

Y-12

OAK RIDGE Y-12 PLANT

LOCKHEED MARTIN



EVALUATION OF CALENDAR YEAR 1997
GROUNDWATER AND SURFACE WATER
QUALITY DATA FOR THE
BEAR CREEK HYDROGEOLOGIC REGIME
AT THE
U.S. DEPARTMENT OF ENERGY Y-12 PLANT,
OAK RIDGE, TENNESSEE

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Prepared by

AJA TECHNICAL SERVICES, INC.
Under Subcontract No. 70Y-MVM64V

for the

Environmental Compliance Department
Environment, Safety, and Health Organization
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831

Managed by

LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. Department of Energy
Under Contract No. DE-AC05-84OR21400

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List of Acronyms and Abbreviations

AGLLSF	Above Grade Low-Level Storage Facility
ASO	Analytical Services Organization
BCV	Bear Creek Valley
BCK	Bear Creek Kilometer
Bear Creek Regime	Bear Creek Hydrogeologic Regime
BG	Burial Grounds
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CY	calendar year
DNAPL	dense, nonaqueous phase liquids
DOE	U.S. Department of Energy
DQO	data quality objective
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
ETTP	East Tennessee Technology Park
ft	feet
HCDA	Hazardous Chemical Disposal Area
MCL	Maximum Contaminant Level
MDA	minimum detectable activity
msl	mean sea level
µg/L	micrograms per liter
mg/L	milligrams per liter
NT	north tributary (Bear Creek)
PCE	tetrachloroethene
pCi/L	picoCuries per liter
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SS	south side (Bear Creek)
TCE	trichloroethene
TDS	total dissolved solids
TSD	treatment, storage, and disposal (unit)
TSS	total suspended solids
UTL	upper tolerance limit
VOC	volatile organic compound
WMA	Waste Management Area

List of Acronyms and Abbreviations (cont'd)

1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
⁹⁹ Tc	technetium-99
²³⁴ U	uranium-234
²³⁵ U	uranium-235
²³⁸ U	uranium-238

1.0 INTRODUCTION

This report presents an evaluation of the groundwater and surface water monitoring data obtained in the Bear Creek Hydrogeologic Regime (Bear Creek Regime) during calendar year (CY) 1997. The monitoring data were obtained in compliance with the Resource Conservation and Recovery Act (RCRA) post-closure permit for the Bear Creek Regime and U.S. Department of Energy (DOE) Order 5400.1, and are reported in: *Calendar Year 1997 Annual Groundwater Monitoring Report for the Bear Creek Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (AJA Technical Services, Inc. 1998a). This report provides an evaluation of the monitoring data with respect to historical results for each sampling location, the regime-wide extent of groundwater and surface water contamination, and long-term concentration trends for selected groundwater and surface water contaminants.

2.0 BACKGROUND INFORMATION

The Bear Creek Regime encompasses several confirmed and suspected sources of groundwater and surface water contamination within Bear Creek Valley (BCV) west of the DOE Y-12 Plant in Oak Ridge, Tennessee (Figure 1); unless otherwise noted, directions are in reference to the Y-12 Plant grid coordinate system. Background information regarding sources of contamination in the regime and an overview of the groundwater flow and surface water drainage characteristics in the regime are provided in the following sections.

2.1 Contaminant Source Areas

The Bear Creek Regime encompasses a portion of BCV used since the early 1950s for the treatment, storage, and disposal (TSD) of various hazardous and nonhazardous wastes (Figure 2). Many of the TSD sites are confirmed or suspected sources of groundwater and surface water contamination, with the primary sources being the S-3 Ponds, the Boneyard/Burnyard/Hazardous Chemical Disposal Area (HCDA), and the Bear Creek Burial Grounds Waste Management Area (WMA). All of the TSD sites except the Above Grade Low-Level Storage Facility (AGLLSF) have undergone some level of engineered closure (e.g., installation of multi-layer, low-permeability caps) and are currently regulated under RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or both; the AGLLSF is an operating facility that is not regulated under either program (Table 1). Contaminated receptor media in the regime (groundwater, surface water, and Bear Creek stream sediments and flood plain soils) are also regulated under CERCLA.

2.2 Topography and Bedrock Geology

The Bear Creek Regime is bound to the north by Pine Ridge and to the south by Chestnut Ridge, and encompasses the portion of BCV extending from a surface water and shallow groundwater divide at the west end of the Y-12 Plant to the western boundary of the Bear Creek watershed. Surface elevations range from 900 feet (ft) above mean sea level (msl) in the Bear Creek

channel along the floor of BCV to about 1,200 ft msl along the crests of Pine Ridge and Chestnut Ridge (Figure 3).

The geology of the Bear Creek Regime is characterized by alternating sequences of clastic and carbonate strata that form the distinctive topography of the Valley and Ridge Physiographic Province. On the Oak Ridge Reservation, shale and siltstone beds of the Rome Formation form Pine Ridge, limestone and shale formations of the Conasauga Group form BCV, and the primarily dolostone formations of the Knox Group form Chestnut Ridge (Figure 3). Strike and dip of bedding are generally N 55°E and 45°SE respectively (as referenced to true north). Bedrock is overlain by up to 50 ft of several materials, including manmade fill, alluvium, colluvium, fine-grained residuum from the weathering of the bedrock, and saprolite (weathered bedrock). In some areas the saprolite retains primary textural features of the bedrock.

2.3 Groundwater System

Within the Bear Creek Regime, the Rome Formation, Conasauga Group, and Knox Group comprise two basic hydrogeologic units: the Aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Copper Ridge Dolomite (lower Knox Group); and the Aquitard, consisting of the remaining, primarily siliciclastic, Conasauga Group formations (Nolichucky Shale, Maryville Limestone, Rogersville Shale, Rutledge Limestone, and Pumpkin Valley Shale) and the Rome Formation (Figure 3). Components of the Aquifer underlie the axis of BCV (Maynardville Limestone) and the steep flank and crest of Chestnut Ridge (Copper Ridge Dolomite). Formations comprising the Aquitard form the northern slope of BCV (Conasauga Group) and Pine Ridge (Rome Formation). The Aquitard underlies the primary contaminant source areas in the Bear Creek Regime and is hydraulically upgradient of the Aquifer, which functions as a hydrologic drain in BCV. Fractures provide the principal groundwater flowpaths in both units, and dissolution of carbonates in the Aquifer has enlarged fractures and produced solution cavities and conduits that greatly enhance its hydraulic conductivity relative to the Aquitard. Flow through the porous rock matrix is negligible in both units. However, groundwater stored in the primary matrix pore spaces plays an important role in contaminant migration because of matrix diffusion processes.

Groundwater flow in the Aquitard and the Aquifer is primarily parallel to bedding (along strike and dip), which in the Aquitard may or may not coincide with the direction of maximum hydraulic gradient inferred from water level isopleths. Flow tangent to bedding occurs primarily along permeable zones formed by crosscutting fractures or fracture zones (and possibly small faults). The northern tributaries of Bear Creek are probably the surficial expression of these crosscutting structures. Such structures provide preferred flowpaths that channel shallow groundwater from the Aquitard to the Aquifer or act as barriers to lateral flow, as well as causing groundwater from deeper intervals to upwell and discharge to the shallower flow system in each hydrogeologic unit.

In the Aquitard, most groundwater flow occurs in a highly conductive interval near the bedrock/residuum interface (the water table interval). Flow occurs above the water table in response to precipitation when flowpaths in the residual soils become saturated and rapidly transmit water laterally down slope toward springs and seeps in drainage features (stormflow), and vertically to the water table interval (recharge). Recharge to the water table interval promotes strike-parallel groundwater flow toward discharge areas in nearby crosscutting streams. Although flow is most active at depths less than 100 ft below ground surface (bgs), contaminants in groundwater more than 200 ft bgs in the Nolichucky Shale clearly indicate permeable flowpaths at depth. However, only a small percentage of total flow ultimately recharges the deeper bedrock. Overall, about 94% of the available groundwater in the Aquitard discharges to Bear Creek tributaries, about 5% flows along crosscutting fractures into the Aquifer, and about 1% flows through strike-parallel pathways in the deeper subsurface (U.S. Department of Energy 1997).

Decreasing groundwater flux with depth in the Aquitard also is reflected by distinct changes in groundwater geochemistry. Most water table interval and shallow (i.e., <100 ft bgs) bedrock wells monitor calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100 ft bgs and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon *et al.* 1992). Further reduced groundwater flux is indicated by the transition from sodium-bicarbonate groundwater to sodium-chloride groundwater that usually occurs at a depth of about 400 ft bgs. The transition to the sodium-chloride groundwater is accompanied by increased total dissolved solids (TDS).

Most groundwater flow in the Aquifer occurs at shallow depths (i.e., <100 ft bgs) in an extensively interconnected maze of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Also, there are seven stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone that are differentiated by distinct geophysical, lithologic, and hydrologic characteristics (Shevenell *et al.* 1995). The more permeable zones are at the bottom (Zone 2) and top (Zone 6) of the formation; Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the formation (Shevenell *et al.* 1995; Goldstrand 1995).

Flow in the shallow karst network in the Aquifer is relatively rapid and, during rainfall, occurs as “quickflow” discharge to Bear Creek. Active groundwater circulation occurs at greater depth than in the Aquitard, and groundwater from the deeper flow system discharges along major gaining (influent) reaches of Bear Creek. These discharge areas are probably related to large-scale structural (e.g., cross-strike faults) or stratigraphic discontinuities in the Maynardville Limestone. Overall, about 81% of the available groundwater in the Aquifer (Maynardville Limestone) discharges directly to Bear Creek, 16% flows into the creek from spring SS-5, and 3% follows strike-parallel flowpaths in the subsurface (U.S. Department of Energy 1997).

Groundwater geochemistry is more homogeneous in the Aquifer than in the Aquitard; virtually every monitoring well in the Maynardville Limestone, regardless of depth, monitors calcium-magnesium-bicarbonate groundwater. Some shallow wells monitor sulfate-enriched groundwater, which probably reflects dissolution of locally disseminated sulfides, and several deep wells monitor calcium-magnesium-sulfate groundwater with TDS that typically exceed 1,000 milligrams per liter (mg/L).

Isopleths of seasonal groundwater surface elevations in the Bear Creek Regime (Figure 4) indicate southwesterly (strike-normal) flow in the Aquitard toward the Aquifer (Maynardville Limestone) and westerly (strike-parallel) flow in the Aquifer toward the west end of BCV. Seasonal water level fluctuations, which were typically less than 10 ft in most water table interval and bedrock interval monitoring wells (Table 2), influenced the magnitude of hydraulic gradients but did not significantly alter the overall groundwater flow patterns.

Based on the CY 1997 water level data for selected Aquitard and Aquifer monitoring wells, seasonal horizontal hydraulic gradients in the water table interval range from 0.009 to 0.073 across strike in the Aquitard, and from 0.004 to 0.043 along strike in the Aquifer (Table 3). Water level data for monitoring well clusters indicate a wide range of upward (0.002 to 0.214) and downward (0.004 to 0.061) vertical hydraulic gradients in the Aquitard and the Aquifer, with seasonal reversals of upward/downward flow directions evident in both hydrogeologic units (Table 3). Upward gradients are most common and highest in the Aquitard, and downward gradients are highest in the Aquifer (Figure 4). Consistently concurrent temporal reversals of upward/downward flow directions are not indicated by the data for the existing network of monitoring well clusters.

2.4 Surface Water System

Surface water in the Bear Creek Regime is drained by Bear Creek and its tributaries. From its headwaters near the west end of the Y-12 Plant, Bear Creek flows southwest for approximately 4.5 miles, where it turns northward to flow into East Fork Poplar Creek. Monitoring locations along the main channel are specified by the Bear Creek kilometer (BCK) value corresponding to the distance upstream from the confluence with East Fork Poplar Creek (e.g., BCK-09.40). Sections of the main channel upstream of BCK-11.97 are referenced as upper Bear Creek, middle Bear Creek lies between BCK-11.97 and BCK-09.40, and downstream of BCK-09.40 is referenced as lower Bear Creek. Tributaries are designated as north (e.g., NT), or south, along with a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side (SS) of Bear Creek are numbered in ascending order from the headwaters (e.g., SS-1).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring (U.S. Department of Energy 1997). Flow in the creek increases rapidly during rainfall and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally returns to pre-precipitation levels within one or two days. Major sections of upper and middle Bear Creek are seasonally dry, but flow is perennial in lower Bear Creek.

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone. Discharge from numerous springs located along the

Maynardville Limestone/Copper Ridge Dolomite contact on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during droughts when they provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with an Aquifer discharge area. Losing reaches in the upper part of BCV, particularly south of Sanitary Landfill I and the Boneyard/Burnyard, play an important role in transferring contaminants from Bear Creek to the Maynardville Limestone.

3.0 CY 1997 GROUNDWATER PROTECTION PROGRAM

Groundwater and surface water monitoring was performed in the Bear Creek Regime during CY 1997 for the purposes of RCRA post-closure corrective action monitoring, DOE Order 5400.1 exit-pathway/perimeter monitoring, and DOE Order 5400.1 surveillance monitoring. The monitoring network for CY 1997 included a total of 46 monitoring wells, seven surface water stations, and three springs. An overview of the groundwater and surface water sampling and analysis activities associated with the monitoring programs, based on detailed information presented in *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant During Calendar Year 1997* (AJA Technical Services, Inc. 1996), is provided in the following sections.

3.1 Sampling Locations and Frequency

Twenty-four monitoring wells were sampled for the purposes of RCRA post-closure corrective action monitoring at the S-3 Site, the Oil Landfarm, and the Bear Creek Burial Grounds/Walk-In Pits (Table 4). These wells include 14 Aquitard wells located hydraulically upgradient of contaminated groundwater at each site; three RCRA point-of-compliance wells, one located downgradient of each respective site; and seven Aquifer wells, all but one of which (GW-521) are located downgradient of the groundwater contaminant plumes in the Bear Creek Regime (Figure 5).

Groundwater samples were collected from nine monitoring wells for the purposes of DOE Order 5400.1 surveillance monitoring (Table 4). These wells include three Aquitard wells (GW-085, GW-537, and GW-829) located along geologic strike between the S-3 Site and the Oil Landfarm WMA; four Aquitard wells located downgradient of the Bear Creek Burial Grounds WMA (GW-053, GW-287, GW-627, and GW-653); and two Aquifer wells, one (GW-311) downgradient of the Rust Spoil Area and one (GW-315) downgradient of Spoil Area I (Figure 5).

Nineteen Aquifer wells, seven Bear Creek surface water stations, and three springs that discharge into Bear Creek were sampled for the purposes of DOE Order 5400.1 exit pathway/perimeter monitoring (Table 4). The monitoring wells comprise the four Maynardville Limestone Exit Pathway Pickets in the Bear Creek Regime: Picket W (GW-710, GW-711, GW-712,

GW-713, GW-714, and GW-715) which is the westernmost Picket; Picket A (GW-056, GW-683, GW-684, and GW-685) located about 2,000 ft west of the Bear Creek Burial Grounds WMA; Picket B (GW-621, GW-695, GW-703, GW-704, and GW-706) located about 1,000 ft southwest of the Oil Landfarm WMA; and Picket C (GW-724, GW-725, GW-738, and GW-740) located about 3,000 ft southwest of the S-3 Site (Figure 6). Wells comprising each Exit Pathway Picket are completed at various depths within different hydrostratigraphic zones along a strike-normal transect across the Maynardville Limestone (Figure 6). The wells in Exit Pathway Picket W also serve as plume boundary wells for RCRA post-closure corrective action monitoring (Table 4).

Samples were collected from each location during the first quarter (January 7 - March 5, 1997) of the year and from each location except spring SS-1 and surface water station NT-01 during the third quarter (July 21 - September 19, 1997) of the year (Table 4). Samples from both these locations were collected on October 13, 1997 because the stations were dry during the third quarter.

3.2 Sample Collection, Transportation, and Chain-of-Custody Control

Personnel from the Sampling and Environmental Support Department of the Analytical Services Organization (ASO) located at the East Tennessee Technology Park (ETTP), formerly the Oak Ridge K-25 Site, were responsible for collection, transportation, and chain-of-custody control of the groundwater and surface water samples.

Groundwater samples were obtained from 17 monitoring wells using dedicated bladder pumps (Well Wizard™) during both semiannual sampling events; samples from six wells were obtained using portable gas-piston pumps (Bennet Pump™) and disposable bailers during the first sampling event and with dedicated equipment during the second sampling event; and samples from the remaining 23 monitoring wells were obtained using portable equipment during both sampling events (Table 4). At least three well-volumes of groundwater were purged with the Well Wizard™ or Bennet Pump™ (if the well did not purge dry) before the samples were collected from each well. Samples from surface water stations and springs were collected with grab sample bottles.

Filtered and unfiltered samples were collected from each monitoring well, spring, and surface water station. Groundwater samples collected with Well Wizards™ and Bennet Pumps™ were filtered in the field using in-line 0.45 micron filters. Surface water samples and groundwater samples collected with bailers were filtered in the laboratory. All samples were collected in

appropriate containers, labeled, logged, placed in ice-filled coolers, and transported to the appropriate ASO laboratory in accordance with chain-of-custody control requirements.

3.3 Field Measurements and Laboratory Analytes

Field personnel measured the depth to water before purging and sampling groundwater in each monitoring well and recorded field measurements of pH, temperature, conductivity, dissolved oxygen, and oxidation-reduction potential for each groundwater and surface water sample. Laboratory analyses of the samples include the following analytes: (1) major ions (e.g., bicarbonate alkalinity); (2) trace metals, which is the term used hereafter to differentiate metals that are typically minor constituents in groundwater (e.g., cobalt) from metals that are usually major ionic species (e.g., magnesium); (3) volatile organic compounds (VOCs); (4) gross alpha and gross beta activity; and (5) pH, specific conductivity, turbidity, total suspended solids (TSS), and TDS (Table 5). Unfiltered groundwater and surface water samples were analyzed for all of these analytes; filtered samples were analyzed only for the major cations and trace metals. Additionally, unfiltered groundwater samples collected from wells used for RCRA post-closure corrective action monitoring were analyzed for several radionuclides, including uranium isotopes (^{234}U , ^{235}U , and ^{238}U) and technetium-99 (^{99}Tc). The ASO laboratories at the ETTP performed the analyses for the major ions, trace metals, and miscellaneous parameters; VOC and radiochemical analyses were performed by the ASO laboratories at the Y-12 Plant.

3.4 Quality Assurance/Quality Control Sampling

Quality assurance/quality control (QA/QC) samples include 60 trip blanks, 42 laboratory blanks, 19 equipment rinsate samples, and two field blanks. Each QA/QC sample was analyzed for VOCs; equipment rinsates were also analyzed for major ions, trace metals, radioanalytes, and several miscellaneous analytes (e.g., TDS). One or more of 15 VOCs were detected in 53 (88%) of the trip blanks, 28 (67%) of the laboratory blanks, all 19 equipment rinsate samples, and both field blanks (Table 6). Results for the VOCs indicate contamination of the QA/QC samples during laboratory analysis and transportation/storage, or a combination of both, as well as contamination of deionized water used to prepare the blank samples and to decontaminate sampling equipment. Additionally,

results for several of the equipment rinsate indicate insufficient decontamination of the portable sampling pumps.

Either acetone, 2-butanone, or both were detected in each type of QA/QC sample (Table 6). The frequent detection of these common laboratory reagents indicates contamination during analysis of these QA/QC samples, which likewise accounts for the bulk of the acetone and 2-butanone results for the associated groundwater and surface water samples. Also, results for the laboratory blanks reflect the change in the ASO laboratory that performed the VOC analyses. For example, acetone was detected in only six of the 51 laboratory blanks analyzed by the ETTP ASO laboratory during CY 1996 compared to 20 of the 42 laboratory blanks analyzed by the Y-12 Plant ASO laboratory during CY 1997. Additionally, at least one VOC was detected in five of the 18 laboratory blanks analyzed during the first quarter compared to 23 of the 24 laboratory blanks analyzed during the third quarter.

Chloroform was detected in both field blanks, 17 (89%) of the equipment rinsate samples, and 36 (60%) of the trip blanks, but was not detected in any of the laboratory blanks (Table 6). The lack of chloroform in the laboratory blanks discounts contamination during analysis of the samples. Contamination during transportation and storage seems unlikely because chloroform was detected in only 10 of the groundwater and surface water samples analyzed during CY 1997. Also, improper decontamination is not indicated because chloroform was detected in equipment rinsate samples associated with wells that monitor uncontaminated groundwater. Chloroform was most likely present in the deionized water that was used to prepare trip blanks and field blanks and to decontaminate sampling equipment. Similarly, the results for 2-hexanone likewise suggest contamination of the deionized water used for laboratory blank samples. This compound was detected in nine (21%) of the laboratory blanks (five during the first quarter and four during the third quarter), but was not detected in any of the trip blanks, equipment rinsate samples, and field blanks (Table 6), or in any of the groundwater and surface water samples.

Trichloroethene (TCE) was detected in three laboratory blanks and five trip blanks (Table 6). All but two of these blanks are associated with groundwater samples collected from wells that monitor TCE-contaminated groundwater in the Bear Creek Regime: GW-311, GW-627, GW-703, GW-704, GW-706, GW-724, and GW-740 (see Section 4.3). Trichloroethene concentrations range from 1 to 22 micrograms per liter ($\mu\text{g/L}$) in the blank samples and from 4 to 100 $\mu\text{g/L}$ in the

associated groundwater samples. These results suggest cross-contamination of the blank samples during laboratory analysis, sample transportation/storage, or both. However, review of the TCE data does not indicate cross-contamination of any groundwater or surface water sample.

The equipment rinsate sample results for several analytes suggest that the portable sampling equipment was not always adequately decontaminated in the laboratory or flushed with deionized water. This is strongly indicated by the following results for the equipment rinsate samples associated with the groundwater samples collected from Aquifer wells GW-725 and GW-710 during the first quarter of CY 1997.

The rinsate sample collected from the bailer before sampling well GW-725 in February 1997 had a low concentration (2 µg/L) of methylene chloride (AJA Technical Services, Inc. 1998a). Methylene chloride also was detected in the GW-725 groundwater sample (2 µg/L) but was not detected in the associated laboratory or trip blank samples, which suggests that this compound was introduced into the groundwater sample by the bailer. Of the 15 samples collected from well GW-725 since May 1992, methylene chloride was detected only in the sample collected in February 1997.

The following results show that the highly mineralized, sulfate-enriched groundwater in well GW-710 (see Section 4.1.2) was not completely flushed from the sampling pump.

GW-710 Samples	Sulfate (mg/L)	TDS (mg/L)	TSS (mg/L)	Turbidity (Turbidity Units)
Groundwater	1,970	3,700	345	134
Equipment Rinsate	1.93	18	200	21.7

Rinsate samples for inorganics are obtained from the pump immediately after the sampling and the field cleaning procedures are completed. Other equipment rinsate samples with similar TDS, TSS, and/or turbidity levels also may reflect inadequate flushing of the portable pumps used to collect groundwater samples from wells GW-627, GW-706, GW-713, and GW-715 during the first quarter and from wells GW-363 and GW-829 during the third quarter. However, a review of the data does not indicate that inadequate flushing of the portable sampling pumps resulted in cross-contamination between well; the purging process likely removed any residual contamination within the pumps.

4.0 GROUNDWATER QUALITY DATA EVALUATION

An evaluation of the groundwater quality data reported for the network of monitoring wells in the Bear Creek Regime that were sampled during CY 1997 is presented in the following sections. The evaluation is organized by major groups of related analytes (major ions, trace metals, VOCs, and radiological parameters) with analysis and interpretation of the data for Aquifer and Aquitard monitoring wells described separately for each group. The evaluation focused on the analytical results that meet the applicable data quality objectives (DQOs) defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (Martin Marietta Energy Systems, Inc. 1993). Analytical results that do not meet applicable DQOs were either replaced with a surrogate value, such as the analytical detection limit, or were considered qualitative for evaluation purposes. A summary of the CY 1997 groundwater monitoring data qualified by the applicable DQO criteria is provided in Appendix C.

4.1 Major Ions

Results for the major anions (carbonate and bicarbonate alkalinity, chloride, fluoride, nitrate, and sulfate) and cations (calcium, magnesium, potassium, and sodium) reported for most of the monitoring wells sampled during CY 1997 generally reflect the respective geochemical characteristics of uncontaminated groundwater in the Aquitard and the Aquifer. Nitrate contamination from the S-3 Site caused the most significant deviations from the ion chemistry typical of the groundwater samples from each hydrogeologic unit.

4.1.1 Aquitard

Most of the Aquitard monitoring wells yield calcium-magnesium-bicarbonate groundwater, and samples from these wells typically exhibit: low proportions (<10%) of chloride and sulfate (Figure 7); carbonate alkalinity, fluoride, and nitrate as N (hereafter synonymous with "nitrate") concentrations below respective analytical reporting limits; TDS of 150 to 350 mg/L; and pH between 6.5 and 8.0. Several wells (e.g., GW-627) yield sodium-bicarbonate groundwater (Figure 7), which is usually encountered more than 100 ft bgs in the Aquitard. Groundwater samples from these wells are generally characterized by: low proportions (<5%) of calcium, magnesium,

potassium, and sulfate; carbonate alkalinity, chloride, and fluoride concentrations above 10, 5, and 1 mg/L, respectively; nitrate levels below the analytical reporting limit; TDS of 250 to 350 mg/L; and pH of about 9. Shallow groundwater in the Pumpkin Valley and Rogersville Shales (upgradient of waste disposal sites) typically have higher proportions (>10 %) of sodium, potassium, and/or sulfate (e.g., wells GW-040 and GW-080) (Figure 7).

The plume of nitrate originating from the S-3 Site is the principal source of variation from the typical ion chemistry of groundwater in the Aquitard. As shown in the following summary, nitrate concentrations reported for one well (GW-276) to the south and three wells (GW-085, GW-537, and GW-829) to the west of the S-3 Site exceed the 10 mg/L Maximum Contaminant Level (MCL) for drinking water (Figure 8).

Well No.	Distance/Direction from S-3 Site (ft)	Monitored Interval Depth (ft below ground surface [bgs])	Nitrate (mg/L)	
			1st Qtr. 1997	3rd Qtr. 1997
GW-276	250 South	11.3 - 18.5	110	125
GW-829	2,100 West	102.9 - 114.6	33.9	54.1
GW-537	2,500 West	4.8 - 23.3	782	696
GW-085	3,100 West	48.4 - 58.8	70.2	63

Elevated nitrate concentrations in the groundwater at these wells are consistent with the primary migration pattern from the S-3 Site that consists of two shallow (i.e., <100 ft bgs) and one intermediate (100 - 300 ft bgs) pathways (U.S. Department of Energy 1998). These pathways include: (1) lateral, cross-strike transport in the water table interval to the south (GW-276) toward Bear Creek; (2) shallow transport along the former (pre-construction) path of Bear Creek that passed beneath the S-3 Site and provides a preferred pathway to the existing Bear Creek main channel; and (3) westward, strike-parallel transport in the intermediate bedrock interval (GW-829) with discharge from the water table interval into crosscutting tributaries (i.e., NT-1 and NT-2) and upward migration from the intermediate bedrock to the shallow flow system (GW-537 and GW-085).

The nitrate results for well GW-276 show that concentrations in the shallow groundwater south of the S-3 Site have decreased substantially (more than an order-of-magnitude) since the late-1980s, but as illustrated by the nitrate concentrations reported for the samples collected in March 1988 (1,217 mg/L), March 1994 (147 mg/L), and March 1997 (110 mg/L) the rate of decrease has slowed. Decreased nitrate concentrations reflect a combination of reduced contaminant flux after closing/capping the S-3 Site and flushing of contaminated groundwater during seasonal and episodic

recharge/discharge cycles (Shevenell 1994). The apparently slower rate of decrease suggests that the most highly contaminated groundwater in the more permeable flowpaths has been flushed from the shallow groundwater system, and that contaminant concentrations may be approaching relatively asymptotic levels generally controlled by relative rates of molecular diffusion from the bedrock matrix into the permeable fractures.

Elevated nitrate concentrations in the sodium-bicarbonate groundwater at well GW-829 (Figure 7) reflect strike-parallel migration of the nitrate plume in the bedrock approximately 800 ft west of Bear Creek NT-1 (Figure 8). This well is paired with GW-828 (located about 100 ft north) and is completed in the Nolichucky Shale at a depth of about 115 ft bgs (well GW-828 is completed at 168 ft bgs). Strongly upward hydraulic gradients in the area (well GW-828 was artesian in April 1995) suggest that the bedrock structure associated with NT-1 promotes upward migration of nitrate (and other S-3 Site groundwater contaminants) from the deep bedrock east of the tributary into the shallow bedrock west of the tributary.

Well GW-829 initially contained residual contamination from shallow groundwater intercepted during installation, most of which was flushed during subsequent purging and sampling. Aside from the results reported for the first two groundwater samples collected from well GW-829 (2,210 mg/L in March 1995 and 200 mg/L in June 1995), nitrate concentrations have remained below 60 mg/L and show a generally downward trend (Figure 9). The probable upward vertical hydraulic gradient and higher concentrations in shallower groundwater suggest that the monitored interval for well GW-829 is near the base of the nitrate plume.

Nitrate concentrations exceed 500 mg/L and dominate the major ion chemistry of the groundwater samples collected from well GW-537 (Figure 7). Total and dissolved sodium concentrations exceed 30 mg/L (an order-of-magnitude higher than typical of shallow groundwater in the Aquitard) and reflect the upward migration of nitrate-contaminated sodium-bicarbonate groundwater from the deeper (i.e., >100 ft bgs) flow system into the water table interval near NT-2 (Figure 8). As noted in the preceding discussion, seasonal and episodic recharge/discharge cycles have flushed the most highly contaminated groundwater from the shallow flow system in the Aquitard, which suggests that the very high nitrate levels in the water table interval at well GW-537 are maintained primarily via upward inflow from the deeper flow system. If the center of mass of the nitrate plume in the Aquitard is slowly migrating westward (along strike) from the S-3 Site,

upwelling of nitrate from the deeper bedrock should produce relatively stable or increasing long-term concentration trends in the shallow groundwater near NT-2 (U.S. Department of Energy 1997). Excluding a conspicuously low result for the sample collected from GW-537 in September 1994 (81 mg/L), nitrate results obtained since January 1990 show relatively stable long-term concentrations, with a possible slightly decreasing trend after February 1995 (Figure 9).

Nitrate also dominates the ion chemistry of the groundwater samples collected from well GW-085 during CY 1997 (Figure 7). Elevated nitrate concentrations in the calcium-magnesium bicarbonate groundwater at this well reflect strike parallel migration of the nitrate plume in the shallow bedrock west of NT-2, and indicate that the leading edge of the plume lies west of the well toward NT-3 (Figure 8). Excluding the unusually high and low nitrate concentrations reported for the samples collected in February 1993 (2,139 mg/L) and in June 1995 (17 mg/L), historical data for well GW-085 show that nitrate levels increased from about 100 mg/L in May 1991 to more than 300 mg/L in October 1993 and subsequently decreased below 100 mg/L through September 1997 (Figure 9).

4.1.2 Aquifer

Most of the Aquifer monitoring wells yield calcium-magnesium-bicarbonate groundwater (Figure 10), and samples from these wells typically exhibit: low proportions (<10%) of chloride, potassium, sodium, and sulfate; carbonate alkalinity and fluoride below respective analytical reporting limits; nitrate concentrations below 1 mg/L; TDS of 200 to 700 mg/L, and pH between 7.2 and 8.0. Distinctive proportions of magnesium characterize the groundwater in many of these monitoring wells, with proportions below 30% of total cations generally characteristic of shallow groundwater inflow from the Aquitard, and proportions above 30% indicative of groundwater inflow from the Copper Ridge Dolomite. Several of the deeper (>500 ft bgs) Aquifer wells, notably Exit Pathway Picket W wells GW-710 and GW-711, yield highly mineralized (TDS >1,000 mg/L) calcium-magnesium-sulfate groundwater (Figure 10). The sulfate-enriched geochemistry of the groundwater in these wells probably results from dissolution of gypsum and anhydrite, which also may enhance dedolomitization in the Maynardville Limestone and influence barium concentrations in the Aquifer (Saunders and Toran 1992). Shallow groundwater along Bear Creek Road has higher proportions (>10%) of sodium and chloride that probably reflect the use of road salt during the

winter months, as shown by samples from wells at Exit Pathway Picket B (GW-695), Picket A (GW-056 and GW-685), and Picket W (GW-715) (Figures 6 and 8), which are located within 50 ft of the road.

Aside from groundwater with locally elevated sodium, chloride, or sulfate concentrations, the plume of nitrate originating from the S-3 Site is the principal source of variation from the typical ion chemistry of groundwater in the Aquifer. Nitrate concentrations above 1 mg/L were reported for at least one groundwater sample from 14 Aquifer wells (Figure 8), but as shown in the following summary, concentrations above the 10 mg/L MCL were reported only for samples from well GW-315 at Spoil Area I; Exit Pathway Picket C wells GW-724, GW-725, and GW-738; Exit Pathway Picket B wells GW-703, GW-704, and GW-706; and Exit Pathway Picket A well GW-683.

Well Location / Number	Distance (ft) /Direction from S-3 Site	Monitored Interval Depth (ft bgs)	Nitrate (mg/L)	
			1st Qtr.	3rd Qtr.
Spoil Area I GW-315	600/South	90.0 - 104.0	2.24	11.4
Exit Pathway Picket C GW-724 GW-725 GW-738	3,000/West	289.6 - 301.6	35.7	36.3
		132.5 - 142.5	76.1	47.5
		63.5 - 88.0	11	10.4
Exit Pathway Picket B GW-703 GW-704 GW-706	7,000/West	135.0 - 182.0	16.5	15.6
		246.0 - 256.0	17.2	16.5
		157.0 - 182.5	18.1	33.1
Exit Pathway Picket A GW-683	10,000/West	133.9 - 196.8	3.4	10.1

Elevated nitrate concentrations in the groundwater at these wells are generally consistent with the following migration pattern:

- inflow from the water table interval south of the S-3 Site (GW-315; Figure 6);
- westward, strike-parallel transport in the shallow karst network and deeper bedrock and influx of contaminated groundwater and surface water from the NT-1 and NT-2 catchments into the basal portion (Zone 2) of the Maynardville Limestone (represented by wells GW-724, GW-725, and GW-738; Figure 6);
- westward, strike-parallel transport in the shallow karst network and deeper bedrock, with influx into the deeper flow system along a losing reach of Bear Creek south of Sanitary Landfill I (represented by wells GW-703, GW-704, and GW-706; Figure 6); and
- westward, strike-parallel transport in the shallow karst network and deeper bedrock, with southward migration into successively higher stratigraphic zones in the Maynardville Limestone and ultimately into the Copper Ridge Dolomite (GW-683; Figure 6) (U.S. Department of Energy 1997).

