	SDM
	CDLVI	GW-544	SDM
CR-12	CDLVII	GW-560	SDM
(Q2,Q4)	CDLVII	GW-562	SDM
	CDLVII	GW-564	SDM
	LV	GW-557	SDM
	LV	GW-799	SDM
	CDLVII	GW-798	SDM
	LV	GW-797	SDM
	LV	GW-796	SDM
	LV	GW-801	SDM
	LV	CBS-1	SDM

Table 17 (cont'd)

Notes:

1 Samples are collected quarterly unless specific sampling quarters are identified.

2 ADB - Ash Disposal Basin
CDLVI - Construction/Demolition Landfill VI
CDLVII - Construction/Demolition Landfill VII
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
ECRWP - East Chestnut Ridge Waste Pile
KHQ - Kerr Hollow Quarry (located in Bethel Valley)
LII - Industrial Landfill II
LIV - Industrial Landfill IV
LV - Industrial Landfill V
RQ - Rogers Quarry (located in Bethel Valley)
UNCS - United Nuclear Corporation Site

3 CBS - Spring Sampling Location

4 AMP - RCRA Assessment Monitoring
BMP - Best-Management Practice Monitoring
RDM - RCRA Detection Monitoring
ROD - CERCLA/RCRA Post-Closure Care Monitoring
SDM - SWDF Detection Monitoring

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