This transport pattern has produced a nitrate plume in the Aquifer that is continuous in the deeper bedrock (i.e., 100 to 300 ft bgs) from south of the S-3 Site for about 10,000 ft along strike to the west, whereas attenuation (i.e., dilution) from more active recharge and groundwater flux has reduced the nitrate concentrations and produced a more discontinuous plume in the shallow karst network (Figure 8).

Nitrate results for the Aquifer wells sampled during CY 1997 are consistent with respective historical data and generally reflect the seasonal and episodic dilution-related and flux-related concentration fluctuations that are characteristic of the nitrate plume in the Aquifer (U.S. Department of Energy 1997). At Exit Pathway Picket C, for example, nitrate levels are typically highest in the shallow karst network at well GW-738 (88 ft bgs; Figure 6) during seasonally low flow (summer and fall), which reflects less dilution from uncontaminated recharge, whereas nitrate levels in the deeper bedrock at well GW-725 (142 ft bgs; Figure 6) are usually highest during seasonally high flow (winter and spring), which suggests greater advective flux of nitrate (Figure 11). Dilution-related and flux-related responses to episodic recharge similarly account for the wide short-term concentration fluctuations indicated by the nitrate data for several wells. For example, about four inches of rainfall (as measured at the National Atmospheric and Oceanic Administration in Oak Ridge, Tennessee) occurred during the week before sampling well GW-315 in March 1997, and the nitrate concentration reported for the sample (2.57 mg/L) is substantially less than that reported for the sample collected from the well in September 1997 (11.4 mg/L) following a ten day period of no rainfall. Conversely, the nitrate levels in the shallow karst network at Exit Pathway Picket A well GW-685 apparently increased in August 1997 in direct response to more than two inches of rain during the previous 16 hours (Figure 11).

Based on aggregate average concentrations determined from historical nitrate data for wells that were sampled during CY 1997, nitrate levels in the Aquifer downgradient of the S-3 Site appear to have generally decreased at Exit Pathway Picket C and Exit Pathway Picket A, remained relatively stable at Exit Pathway Picket B, and continue to sporadically exceed 1 mg/L in the shallow groundwater at Exit Pathway Picket W (Figure 12). Slowly decreasing nitrate concentrations in the groundwater at Exit Pathway Picket C and Exit Pathway Picket A probably reflect the long-term effects of reduced contaminant flux and greater attenuation (i.e., dilution) following closure of the

S-3 Site. Discharge of nitrate-contaminated groundwater and surface water from the NT-1 and NT-2 catchments and inflow along the losing reach of Bear Creek south of Sanitary Landfill I probably helps maintain the nitrate levels in the groundwater at Exit Pathway Picket B. Nitrate has been detected in the groundwater samples from each of the Exit Pathway Picket W wells except GW-710 and GW-711, with concentrations above 1 mg/L typical of the groundwater at shallower wells (GW-714 and GW-715) indicating a possible relationship with nitrate-contaminated surface water in Bear Creek.

4.2 Trace Metals

Evaluation of the CY 1997 groundwater quality data with respect to trace metals focused on the total (unfiltered sample) concentrations of barium, boron, strontium, and uranium that exceed the applicable upper tolerance limit (UTL) reported in: *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW Environmental Consultants, Inc. *et al.* 1995). Barium, boron, strontium, and uranium are the primary trace metal contaminants in the Bear Creek Regime. The UTLs for these metals, summarized below, were determined from statistical analysis of historical (CY 1986 - CY 1993) data for specific groups of wells (i.e., clusters) differentiated by similar geochemical characteristics (the well-cluster designations for the wells sampled during CY 1997 are provided in Appendix C).

Trace Metal	UTL (mg/L)					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 6	Cluster 10
Barium	0.71	0.68	0.79	0.34	0.34	0.35
Boron	0.12	0.028	0.041	0.028	3.1	3.1
Strontium	4.4	0.079	0.92	0.079	0.92	0.92
Uranium	0.012	0.004	0.005	0.005	0.004	0.005

The UTL for each metal represents the maximum concentration expected in the groundwater monitored by the wells comprising each cluster, and results that exceed the UTL (i.e., elevated concentrations) may be considered as potential evidence of groundwater contamination (HSW Environmental Consultants, Inc. *et al.* 1995).

4.2.1 Aquitard

As shown in the following data summary, total concentrations of barium, boron, strontium, or uranium that exceed respective UTLs were reported for unfiltered groundwater samples from four Aquitard monitoring wells located downgradient of contaminant source areas in the Bear Creek Regime: GW-069 south of Burial Grounds A-South; GW-276 south of the S-3 Site, and wells GW-537 and GW-829 west (along strike) of the S-3 Site.

Well No.	UTL Well Cluster	Total Concentration (mg/L)							
		Barium		Boron		Strontium		Uranium	
		1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.
GW-069	10	0.37	0.37	<	<	<	<	<	<
GW-276	3	<	<	<	0.043	<	<	0.78	1.3
GW-537	3	2.4	2.0	<	<	3.0	2.4	<	<
GW-829	10	0.83	0.69	<	<	1.4	1.3	<	<

Note: "<" = Less than applicable UTL.

Total barium concentrations reported for well GW-069 are only slightly above the applicable UTL (0.35 mg/L) and probably reflect ambient levels in the groundwater. Groundwater throughout the Oak Ridge Reservation is typically saturated with respect to barite ($BaSO_4$), which has been observed in the Conasauga Group (Pumpkin Valley Shale) and may be a control on barium levels in the Bear Creek Regime (Saunders and Toran 1992). Results for the remaining wells reflect migration of trace metal contaminants from the S-3 Site.

The plume of groundwater contamination in the Aquitard near the S-3 Site contains a heterogeneous mix of trace metals that were either entrained in the acidic wastewater disposed at the site (e.g., uranium) or were dissolved from the saprolite and bedrock (e.g., barium). As illustrated by the following summary of barium, boron, strontium, and uranium results for well GW-276, trace metal concentrations in the shallow groundwater south of the site have generally decreased, but at different relative rates.

Trace Metal	Total Concentration (mg/L)									
	Oct. 1988	Jan. 1990	Mar. 1994	Aug. 1994	Jan. 1995	July 1995	Feb. 1996	July 1996	Mar. 1997	Aug. 1997
Barium	3.6	2.3	0.61	0.73	0.66	0.83	0.5	0.52	0.42	0.41
Boron	.	.	0.036	0.068	0.068	0.051	0.048	0.041	0.031	0.043
Strontium	.	.	0.31	0.35	0.36	0.35	0.35	0.32	0.26	0.33
Uranium	5.99	3.7	1.16	1.55	1.6	2.0	1.9	1.2	0.78	1.3

Note: "." = Not analyzed; **BOLD** = result exceeds the applicable UTL (Well Cluster 3).

Differential retardation probably explains the relative rates at which trace metal concentrations decreased following closure of the S-3 Ponds. For example, uranium concentrations have decreased at a slower rate compared to barium levels because uranium is more readily adsorbed to mineral surfaces, and the elevated concentrations have been maintained by this subsurface reservoir of adsorbed uranium (U.S. Department of Energy 1997). Conversely, barium and other similarly mobile trace metals are more readily flushed from the shallow flow system and concentrations have decreased more rapidly.

Assuming a migration pattern similar to that of nitrate from the S-3 Site, elevated barium and strontium concentrations in the shallow groundwater at well GW-537 and deeper bedrock at well GW-829 reflect strike-parallel transport from the S-3 Site and upward migration from the deeper bedrock east of NT-1 into the shallow bedrock west of the tributary (U.S. Department of Energy 1997). Barium and strontium results for well GW-829 (omitting the initial sampling results, which had high, non-representative metal contamination from shallower groundwater encountered during installation) suggest decreasing trends following installation of the well in March 1995 (Figure 13). In contrast, results for well GW-537 show that the concentrations of both metals concurrently increased steadily until June 1994 and have remained fairly constant with a slightly decreasing trend thereafter (Figure 13). Barium and strontium results for well GW-085 show a similar long-term trend: concentrations increased above the respective UTLs through October 1993 and have subsequently decreased below the UTLs (Figure 13). The long-term concentration trends for wells GW-537 and GW-085 suggest westward, strike parallel migration of a "pulse" of barium and strontium in the shallow flow system in the Aquitard west of the S-3 Site. The decreasing trend in recent years may reflect a delayed response to reduced contaminant flux after closure/capping of the site.

4.2.2 Aquifer

As shown in the following summary, elevated total concentrations of boron, strontium, or uranium were reported for unfiltered groundwater samples from seven Aquifer monitoring wells located downgradient of contaminant source areas in the Bear Creek Regime (listed in order from farthest upgradient to farthest downgradient).

Well No.	UTL Well Cluster	Total Boron (mg/L)		Total Strontium (mg/L)		Total Uranium (mg/L)	
		1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.
GW-706	1	<	<	<	<	0.13	0.11
GW-053	1	0.22	0.27	<	<	<	<
GW-683	4	<	0.048	<	<	0.031	0.034
GW-684	1	<	<	<	<	0.025	0.034
GW-710	1	0.34	0.25	7.6	8.9	<	<
GW-711	1	1.2	1.2	12	12	<	<
GW-714	3	0.072	0.059	<	<	<	<

Note: "<" = Less than the applicable UTL.

Boron and strontium concentrations reported for Exit Pathway Picket W wells GW-710 and GW-711 reflect ambient levels in the highly mineralized and sulfate-enriched groundwater produced by each well. A combination of several natural processes may account for the boron and strontium concentrations at these wells, including: mixing of the sulfate-enriched groundwater with brines in the deeper bedrock, which may cause precipitation of barite and celestite (SrSO_4); upward diffusion of solutes from the deeper brine (which should also enrich sodium and chloride levels); and matrix diffusion from the bedrock (Saunders and Toran 1992). The elevated uranium concentrations reported for wells GW-706, GW-683, and GW-684 probably reflect groundwater contamination originating from the S-3 Site and/or the Boneyard/Burnyard, and the elevated boron concentrations reported for wells GW-053 and GW-714 probably reflect groundwater contamination from sources associated with the Bear Creek Burial Grounds WMA.

The Boneyard/Burnyard is a principal source of uranium in the Aquifer. Uranium leached from the source(s) at this site recharges directly into the Maynardville Limestone or migrates along strike in the Aquitard toward NT-3 and enters the Aquifer along the major losing reach of the Bear Creek south of the Sanitary Landfill I (U.S. Department of Energy 1997). Total uranium concentrations reported for Exit Pathway Picket B well GW-706 are consistent with this migration

pattern. This well is downgradient of the Burnyard/Boneyard, the confluence of NT-3 and Bear Creek, and the losing reach of the creek. Historical uranium results for this well show a relatively stable, if not a slightly increasing, long-term concentration trend (Figure 14).

Elevated uranium concentrations in the groundwater at Exit Pathway Picket A wells GW-683 and GW-684 probably reflect downgradient, strike-parallel transport of uranium from the Boneyard/Burnyard, but may also be at least partially attributed to inflow of radiologically contaminated groundwater/surface water from the three Bear Creek tributaries that drain the Bear Creek Burial Grounds WMA, particularly NT-8, which discharges into Bear Creek just upstream of Exit Pathway Picket A (Figure 14). Substantial volumes of wastes containing uranium isotopes were disposed at the Bear Creek Burial Grounds WMA. Uranium is not a pervasive contaminant in the Aquitard at the site (as illustrated by the overall lack of elevated gross alpha and gross beta activity), although surface water in each tributary is radiologically contaminated, with the highest activities evident in the southern branch of NT-8 (U.S. Department of Energy 1997). Regardless of the source, the uranium results for wells GW-683 and GW-684 suggest a transport pattern similar to that of nitrate, with downgradient transport into successively higher hydrostratigraphic zones in the Maynardville Limestone and ultimately into the lower Copper Ridge Dolomite (Figure 14).

The Bear Creek Burial Grounds WMA received substantial volumes of borax (hydrated sodium borate) waste water from the Y-12 Plant, and elevated total boron concentrations reported for the groundwater samples from Aquifer well GW-053 probably reflect influx of boron-contaminated groundwater/surface water from one or more source areas (e.g., Burial Grounds (BG)-A South). Elevated boron concentrations reported for several Aquitard monitoring wells that were not sampled during CY 1997 indicate groundwater transport toward the tributaries of Bear Creek (NT-6, NT-7, and NT-8) that traverse the site (AJA Technical Services, Inc. 1996). Well GW-053 is located north of Bear Creek, about 1,200 ft downstream of the confluence with NT-6 and about 200 ft upstream of the confluence with NT-7 (Figure 5). Along with seasonal concentration fluctuations, which may correlate with flow levels in Bear Creek, historical boron data for the well show a relatively stable long-term concentration trend (Figure 15). Infiltration of boron-contaminated surface water discharged from these tributaries into of Bear Creek may also explain the elevated boron concentration reported for the samples collected from Exit Pathway Picket W well GW-714, which is completed in the shallow karst network about 250 ft west (along strike) from

where Bear Creek turns abruptly northward (Figure 5). Boron results for this well show a relatively stable long-term concentration trend (Figure 15).

4.3 Volatile Organic Compounds

Excluding false-positive results, one or more of the following VOCs were detected (including estimated concentrations below the analytical reporting limit) in groundwater samples collected from 19 monitoring wells during CY 1997: carbon tetrachloride, chloroform, tetrachloroethene (PCE), TCE, 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), and vinyl chloride (see Appendix C). Maximum concentrations of each compound except PCE (83 $\mu\text{g/L}$), TCE (100 $\mu\text{g/L}$), and 1,2-DCE (26 $\mu\text{g/L}$) were less than 10 $\mu\text{g/L}$. The maximum summed VOC concentrations for each well, except Aquitard well GW-627 (110 $\mu\text{g/L}$) and Aquifer wells GW-704 (115 $\mu\text{g/L}$) and GW-740 (78 $\mu\text{g/L}$), were less than 50 $\mu\text{g/L}$ (Table 7).

4.3.1 Aquitard

Few of the Aquitard monitoring wells that were sampled during CY 1997 monitor VOC-contaminated groundwater. Excluding false-positive results, VOCs were detected only in the groundwater samples from seven Aquitard wells: GW-069, GW-085, GW-276, GW-287, GW-537, GW-627, and GW-653 (Table 7). Results for each of these wells except GW-085 are consistent with respective historical data showing dissolved chloroethenes (primarily PCE, TCE, and 1,2-DCE) and/or lesser plume components (e.g., chloroform) in the shallow groundwater south (GW-276) and west (GW-537) of the S-3 Site, and in the shallow and deep groundwater south (GW-069) and west (GW-627 and GW-653) of BG-A South (Figure 16). Chloroform was detected at an estimated concentration of 2 $\mu\text{g/L}$ in the groundwater sample collected from well GW-085 in September 1997; this compound was previously detected only in samples collected from the well in June 1994, December 1994, and March 1995.

Historical data for wells located adjacent to the S-3 Site show dissolved PCE concentrations above 5,000 $\mu\text{g/L}$ in the shallow groundwater and indicate the presence of dense, nonaqueous phase liquids (DNAPLs) in the subsurface. However, the PCE results for samples collected in January (24 $\mu\text{g/L}$) and August (23 $\mu\text{g/L}$) 1997 from well GW-276, which is only 250 ft south of the S-3 Site,

illustrate the substantial attenuation of VOCs in the Aquitard. Both results exceed the MCL for PCE (5 µg/L) but are an order-of-magnitude lower than the levels reported for samples collected from the well in the late-1980s (e.g., 230 µg/L in March 1988). Substantially decreased PCE concentrations mirror the trends evident for nitrate and trace metals, and likewise result from closure/capping of the S-3 Site and subsequent flushing of the highly contaminated groundwater from the shallow flow system.

Trace levels (2 µg/L) of chloroform were detected in both groundwater samples collected from well GW-537 during CY 1997. Chloroform is a component of the S-3 Site contamination plume in the Aquitard, and similar concentrations have been detected in every sample collected from the well since October 1995. Low levels of chloroform in the groundwater at the well suggest strike-parallel transport in the shallow groundwater west of the S-3 Site, which also may explain the first-time detection of PCE (1 µg/L) in the sample collected in March 1996 (PCE was not detected in either sample collected during CY 1997). In light of the very low concentrations, however, it is possible both chloroform and PCE are present in the groundwater but are often volatilized during sampling. Considering the substantially higher concentrations of more mobile, nonvolatile S-3 Site contaminants (e.g., nitrate) in the groundwater at the well, the trace levels of chloroform (and PCE) illustrate the significantly greater attenuation of VOCs in the Aquitard.

Groundwater in the Aquitard underlying the Bear Creek Burial Grounds WMA is extensively contaminated with VOCs at both shallow (water table) and deep (bedrock) intervals (Figure 16). There are five primary source areas: BG-A (North and South), BG-C (East and West), and the Walk-In Pits. Dissolved VOC plumes in the shallow groundwater at several of these source areas are probably related to widespread subsurface DNAPLs consisting primarily of PCE and TCE. These parent compounds and/or several of their degradation products (e.g., 1,2-DCE) were detected in each of the groundwater samples collected from wells GW-653 and GW-627 in February and September 1997; vinyl chloride, also a degradation product of TCE and PCE, was detected in the sample collected from well GW-069 in August 1997 (see Appendix C). Concentrations of PCE, TCE, and vinyl chloride exceed respective MCLs in samples collected from wells GW-069, GW-627, and GW-653 (Table 7).

Several chloroethenes (PCE, TCE, 1,2-DCE, and 1,1-DCE) and chloroethanes (1,1,1-TCA and 1,2-dichloroethane) were detected (1 - 26 µg/L) in the groundwater samples collected from well

GW-653, with the highest concentration of each compound reported for the sample collected in February 1997 (Table 7). The presence of dissolved VOCs in the shallow groundwater at this well, which is completed at a depth of 39 ft bgs in the Nolichucky Shale about 1,000 ft west of BG-A South, reflects westward strike-parallel transport toward NT-8 (Figure 16). Results for this well also show proportionally higher concentrations of degradation products (e.g., 1,2-DCE) relative to the parent chemicals (e.g., PCE), which is characteristic of the VOC data for many water table interval and shallow bedrock wells that monitor the VOC plume originating from BG-A South. As illustrated by summed concentrations of PCE, TCE, and 1,2-DCE determined from historical results for well GW-653, concentrations within the shallow groundwater VOC plume are often highest during winter and spring, which suggests seasonally variable flux of VOCs toward discharge areas in NT-8; although dominated by these seasonal fluctuations, a slightly upward long-term concentration trend is evident (Figure 17).

The CY 1997 results for well GW-627, which is completed at a depth of 270 ft bgs in the Nolichucky Shale about 500 ft to the west (along strike) of BG-A South (Figure 16), are consistent with historical data showing primarily dissolved chloroethenes with proportionally higher concentrations of parent compounds (PCE and TCE) relative to degradation products (1,2-DCE) (Table 7). Results for the well also reflect the steadily increasing PCE and TCE concentration trends evident since February 1990 (Figure 17). The detection of these chloroethenes generally coincides with the January 1990 discovery of PCE and TCE DNAPL within the Nolichucky Shale at depths between 260 to 330 ft down-dip of BG-A South (Haase and King 1990). The subsequent increasing concentration trend clearly indicates migration of VOCs at depth in the Aquitard; fate and transport modeling suggest it will take as long as 600 years for the PCE to migrate about 1,200 ft. to NT-8 (U.S. Department of Energy 1997).

Vinyl chloride was detected at an estimated concentration of 3 $\mu\text{g/L}$ in the groundwater sample collected in August 1997 from well GW-069 (Table 7), which is completed at a depth of 99 ft bgs immediately south of BG-A South (Figure 16). Similar levels of this compound also were detected in previous samples collected during seasonally low groundwater flow, including those collected in July 1996 (2 $\mu\text{g/L}$), August 1995 (2 $\mu\text{g/L}$), and September 1994 (2 $\mu\text{g/L}$). Vinyl chloride is a degradation product of TCE and PCE, and low levels in the groundwater at this well, combined with the upward vertical hydraulic gradients in the Nolichucky Shale, potentially indicate upward

migration from TCE DNAPL deeper in the bedrock. As noted previously, the apparently sporadic detection of vinyl chloride may reflect volatilization during sampling rather than the absence of the compound in the groundwater at well GW-069.

4.3.2 Aquifer

A discontinuous plume of dissolved VOCs (primarily TCE) occurs in the shallow karst network and the deeper bedrock in the Aquifer (Maynardville Limestone) and is commingled with the nitrate plume downgradient of the Boneyard/Burnyard/HCDA. The distribution of plume constituents indicates contributions from several source areas via direct recharge, hydrologic communication with Bear Creek, and inflow of shallow groundwater from the Aquitard. The extent of the plume (as defined by summed VOC concentrations for each well) indicate a migration pattern similar to that of nitrate in the Aquifer (Figure 16). Plume constituents in the upper part of BCV are TCE, PCE, and 1,2-DCE; probable source areas are Spoil Area I, the S-3 Site, and possibly the Fire Training Facility located in the Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime). Additional inputs to the plume occur from the Rust Spoil Area or a nearby source in the Bear Creek floodplain (TCE), the Boneyard/Burnyard/HCDA (TCE and 1,2-DCE), Sanitary Landfill I (1,1,1-TCA and 1,1-DCA), and discharge from the Bear Creek tributary (NT-7) that traverses BG-A North and BG-A South (1,2-DCE and 1,2-DCA).

Excluding false-positive results, one or more VOCs were detected in the groundwater samples collected from the following Aquifer wells (listed in order from upgradient to downgradient): GW-315 at Spoil Area I; GW-311 at Rust Spoil Area; Exit Pathway Picket C wells GW-724, GW-725, GW-738, and GW-740; Exit Pathway Picket B wells GW-695, GW-703, GW-704, and GW-706; GW-053 at BG-A South; and Exit Pathway Picket A well GW-685 (Table 7). Results for these wells are consistent with respective historical data and do not indicate any significant changes in the extent or distribution of VOCs in the groundwater in the Aquifer (Figure 16).

Dissolved chloroethenes (PCE, TCE, and 1,2-DCE) were detected in both of the groundwater samples from well GW-315 during CY 1997 (Appendix C), which is completed at a depth of 104 ft bgs on the northern flank of Chestnut Ridge south of Spoil Area I (Figure 16). Excluding suspect results for acetone (47 µg/L) and 2-butanone (3 µg/L) detected in the sample collected from the well

in September 1997, both of which probably reflect laboratory contamination although neither compound was detected in the associated blank samples, summed VOC concentrations determined for each sample are less than 50 µg/L and are dominated by PCE (14 and 19 µg/L). These results are consistent with historical data for the well and reflect input of dissolved chloroethenes from Spoil Area I or possibly the Fire Training Facility, which is a confirmed source of chloroethenes in the East Fork Regime about 1,000 ft east of the well. As illustrated by TCE data, chloroethene concentrations in the groundwater at well GW-315 have decreased about 50% from levels evident in the early 1990s (Figure 18). However, the TCE concentration in the sample collected after heavy rainfall in March 1997 was not significantly lower (from dilution) as was noted for the nitrate concentration in the sample (Figure 11). The contrasting concentration responses with influx of fresh shallow groundwater suggest different transport mechanisms and different sources of nitrate and TCE.

Results for well GW-311 are consistent with historical data showing relatively low (<50 µg/L) levels of TCE in the shallow groundwater (40 ft bgs) south of the Rust Spoil Area (Figure 16). Trichloroethene was detected in both samples collected from the well during CY 1997, but the result for the sample collected in March 1997 (10 µg/L) is a false positive because of TCE-contamination in the associated trip blank sample; trace levels (1 µg/L) of carbon tetrachloride and chloroform also were detected in the groundwater samples from the well (Table 7). The composition of the dissolved VOC plume in the shallow groundwater at the well probably reflects influx of TCE from the Rust Spoil Area and transport of carbon tetrachloride and chloroform from an upgradient source area (possibly the S-3 Site). Historical results for the well show that TCE concentrations have decreased more than 50% since the late 1980s and early 1990s (Figure 18). The rate of decrease suggests that TCE concentrations may soon drop below the 5 µg/L MCL.

Results for the wells comprising Exit Pathway Picket C that were sampled during CY 1997 are consistent with respective historical data and reflect strike-parallel transport of TCE from the Rust Spoil Area in the shallow karst network (GW-738) and deeper bedrock (GW-724, GW-725, and GW-740), but trace concentrations (1 to 2 µg/L) of carbon tetrachloride (GW-740) and chloroform (GW-738) suggest migration from another upgradient source, possibly the S-3 Site (Figure 16). Trichloroethene has been detected in every sample collected from well GW-724 since May 1992, and concentrations have increased from about 50 µg/L in 1992 to more than 150 µg/L in 1996 (Figure 19), although concentrations have been erratic. This well is completed with a 12-ft open

interval more than 300 ft bgs, and the increasing TCE levels potentially indicate increased flux along strike-parallel flowpaths at depth in the middle (Zone 4) of the Maynardville Limestone (Figure 6).

Results for Exit Pathway Picket B wells GW-695, GW-703, and GW-704 are consistent with respective historical data and reflect the TCE-dominated composition of the dissolved VOC plume in the Aquifer downgradient of the Oil Landfarm WMA (Figure 16). Excluding false positives, which include the TCE results reported for the samples collected from wells GW-703 (61 µg/L), GW-704 (100 µg/L), and GW-706 (4 µg/L) in February 1997 (the trip blanks associated with these samples were contaminated with TCE), summed concentrations of the VOCs detected in the samples from each well range from 5 µg/L (GW-695) to 115 µg/L (GW-704) (Figure 19). Considering that the highest summed VOC concentrations occur in the groundwater at well GW-704 (Table 7), which is the deepest (256 ft bgs) well in Exit Pathway Picket B, the composition of the dissolved VOC plume reflects strike-parallel transport from the Rust Spoil Area and vertical influx via the losing reach of Bear Creek south of Sanitary Landfill I (U.S. Department of Energy 1997). Relatively low (<10 µg/L) concentrations of 1,1-DCE and 1,2-DCE in the groundwater at Picket C wells may be from degradation of TCE, but trace levels (<5 µg/L) of carbon tetrachloride in the groundwater at well GW-704 suggest influx of chloromethanes from sources in the Boneyard/Burnyard/HCDA or Sanitary Landfill I (portions of both sites directly overlie the Maynardville Limestone).

4.4 Radioactivity

Evaluation of groundwater quality with respect to radiological contamination was based on CY 1997 results for gross alpha and gross beta that exceed the associated minimum detectable activity (MDA) and counting error (the value which expresses the degree of analytical uncertainty) reported for each sample. Gross alpha and gross beta results that meet these DQO criteria were reported for a total of 33 groundwater samples from 24 monitoring wells (Table 8). Considering the characteristic variability of the analytical results for gross alpha and gross beta, these results are generally consistent with historical data and do not indicate any significant changes in the overall extent of radiological contamination in the Bear Creek Regime. Elevated gross alpha activity (as defined by results that exceed the 15 picoCuries per liter (pCi/L) MCL for drinking water) mainly occurs in the Aquitard near the S-3 Site and the Boneyard/Burnyard in the Oil Landfarm WMA, and in the Aquifer downgradient of each site (Figure 20). The elevated gross alpha activity basically

reflects the extent of ^{234}U and ^{238}U in the groundwater (U.S. Department of Energy 1997). Elevated gross beta activity, as defined by results that exceed the Safe Drinking Water Act (SDWA) screening level of 50 pCi/L, also occurs in the Aquitard and Aquifer downgradient of these sites (Figure 21), but is much more extensive than elevated gross alpha activity in the Aquifer and primarily reflects transport of ^{99}Tc from the S-3 Site (U.S. Department of Energy 1997).

4.4.1 Aquitard

Gross alpha and gross beta results that exceeded MDAs were reported for at least one groundwater sample collected from eight Aquitard wells during CY 1997 (Table 8), including two wells (GW-040 and GW-079) located hydraulically upgradient of the waste management sites and regulated units in the regime. Only the results reported for wells downgradient of the S-3 Site to the south (GW-276) and west (GW-085 and GW-537) reflect groundwater contamination (Figures 20 and 21).

Shallow and deep groundwater at the S-3 Site contains a heterogeneous mixture of several alpha- and beta-emitting radionuclides, including Neptunium-237, ^{99}Tc , ^{234}U , ^{235}U , and ^{238}U . Each of these radionuclides was detected above MDAs in the groundwater samples collected from well GW-276 (see Appendix C), with the highest concentrations reported for ^{99}Tc (920 ± 93 pCi/L) and ^{238}U (410 ± 73 pCi/L). As with other contaminants in the groundwater at this well, historical gross alpha and gross beta results show that radionuclide concentrations have decreased substantially since the late 1980s, but gross beta has generally decreased more rapidly. For example, gross beta activity decreased from more than 10,000 pCi/L in March 1988 to 680 ± 89 pCi/L in March 1997, whereas gross alpha activity decreased from about 3,000 pCi/L to 360 ± 50 pCi/L over this same period. Alpha activity levels are probably maintained by the slow release of alpha-emitting isotopes adsorbed by sludges remaining in the S-3 Ponds and with the bedrock matrix in the Aquitard, whereas more rapidly decreasing beta activity reflects the greater flushing of ^{99}Tc from the shallow flow system, which is more mobile and less readily absorbed in the subsurface (U.S. Department of Energy 1997).

The CY 1997 gross alpha and gross beta results for groundwater samples from wells GW-085 and GW-537 are generally consistent with respective historical data and clearly illustrate the differential retardation of radionuclides in the Aquitard. The low gross alpha in the groundwater at

each well (gross alpha activity did not exceed the associated MDAs reported for both groundwater samples collected from each well during CY 1997) reflects substantial attenuation of uranium isotopes (and other alpha-emitting radionuclides) in the Aquitard west (and east) of the S-3 Site. The ^{234}U , ^{235}U , and ^{238}U activities reported for samples collected from these two wells in CY 1995 are either less than the associated MDAs or have proportionally high counting errors. In contrast, the much higher gross beta in the shallow groundwater at each well reflects lesser retardation of ^{99}Tc and substantially greater strike-parallel transport from the S-3 Site. Respective ^{99}Tc activities above 100 and 1,000 pCi/L were reported for samples collected from wells GW-085 and GW-537 in CY 1995. Historical gross beta results for these wells show significant temporal fluctuations (some of which probably reflect analytical variability) but generally upward long-term trends (Figure 22). Slow, westward migration of the center of mass of the S-3 Site contaminant plume may explain the increasing gross beta activity in the shallow groundwater at these wells (U.S. Department of Energy 1997).

4.4.2 Aquifer

Gross alpha and gross beta activity in the Aquifer is from uranium isotopes (primarily ^{234}U and ^{238}U) and ^{99}Tc . Uranium isotopes enter the Aquifer via inflow from the buried tributary of Bear Creek that extends beneath the S-3 Site, direct recharge from the Boneyard/Burnyard (and inflow from the NT-3 catchment), and inflow from tributary catchments to the east (NT-6) and west (NT-7 and NT-8) of BG-A North and BG-A South (U.S. Department of Energy 1997). Although uranium isotopes may account for both gross alpha and gross beta activity in the groundwater at some Aquifer wells, particularly those near the Boneyard/Burnyard, the distribution of gross beta activity in the Aquifer generally delineates the extent of ^{99}Tc transport and reflects essentially identical patterns of nitrate and ^{99}Tc migration from the S-3 Site (U.S. Department of Energy 1997).

Gross alpha results that meet DQOs were reported for at least one groundwater sample collected from eight Aquifer wells during CY 1997 (Table 8), but only the results reported for Exit Pathway Picket B well GW-706 and Exit-Pathway Picket A well GW-683 exceed the 15 pCi/L MCL (Figure 20). Considering the characteristic variability of gross alpha, these results are consistent with historical data for each well, which share a common characteristic: gross alpha activity is usually highest in the groundwater samples collected during seasonally low groundwater flow conditions.

For example, gross alpha above the associated MDA was reported only for the groundwater samples collected from wells GW-311 (5 ± 2.1 pCi/L), GW-685 (5.5 ± 3.3 pCi/L), GW-695 (5.4 ± 3.2 pCi/L), and GW-714 (4.7 ± 2.8 pCi/L) during September 1997. This suggests that dilution from uncontaminated recharge is a primary control on gross alpha activity in the Aquifer during seasonally higher flow conditions.

Gross alpha activity did not exceed the associated MDAs reported for the groundwater samples collected during CY 1997 from the Exit Pathway Picket C wells GW-724, GW-725, GW-738, and GW-740 (Table 8). Low gross alpha activity in the groundwater at Exit Pathway Picket C reflects substantial attenuation of uranium isotopes along strike-parallel flowpaths in the Aquifer downgradient of the S-3 Site, particularly considering the high nitrate (>50 mg/L) in the groundwater at wells GW-724 and GW-725. Historical data for the Exit Pathway Picket C wells that were sampled during CY 1997, as illustrated by the maximum gross alpha activity reported during each sampling event, show that gross alpha activity has decreased substantially since the early 1990s (Figure 23). Decreased gross alpha activity most likely reflects reduced flux of uranium isotopes (and other alpha-emitting radionuclides) following closure of the S-3 Site.

Gross alpha activities reported for the groundwater samples collected from Exit Pathway Picket B well GW-706 in February 1997 (45 ± 11 pCi/L) and September 1997 (29 ± 7 pCi/L) were higher than results for all of the other Aquifer wells sampled during the year (Table 8). Elevated gross alpha activity in the groundwater at well GW-706, which is completed at a depth of 182.5 ft bgs in the upper part of the Maynardville Limestone (Figure 6), probably reflects influx of uranium isotopes from the Boneyard/Burnyard. This probably explains why the gross alpha activity is higher in the groundwater at the Exit Pathway Picket B wells than at the Exit Pathway Picket C wells. Steady influx of uranium isotopes from the Boneyard/Burnyard also probably accounts for the more stable long-term gross alpha activity trends in the groundwater at Exit Pathway Picket B compared to the decreasing long-term trends in the groundwater at Exit Pathway Picket C, as shown by plots of the maximum gross alpha activity reported during sampling events at each picket (Figure 23).

Gross alpha activity above the associated MDA and counting error was reported for at least one groundwater sample collected from each of the Exit Pathway Picket A wells that were sampled during CY 1997, with the highest levels reported for wells GW-683 (16 ± 7 pCi/L and 19 ± 5 pCi/L)

and GW-684 (13 ± 6 pCi/L and 13 ± 5 pCi/L) (Table 8). Results for these wells, which are completed in the lower Knox Group and upper Maynardville Limestone at respective depths of 197 ft bgs and 128 ft bgs (Figure 6), may reflect migration of uranium isotopes from the Boneyard/Burnyard into successively higher hydrostratigraphic zones in the Maynardville Limestone and ultimately into the lower Copper Ridge Dolomite. However, considering attenuation during transport from this site, which is about a mile east of Exit Pathway Picket A, influx of uranium isotopes discharged from the Bear Creek tributaries that drain the Bear Creek Burial Grounds WMA seems a more likely source of the gross alpha in the groundwater at these wells. A plot of the historical maximum gross alpha activities reported for each of the Exit Pathway Picket A wells that were sampled during CY 1997 suggests a relatively stable long-term trend (Figure 23).

Gross beta above the associated MDA and counting error was reported for at least one groundwater sample collected from 13 Aquifer wells during CY 1997 (Table 8), but results that exceed the 50 pCi/L SDWA screening level were reported only for the samples collected from Exit Pathway Picket B well GW-706 in February 1997 (73 ± 13 pCi/L) and September 1997 (67 ± 8 pCi/L), and the sample collected in September 1997 from well Exit Pathway Picket W well GW-710 (63 ± 7 pCi/L); the latter result is probably an analytical error considering the depth of the well (>500 ft bgs) and the lack of similarly elevated beta activity in any of the previous samples collected from the well. Although gross beta results for most of the Aquifer wells do not exceed 50 pCi/L, they generally mirror their respective nitrate data and reflect similar strike-parallel transport of ^{99}Tc from the S-3 Site (Figure 21); this is supported by the ^{99}Tc concentrations reported for groundwater samples collected from Exit Pathway Picket B wells GW-694 (44.5 ± 6.5 pCi/L) and GW-706 (65.5 ± 8.5 pCi/L) during CY 1996.

As illustrated by the maximum gross beta activity reported for each of the Exit Pathway wells that were sampled during CY 1997, historical data show that gross beta activity is highest in the groundwater at Exit Pathway Picket B and decreasing long-term trends in the groundwater throughout the gross beta plume in the Aquifer (Figure 24). Long-term decreasing trends probably reflect reduced flux of ^{99}Tc following closure of the S-3 Site. Discharge of groundwater and surface water carrying ^{99}Tc from the NT-1 and NT-2 catchments (U.S. Department of Energy 1997) and inflow along the losing reach of Bear Creek south of Sanitary Landfill I probably explains why gross

beta activity is higher in the groundwater at Exit Pathway Picket B than in the groundwater upgradient at Exit Pathway Picket C or downgradient at Exit Pathway Picket A.

5.0 SURFACE WATER QUALITY DATA EVALUATION

This section presents an evaluation of surface water quality in Bear Creek, as indicated by the CY 1997 data for samples from the main channel (BCK-00.63, BCK-04.55, BCK-07.75, BCK-09.40, BCK-10.60, and BCK-11.97), one major northern tributary (NT-1), and three springs that discharge to the creek (SS-1, SS-4, and SS-5) (Figure 5). The evaluation is based on the results that meet applicable DQOs described in Section 4.0 for major ions, trace metals, VOCs, and radiological parameters; a summary of the CY 1997 results that meet the DQOs is provided in Appendix C. For the purposes of this evaluation, Bear Creek (and associated tributaries and springs) is divided into three sections: Upper Bear Creek is the main channel between the headwaters and BCK-11.97; Middle Bear Creek is the section of the main channel between BCK-11.97 and BCK-09.40; and Lower Bear Creek is the section of the main channel downstream of BCK-09.40.

The CY 1997 maximum results reported for the principal contaminants at each sampling location are presented below.

Sampling Point	Inorganics (mg/L)		Organics (µg/L)			Radioactivity (pCi/L)	
	Nitrate	Uranium	PCE	TCE	1,2-DCE	Gross Alpha	Gross Beta
Upper Bear Creek							
NT-01	382	0.32	19	1	1	100	920
SS-1	14.6	0.047	2	ND	ND	20	42
BCK-11.97	135	0.11	ND	ND	ND	21	270
Middle Bear Creek							
BCK-10.60	17	0.084	ND	ND	ND	48	45
SS-4	42	0.13	ND	10	5	50	100
SS-5	11.4	0.07	ND	3	ND	18	34
BCK-09.40	10.6	0.066	1	ND	5	32	37
Lower Bear Creek							
BCK-07.75	9.43	0.066	ND	ND	3	22	29
BCK-04.55	5.68	0.046	ND	ND	ND	19	17
BCK-00.63	2.16	0.021	ND	ND	ND	11	9
Note: Results for each sampling point may be from more than one sampling date. "ND"=not detected; BOLD =exceeds water quality standard (MCL or UTL).							

As shown in the preceding data summary, contaminant concentrations in Bear Creek decrease with distance from the S-3 Site. Localized segments of the creek show increases in the concentration of

some contaminants with distance from the S-3 Site that reflects input of contaminated groundwater from other waste sites or from the Aquifer.

5.1 Upper Bear Creek

The surface water quality in the upper reaches of Bear Creek primarily reflects discharge of contaminated groundwater from the water table interval in the Aquitard and Aquifer downgradient of the S-3 Site. Discharge of contaminated groundwater from the Aquitard is demonstrated by results for samples collected from tributary NT-1, and results for spring SS-1 show influx of contaminated groundwater from the Aquifer. The highest levels of nitrate, PCE, and gross beta activity were reported for samples from NT-1, suggesting migration along strike from the S-3 Site in the Aquitard for these contaminants. As indicated by the nitrate concentrations and gross alpha activity reported since 1990, contaminant levels in Upper Bear Creek fluctuate seasonally but generally decrease with time (Figure 25). Decreasing contaminant concentrations in the upper part of Bear Creek mirror the decreasing concentration trends evident in the shallow groundwater near the S-3 Site. Additionally, contaminant concentrations are generally highest at BCK-11.97 during the seasonally dry periods of the year (summer and fall) when the bulk of the flow in the creek is from groundwater discharge (Figure 25). These results suggest that contaminant concentrations in Bear Creek are generally controlled by varying degrees of seasonal dilution.

5.2 Middle Bear Creek

Surface water quality in Bear Creek downstream of BCK-11.97 reflects contaminant transport from the upper reaches of the creek, from the Boneyard/Burnyard (uranium, TCE, and 1,2-DCE), and from the Burial Grounds WMA (PCE and 1,2-DCE). Much of this section of the creek loses flow to the Aquifer, particularly the section of the channel immediately south of Sanitary Landfill I, which plays an important role in transferring contaminants from the creek to the groundwater.

Concentrations of nitrate, a "signature" constituent of the plume that originates from the S-3 Site, generally decrease steadily with distance from the site. However, concentrations of other contaminants do not show as strong a decrease with distance downstream, which reflects influx of

contaminants from other sources. For example, maximum nitrate concentrations and gross beta activity at BCK-10.60 are significantly lower (69% and 66%, respectively) than the maximum levels reported for BCK-11.97, whereas the uranium concentration at BCK-10.60 is similar (8% lower) and gross alpha activity is slightly higher (3%) than at BCK-11.97. These results show input of uranium from the Boneyard/Burnyard, which lies between BCK-11.97 and BCK-10.60 (Figures 2 and 5). As noted in Section 4.4.2, surface water in each tributary that drains the Bear Creek Burial Grounds WMA is radiologically contaminated, with the highest activities evident in the southern branch of NT-8 (U.S. Department of Energy 1997). Inflow of groundwater and surface water from the catchments of these tributaries probably accounts for the gross alpha and gross beta activity in Bear Creek at BCK-09.40. The long-term trend for nitrate concentration at BCK-09.40 shows a general decrease while the long-term trend for gross alpha activity remains fairly constant (Figure 25).

Discharge of groundwater from springs SS-4 and SS-5 sustains flow in the Bear Creek during seasonally low flow periods (U.S. Department of Energy 1997) and contributes to surface water contamination downstream of BCK-11.97. As shown in the preceding summary of CY 1997 data, groundwater discharged from both springs contains nitrate, uranium, PCE, gross alpha (i.e., uranium isotopes), and gross beta (i.e., uranium isotopes and/or ⁹⁹Tc), with the higher levels of each contaminant evident for spring SS-4. Higher concentrations in the groundwater discharged from spring SS-4 probably reflect transfer of contaminants from Bear Creek into the Aquifer along the losing reach of the creek upgradient of the spring (U.S. Department of Energy 1997).

5.3 Lower Bear Creek

As shown in the preceding data summary, surface water downstream of BCK-09.40 contains slightly elevated concentrations of several contaminants, but only uranium is consistently above applicable groundwater quality standards. Long-term trends for nitrate concentration and gross alpha activity show a general decrease at BCK-04.55 (Figure 25). Results for BCK-00.63 reflect surface water quality as it exits the regime. Total uranium and gross alpha activity are the only constituents with results above groundwater quality standards.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The groundwater and surface water quality data obtained during CY 1997 are generally consistent with historical results regarding the sources of contamination in the Bear Creek Regime, the types of contaminants from each source area, the pattern and extent of groundwater transport in the Aquitard and the Aquifer, and the downstream extent of surface water contamination in Bear Creek. This conclusion is based on evaluation of the data for the primary groundwater and surface water contaminants (nitrate, barium, boron, strontium, uranium, PCE, TCE, gross alpha, and gross beta).

Most of the Aquitard wells that were sampled during CY 1997 monitor uncontaminated calcium-magnesium-bicarbonate groundwater upgradient of the waste management sites in the Bear Creek Regime. Results that indicate groundwater contamination, summarized below, are consistent with historical data and indicate strike-parallel migration of contaminants from the S-3 Site (GW-085, GW-276, GW-537, and GW-829) and the Bear Creek Burial Grounds WMA (GW-627 and GW-653).

Aquitard Well	Groundwater Contaminant (●) Above MCL (★)							
	Nitrate	Barium	Boron	Strontium	Uranium	VOCs	Gross Alpha	Gross Beta
GW-085	★	.	●	.	●	.	.	●
GW-276	★	.	●	.	●	★	★	★
GW-287	.	.	.	●	.	●	.	.
GW-537	★	★	.	●	.	★	.	★
GW-627	★	.	.
GW-653	●	.	.
GW-829	★	●	.	●

Slow, westward migration of the center of mass of the contaminant plume originating from the S-3 Site should produce increasing long-term concentration trends in the shallow groundwater near NT-1 and NT-2 (U. S. Department of Energy 1997), and increasing gross beta trends indicated by historical data for wells GW-085 and GW-537 support this interpretation. However, nitrate, barium, and strontium results for these wells do not clearly indicate increasing long-term concentration trends. Mobilization of DNAPL encountered south (downdip) of BG-A South in January 1990 probably

accounts for the coincident detection and subsequent increase of dissolved TCE and PCE in the groundwater at well GW-627.

Each of the Aquifer wells sampled during CY 1997 monitor calcium-magnesium-bicarbonate groundwater downgradient of at least one contaminant source area in the Bear Creek Regime. Results reported for the Aquifer wells in the following summary (listed in general order from upgradient to downgradient) reflect transport of the specified contaminants from one or more of the source areas.

Well Location/Number	Groundwater Contaminant (●) Above MCL (★)					
	Nitrate	Boron	Uranium	VOCs	Gross Alpha	Gross Beta
Spoil Area I GW-315	★	.	.	★	.	.
Rust Spoil Area GW-311	.	.	.	★	.	.
Exit Pathway Picket C GW-724 GW-725 GW-738 GW-740	★	.	.	★	.	●
	★	.	.	★	.	●
	★	.	.	★	.	.
	●	.	.	★	.	.
Exit Pathway Picket B GW-621 GW-695 GW-703 GW-704 GW-706	●
	●	.	.	★	.	.
	★	.	.	★	.	.
	★	.	.	★	.	.
	★	.	●	★	★	★
BG-A South GW-053	.	●	.	●	.	.
Exit Pathway Picket A GW-683 GW-684 GW-685	★	.	●	.	★	.
	●	.	●	.	●	.
	●	.	.	●	.	.
Exit Pathway Picket W GW-714	●	●

Results for these Aquifer wells are generally consistent with respective historical data and indicate influx/transport of contaminants from: the S-3 Site (nitrate, gross beta, and VOCs); Spoil Area I (VOCs); the Rust Spoil Area (VOCs), including a nearby unidentified source in the Bear Creek floodplain; the Oil Landfarm WMA, including the Boneyard/Burnyard/HCDA (uranium, gross alpha, and VOCs) and Sanitary Landfill I (VOCs); and the Bear Creek Burial Grounds WMA (boron, uranium, and VOCs).

The CY 1997 results for samples from Bear Creek are consistent with historical data showing decreasing contaminant concentrations in the creek and springs that discharge into the creek. As shown in the following summary, most of the principal groundwater contaminants were detected above water quality screening levels in samples collected upstream of BCK-09.40.

Sampling Station	Surface Water Contaminant (●) Above MCL (★)					
	Nitrate	Uranium	VOCs	Gross Alpha	Gross Beta	
Upper Bear Creek	NT-01	★	●	★	★	★
	SS-1	★	●	●	★	●
	BCK-11.97	★	●	.	★	★
Middle Bear Creek	BCK-10.60	★	●	.	★	●
	SS-4	★	●	★	★	★
	SS-5	★	●	●	★	●
	BCK-09.40	★	●	●	★	●
Lower Bear Creek	BCK-07.75	●	●	●	★	.
	BCK-04.55	●	●	.	★	.
	BCK-00.63	●	●	.	★	.

The CY 1997 data for each sampling location also reflect seasonal concentration fluctuations; concentrations are typically highest during seasonally dry periods when groundwater discharge provides the bulk of the flow in the creek.

Groundwater and surface water sampling and analysis activities planned for the Bear Creek Regime during CY 1999 are specified in the *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant for Calendar Year 1999* (AJA Technical Services, Inc. 1998b). Besides these planned monitoring activities, the following actions are recommended:

- Collect groundwater samples (one time only) from the following wells: GW-345, GW-346, and GW-526 near the S-3 Site; GW-087 near the Boneyard/Burnyard/HCDA; GW-082, GW-126, and GW-242 at the Bear Creek Burial Grounds; and GW-601 in the Maynardville Limestone south of Sanitary Landfill I. None of these wells have been sampled since 1995 and two wells have not been sampled since 1990. Furthermore, the existing data for these wells were obtained from samples collected using the old sampling procedure (three well-volume purging) and new data would reflect the current sampling procedure (low-flow minimal drawdown purging/sampling).

- Collect surface water samples (one time only) from the following tributaries at locations near the confluence with Bear Creek: NT-2, NT-6, NT-7, NT-8. These tributaries have not been sampled since 1995.
- Collect groundwater samples (one time only) from eight sampling ports (135 to 586 ft bgs) of Westbay well GW-726 to investigate westward migration of VOCs from the DNAPL south of the Bear Creek Burial Grounds (BG-A South).

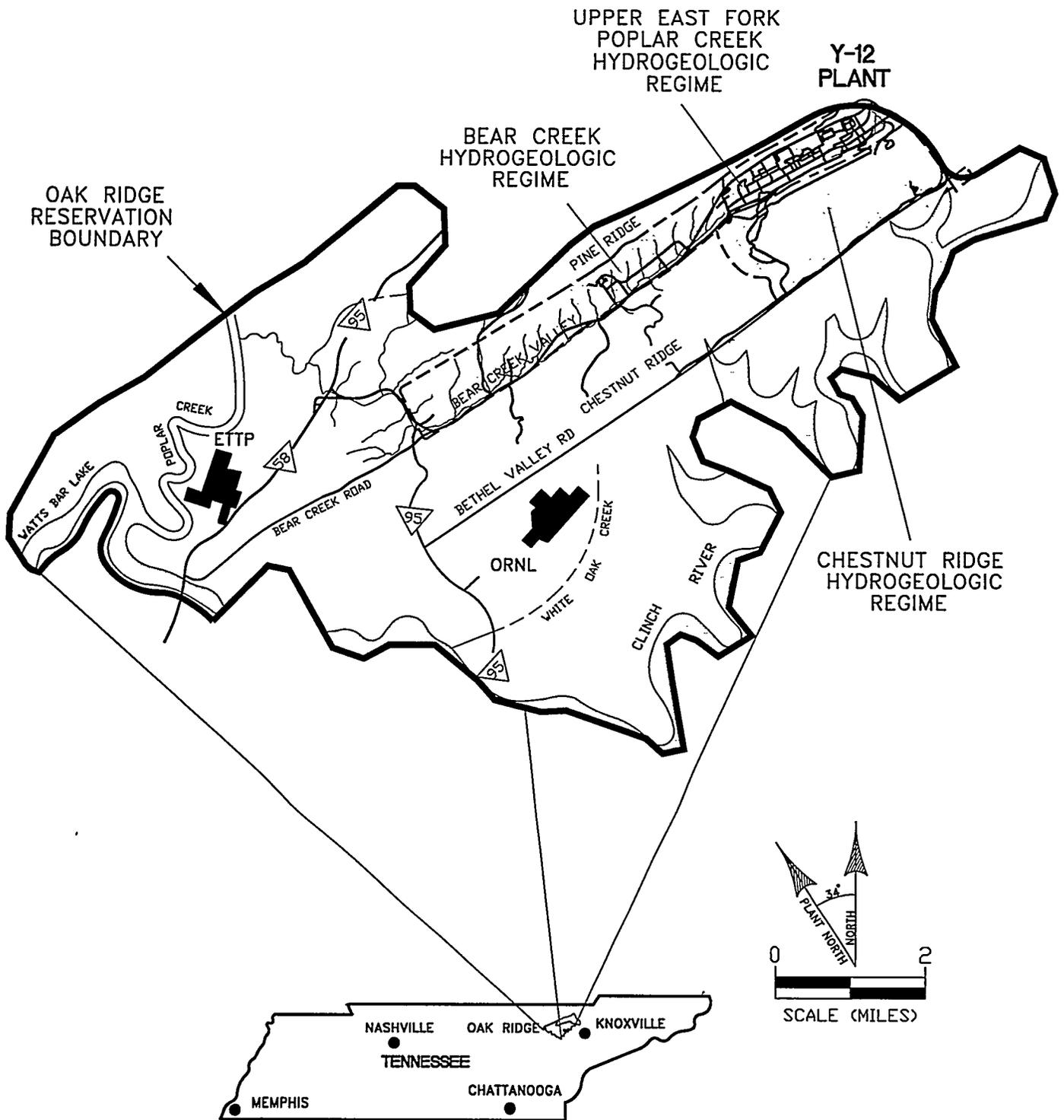
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APPENDIX A

FIGURES



PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

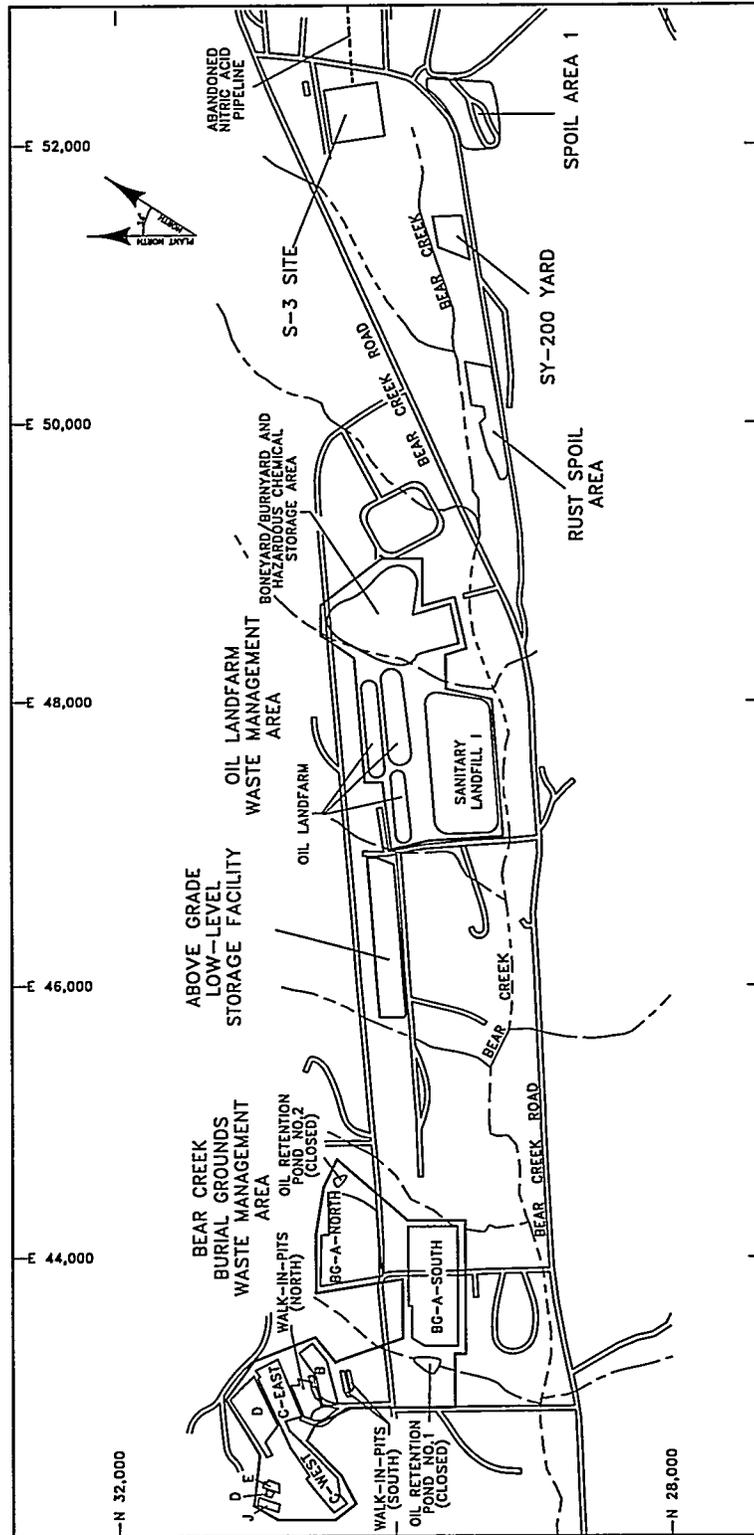
LOCATION: Y-12 PLANT
OAK RIDGE, TN.

FIGURE 1

PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

DOC NUMBER: MVM64V/1
DWG ID.: 97-007
DATE: 5-22-98

HYDROGEOLOGIC REGIMES
AT THE Y-12 PLANT



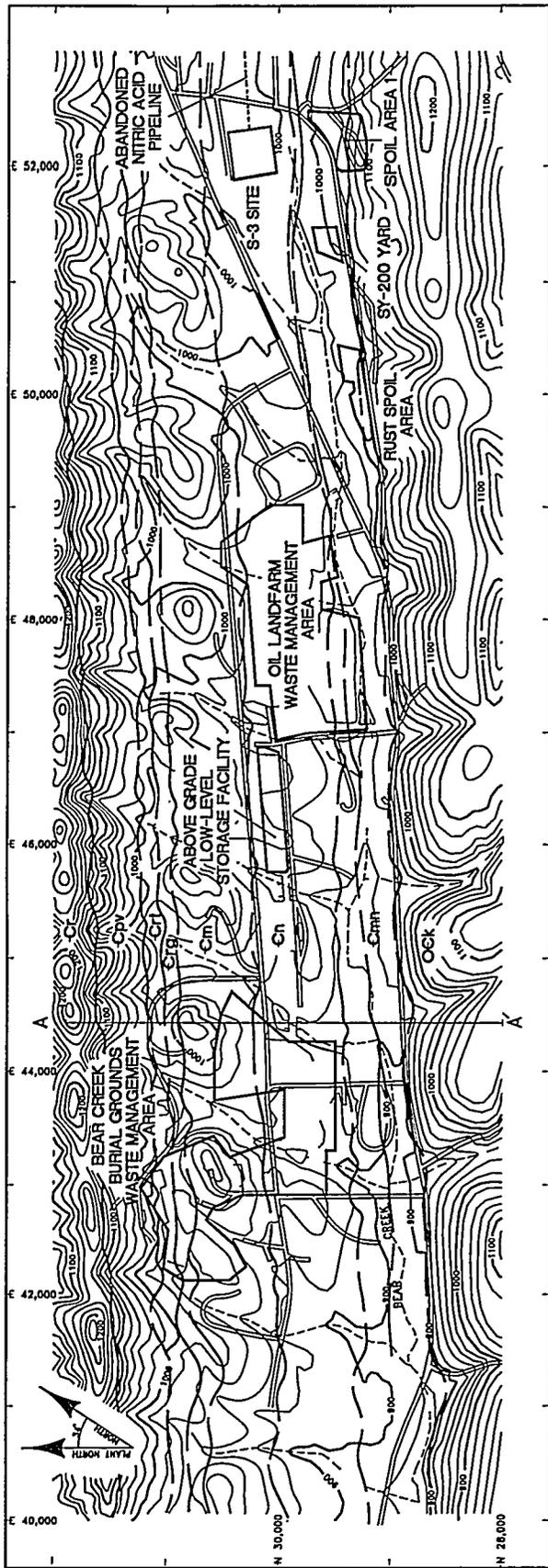
PREPARED FOR:
**LOCKHEED MARTIN
 ENERGY SYSTEMS, INC.**

PREPARED BY:
**AJA TECHNICAL
 SERVICES, INC.**

LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DOC NUMBER:	MVM64V/1
DWG ID.:	96-035
DATE:	9-7-98

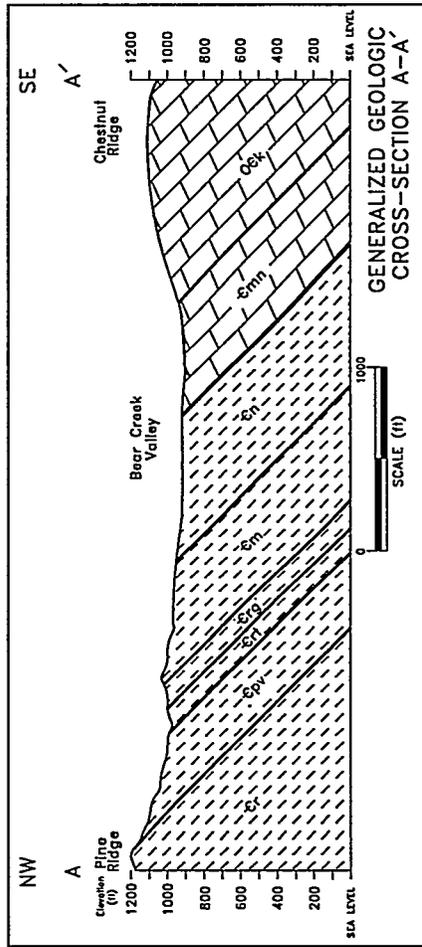
FIGURE 2

**WASTE MANAGEMENT SITES
 AND REGULATED UNITS IN THE
 BEAR CREEK HYDROGEOLOGIC REGIME**



SOURCE: King and Haase, 1987

SYSTEM GROUP	GROUP	HYDRO UNIT	FORMATION	MAP SYMBOL	THICKNESS (ft)
CAMBRIAN	UPPER	KNOX AQUIFER	COPPER RIDGE DOLOMITE	Ock	NOT DETERMINED
	MIDDLE		MAYNARDVILLE LIMESTONE	cmn	418-450
ORR AQUITARDS	CONASAUGA	ORR AQUITARDS	NOLICHUCKY SHALE	Cn	422-550
			MARYVILLE LIMESTONE	Cm	346-445
			ROGERSVILLE SHALE	Crg	90-120
			RUTLEDGE LIMESTONE	CrI	90-120
			PUMPKIN VALLEY SHALE	Cpv	260-320
LOWER			ROME	Cr	NOT DETERMINED



ORR AQUITARDS
 KNOX AQUIFER

PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

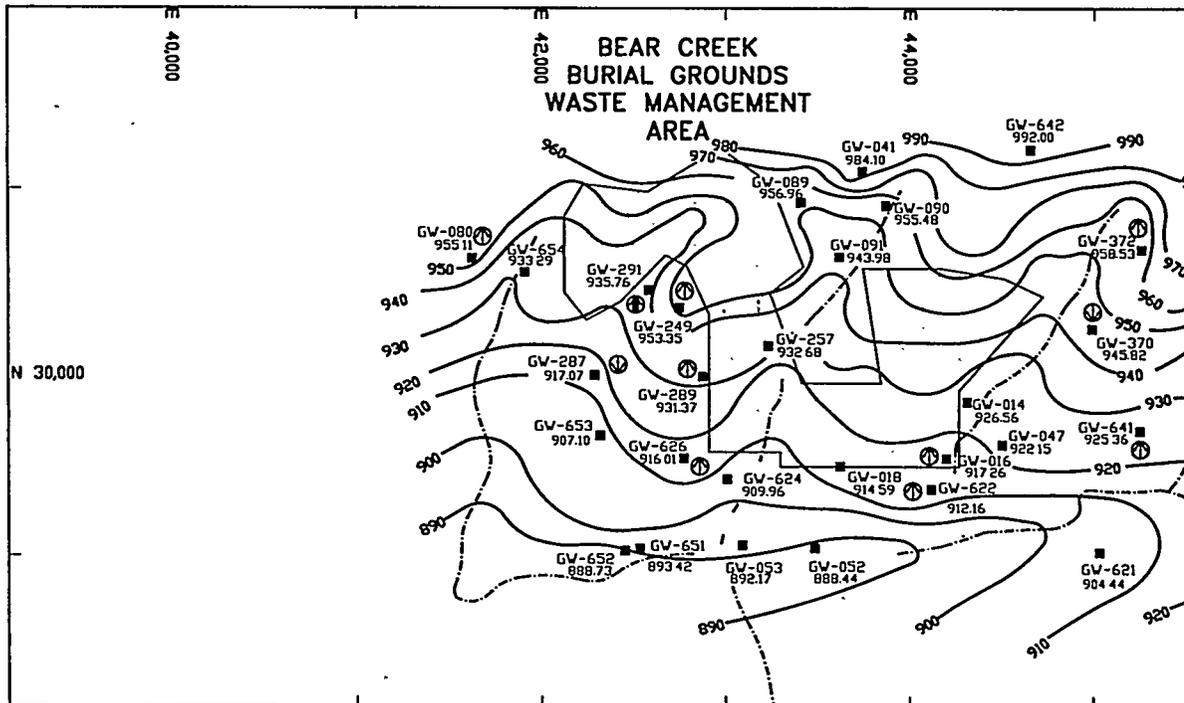
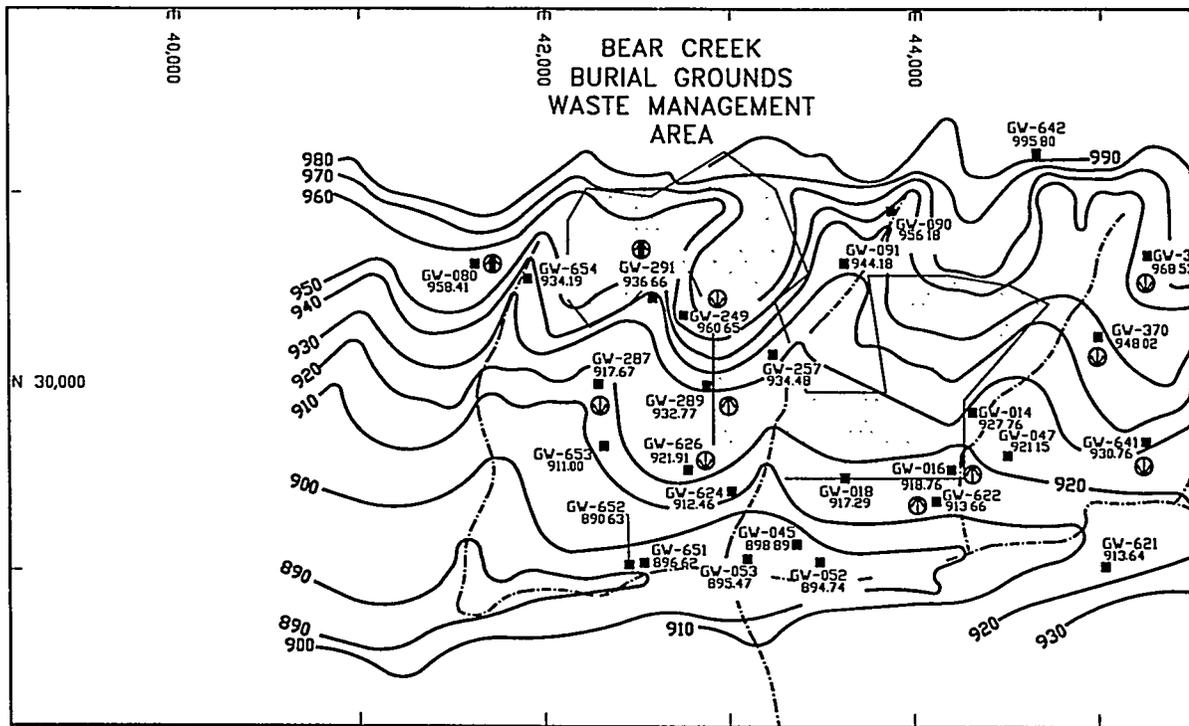
LOCATION: Y-12 PLANT OAK RIDGE, TN.

FIGURE 3

PREPARED BY:
AJA TECHNICAL SERVICES, INC.

DOC NUMBER: MVM64V/1
 DWG ID.: 96-090
 DATE: 7-9-98

TOPOGRAPHY AND BEDROCK GEOLOGY IN THE BEAR CREEK HYDROGEOLOGIC REGIME



EXPLANATION

GW-652 890.13 ■ — Water Table Monitoring Well and Groundwater Elevation (ft msl)

— Approximate Water Level Isoleth (ft msl)

- - - Surface Drainage Feature

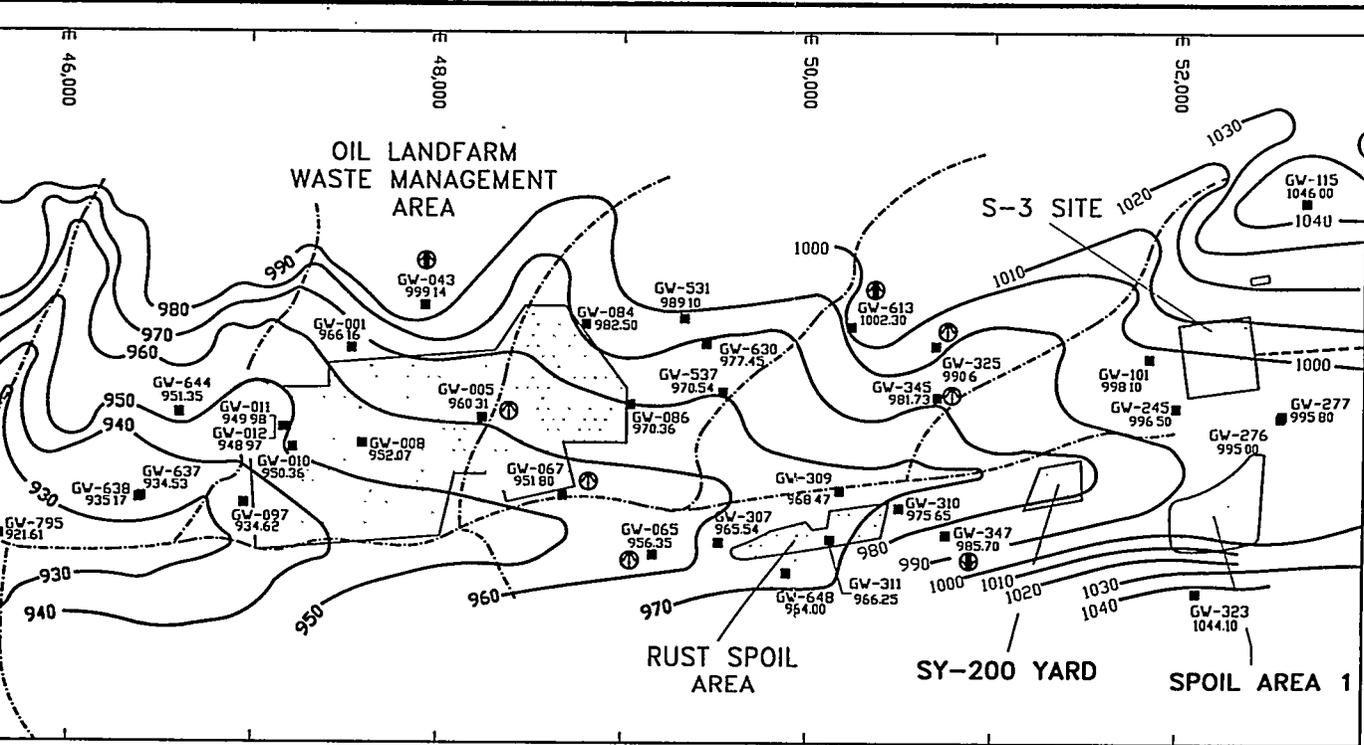
Vertical Hydraulic Gradient Determined From Data For Paired Wells

0.01-0.09 0.1-0.9 — Less Than 0.01 is Considered Insignificant

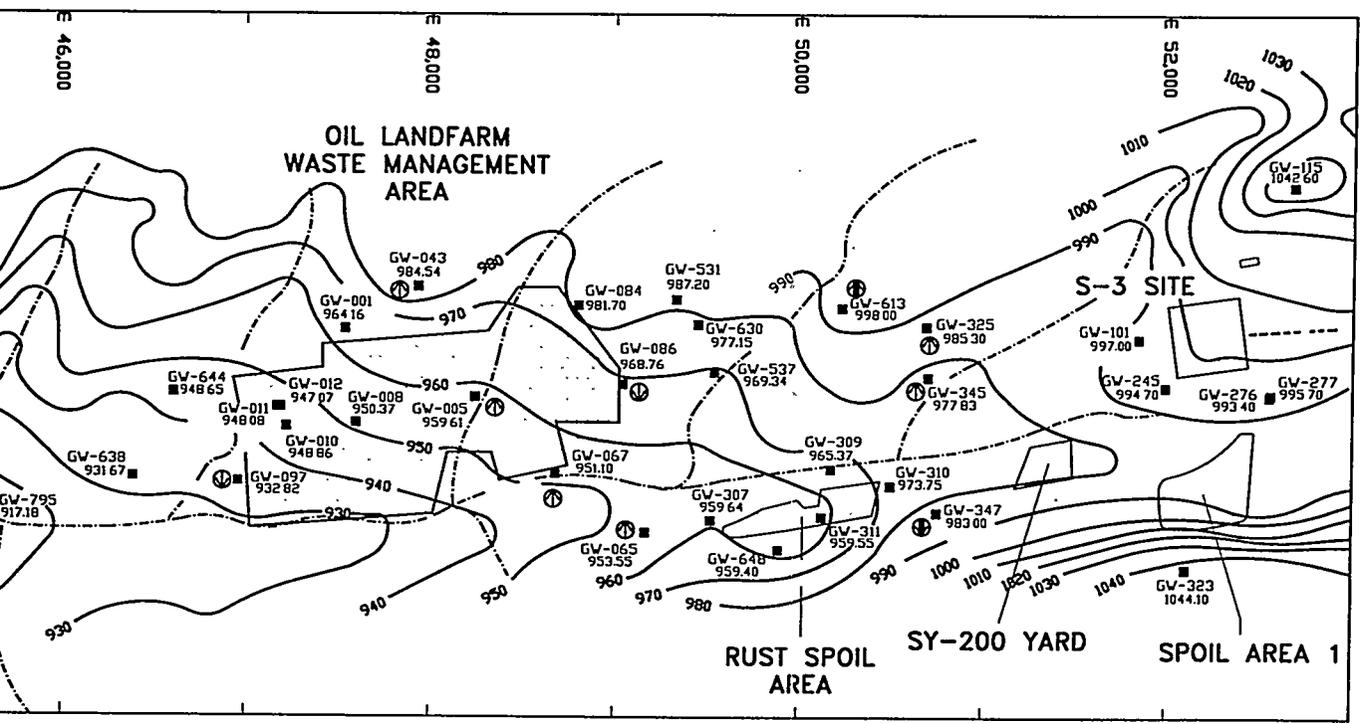
⊕ ⊕ — Upward From Bedrock Interval

⊖ ⊖ — Downward to Bedrock Interval

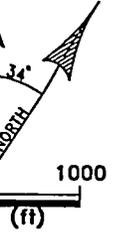




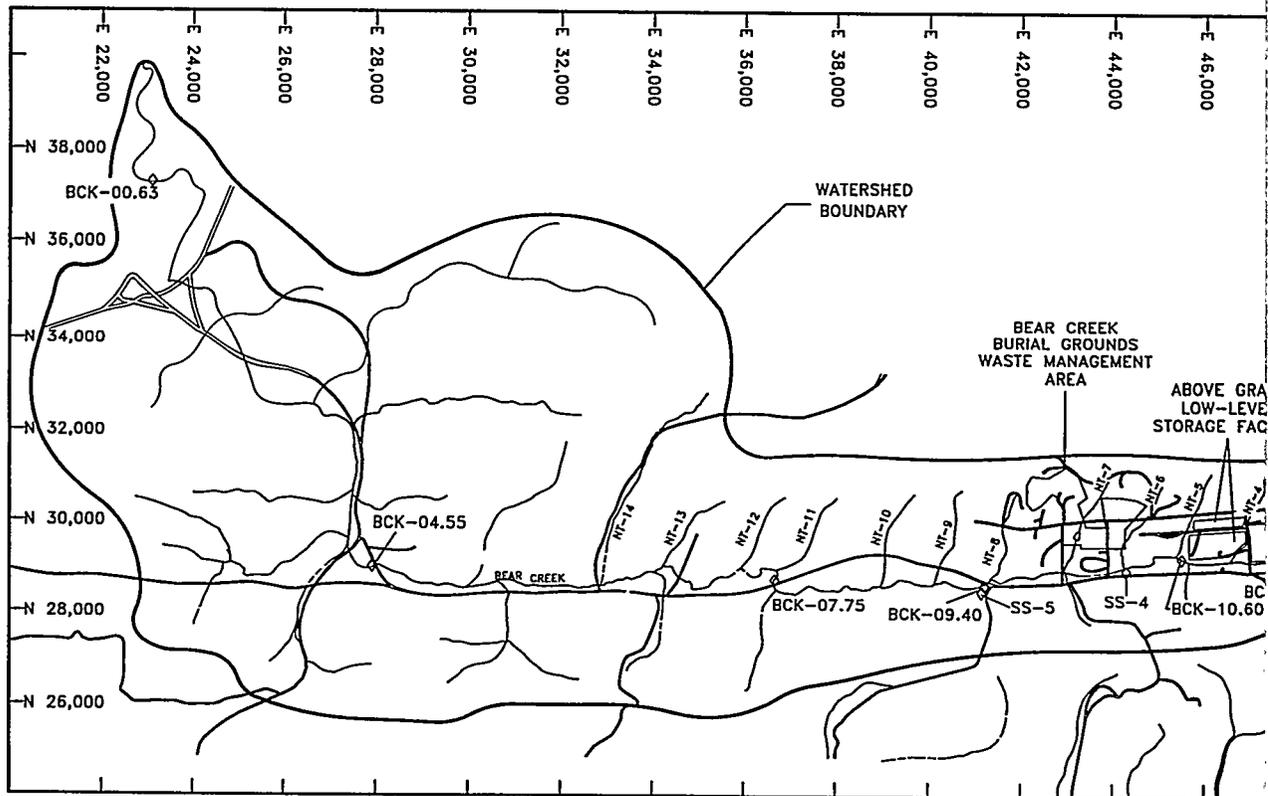
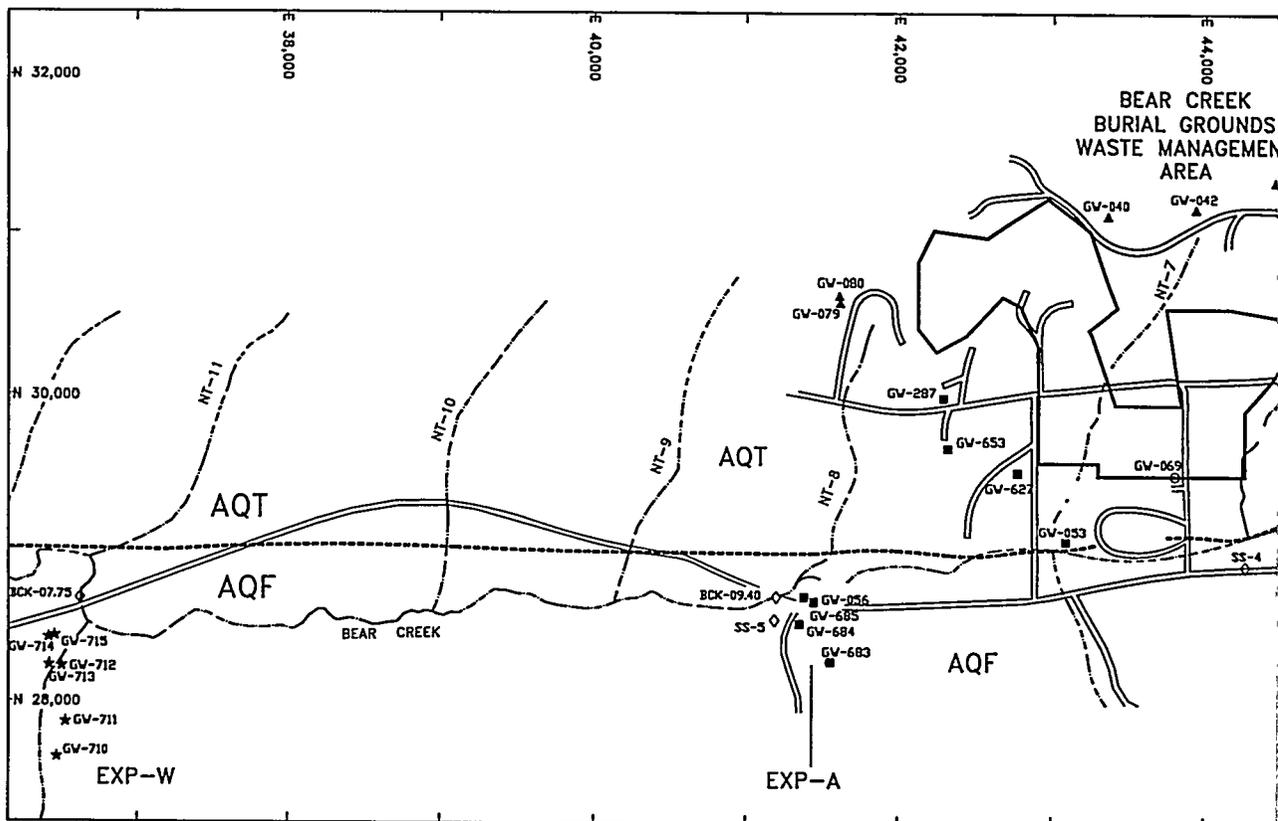
APRIL 1 - 4, 1997



OCTOBER 6 - 10, 1997

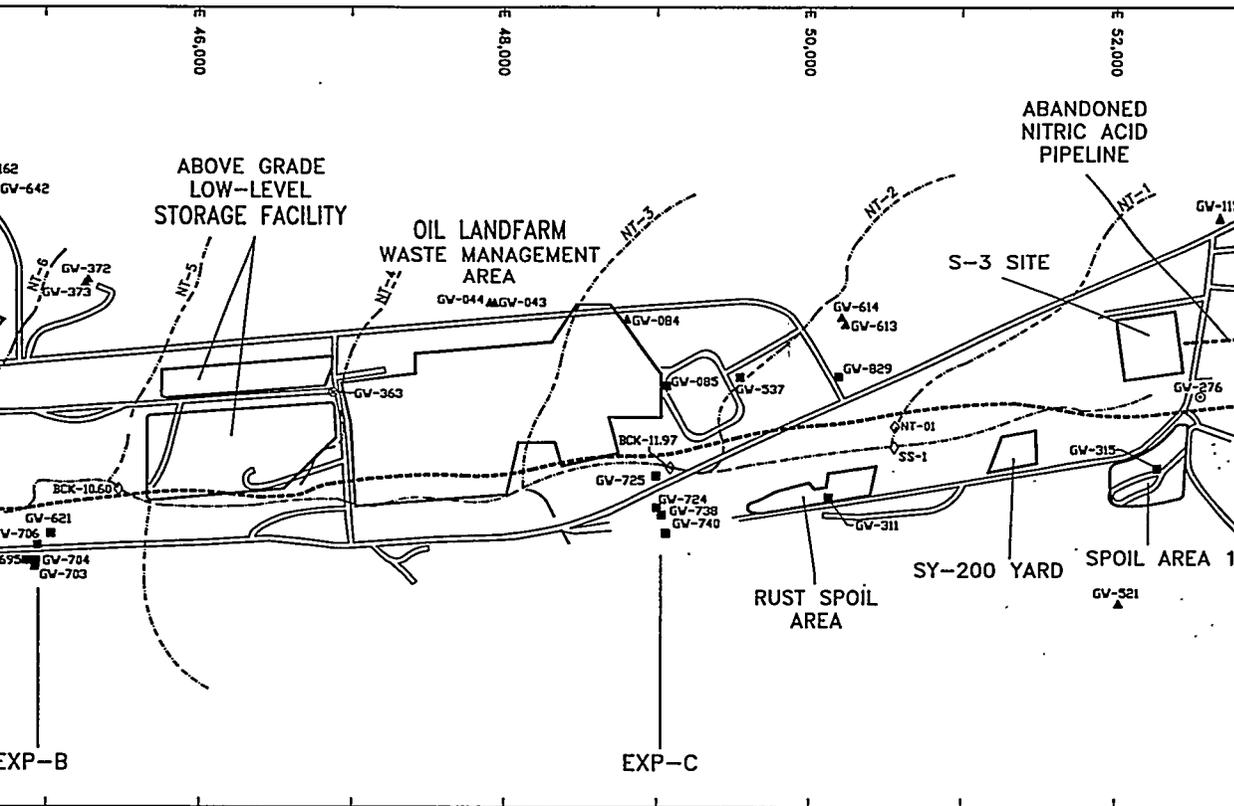


PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION: Y-12 PLANT OAK RIDGE, TN.	FIGURE 4 SEASONAL GROUNDWATER ELEVATIONS IN THE BEAR CREEK HYDROGEOLOGIC REGIME
PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC NUMBER: MVM64V/1	
	DWG ID.: 96-082	
	DATE: 9-7-98	

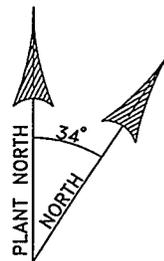
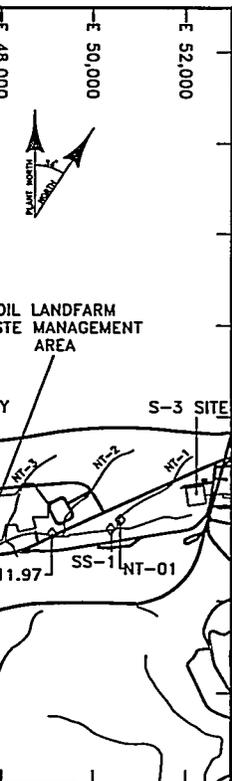


SPRINGS AND SURFACE WATER SAMPLING LOCATIONS





1250
(ft)



EXPLANATION

- — MONITORING WELL
- — RCRA POINT-OF-COMPLIANCE MONITORING WELL
- ▲ — RCRA BACKGROUND/UPGRADIENT MONITORING WELL
- ★ — RCRA PLUME DELINEATION MONITORING WELL
- ◇ — SPRING OR SURFACE WATER SAMPLING LOCATION
- EXP-C — EXIT PATHWAY, MAYNARDVILLE LIMESTONE PICKET
- — SURFACE DRAINAGE FEATURE
- NT-5 — NORTH TRIBUTARY
- AQT — AQUITARD
- - - - - APPROXIMATE NOLICHUCKY SHALE/MAYNARDVILLE LIMESTONE CONTACT AT GROUND SURFACE
- AQF — AQUIFER

PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

LOCATION: Y-12 PLANT
OAK RIDGE, TN.

FIGURE 5

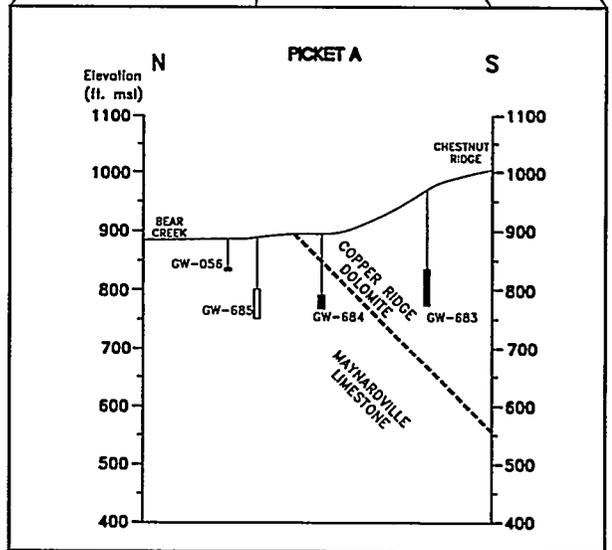
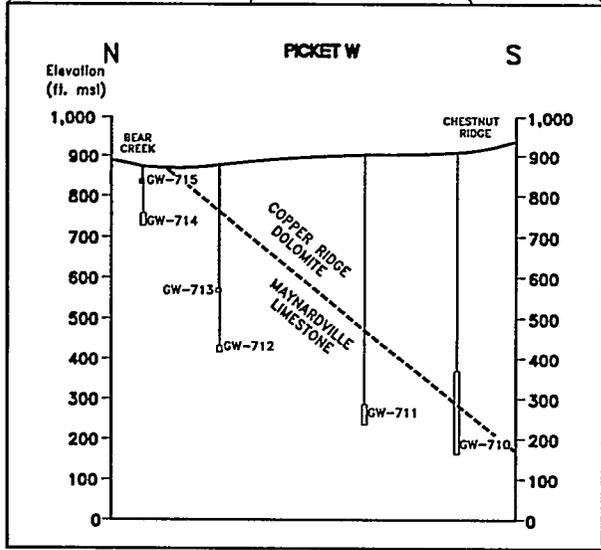
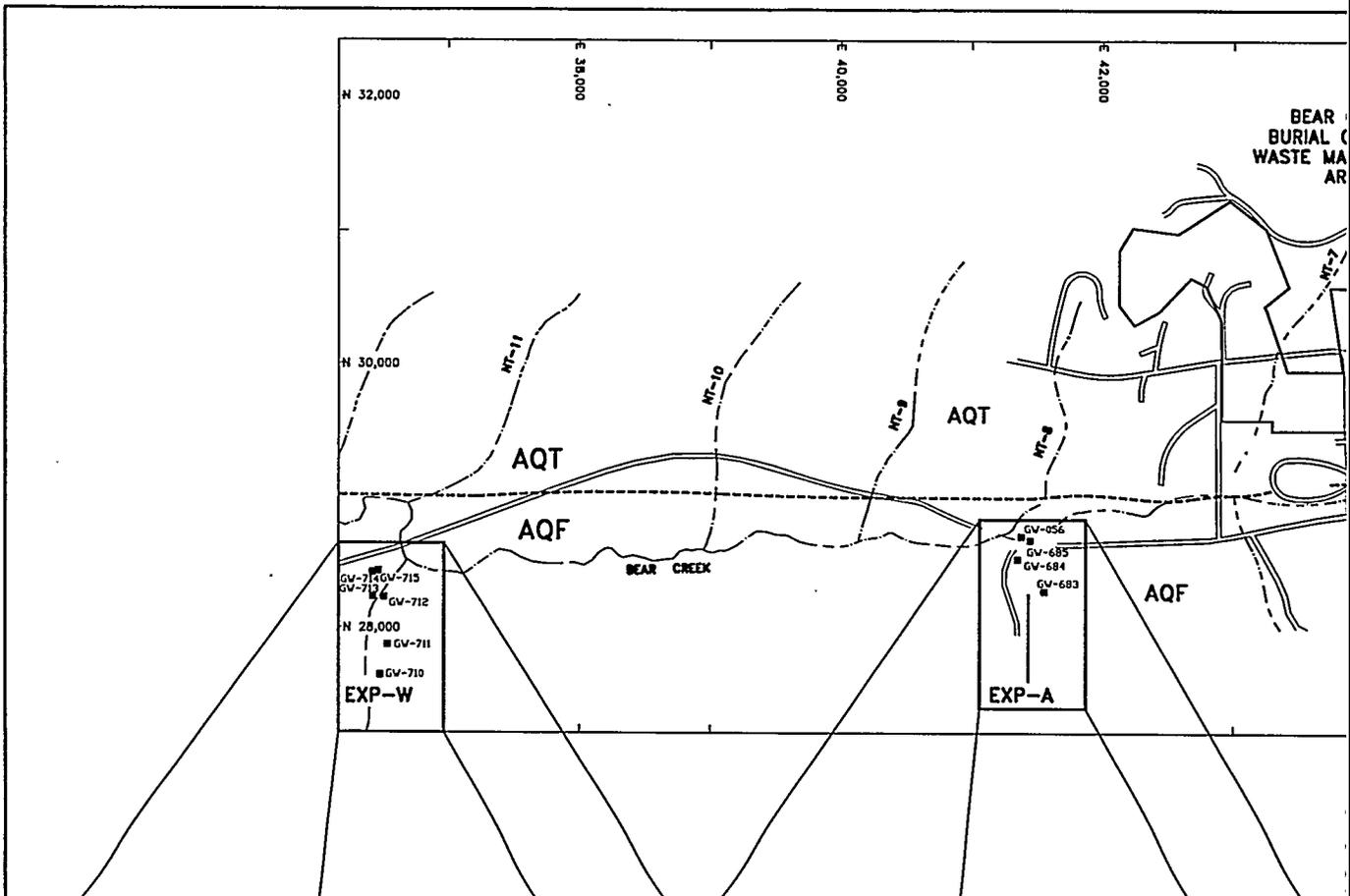
PREPARED BY:
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SERVICES, INC.**

DOC NUMBER: MVM64V/1

DWG ID.: 96-083

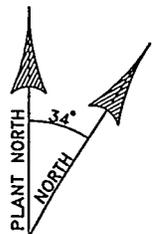
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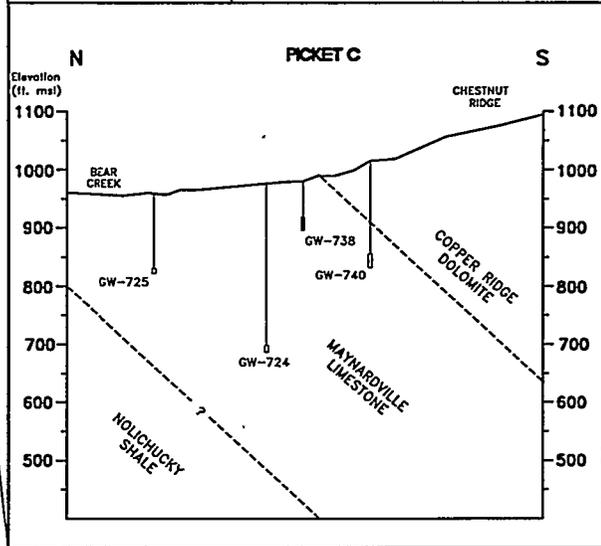
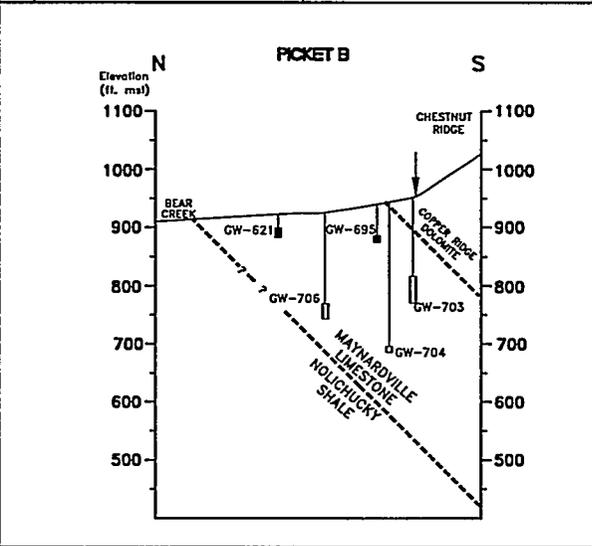
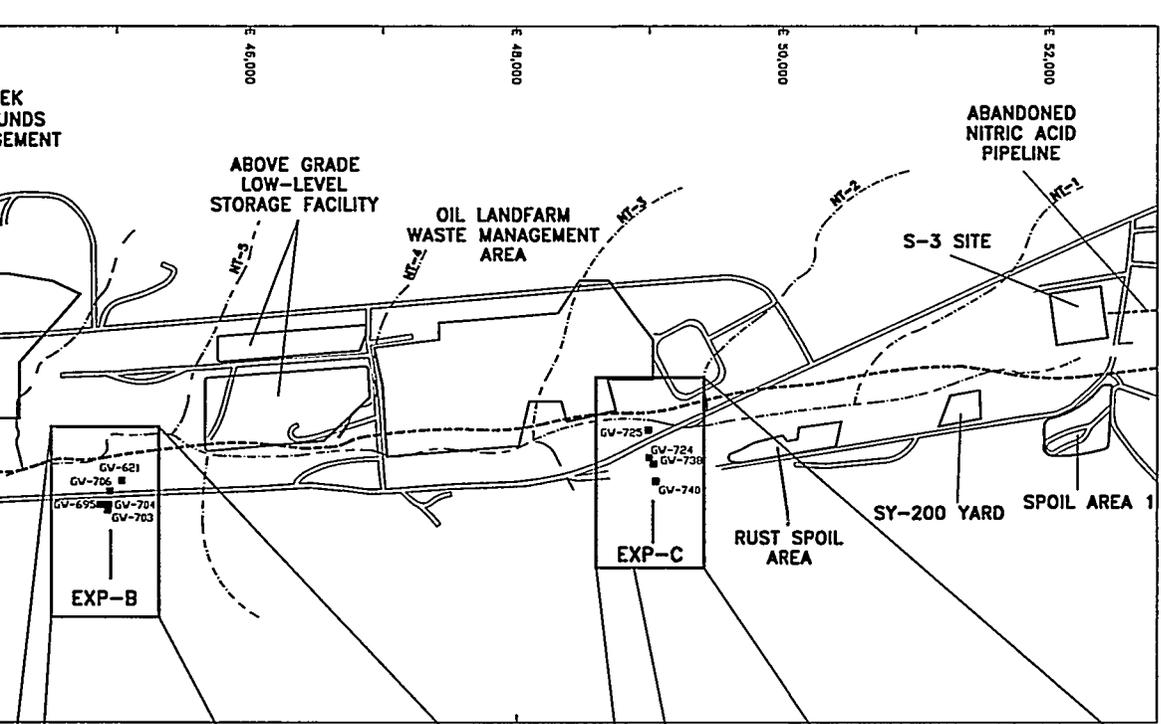
**CY 1997 GROUNDWATER AND SURFACE WATER
SAMPLING LOCATIONS**



EXPLANATION

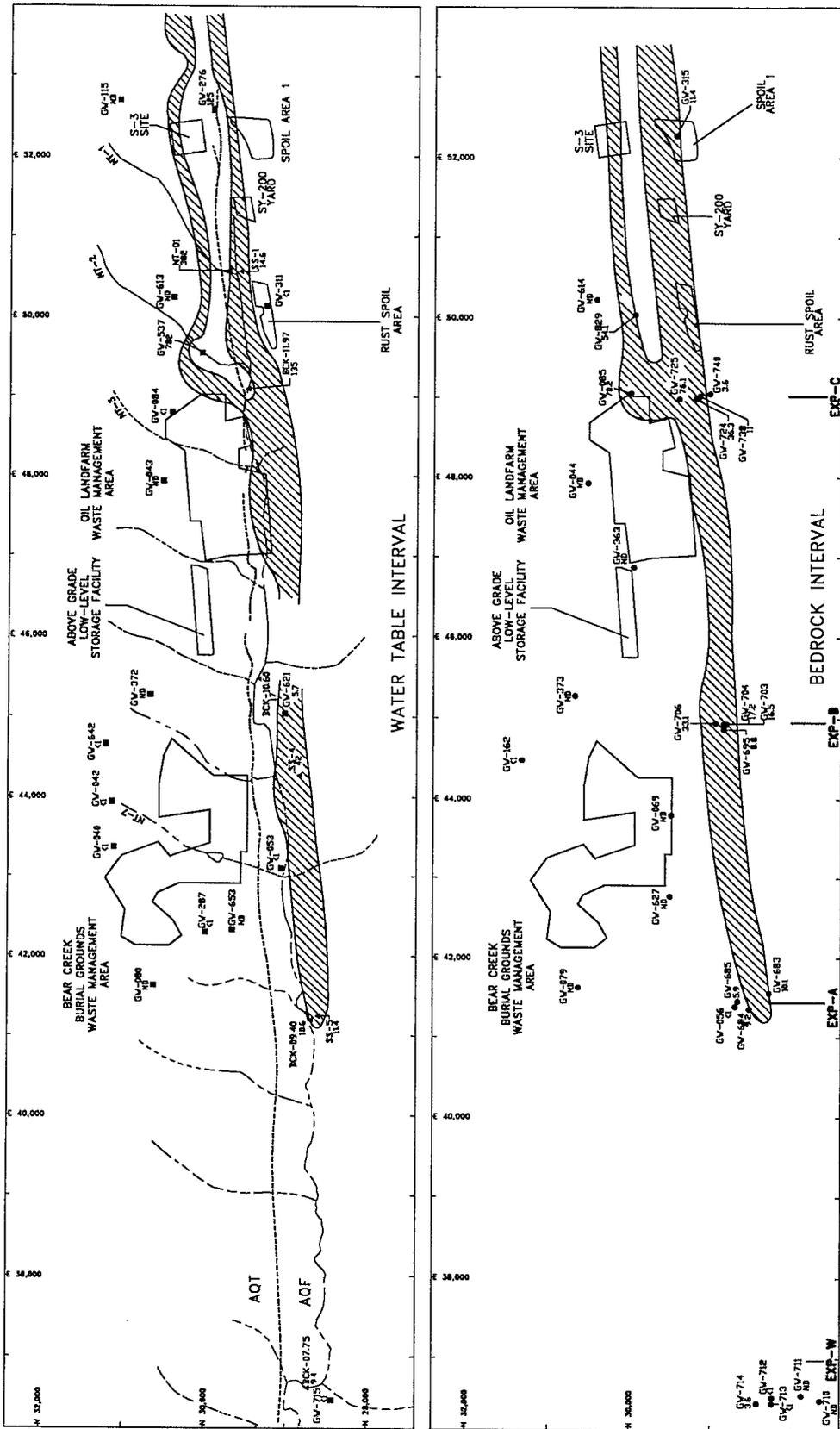
- — MONITORING WELL
- EXP-W — EXIT PATHWAY, MAYNARDVILLE LIMESTONE PICKET
- SURFACE DRAINAGE FEATURE
- NT-5 — NORTH TRIBUTARY
- AQT — AQUITARD
- - - - - APPROXIMATE NOLICHUCKY SHALE/MAYNARDVILLE LIMESTONE CONTACT AT GROUND SURFACE
- AQF — AQUIFER
- ⊥ — SCREENED WELL CONSTRUCTION
- ⊔ — OPEN-HOLE WELL CONSTRUCTION



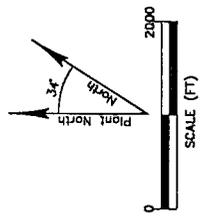


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PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC NUMBER:	MVM64V/1
	DWG ID.:	98-010
	DATE:	9-7-98

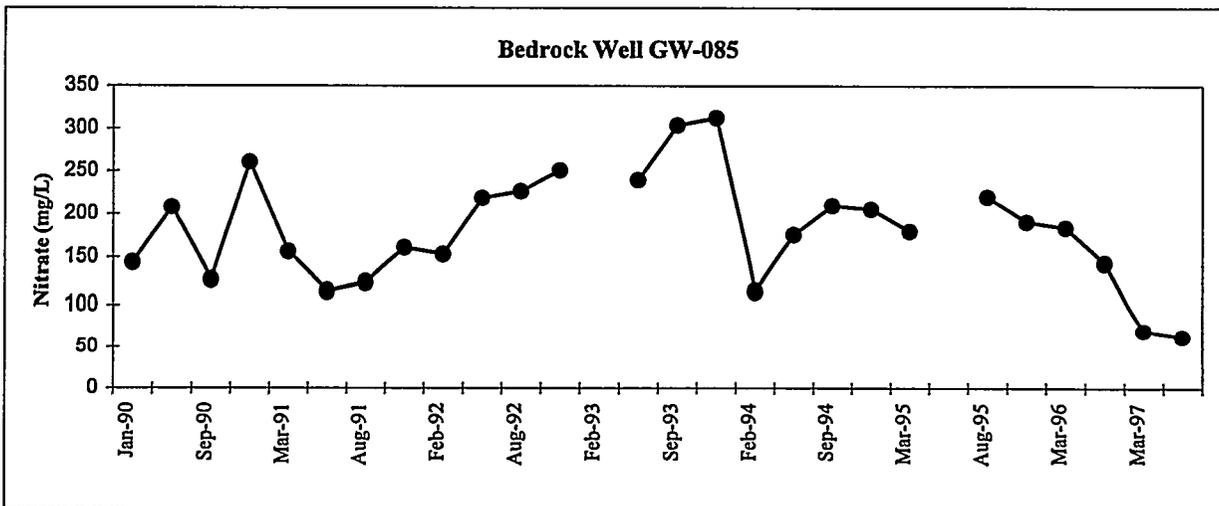
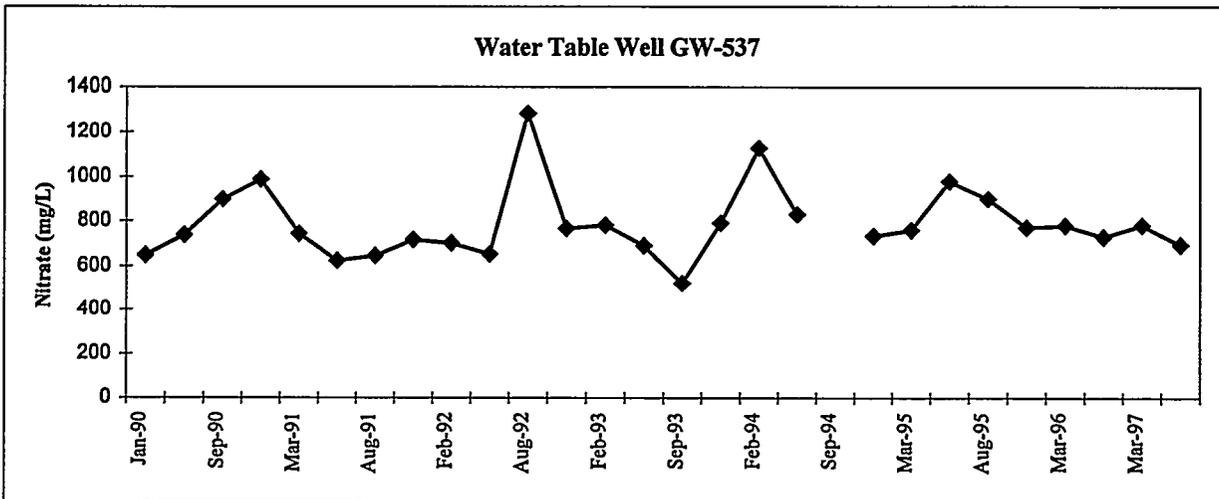
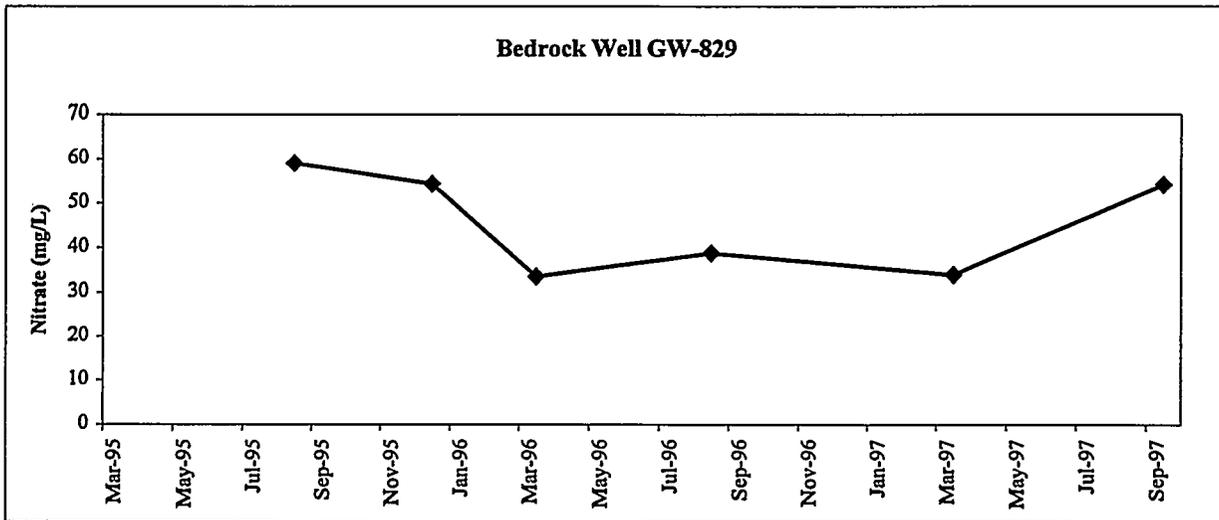
FIGURE 6
**COMPONENTS OF MAYNARDVILLE LIMESTONE
EXIT PATHWAY PICKETS A, B, C, AND W**



- EXPLANATION**
- - Water Table Monitoring Well
 - - Bedrock Monitoring Well
 - ▲ - Spring or Surface Water Sampling Station
 - EXP-A - Exit Pathway, Maynardville Limestone Picket
 - - Boundary of Site or Waste Management Area
 - - Surface Drainage Feature
 - AQT - Aquitard
 - - Approximate Geologic Contact
 - AQF - Aquifer
- 19 — CY 1997 Maximum Nitrate (as N) Concentration (mg/L)
 ND — NOT DETECTED
- Approximate Plume Boundary Based on Historic Data
- ▨ — 10-100 mg/L
 - ▩ — >100 mg/L



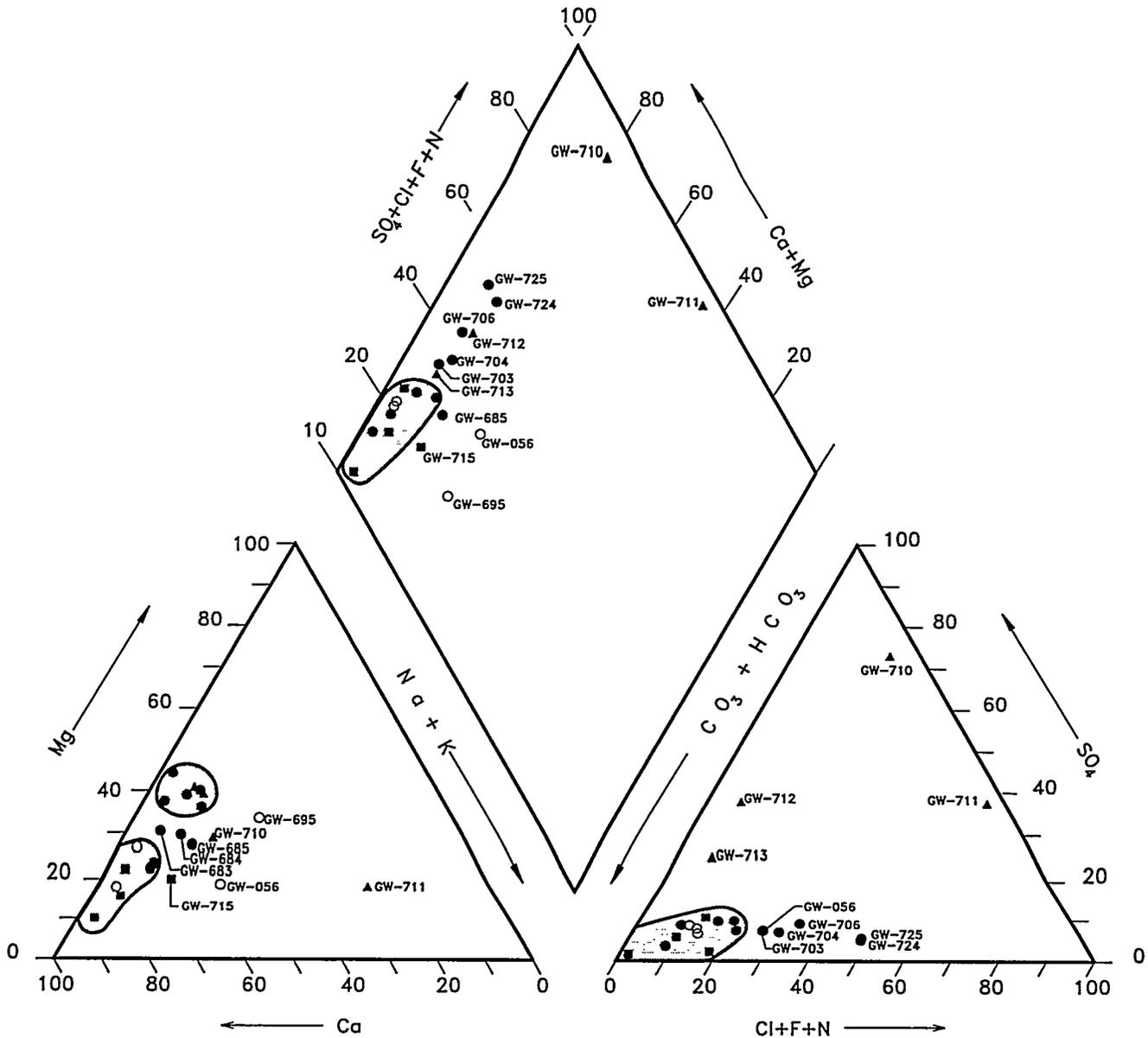
PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.		LOCATION: Y-12 PLANT OAK RIDGE, TN.	FIGURE 8 NITRATE IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK HYDROGEOLOGIC REGIME, 1997
PREPARED BY: AJA TECHNICAL SERVICES, INC.		DOC NUMBER: MVM64V/1	
		DWG ID.: 96-042 DATE: 9-7-98	



Notes: Nitrate MCL = 10 mg/L

Anomalous Results omitted: GW-829 2,210 mg/L (Mar-95), 200 mg/L (Jun-95)
 GW-537 81 mg/L (Sept-94)
 GW-085 2,139 mg/L (Feb-93), 17 mg/L (Jun-95)

PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 9 NITRATE CONCENTRATION TRENDS IN GROUNDWATER AT AQUITARD MONITORING WELLS GW-085, GW-537, AND GW-829
	DOC No.:	MVM64V/1	
	DWG ID.:	BC PT297	
PREPARED BY: AJA TECHNICAL SERVICES, INC.	DATE:	5/21/98	



EXPLANATION

- GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS, 22 WELLS ARE PLOTTED ON THIS DIGRAM
- WATER TABLE MONITORING WELL
- BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP
- BEDROCK MONITORING WELL, 100 TO 300 FT DEEP
- BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP
- SURFACE WATER OR SPRING SAMPLING LOCATION

PREPARED FOR:
**LOCKHEED MARTIN
 ENERGY SYSTEMS, INC.**

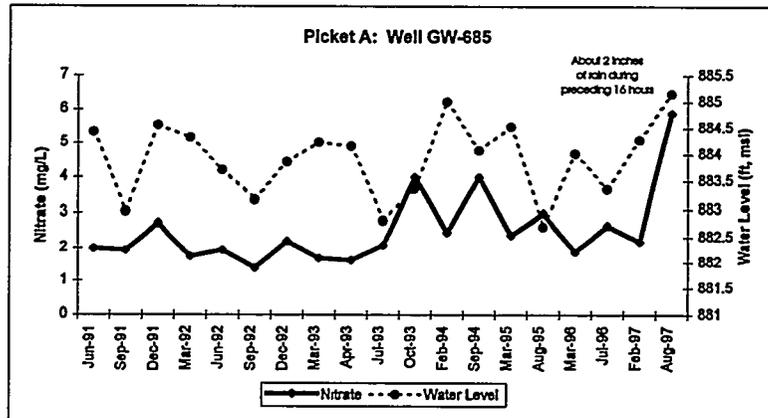
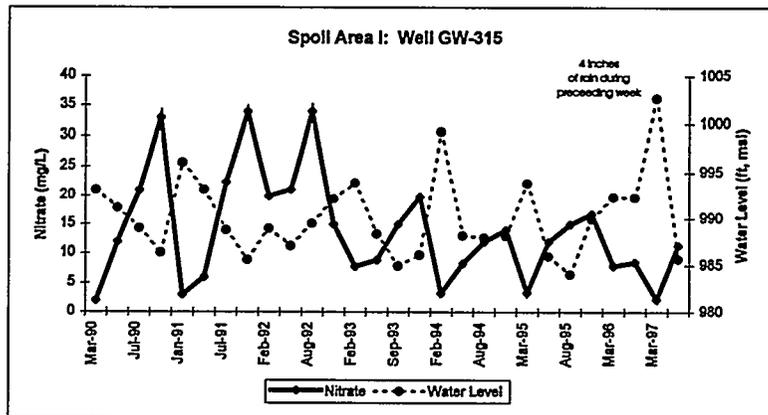
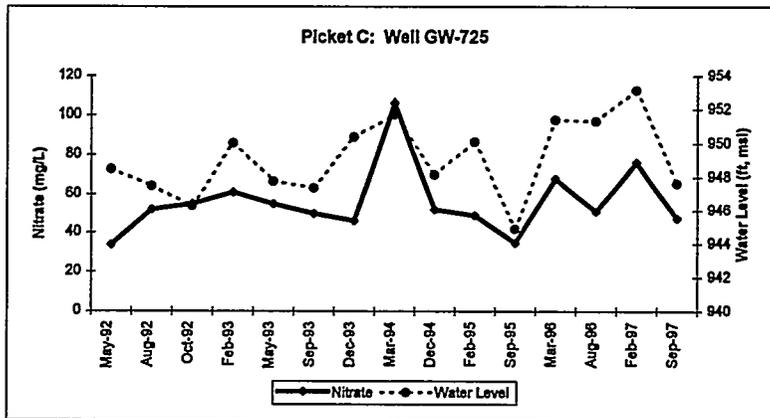
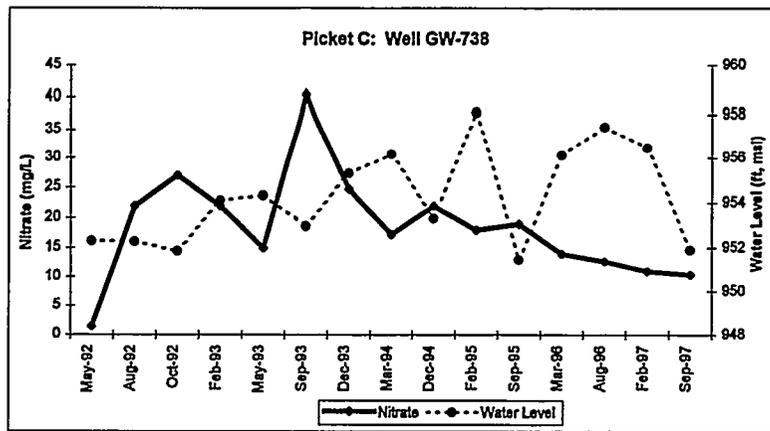
LOCATION: Y-12 PLANT
 OAK RIDGE, TN.

FIGURE 10

PREPARED BY:
**AJA TECHNICAL
 SERVICES, INC.**

DOC NUMBER: MVM64V/1
 DWG ID.: 96-039N
 DATE: 6-1-98

GROUNDWATER GEOCHEMISTRY IN THE AQUIFER



PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

LOCATION:

Y-12 PLANT
OAK RIDGE, TN.

DOC No.:

MVM64V/1

DWG ID.:

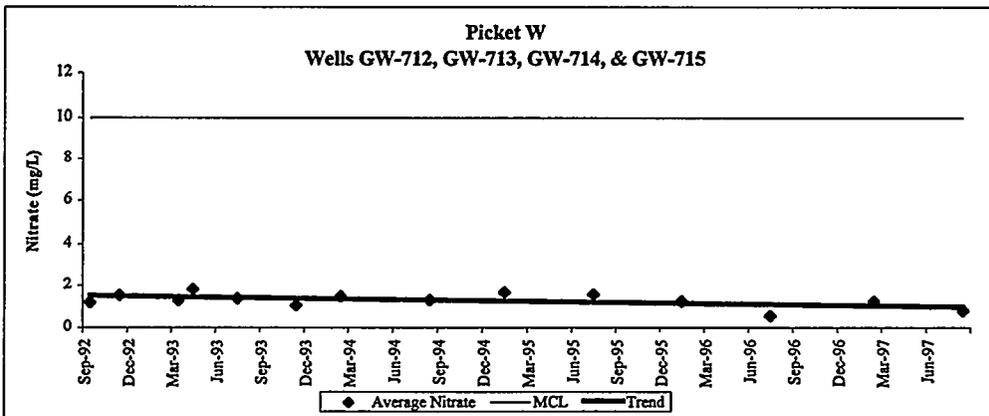
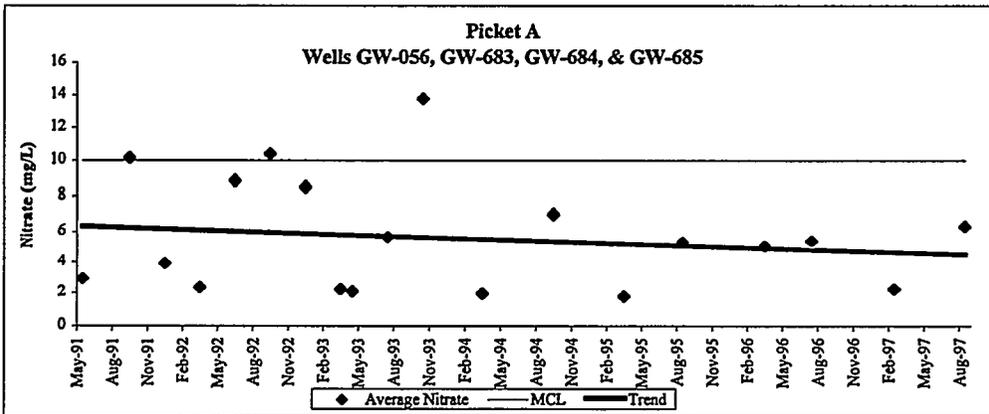
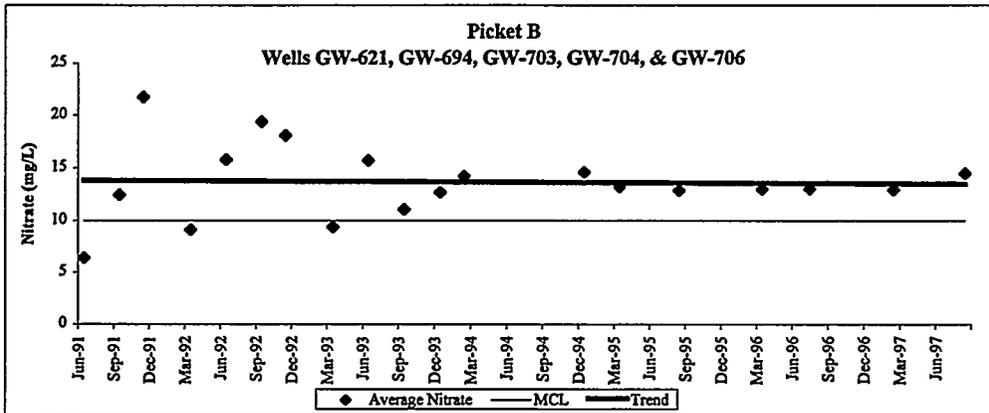
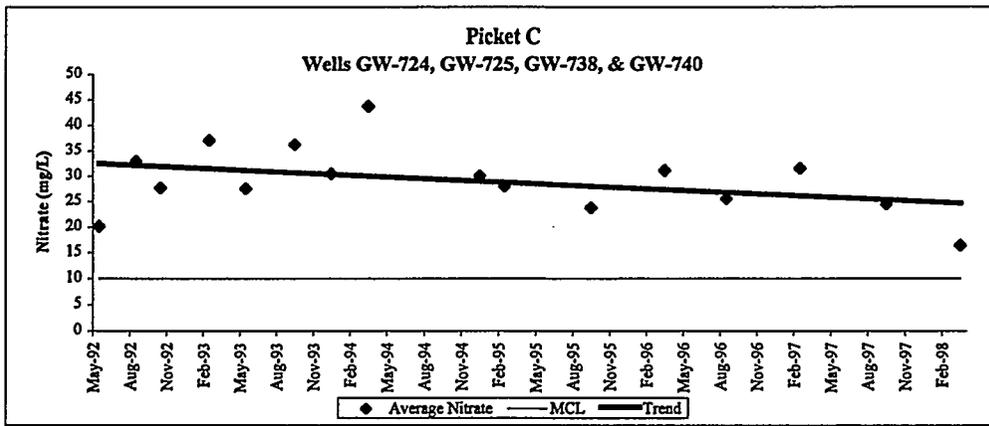
BC PT297

DATE:

5/21/98

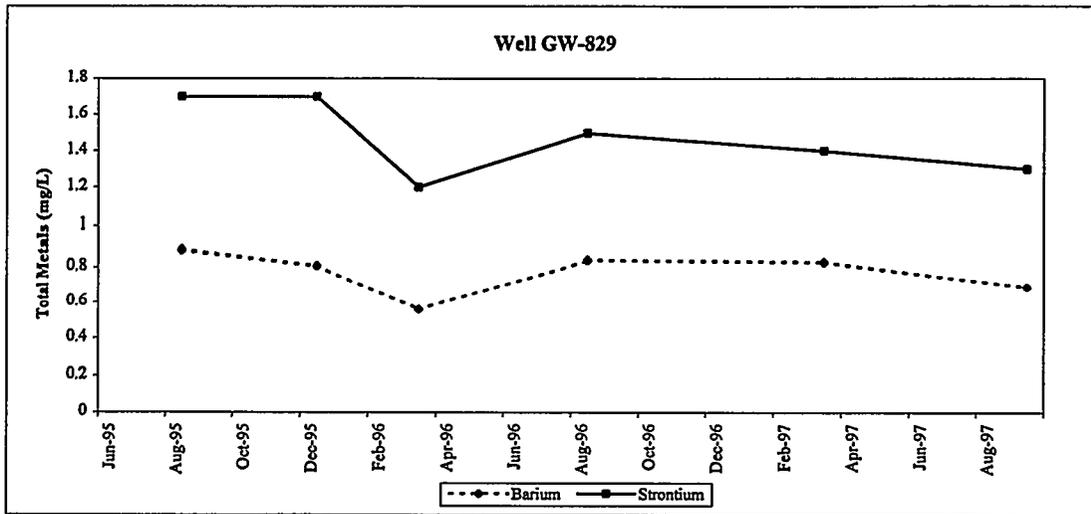
FIGURE 11

NITRATE CONCENTRATION TRENDS IN
GROUNDWATER AT AQUIFER MONITORING WELLS
GW-315, GW-685, GW-725, AND GW-738

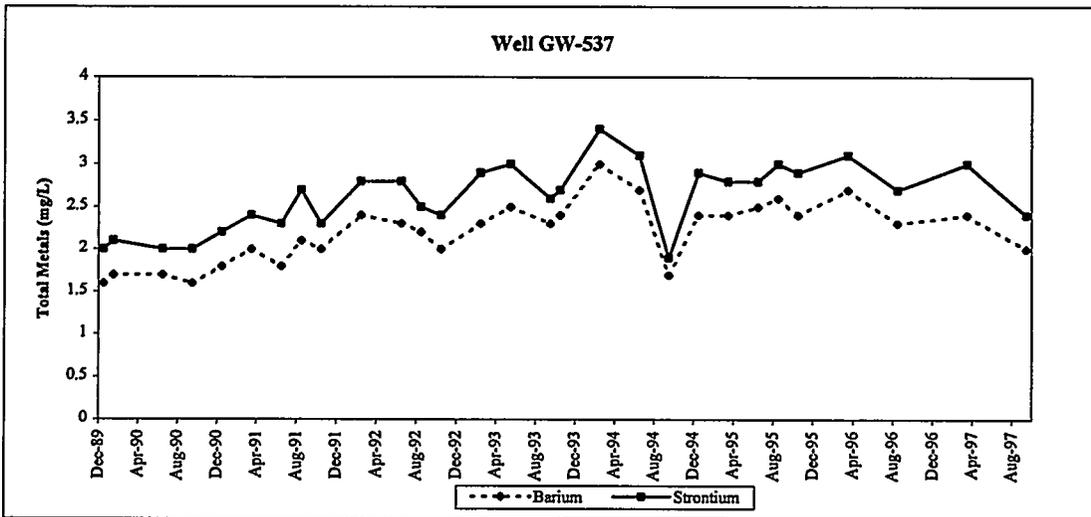


Note: Average Nitrate = average concentration calculated from data for all the listed wells during each sampling event.

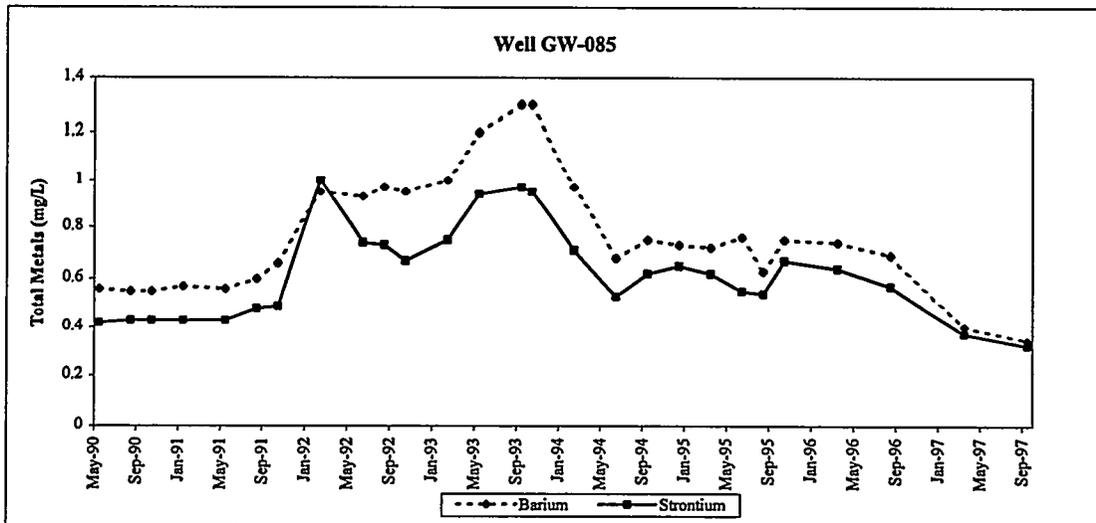
PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 12 AVERAGE NITRATE CONCENTRATION TRENDS IN GROUNDWATER AT EXIT PATHWAY PICKETS A, B, C, AND W
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.:		MVM64V/1
	DWG ID.:	BC PT297	
	DATE:	5/21/98	



Notes: Barium UTL = 0.35 mg/L; MCL = 2.0 mg/L
Strontium UTL = 0.92 mg/L



Notes: Barium UTL = 0.79 mg/L; MCL = 2.0 mg/L
Strontium UTL = 0.92 mg/L



Notes: Barium UTL = 0.79 mg/L; MCL = 2.0 mg/L
Strontium UTL = 0.92 mg/L

PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

LOCATION:

Y-12 PLANT
OAK RIDGE, TN.

FIGURE 13

PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

DOC No.:

MVM64V/1

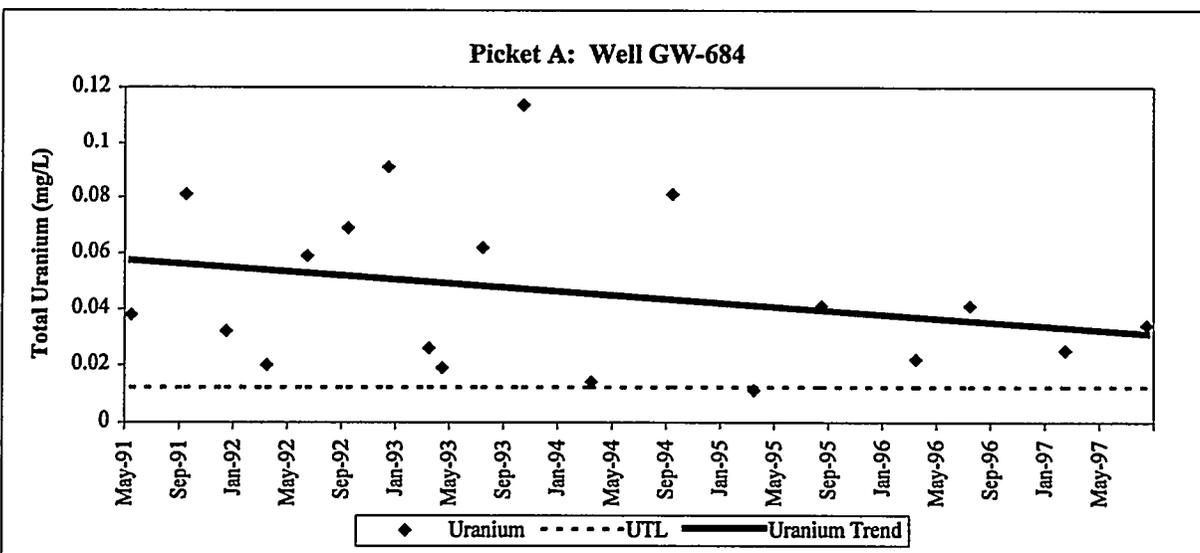
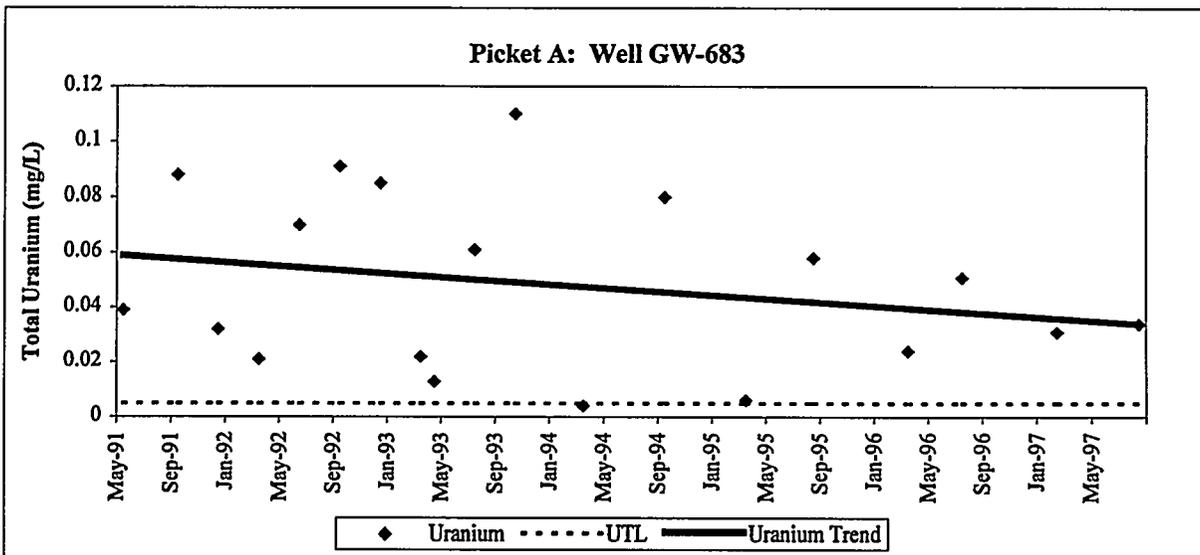
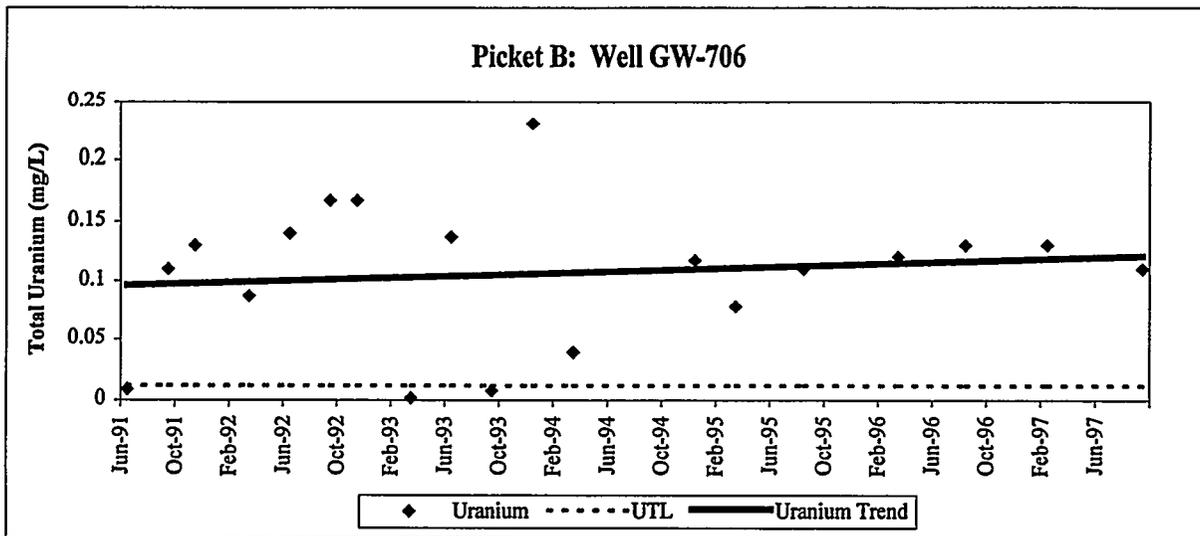
DWG ID.:

BC PT297

DATE:

5/21/98

**BARIUM AND STRONTIUM CONCENTRATION
TRENDS IN GROUNDWATER AT
AQUITARD MONITORING WELLS
GW-085, GW-537, AND GW-829**



PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

LOCATION:

Y-12 PLANT
OAK RIDGE, TN.

FIGURE 14

PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

DOC No.:

MVM64V/1

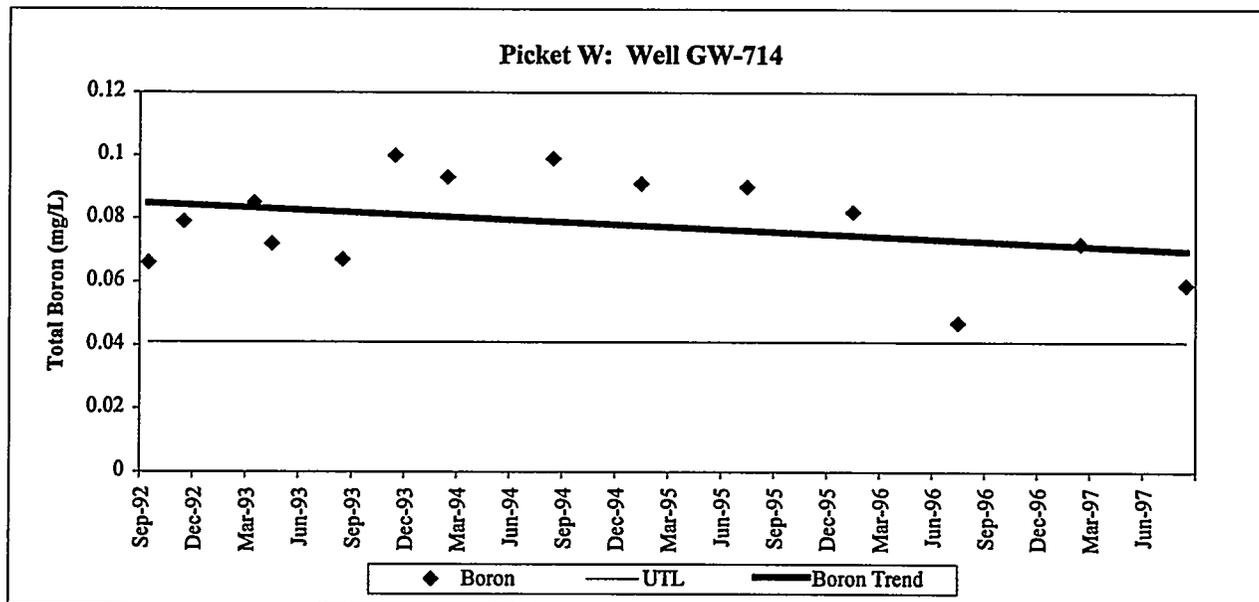
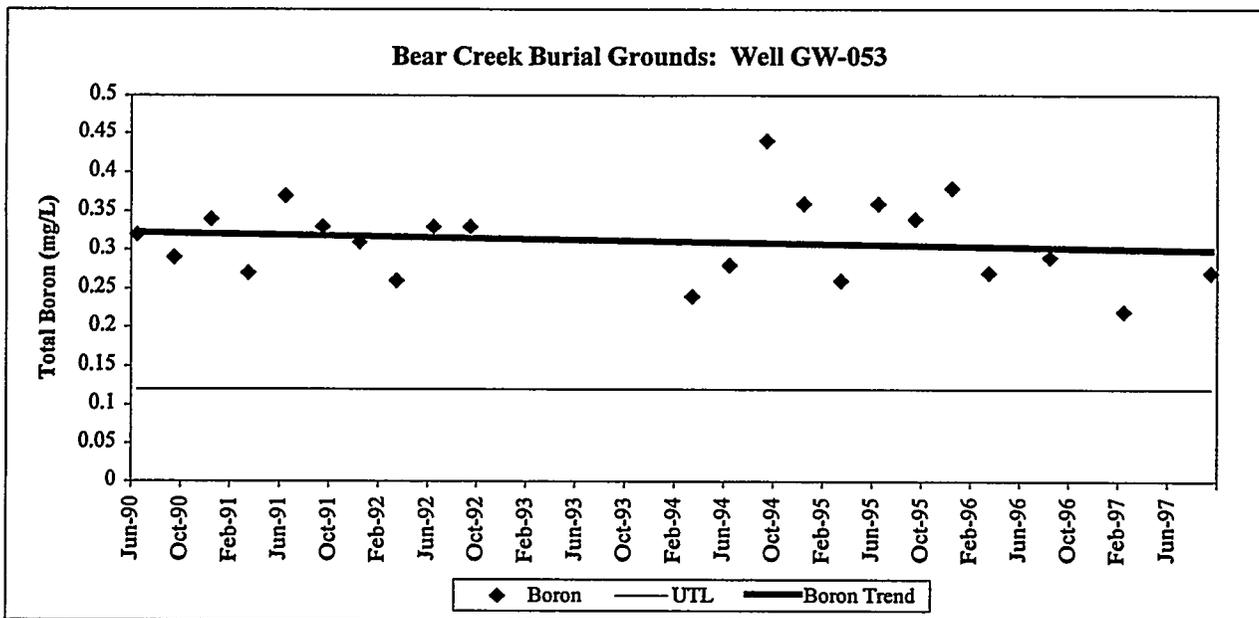
DWG ID.:

BC PT297

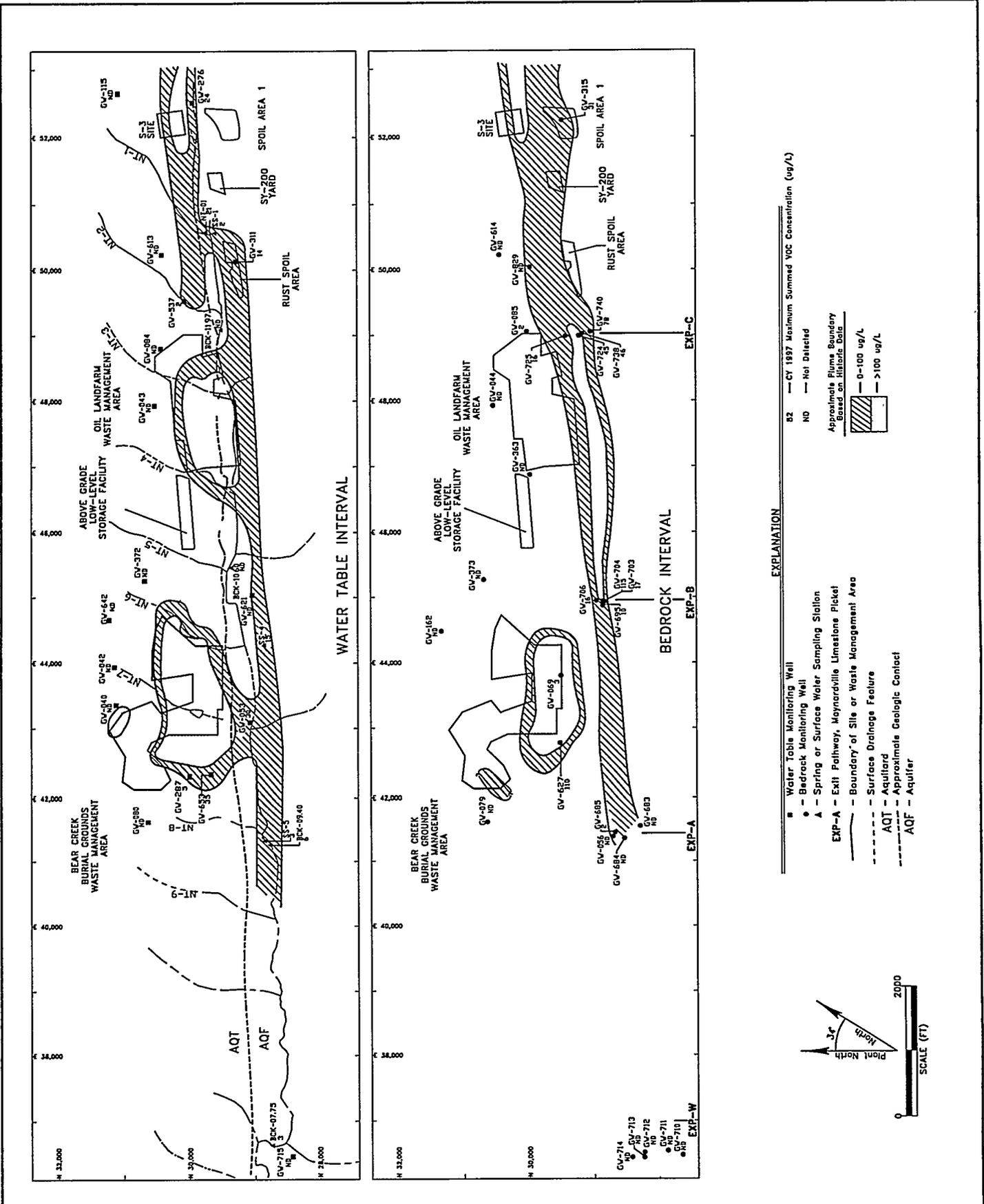
DATE:

5/21/98

URANIUM CONCENTRATION TRENDS IN
GROUNDWATER AT AQUIFER MONITORING
WELLS GW-683, GW-684, AND GW-706

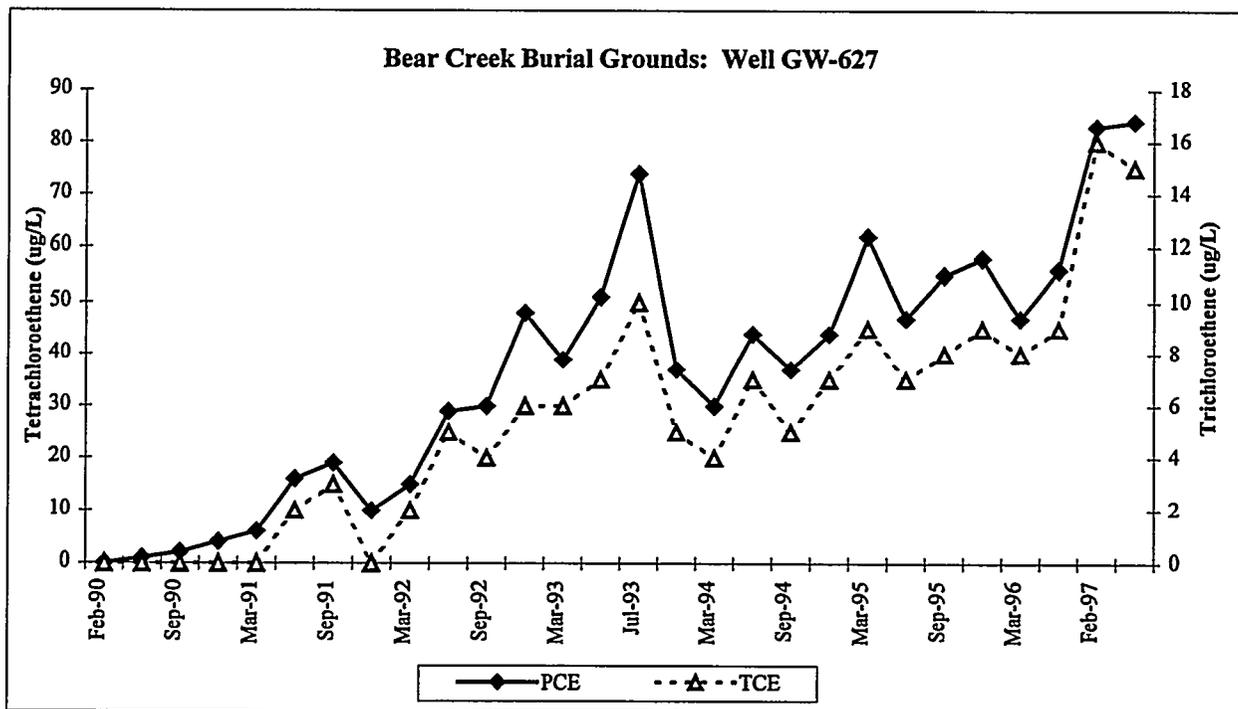
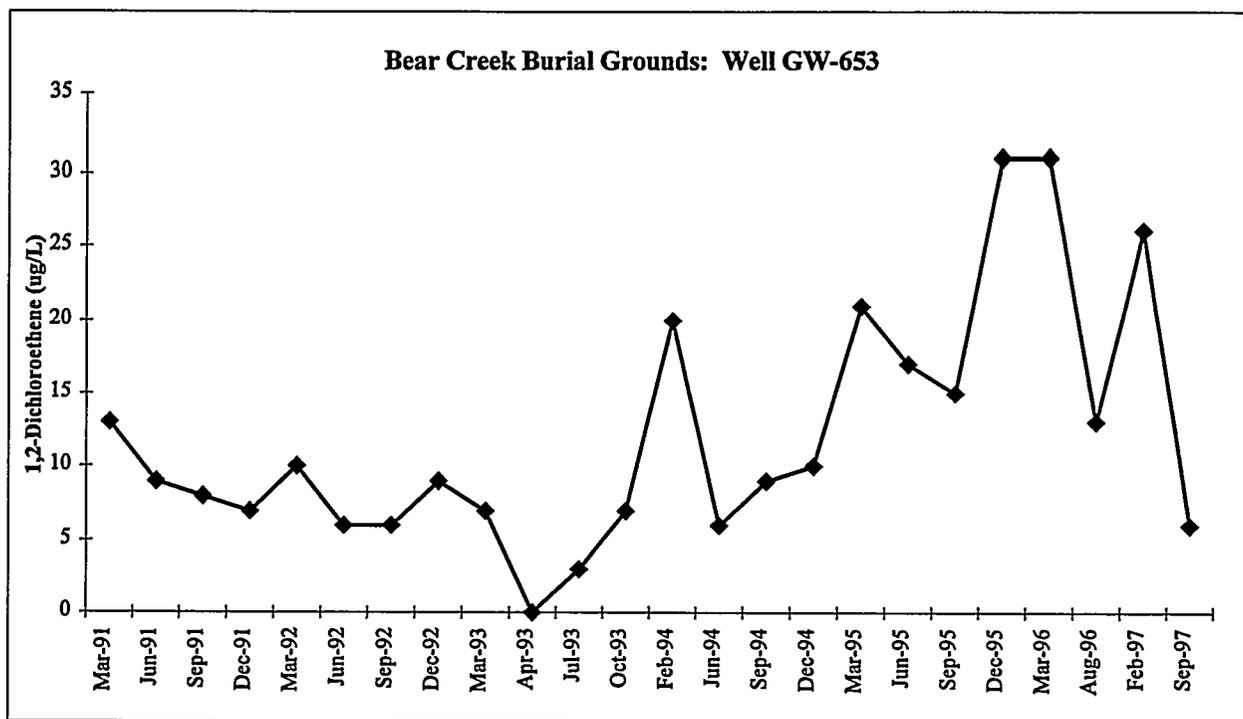


PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 15 BORON CONCENTRATION TRENDS IN GROUNDWATER AT AQUIFER MONITORING WELLS GW-053 AND GW-714
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.:		MVM64V/1
	DWG ID.:	BC PT297	
	DATE:	5/21/98	

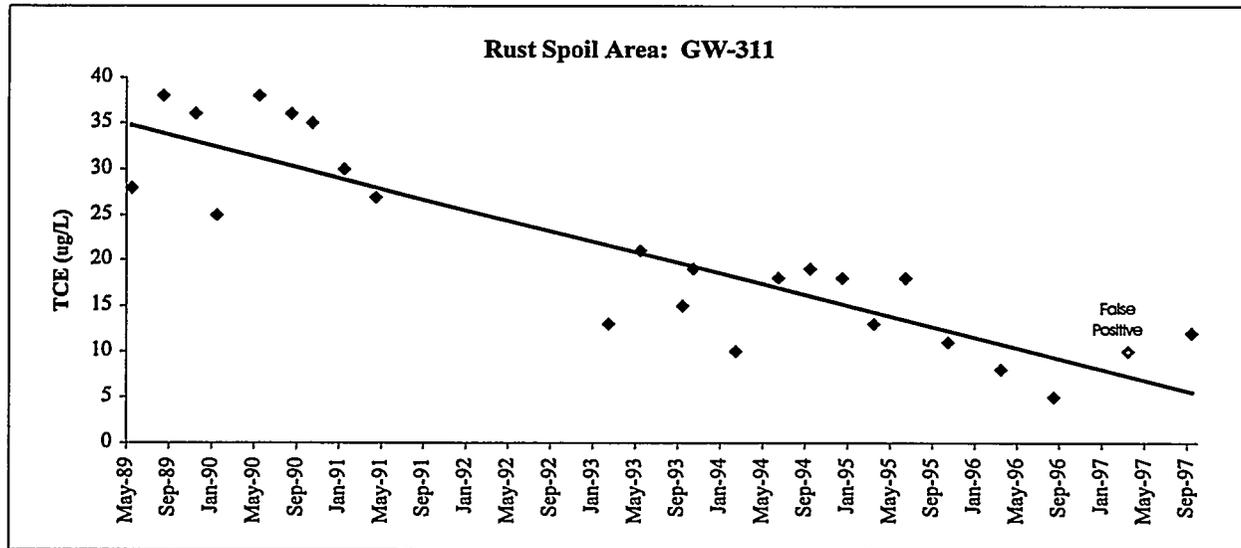
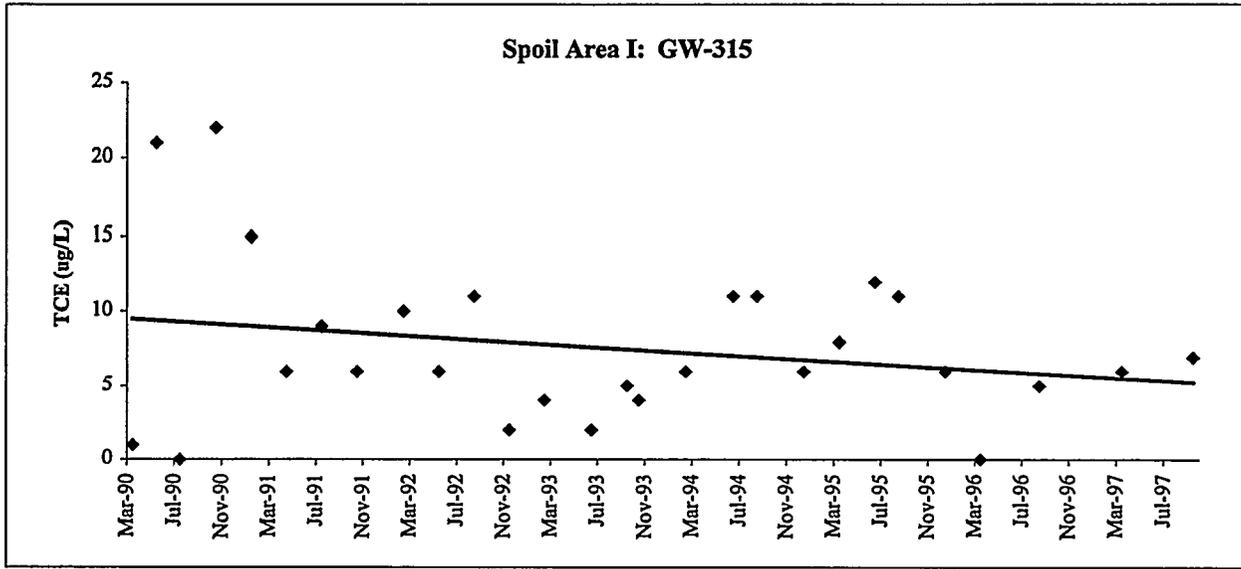


PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.
PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC NUMBER:	MVM64V/1
	DWG ID.:	96-041
	DATE:	9-7-98

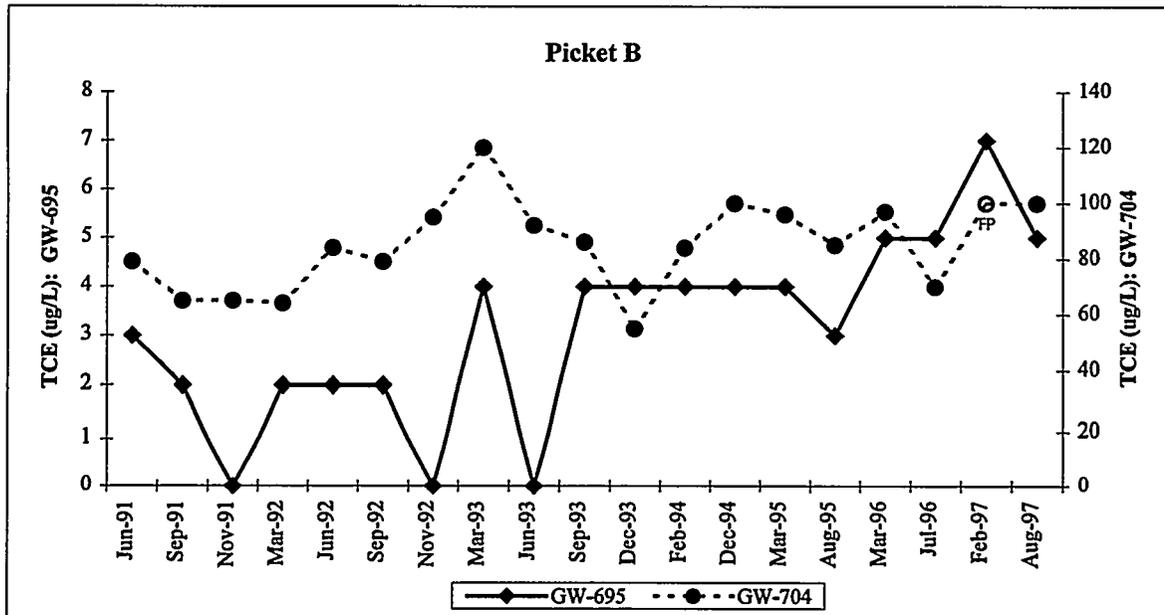
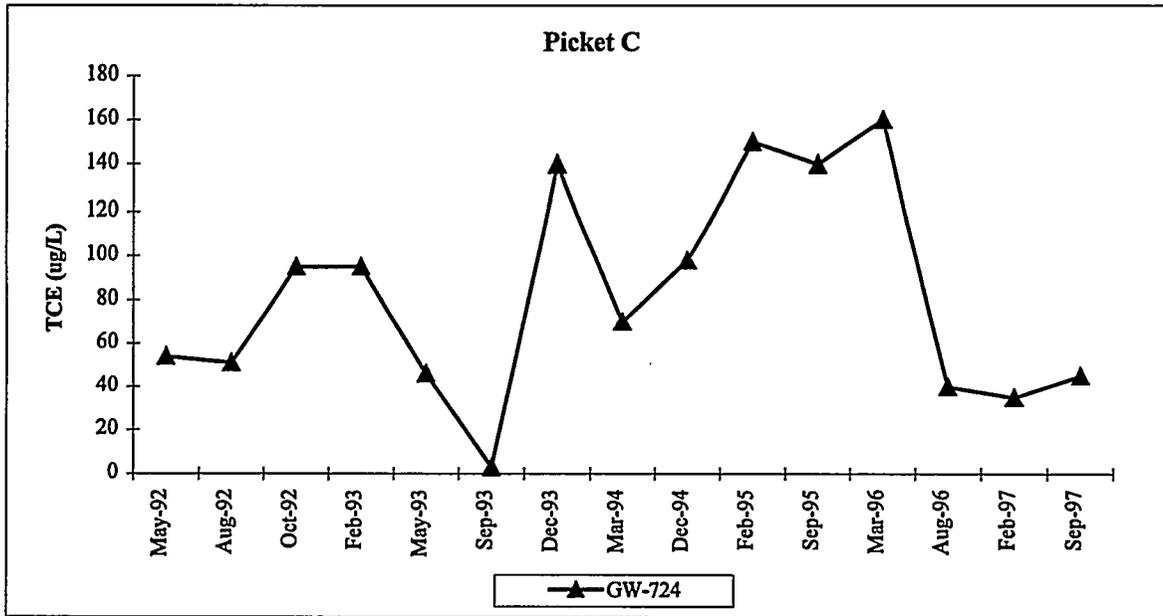
FIGURE 16
**VOCs IN GROUNDWATER
AND SURFACE WATER IN THE
BEAR CREEK HYDROGEOLOGIC REGIME, 1997**



PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 17 VOC CONCENTRATION TRENDS IN GROUNDWATER AT AQUITARD MONITORING WELLS GW-627 AND GW-653
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:		MVM64V/1 BC PT297 5/21/98



PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 18
PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:	MVM64V/1 BC PT297 5/21/98	TCE CONCENTRATION TRENDS IN GROUNDWATER AT AQUIFER MONITORING WELLS GW-311 AND GW-315



Note: TCE MCL = 5 ug/L

PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

LOCATION:

Y-12 PLANT
OAK RIDGE, TN.

FIGURE 19

PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

DOC No.:

MVM64V/1

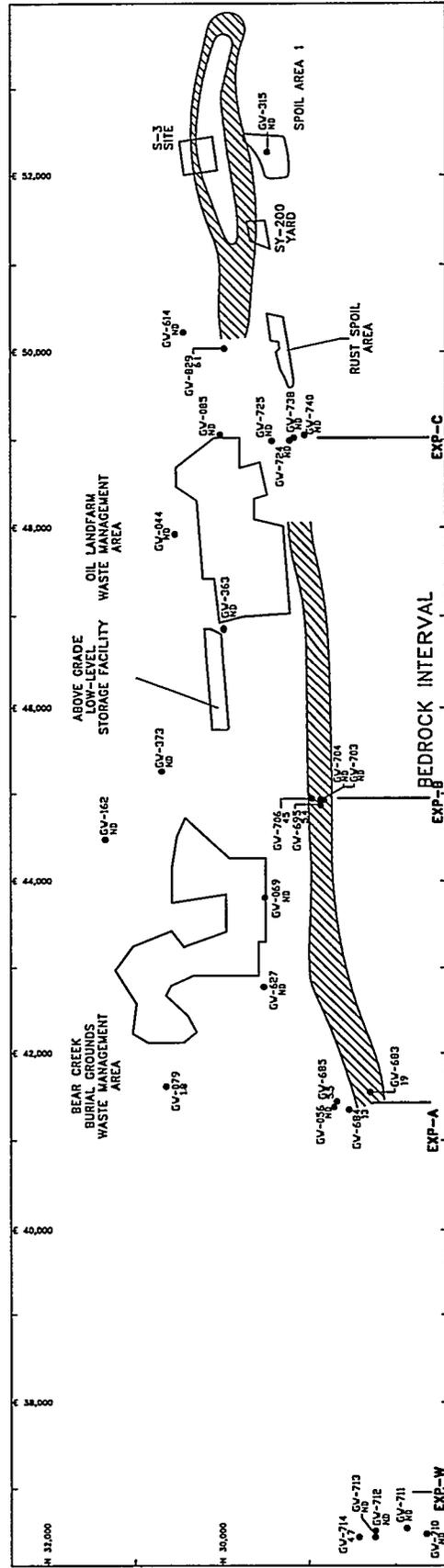
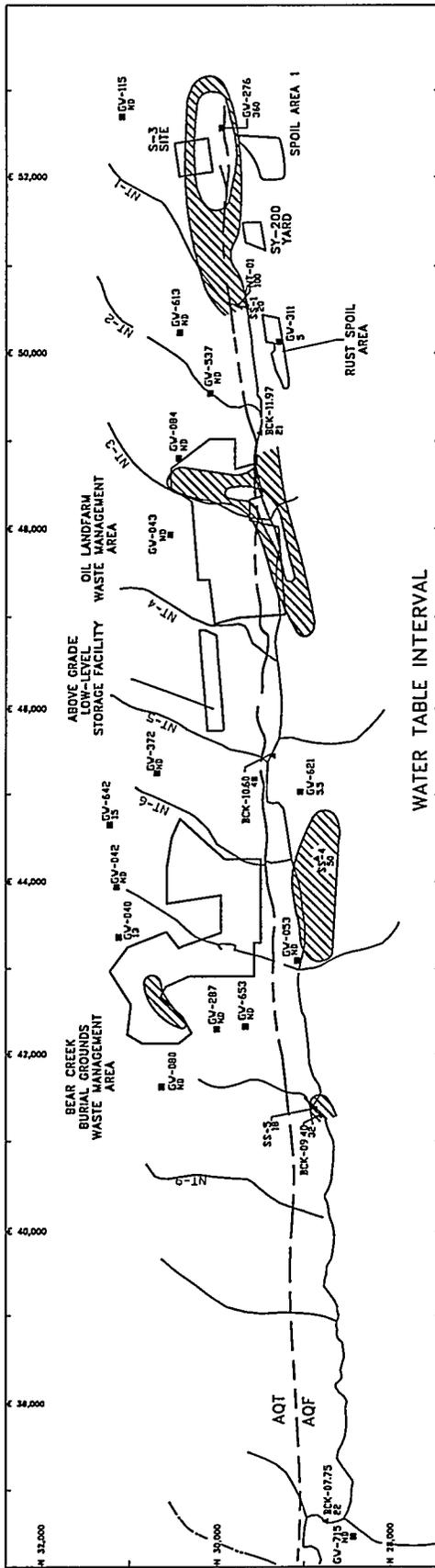
DWG ID.:

BC PT297

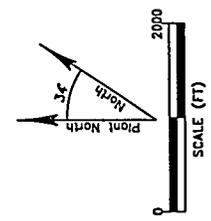
DATE:

5/21/98

TCE CONCENTRATION TRENDS IN GROUNDWATER
AT AQUIFER MONITORING
WELLS GW-695, GW-704, AND GW-724



- EXPLANATION**
- Water Table Monitoring Well
 - Bedrock Monitoring Well
 - ▲ Spring or Surface Water Sampling Station
 - EXP-A - Exit Pathway, Maynardville Limestone Picket
 - - - Boundary of Site or Waste Management Area
 - - - Surface Drainage Feature
 - - - AQT - Aquifer
 - - - AQP - Aquifer
 - 19 - 15-100 pCi/L
 - ND - >100 pCi/L

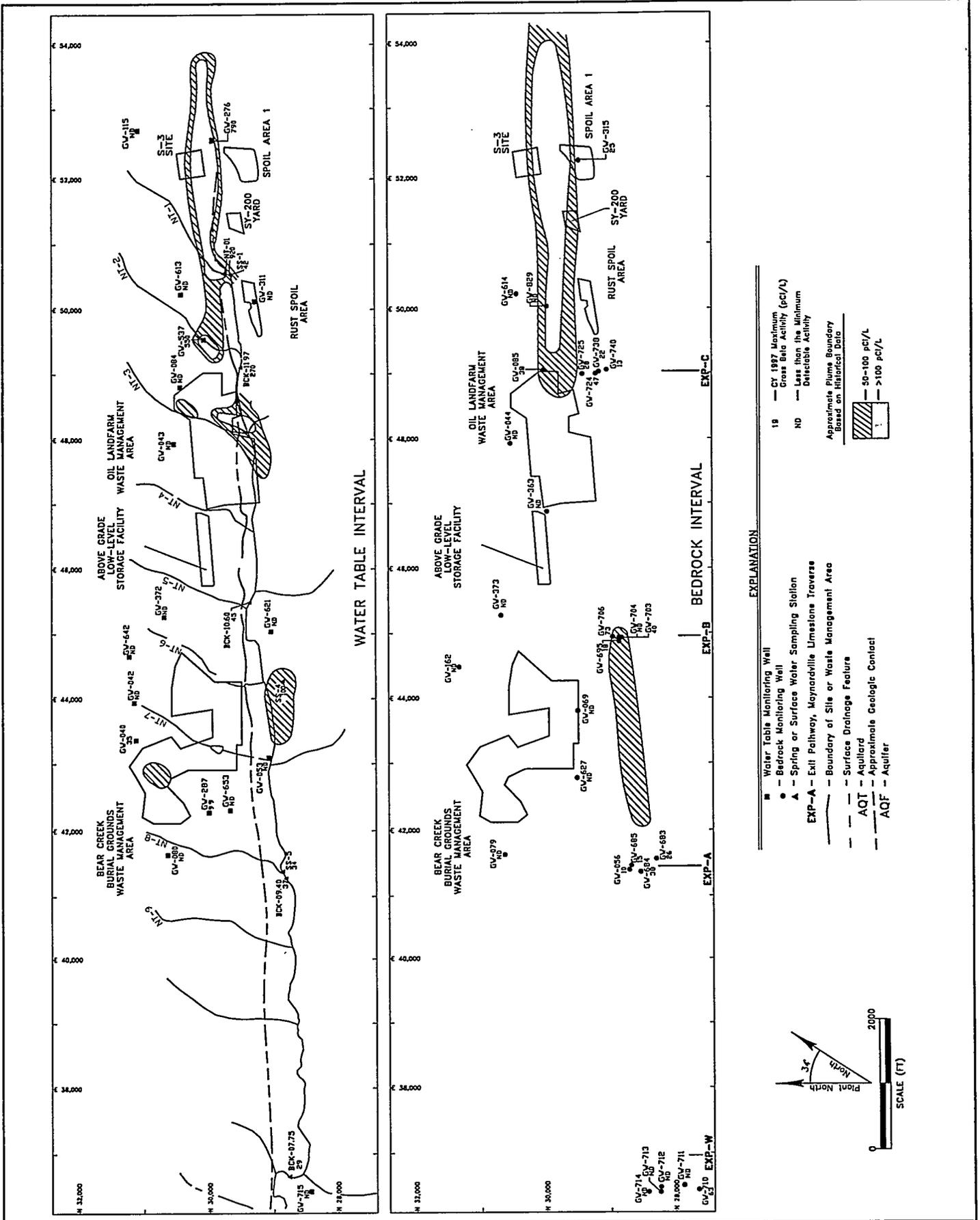


PREPARED FOR:
**LOCKHEED MARTIN
ENERGY SYSTEMS, INC.**

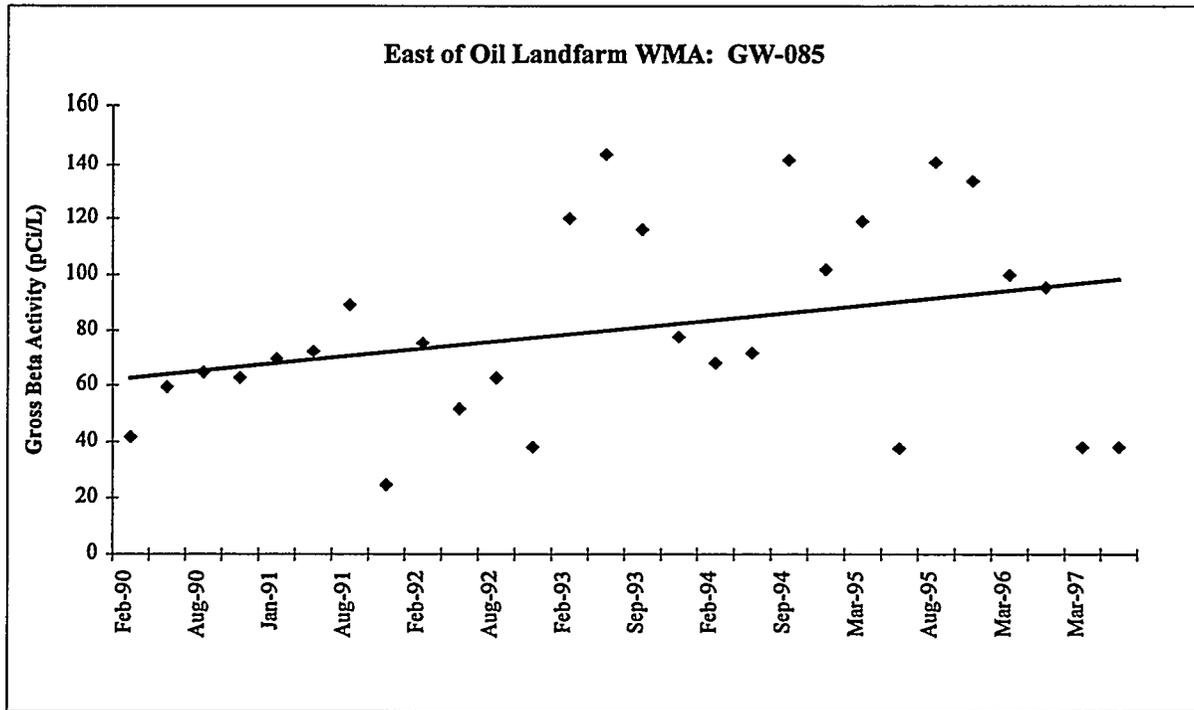
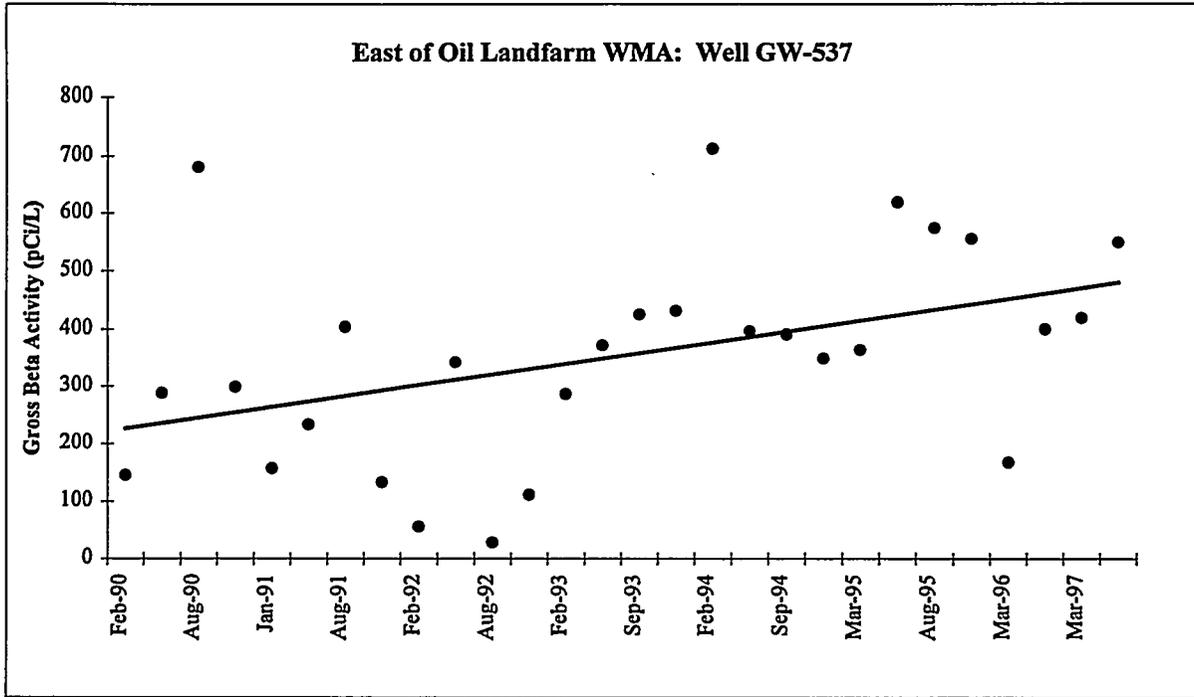
PREPARED BY:
**AJA TECHNICAL
SERVICES, INC.**

LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DOC NUMBER:	MVM64V/1
DWG ID.:	96-050
DATE:	9-7-98

FIGURE 20
**GROSS ALPHA ACTIVITY
IN GROUNDWATER AND SURFACE WATER IN THE
BEAR CREEK HYDROGEOLOGIC REGIME, 1997**

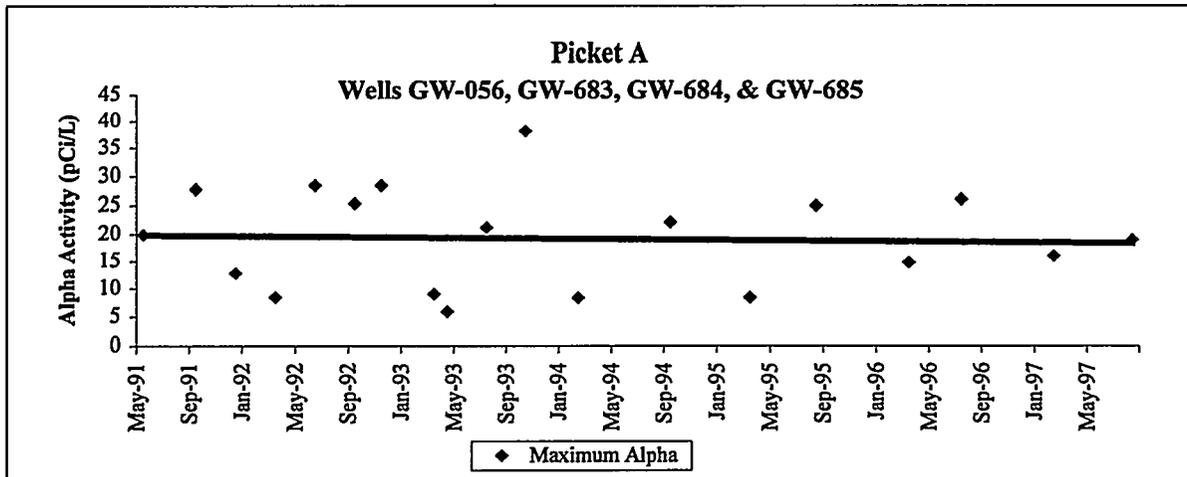
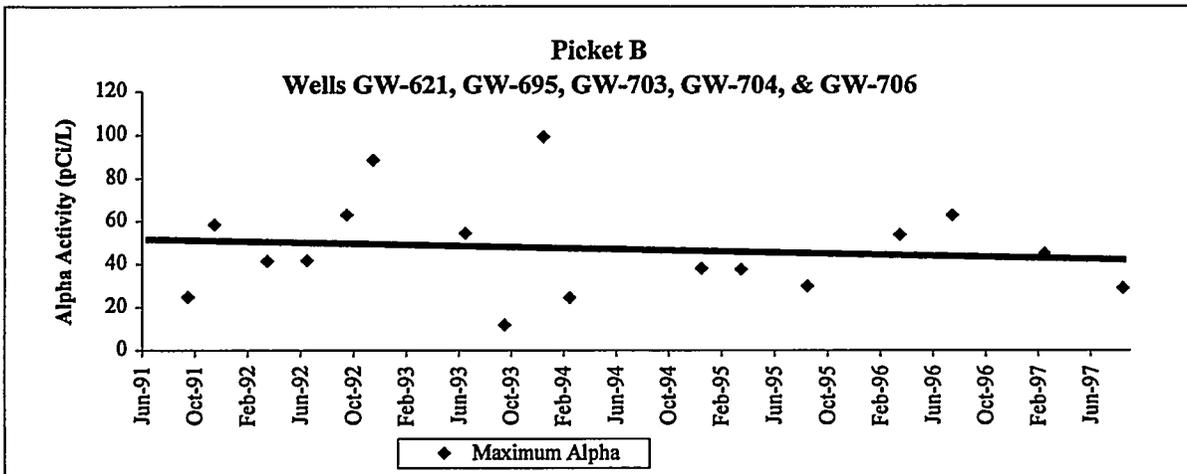
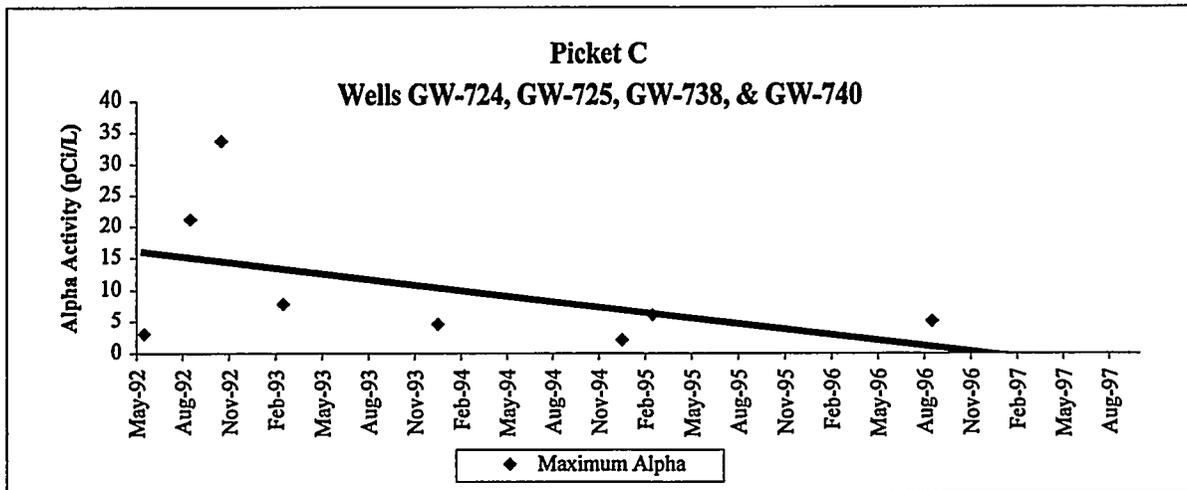


PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 21 GROSS BETA ACTIVITY IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK HYDROGEOLOGIC REGIME, 1997
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC NUMBER:		MVM64V/1
	DWG ID.:	96-051	
	DATE:	9-7-98	



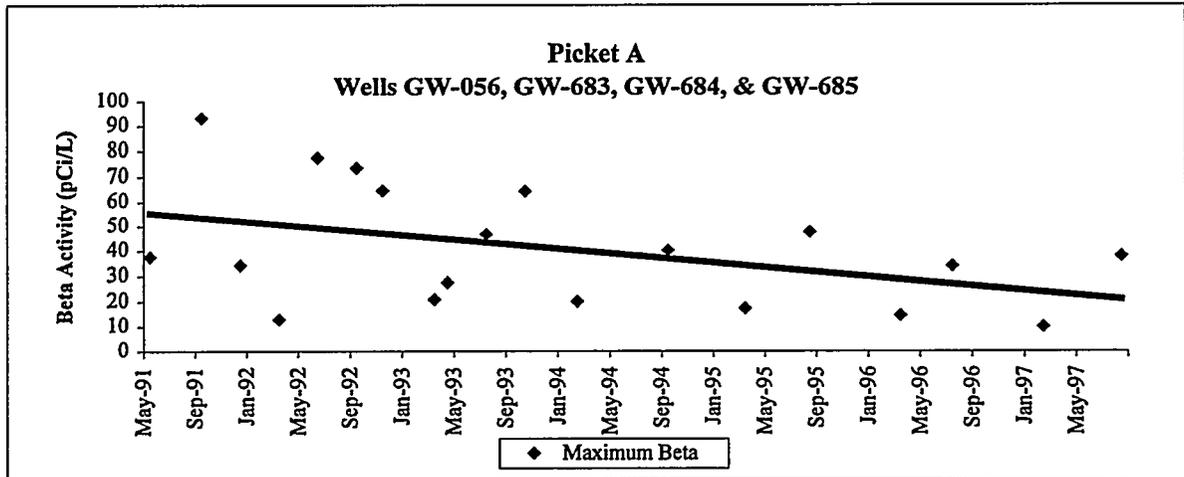
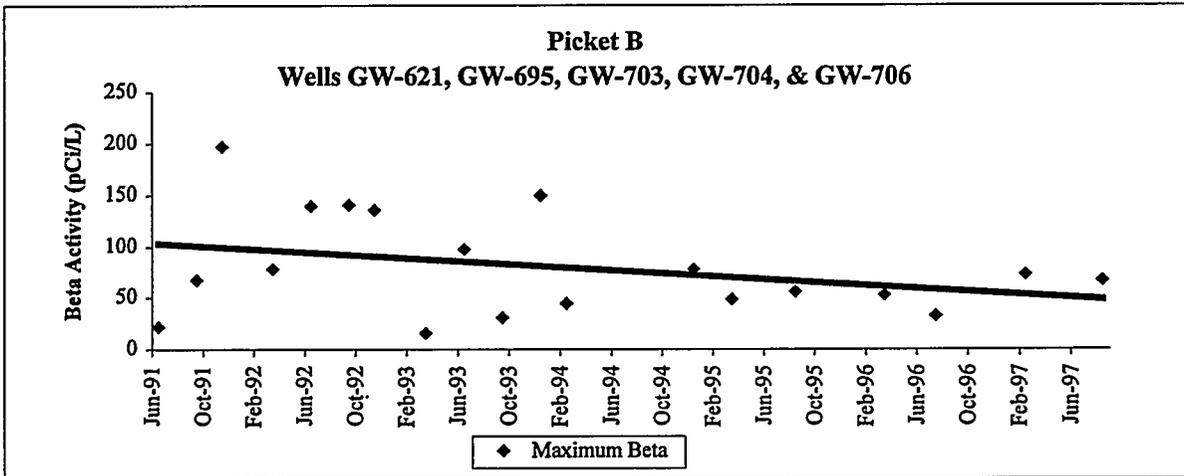
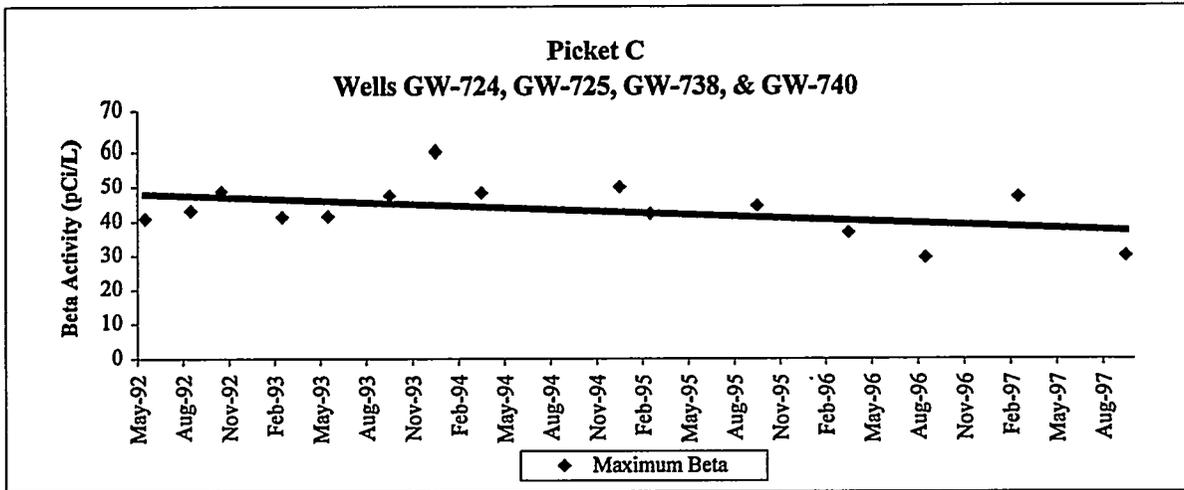
Note: SDWA Screening Level = 50 pCi/L

PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 22 GROSS BETA ACTIVITY TRENDS IN GROUNDWATER AT AQUITARD MONITORING WELLS GW-085 AND GW-537
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:		MVM64V/1 BC PT297 5/21/98



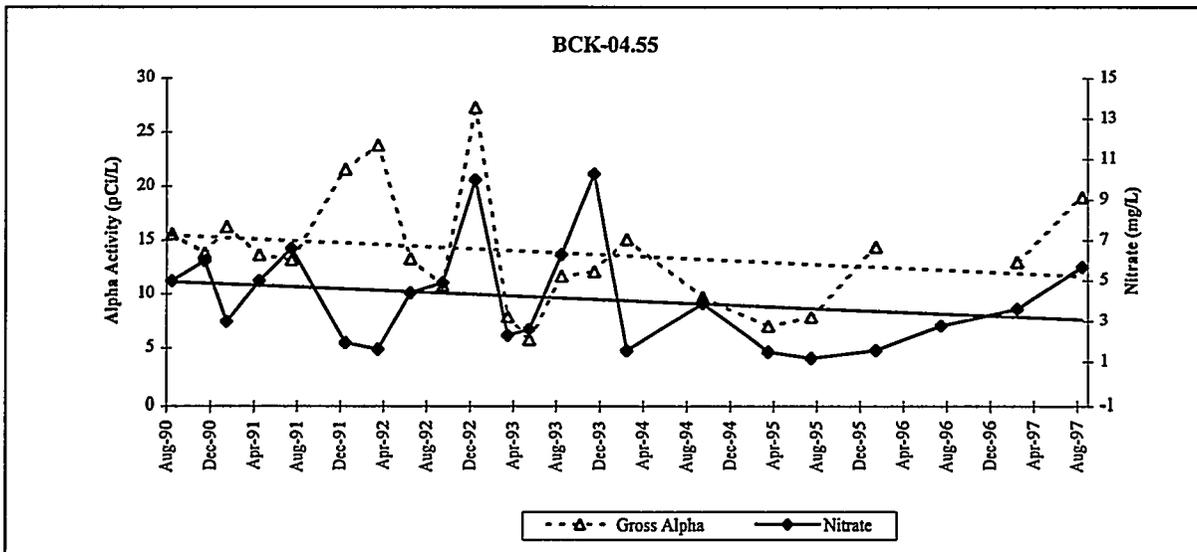
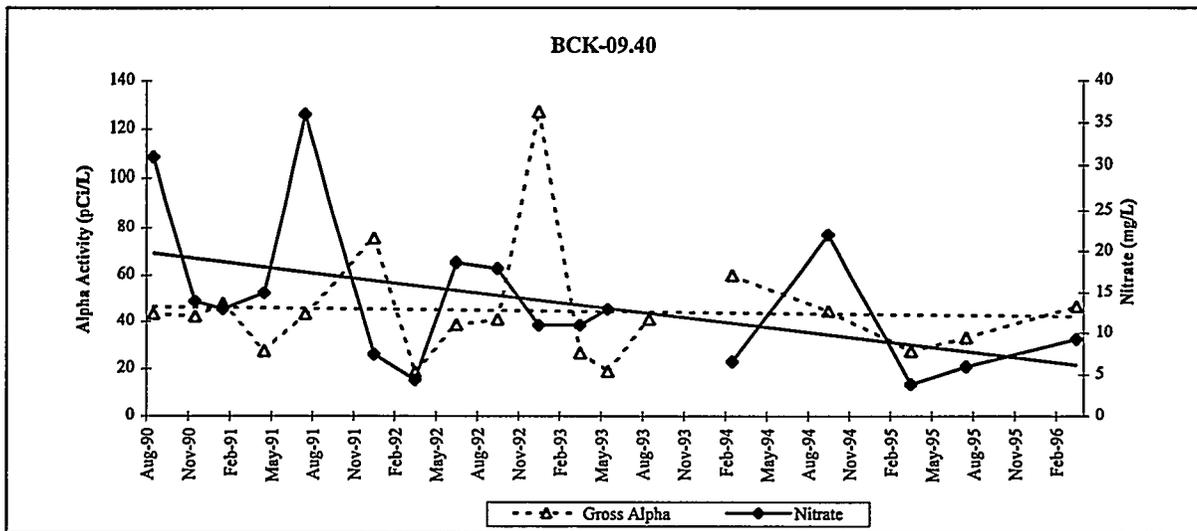
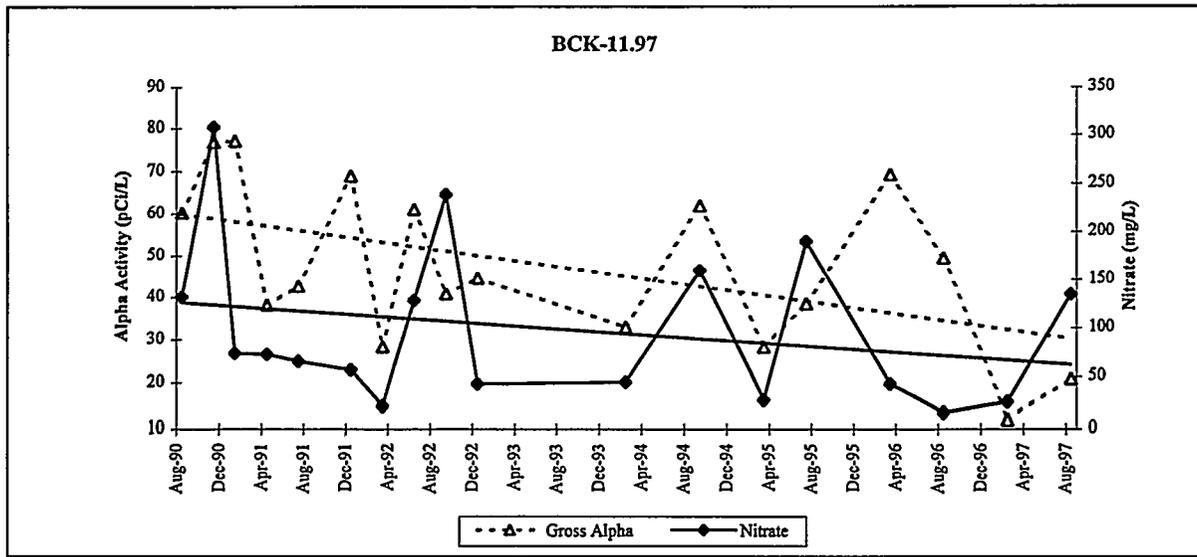
Note: Maximum Alpha = highest gross alpha activity reported for the listed wells during each sampling event.

PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 23 MAXIMUM GROSS ALPHA ACTIVITY TRENDS IN GROUNDWATER AT EXIT PATHWAY PICKETS A, B, AND C
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:		MVM64V/1 BC PT297 5/21/98



Note: Maximum Beta = highest gross beta activity reported for the listed wells during each sampling event.

PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 24 MAXIMUM GROSS BETA ACTIVITY TRENDS IN GROUNDWATER AT EXIT PATHWAY PICKETS A, B, AND C
	PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:		MVM64V/1 BC PT297 5/21/98



Notes: Nondetected results not plotted.
 Gross Alpha MCL = 15 pCi/L; Nitrate MCL = 10 mg/L.

PREPARED FOR: LOCKHEED MARTIN ENERGY SYSTEMS, INC.	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 25 NITRATE CONCENTRATION AND GROSS ALPHA ACTIVITY TRENDS IN BEAR CREEK AT BCK-04.55, BCK-09.40, AND BCK-11.97
PREPARED BY: AJA TECHNICAL SERVICES, INC.	DOC No.: DWG ID.: DATE:	MVM64V/1 BC PT297 5/21/98	

APPENDIX B

TABLES

**Table 1.
Groundwater Monitoring Programs Associated with Waste Management Sites and Regulated Units
in the Bear Creek Hydrogeologic Regime**

PROGRAM DRIVER		MONITORING PROGRAM		
RCRA Post-Closure Permit for the Bear Creek Regime DOE Order 5400.1		RCRA Post-Closure Corrective Action Monitoring Exit Pathway/Perimeter Monitoring		
Waste Management Site/ Regulated Unit	Regulatory Classification ¹	General Waste Inventory	Operational Status	
			Closed	Active
Above Grade Low-Level Storage Facility	NR	Low-level radioactive construction and demolition wastes.		●
Boneyard, Burnyard, and Hazardous Chemical Storage Area	CERCLA	Magnesium chips, construction debris, pesticide containers, metal shavings, solvents, oils, laboratory chemicals, acids, bases, organics, water-reactive compounds, and shock-sensitive compounds.	●	
Burial Grounds A (North and South)	RCRA/ CERCLA	Waste oils, coolants, and spent solvents.	●	●
Burial Grounds C (West)	RCRA/ CERCLA	Waste oils, coolants, and spent solvents.	●	●
Burial Grounds B, D, E, and J	CERCLA	Solid wastes including salts, metals (beryllium and uranium) and metal oxides, metal saw fines, and asbestos.	●	●
Oil Landfarm	RCRA/ CERCLA	Waste oils and coolants containing beryllium compounds, depleted uranium, polychlorinated biphenyls, and spent solvents.	●	●
Oil Retention Pond No. 1	CERCLA	Oil seepage from Burial Ground A South.	●	
Oil Retention Pond No. 2	CERCLA	Oil seepage from Burial Ground A North.	●	●
Receptor Media	CERCLA	Contaminated groundwater, surface water, Bear Creek stream sediments, and Bear Creek floodplain soils.		Not Applicable

Table 1 (cont'd)

PROGRAM DRIVER		MONITORING PROGRAM		
RCRA Post-Closure Permit for the Bear Creek Regime		RCRA Post-Closure Corrective Action Monitoring		
DOE Order 5400.1		Exit Pathway/Perimeter Monitoring		
Waste Management Site/ Regulated Unit	Regulatory Classification	General Waste Inventory	Operational Status	
			Closed	Active
Rust Spoil Area	CERCLA	Nonradioactive construction debris.	●	●
Sanitary Landfill I	CERCLA	Nonhazardous solid wastes.	●	●
Spoil Area I	CERCLA	Nonradioactive construction debris.	●	●
SY-200 Yard	CERCLA	Temporary storage of equipment, machinery, and miscellaneous items.	●	●
S-3 Site	RCRA/ CERCLA	Liquid, radioactive, nitric acid wastes and denitrification sludge	●	●
Walk-In Pits	RCRA/ CERCLA	Chemical wastes, shock-sensitive reagents, and uranium metal saw fines.	●	●

Notes:

- 1 From: Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program (U.S. Department of Energy 1995). This classification applies only to CERCLA and RCRA regulations and may not reflect other applicable regulations (e.g., solid waste regulations at Spoil Area I).
- CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
 - RCRA - Resource Conservation and Recovery Act
 - NR - Not regulated under RCRA or CERCLA.

Table 2.
Depth-to-Water Measurements and Water-Level Elevations in the Bear Creek
Hydrogeologic Regime, April/October 1997

Water-Level Elevation (ft above mean sea level)					October 6 - 10, 1997				
					April 1 - 4, 1997				
					Seasonal Fluctuation (+/- ft)				
Depth-to-Water (ft below top of well casing)				October 6 - 10, 1997		April 1 - 4, 1997			
Well No. ¹	Location ²	Hydrogeologic Unit		Top of Casing Elevation ³					
		Aquifer	Aquitard						
GW-001	OLF		●	980.86	14.7	16.7	-2.0	966.16	964.16
GW-005	OLF		●	967.21	6.9	7.6	-0.7	960.31	959.61
GW-008	OLF		●	966.77	14.7	16.4	-1.7	952.07	950.37
GW-010	OLF		●	952.76	2.4	3.9	-1.5	950.36	948.86
GW-011	OLF		●	953.08	3.1	5.0	-1.9	949.98	948.08
GW-012	OLF		●	954.97	6.0	7.9	-1.9	948.97	947.07
GW-014	BG		●	933.76	6.0	7.2	-1.2	927.76	926.56
GW-016	BG		●	928.06	9.3	10.8	-1.5	918.76	917.26
GW-018	BG		●	924.49	7.2	9.9	-2.7	917.29	914.59
GW-041	BG		●	1007.60	NM ⁴	23.5	NA ⁵	NA	984.10
GW-043	OLF		●	1013.44	14.3	28.9	-14.6	999.14	984.54
GW-045	BG	●		909.79	10.9	NM	NA	898.89	NA
GW-047	BG		●	928.25	7.1	6.1	1.0	921.15	922.15
GW-052	BG	●		906.04	11.3	17.6	-6.3	894.74	888.44
GW-053	BG	●		902.67	7.2	10.5	-3.3	895.47	892.17
GW-065	OLF	●		982.25	25.9	28.7	-2.8	956.35	953.55
GW-067	OLF	●		961.50	9.7	10.4	-0.7	951.80	951.10
GW-080	BG		●	980.31	21.9	25.2	-3.3	958.41	955.11
GW-084	OLF		●	996.60	14.1	14.9	-0.8	982.50	981.70
GW-086	OLF		●	982.76	12.4	14.0	-1.6	970.36	968.76
GW-087	OLF		●	964.36	NM	7.4	NA	NA	956.96
GW-090	BG		●	961.88	5.7	6.4	-0.7	956.18	955.48
GW-091	BG		●	953.48	9.3	9.5	-0.2	944.18	943.98
GW-097	OLF		●	944.62	10.0	11.8	-1.8	934.62	932.82
GW-101	S3		●	1007.30	9.2	10.3	-1.1	998.10	997.00
GW-115	S3		●	1054.40	8.4	11.8	-3.4	1046.00	1042.60
GW-245	S3		●	1009.10	12.6	14.4	-1.8	996.50	994.70
GW-249	BG		●	991.15	30.5	37.8	-7.3	960.65	953.35
GW-257	BG		●	961.68	27.2	29.0	-1.8	934.48	932.68
GW-276	S3		●	1001.30	6.3	7.9	-1.6	995.00	993.40
GW-277	S3		●	1001.80	6.0	6.1	-0.1	995.80	995.70
GW-287	BG		●	926.87	9.2	9.8	-0.6	917.67	917.07

Table 2 (cont'd)

Water-Level Elevation (ft above mean sea level)				October 6 - 10, 1997					
				April 1 - 4, 1997					
				Seasonal Fluctuation (+/- ft)					
Depth-to-Water (ft below top of well casing)				October 6 - 10, 1997					
				April 1 - 4, 1997					
Well No. ¹	Location ²	Hydrogeologic Unit		Top of Casing Elevation ³					
		Aquifer	Aquitard						
GW-289	BG		●	948.47	15.7	17.1	-1.4	932.77	931.37
GW-291	BG		●	948.36	11.7	12.6	-0.9	936.66	935.76
GW-307	RS	●		993.14	27.6	33.5	-5.9	965.54	959.64
GW-309	RS	●		988.17	19.7	22.8	-3.1	968.47	965.37
GW-310	RS	●		995.35	19.7	21.6	-1.9	975.65	973.75
GW-311	RS	●		999.35	33.1	39.8	-6.7	966.25	959.55
GW-323	SPI	●		1130.10	86.0	86.0	0.0	1044.10	1044.10
GW-325	S3		●	1003.00	12.4	17.7	-5.3	990.60	985.30
GW-345	S3		●	997.73	16.0	19.9	-3.9	981.73	977.83
GW-347	S3	●		1001.60	15.9	18.6	-2.7	985.70	983.00
GW-370	BG		●	960.62	12.6	14.8	-2.2	948.02	945.82
GW-372	BG		●	983.53	15.0	25.0	-10.0	968.53	958.53
GW-531	LD		●	1004.60	15.5	17.4	-1.9	989.10	987.20
GW-537	OLF		●	976.24	5.7	6.9	-1.2	970.54	969.34
GW-613	S3		●	1013.40	11.1	15.4	-4.3	1002.30	998.00
GW-621	EXP-B	●		925.24	11.6	20.8	-9.2	913.64	904.44
GW-622	BG		●	924.16	10.5	12.0	-1.5	913.66	912.16
GW-624	BG		●	921.96	9.5	12.0	-2.5	912.46	909.96
GW-626	BG		●	942.61	20.7	26.6	-5.9	921.91	916.01
GW-630	LD		●	986.65	9.2	9.5	-0.3	977.45	977.15
GW-637	OLF		●	941.83	7.3	12.0	-4.7	934.53	929.83
GW-638	OLF		●	941.77	6.6	10.1	-3.5	935.17	931.67
GW-641	BG		●	946.66	15.9	21.3	-5.4	930.76	925.36
GW-642	BG		●	1014.70	18.9	22.7	-3.8	995.80	992.00
GW-644	OLF		●	959.75	8.4	11.1	-2.7	951.35	948.65
GW-648	RS	●		1029.20	65.2	69.8	-4.6	964.00	959.40
GW-651	BG	●		903.12	6.5	9.7	-3.2	896.62	893.42
GW-652	BG	●		900.83	10.2	12.1	-1.9	890.63	888.73
GW-653	BG		●	931.60	20.6	24.5	-3.9	911.00	907.10
GW-654	BG		●	940.79	6.6	7.5	-0.9	934.19	933.29
GW-715	EXP-W	●		874.72	27.7	29.5	-1.8	847.02	845.22
GW-795	AGLLSF		●	925.98	4.4	8.8	-4.4	921.61	917.18

Table 2 (cont'd)

Notes:

- 1 Well locations are shown on Figure 4.
Wells sampled during CY 1997 are denoted by shading and bold typeface.
- 2 AGLLSF - Above Grade Low-Level Storage Facility
BG - Bear Creek Burial Grounds Waste Management Area
EXP-B - Exit Pathway (Maynardville Limestone) Picket B
EXP-W - Exit Pathway (Maynardville Limestone) Picket W
LD - Lysimeter Demonstration Site
OLF - Oil Landfarm Waste Management Area
RS - Rust Spoil Area
SPI - Spoil Area I
S3 - S-3 Site
- 3 Measuring point (top of well casing) elevation (ft above mean sea level).
- 4 NM - Not Measured
- 5 NA - Not Applicable

Table 3.
Hydraulic Gradients in the Bear Creek Hydrogeologic Regime, April/October 1997

HORIZONTAL						
Wells		Horizontal Distance¹ (ft)	Difference in Water-Level Elevation² (ft)		Horizontal Gradient³	
Upgradient	Downgradient		April	October	April	October
Aquitard						
GW-249	GW-287	587.84	42.98	36.28	0.073	0.062
GW-115	GW-276	1154.12	51.00	49.20	0.044	0.043
GW-289	GW-626	458.40	10.86	15.36	0.009	0.013
GW-089	GW-091	357.69	NM	12.98	Unknown	0.011
GW-043	GW-008	813.21	47.07	34.17	0.041	0.030
GW-531	GW-537	446.77	18.56	17.86	0.016	0.015
Aquifer						
GW-309	GW-065	1066.35	12.12	11.82	0.011	0.010
GW-065	GW-621	4137.25	42.71	49.11	0.037	0.043
GW-621	GW-052	1452.00	18.90	16.00	0.016	0.014
GW-651	GW-652	83.99	5.99	4.69	0.005	0.004
VERTICAL						
Wells		Vertical Distance⁴ (ft)	Difference in Water-Level Elevation⁵ (ft)		Vertical Gradient⁶	
Water Table	Bedrock		April	October	April	October
Aquitard						
GW-005	GW-076	66.09	-2.05	-1.55	-0.031	-0.023
GW-016	GW-072	79.70	-3.26	-0.65	-0.041	-0.008
GW-043	GW-044	30.73	-3.36	-1.26	-0.109	-0.041
GW-080	GW-079	32.04	-4.19	-1.89	-0.131	-0.059
GW-086	GW-085	27.98	-0.11	0.49	-0.004	0.018
GW-097	GW-098	75.66	-0.18	4.62	-0.002	0.061
GW-249	GW-250	24.02	0.40	-1.40	0.017	-0.058
GW-287	GW-286	16.93	0.34	0.34	0.020	0.020
GW-289	GW-288	18.40	-0.39	-0.39	-0.021	-0.021
GW-291	GW-290	15.43	-3.20	-3.30	-0.207	-0.214
GW-325	GW-324	60.85	-2.13	-1.40	-0.035	-0.023
GW-345	GW-346	37.30	-0.82	-1.82	-0.022	-0.049
GW-370	GW-371	90.21	3.70	3.30	0.041	0.037
GW-372	GW-373	93.92	1.43	-4.67	0.015	-0.050
GW-613	GW-614	45.68	-8.70	-7.40	-0.190	-0.162
GW-622	GW-623	242.03	-8.35	-7.95	-0.035	-0.033
GW-626	GW-627	191.06	1.06	-1.94	0.006	-0.010
GW-641	GW-640	24.97	0.58	-0.32	0.023	-0.013

Table 3 (cont'd)

VERTICAL (cont'd)						
Wells		Vertical Distance⁴ (ft)	Difference in Water-Level Elevation⁵ (ft)		Vertical Gradient⁶	
Water Table	Bedrock		April	October	April	October
Aquifer						
GW-065	GW-064	18.65	-1.01	-0.91	-0.054	-0.049
GW-067	GW-066	40.26	-0.90	-0.30	-0.022	-0.007
GW-347	GW-348	55.61	6.60	8.40	0.119	0.151
GW-715	GW-714	91.92	0.34	0.94	0.004	0.010

Notes:

- 1 The horizontal distance from the upgradient well to the downgradient well.
- 2 The difference in the water levels between the upgradient and downgradient well. NM = Not Measured; a water level was not obtained from well GW-089 in April.
- 3 The horizontal gradient was calculated by dividing the difference in water level by the distance between wells.
- 4 The vertical distance between the monitored interval midpoints of the water table well and the paired bedrock interval well.
- 5 The difference in water levels, calculated by subtracting the water level in the bedrock well from the water level in the water table well.
- 6 A negative result (which occurs when the deeper well has a higher water level) indicates an upward gradient.

Table 4.
CY 1997 Sampling Dates for Monitoring Wells, Springs, and
Surface Water Stations in the Bear Creek Hydrogeologic Regime

Monitoring Program ¹		RCRA Post-Closure Corrective Action Monitoring					
		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring				DOE Order 5400.1 Surveillance Monitoring	
		Sampling Point ²	Sampling Location ³	Sampling Equipment ⁴				Sampling Date^{5}
Dedicated	Portable			1st Quarter	3rd Quarter		
GW-040	BG	●		01/22/97	09/02/97		●
GW-042	BG	●		01/31/97	09/02/97		●
GW-043	OLF	●		01/23/97	08/13/97		●
GW-044	OLF	●		01/23/97	08/11/97		●
GW-053	BG	●	●	02/06/97	09/03/97	●	
GW-056	EXP-A	●		02/13/97	08/19/97		●
GW-069	BG	●		01/22/97	08/18/97		●
GW-079	BG		●	01/23/97	08/18/97		●
GW-080	BG	●		01/21/97	08/14/97		●
GW-084	OLF	●		01/27/97	08/13/97		●
GW-085	OLF	●		03/05/97 D	09/17/97	●	
GW-115	S3	●		01/22/97	08/11/97		●
GW-162	BG		●	01/24/97	08/19/97 D		●
GW-276	S3	●		01/28/97	08/13/97		●
GW-287	BG	●	●	02/06/97	09/03/97	●	
GW-311	RS	●	●	03/04/97	09/19/97	●	
GW-315	SPI	●		03/05/97	09/16/97	●	
GW-363	OLF		●	01/28/97 D	08/14/97		●
GW-372	BG	●		01/27/97 D	08/14/97		●
GW-373	BG		●	01/27/97	08/20/97		●
GW-521	LIV		●	01/07/97 D	07/21/97		●
GW-537	OLF	●		03/04/97	09/17/97 D	●	
GW-613	S3	●		01/22/97	08/11/97		●
GW-614	S3		●	01/27/97	08/14/97 D		●
GW-621	EXP-B	●	●	02/17/97	08/21/97		●
GW-627	BG		●	02/08/97 D	09/09/97 D	●	
GW-642	BG	●		01/21/97	08/14/97		●
GW-653	BG	●	●	02/06/97	09/03/97	●	
GW-683	EXP-A		●	02/17/97	08/21/97		●
GW-684	EXP-A		●	02/18/97	08/21/97		●
GW-685	EXP-A		●	02/12/97	08/20/97 D		●
GW-695	EXP-B	●		02/17/97	08/19/97		●
GW-703	EXP-B		●	02/19/97	08/27/97		●
GW-704	EXP-B		●	02/19/97	08/28/97		●

Table 4 (cont'd)

Monitoring Program ¹		RCRA Post-Closure Corrective Action Monitoring						
		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring						
		DOE Order 5400.1 Surveillance Monitoring						
Sampling Point ²	Sampling Location ³	Sampling Equipment ⁴		Sampling Date ⁵				
		Dedicated	Portable	1st Quarter	3rd Quarter			
GW-706	EXP-B		●	02/21/97	09/03/97		●	
GW-710	EXP-W		●	02/02/97	08/28/97		● ●	
GW-711	EXP-W		●	01/31/97	08/26/97		● ●	
GW-712	EXP-W		●	02/02/97	08/26/97 D		● ●	
GW-713	EXP-W		●	02/02/97 D	08/27/97		● ●	
GW-714	EXP-W		●	02/03/97	08/27/97		● ●	
GW-715	EXP-W	●	●	02/03/97	08/27/97		● ●	
GW-724	EXP-C		●	02/27/97 D	09/05/97		●	
GW-725	EXP-C		●	02/28/97	09/05/97		●	
GW-738	EXP-C		●	02/25/97	09/04/97 D		●	
GW-740	EXP-C		●	02/24/97	09/04/97		●	
GW-829	OLF		●	03/04/97	09/16/97	●		
BCK-00.63	EXP-SW		●	02/04/97	08/28/97		●	
BCK-04.55	EXP-SW		●	02/04/97	08/28/97		●	
BCK-07.75	EXP-SW		●	02/04/97	08/29/97		●	
BCK-09.40	EXP-SW		●	02/04/97	08/29/97		●	
BCK-10.60	EXP-SW		●	02/04/97	08/29/97		●	
BCK-11.97	EXP-SW		●	02/04/97	08/29/97 ⁶		●	
NT-01	EXP-SW		●	02/03/97	10/13/97 ⁷		●	
SS-1	EXP-SW		●	02/03/97	10/13/97 ⁷		●	
SS-4	EXP-SW		●	02/03/97	08/29/97 D		●	
SS-5	EXP-SW		●	02/03/97	08/29/97		●	

Notes:

- 1 See Table 5 for list of field measurements and laboratory analytes.
- 2 BCK - Bear Creek Kilometer
 GW - Groundwater Monitoring Well
 NT - Northern Tributary
 SS - South Spring

Table 4 (cont'd)

Notes: (cont'd)

- 3 BG - Bear Creek Burial Grounds Waste Management Area
EXP-A - Exit Pathway (Maynardville Limestone) Picket A
EXP-B - Exit Pathway (Maynardville Limestone) Picket B
EXP-C - Exit Pathway (Maynardville Limestone) Picket C
EXP-W - Exit Pathway (Maynardville Limestone) Picket W
EXP-SW - Exit Pathway (Bear Creek) Surface Water
LIV - Industrial Landfill IV (Chestnut Ridge Regime)
OLF - Oil Landfarm Waste Management Area
RS - Rust Spoil Area
SPI - Spoil Area I
S3 - S-3 Site
- 4 Dedicated: Well Wizard™ (dedicated bladder pump).
Portable: Bennet Pumps™ and disposable bailers (groundwater) and grab
 bottles (surface water and springs).
- Well Wizards™ were removed from wells GW-311 and GW-621, and
installed in wells GW-053, GW-287, GW-653, and GW-715 after the first
quarter sampling event but before the third quarter sampling event.
- 5 "D" used to denote sampling locations from which duplicate samples were
collected on the specified sampling date.
- 6 Surface water station BCK-11.97 was resampled on September 12, 1997,
for tritium analysis during the third quarter sampling event.
- 7 Surface water station NT-01 and spring SS-1 were dry during August.
They were sampled in October when sufficient flow was available.

Table 5.
Laboratory Analytes and Field Measurements for CY 1997
Groundwater and Surface Water Samples

MONITORING PROGRAM		RCRA Post-Closure Corrective Action Monitoring ¹				
		DOE Order 5400.1 Monitoring ²				
PRINCIPAL IONS	Analytical Method ³	GWPS Constituent ⁴	Sample Type ⁵			
			Filtered	Unfiltered		
Alkalinity - HCO ₃	EPA-310.1	.	.	●	●	●
Alkalinity - CO ₃	EPA-310.1	.	.	●	●	●
Calcium	EPA-6010A	.	●	●	●	●
Chloride	EPA-300.0	.	.	●	●	●
Fluoride	EPA-340.2	.	.	●	●	●
Magnesium	EPA-6010A	.	●	●	●	●
Nitrate (as N)	EPA-300.0	●	.	●	●	●
Potassium	EPA-6010A	.	●	●	●	●
Sodium	EPA-6010A	.	●	●	●	●
Sulfate	EPA-300.0	.	.	●	●	●
TRACE METALS	Analytical Method	GWPS Constituent	Sample Type			
			Filtered	Unfiltered		
Aluminum	EPA-6010A	.	●	●	●	●
Antimony	EPA-6010A	.	●	●	●	●
Arsenic	EPA-200.8	.	●	●	●	●
Barium	EPA-6010A	●	●	●	●	●
Beryllium	EPA-6010A	.	●	●	●	●
Boron	EPA-6010A	.	●	●	●	●
Cadmium	EPA-6010A	●	●	●	●	●
Chromium	EPA-6010A	●	●	●	●	●
Cobalt	EPA-6010A	.	●	●	●	●
Copper	EPA-6010A	.	●	●	●	●
Iron	EPA-6010A	.	●	●	●	●
Lead	EPA-200.8	●	●	●	●	●
Lithium	EPA-6010A	.	●	●	●	●
Manganese	EPA-6010A	.	●	●	●	●
Mercury	EPA-7470	●	●	●	●	●
Molybdenum	EPA-6010A	.	●	●	●	●
Nickel	EPA-6010A	●	●	●	●	●
Selenium	EPA-6010A	.	●	●	●	●
Silver	EPA-6010A	.	●	●	●	●
Strontium	EPA-6010A	.	●	●	●	●
Thallium	EPA-200.8	.	●	●	●	●
Thorium	EPA-6010A	.	●	●	●	●

Table 5 (cont'd)

MONITORING PROGRAM		RCRA Post-Closure Corrective Action Monitoring ¹				
		DOE Order 5400.1 Monitoring ²				
TRACE METALS (cont'd)	Analytical Method ³	GWPS Constituent ⁴	Sample Type ⁵			
			Filtered	Unfiltered		
Uranium	EPA-200.8	●	●	●	●	●
Vanadium	EPA-6010A	.	●	●	●	●
Zinc	EPA-6010A	.	●	●	●	●
VOLATILE ORGANIC COMPOUNDS	Analytical Method	GWPS Constituent	Sample Type			
			Filtered	Unfiltered		
Acetone	EPA-8260	●	.	●	●	●
Acrolein	EPA-8260	.	.	●	●	●
Acrylonitrile	EPA-8260	.	.	●	●	●
Benzene	EPA-8260	●	.	●	●	●
Bromochloromethane	EPA-8260	.	.	●	●	●
Bromodichloromethane	EPA-8260	.	.	●	●	●
Bromoform	EPA-8260	●	.	●	●	●
Bromomethane	EPA-8260	.	.	●	●	●
2-Butanone	EPA-8260	●	.	●	●	●
Carbon disulfide	EPA-8260	.	.	●	●	●
Carbon tetrachloride	EPA-8260	●	.	●	●	●
Chlorobenzene	EPA-8260	.	.	●	●	●
Chloroethane	EPA-8260	.	.	●	●	●
2-Chloroethyl vinyl ether	EPA-8260	.	.	●	●	●
Chloroform	EPA-8260	●	.	●	●	●
Chloromethane	EPA-8260	.	.	●	●	●
Dibromochloromethane	EPA-8260	.	.	●	●	●
1,2-Dibromo-3-chloropropane	EPA-8260	.	.	●	●	●
1,2-Dibromoethane	EPA-8260	.	.	●	●	●
Dibromomethane	EPA-8260	.	.	●	●	●
1,2-Dichlorobenzene	EPA-8260	.	.	●	●	●
1,4-Dichlorobenzene	EPA-8260	.	.	●	●	●
1,4-Dichloro-2-butene	EPA-8260	.	.	●	●	●
trans-1,4-Dichloro-2-butene	EPA-8260	.	.	●	●	●
Dichlorodifluoromethane	EPA-8260	.	.	●	●	●
1,1-Dichloroethane	EPA-8260	.	.	●	●	●
1,2-Dichloroethane	EPA-8260	.	.	●	●	●
1,1-Dichloroethene	EPA-8260	●	.	●	●	●
1,2-Dichloroethene	EPA-8260	.	.	●	●	●
cis-1,2-Dichloroethene	EPA-8260	.	.	●	●	●
trans-1,2-Dichloroethene	EPA-8260	●	.	●	●	●
1,2-Dichloropropane	EPA-8260	.	.	●	●	●

Table 5 (cont'd)

MONITORING PROGRAM		RCRA Post-Closure Corrective Action Monitoring ¹				
		DOE Order 5400.1 Monitoring ²				
VOLATILE ORGANIC COMPOUNDS (cont'd)	Analytical Method ³	GWPS Constituent ⁴	Sample Type ⁵			
			Filtered	Unfiltered		
cis-1,3-Dichloropropene	EPA-8260	.	.	●	●	●
trans-1,3-Dichloropropene	EPA-8260	.	.	●	●	●
Dimethylbenzene	EPA-8260	.	.	●	●	●
Ethanol	EPA-8260	.	.	●	●	●
Ethylbenzene	EPA-8260	.	.	●	●	●
Ethyl methacrylate	EPA-8260	.	.	●	●	●
2-Hexanone	EPA-8260	.	.	●	●	●
Iodomethane	EPA-8260	.	.	●	●	●
4-Methyl-2-pentanone	EPA-8260	●	.	●	●	●
Methylene chloride	EPA-8260	●	.	●	●	●
Styrene	EPA-8260	.	.	●	●	●
1,1,1,2-Tetrachloroethane	EPA-8260	.	.	●	●	●
1,1,2,2-Tetrachloroethane	EPA-8260	.	.	●	●	●
Tetrachloroethene	EPA-8260	●	.	●	●	●
Toluene	EPA-8260	●	.	●	●	●
1,1,1-Trichloroethane	EPA-8260	●	.	●	●	●
1,1,2-Trichloroethane	EPA-8260	.	.	●	●	●
Trichloroethene	EPA-8260	●	.	●	●	●
Trichlorofluoromethane	EPA-8260	.	.	●	●	●
1,2,3-Trichloropropane	EPA-8260	.	.	●	●	●
Vinyl acetate	EPA-8260	.	.	●	●	●
Vinyl chloride	EPA-8260	.	.	●	●	●
RADIOLOGICAL ANALYTES	Analytical Method	GWPS Constituent	Sample Type			
			Filtered	Unfiltered		
Gross Alpha Activity	EPA-900.0	●	.	●	●	●
Gross Beta Activity	EPA-900.0	●	.	●	●	●
Americium-241	AC-MM-2-22012	●	.	●	●	●
Iodine-129	EPA-901.1	●	.	●	●	●
Neptunium-237	Y/P65-7206	●	.	●	●	●
Plutonium-238	AC-MM-2-22012	●	.	●	●	●
Plutonium-239/240	AC-MM-2-22012	.	.	●	●	●
Radium-223/224/226	EPA-903.0	●	.	●	●	●
Strontium-89/90	EPA-905.0	●	.	●	●	●
Technetium-99	Y/P65-7154	●	.	●	●	●
Thorium-228,230,232,234	Y/P65-7206	.	.	●	●	●
Tritium	EPA-906.0	●	.	●	●	●
Total Uranium and % U-235	Y/P65-8044	.	.	●	●	●
Uranium-234,235,238	AC-MM-2-22012	●	.	●	●	●

Table 5 (cont'd)

MONITORING PROGRAM		RCRA Post-Closure Corrective Action Monitoring ¹				
		DOE Order 5400.1 Monitoring ²				
MISC. LABORATORY ANALYTES	Analytical Method ³	GWPS Constituent ⁴	Sample Type ⁵			
			Filtered	Unfiltered		
pH	EPA-150.1	.	.	●	●	●
Conductivity	EPA-129.1	.	.	●	●	●
Total Dissolved Solids	EPA-160.1	.	.	●	●	●
Total Suspended Solids	EPA-160.2	.	.	●	●	●
Turbidity	EPA-180.1	.	.	●	●	●
FIELD MEASUREMENTS	Analytical Method	GWPS Constituent	Sample Type			
			Filtered	Unfiltered		
Depth-to-Water	ESP 302-1	.	.	.	●	●
Water Temperature	ESP 307-1	.	.	●	●	●
pH	ESP 307-2	.	.	●	●	●
Conductivity	ESP 307-8	.	.	●	●	●
Dissolved Oxygen	ESP 307-5	.	.	●	●	●
Oxidation-Reduction Potential	ESP 307-5	.	.	●	●	●

Notes:

- 1 Monitoring per the requirements of the Resource Conservation and Recovery Act (RCRA) Post-Closure Permit for the Bear Creek Regime.
- 2 Surveillance monitoring and exit pathway/perimeter monitoring per the requirements of U.S. Department of Energy (DOE) Order 5400.1. Only samples from surface water station BCK-11.97 were analyzed for radionuclides.
- 3 Volatile Organic analyses were performed using method EPA-8240 during the first semiannual sampling event. Analytical/field methods/procedures from:
 - *Test Methods for Evaluating Solid Waste Physical/Chemical Methods* (U.S. Environmental Protection Agency 1986)
 - *Methods for Chemical Analysis of Water and Wastes* (U.S. Environmental Protection Agency 1983)
 - *Environmental Surveillance Procedures Quality Control Program* (Lockheed Martin Energy Systems, Inc. 1988)
 - Lockheed Martin Energy Systems ASO radiological methods
- 4 Groundwater protection standard (GWPS) constituent specified in the RCRA Post-Closure Permit for the Bear Creek Regime.
- 5 Groundwater samples for metals analysis collected with dedicated sampling equipment or portable Bennet Pumps™ were filtered in the field; samples collected with bailers and surface water samples were filtered in the laboratory.

Table 6.
Summary of VOC Results for CY 1997 QA/QC Samples

Compounds	Number of Detected Results by Sample Type			
	Laboratory Blanks	Trip Blanks	Rinsates	Field Blanks
Groundwater Artifacts				
Acetone	20	26	9	1
2-Butanone	13	15	7	0
Dimethylbenzene	7	3	0	0
Ethylbenzene	2	1	0	0
Iodomethane	2	4	1	0
4-Methyl-2-pentanone	5	1	0	0
Toluene	0	8	2	0
Plume Constituents				
Chloroform	0	36	17	2
Trichloroethene	3	5	0	0
Miscellaneous Compounds				
Acrylonitrile	0	1	0	0
Carbon disulfide	1	0	0	0
1,2-Dichloroethane	0	2	0	0
Ethanol	2	0	0	0
2-Hexanone	9	0	0	0
Sampling Artifact				
Methylene chloride	0	0	1	0
Total Number of Samples	42	60	19	2
Samples With VOCs¹	28	53	19	2
Percent Contaminated	67%	88%	100%	100%

Notes:

- 1 Groundwater artifacts were commonly introduced into groundwater samples from the laboratory environment and screened as false positives.
Plume constituents were commonly detected in groundwater samples from wells located downgradient of waste management sites.
Miscellaneous compounds were never detected in groundwater samples.
The sampling artifact was probably introduced into a groundwater sample by the sampling equipment.
- 2 Some samples had more than one compound detected.

Table 7.
CY 1997 Maximum Summed VOC Concentrations in Groundwater Samples

Well Number	Location ¹	Date Sampled ²	Maximum CY 1997 Concentration ³ (µg/L)										SUMMED VOCs
			Chloroethenes				Chloromethanes		Chloroethanes				
			PCE	TCE	1,2-DCE	1,1-DCE	Vinyl Chloride	Carbon Tet.	Chloroform	1,1,1-TCA	1,1-DCA		
AQUITARD WELLS													
GW-276	S3	08/13/97	23	0	0	0	0	0	1J	0	0	24	
GW-085	OLF	09/17/97	0	0	0	0	0	0	2J	0	0	2	
GW-537	OLF	03/04/97	0	0	0	0	0	0	2J	0	0	2	
GW-069	BG	08/18/97	0	0	0	0	3J	0	0	0	0	3	
GW-287	BG	02/06/97	5	0	0	0	0	0	0	0	0	5	
GW-627	BG	02/08/97	83	16	0	3J	0	0	0	0	8	110	
GW-653	BG	02/06/97	3J	2J	26	1J	0	0	0	1J	2J	35	
AQUIFER WELLS													
GW-315	SPI	09/16/97	19	7	5	0	0	0	0	0	0	31	
GW-311	RS	09/19/97	0	12	0	0	0	1J	1J	0	0	14	
GW-724	EXP-C	09/05/97	0	45	0	0	0	0	0	0	0	45	
GW-725	EXP-C	09/05/97	0	16	0	0	0	0	0	0	0	16	
GW-738	EXP-C	02/25/97	0	43	2J	0	0	0	1J	0	0	46	
GW-740	EXP-C	09/04/97	0	73	3J	0	0	2J	FP	0	0	78	
GW-695	EXP-B	02/17/97	0	7	3J	0	0	0	0	0	0	10	
GW-703	EXP-B	08/27/97	0	14	3J	0	0	0	0	0	0	17	
GW-704	EXP-B	08/28/97	0	100	3J	7	0	2J	0	2J	1J	115	
GW-706	EXP-B	09/03/97	0	11	5	0	0	0	0	0	0	16	
GW-053	BG	09/03/97	0	2J	15	0	6	0	0	0	7	30	
GW-685	EXP-A	08/20/97	0	1J	1J	0	0	0	0	0	0	2	
Maximum Contaminant Level			5	5	70	7	2	5	0	200	0		

Table 7 (cont'd)

Notes:

- 1 BG - Bear Creek Burial Grounds Waste Management Area
- EXP-A - Exit Pathway (Maynardville Limestone) Picket A
- EXP-B - Exit Pathway (Maynardville Limestone) Picket B
- EXP-C - Exit Pathway (Maynardville Limestone) Picket C
- OLF - Oil Landfarm Waste Management Area
- RS - Rust Spoil Area
- SPI - Spoil Area I
- S3 - S-3 Site

2 Only results for the sample date with highest summed concentration are presented; all results are in Appendix C.

3 Concentrations are reported in micrograms per liter ($\mu\text{g/L}$). All detected compounds are shown, excluding false-positive results and anomalous results (potential artifacts). Results in bold typeface exceed the Maximum Contaminant Level. All of the 1,2-DCE in the samples was cis-1,2-DCE (trans-1,2-DCE was never detected).

- J - Estimated value below the reporting limit.
- FP - False-positive result.

Table 8.
CY 1997 Gross Alpha and Gross Beta Activity in Groundwater
and Surface Water Samples

Sampling Point	Gross Alpha Activity ¹ (pCi/L)		Gross Beta Activity ¹ (pCi/L)	
	1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.
Aquitard Wells				
GW-040	13 ± 7.4	2.8 ± 2	35 ± 14	.
GW-079	.	1.8 ± 1.6	.	.
GW-085	.	.	38 ± 7	38 ± 5
GW-276	360 ± 50	340 ± 30	680 ± 89	790 ± 27
GW-287	.	.	9.9 ± 5.6	.
GW-537	.	.	420 ± 28	550 ± 60
GW-642	15 ± 6.7	.	.	.
GW-829	6.1 ± 4.3	.	.	.
Aquifer Wells				
GW-056	.	.	10 ± 5.4	.
GW-311	.	5 ± 2.1	.	.
GW-315	.	.	.	25 ± 6
GW-621	5.5 ± 3.9	.	.	.
GW-683	16 ± 7	19 ± 5	.	26 ± 6
GW-684	13 ± 6	13 ± 5	.	38 ± 7
GW-685	.	5.5 ± 3.3	.	15 ± 5
GW-695	.	5.4 ± 3.2	.	18 ± 5
GW-703	.	.	.	40 ± 6
GW-706	45 ± 11	29 ± 7	73 ± 13	67 ± 8
GW-710	.	.	.	63 ± 7
GW-714	.	4.7 ± 2.8	.	.
GW-724	.	.	47 ± 11	30 ± 6
GW-725	.	.	27 ± 9	28 ± 5.8
GW-738	.	.	.	22 ± 6
GW-740	.	.	.	13 ± 4
Springs				
SS-1	20 ± 8	14 ± 5	20 ± 6.9	42 ± 7
SS-4	43 ± 10	50 ± 9	32 ± 8	100 ± 10
SS-5	9.3 ± 6	18 ± 7	11 ± 5.6	34 ± 6

Table 8 (cont'd)

Sampling Point	Gross Alpha Activity ¹ (pCi/L)		Gross Beta Activity ¹ (pCi/L)	
	1st Qtr.	3rd Qtr.	1st Qtr.	3rd Qtr.
Surface Water				
NT-01	.	100 ± 40	71 ± 12	920 ± 90
BCK-11.97	12 ± 6.5	21 ± 7	36 ± 8.2	270 ± 15
BCK-10.60	48 ± 11	18 ± 5	45 ± 9.2	.
BCK-09.40	32 ± 9	28 ± 7	27 ± 7.3	37 ± 7
BCK-07.75	22 ± 7.6	21 ± 6	20 ± 6.5	29 ± 6
BCK-04.55	13 ± 6.4	19 ± 6	17 ± 6.2	.
BCK-00.63	.	11 ± 4	9 ± 5.5	.

Notes:

- 1 Activity, reported in picoCuries per liter (pCi/L), that exceeded the error associated with the result and the sample-specific minimum detectable activity (MDA).
 - . - Result less than the MDA and the associated error.

APPENDIX C

**SUMMARY OF CY 1997 DATA
THAT MEET APPLICABLE DQOs**

EXPLANATION

SAMPLING POINT:

- BCK - Bear Creek Kilometer
- GW - Monitoring Well
- NT - Northern Tributary
- SS - Spring (south side of Bear Creek)

LOCATION:

- BG - Bear Creek Burial Grounds WMA
- EXP - Exit Pathway Monitoring Location:
 - Maynardville Limestone Picket (-A, -B, -C, -W)
 - Spring or Surface Water Sampling Location (-SW)
- OLF - Oil Landfarm WMA
- RS - Rust Spoil Area
- S3 - S-3 Site
- SPI - Spoil Area I

UNITS:

- ft - feet (water-level elevation is in feet above mean sea level)
- mg/L - milligrams per liter
- ug/L - micrograms per liter
- pCi/L - picoCuries per liter

DATA QUALIFIERS:

- . - Not detected or not analyzed.
- TOT < DIS - Total concentration (unfiltered sample) is at least an order of magnitude less than the dissolved concentration (filtered sample).
- FP - False-positive VOC result, screened by data from the associated laboratory blank (FP1) or trip blank (FP2) sample.
- ND - Not detected; Summed VOCs
- <MDA - Reported activity is less than the Minimum Detectable Activity.
- <CE - Reported activity is greater than the MDA, but less than the associated counting error.

EXPLANATION (cont'd)

NOTES:

Only unfiltered results that meet data quality objectives of the Y-12 Plant Groundwater Protection Program for the constituents detected at least once in CY 1997 are presented in this appendix. All of the analytical results for groundwater and surface water samples collected in 1997 are available in the Annual Groundwater Monitoring Report (AJA Technical Services, Inc. 1998).

Miscellaneous:

TSS - Total Suspended Solids

Major Ions:

The relative percent difference (RPD) between summed positive and negative charges (charge balance) is used to evaluate the accuracy of the data. Results for major ions are considered qualitative if the Charge Balance RPD is greater than 20 or less than -20.

Trace Metals:

The Cluster Designation reflects a group (summarized below) based on similar geochemical characteristics assigned to each sampling location (HSW Environmental Consultants, Inc. 1995).

Cluster	Description
1	Shallow groundwater with variable calcium-magnesium-bicarbonate geochemistry.
2	Shallow calcium-magnesium-bicarbonate groundwater with very low TDS.
3	Shallow groundwater with fairly uniform calcium-magnesium-bicarbonate.
4	Calcium-magnesium bicarbonate groundwater with equal or nearly equal proportions of calcium and magnesium.
6	Intermediate depth sodium-bicarbonate groundwater.
10	Deep sodium-chloride bicarbonate groundwater with very high TDS.

Data for wells that comprise clusters 5, 7, 8, and 9 were excluded from upper tolerance level (UTL) calculations because groundwater from these wells had elevated nitrate concentrations and may include contamination from the S-3 Site metals plume. For comparison to UTLs, wells that comprise clusters 5, 7, 8, and 9 were assigned to one of the above clusters as a "surrogate" group based on selected well construction information and water quality data. The following

EXPLANATION (cont'd)

table provides the UTLs that represent trace metal background levels for the wells in clusters that apply to the CY 1997 monitoring locations in the Bear Creek Regime.

Trace Metal	Upper Tolerance Limit (mg/L)				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 10
Aluminum	2.4	6.1	2.4	2.4	2.4
Antimony	0.05	0.05	0.05	0.05	0.05
Arsenic	0.05	0.05	0.05	0.05	0.05
Barium	0.71	0.68	0.79	0.34	0.35
Beryllium	0.00045	0.00045	0.00045	0.00045	0.00045
Boron	0.12	0.028	0.041	0.028	3.1
Cadmium	0.002	0.002	0.002	0.002	0.002
Chromium	0.029	0.041	0.041	0.029	0.029
Cobalt	0.019	0.019	0.019	0.019	0.019
Copper	0.012	0.012	0.012	0.012	0.012
Iron	8.7	8.7	8.7	4.6	6.9
Lead	0.0096	0.0096	0.0096	0.0096	0.009
Manganese	1.7	1.7	1.7	0.13	0.13
Mercury	0.0003	0.0003	0.0003	0.0003	0.0003
Molybdenum	0.018	0.018	0.018	0.018	0.018
Nickel	0.06	0.06	0.02	0.02	0.02
Selenium	0.05	0.05	0.05	0.05	0.05
Silver	0.006	0.006	0.006	0.006	0.0006
Strontium	4.4	0.079	0.92	0.079	0.92
Thorium	0.2	0.2	0.2	0.2	0.2
Uranium	0.012	0.004	0.005	0.005	0.005
Vanadium	0.005	0.005	0.005	0.005	0.005
Zinc	0.041	0.043	0.041	0.041	0.04

All metals analyses were performed using the inductively coupled plasma (ICP) spectroscopy method unless otherwise noted.

PMS - Plasma Mass Spectroscopy

Organics:

The maximum summed VOC value for each sampling location is used as a plume delineation value (see Section 4.3). Trans-1,2-dichloroethene (DCE) was not detected in any samples, therefore the total 1,2-DCE equals the cis-1,2-DCE concentration.

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	BCK-00.63		BCK-04.55		BCK-07.75		BCK-09.40		BCK-10.60	
Location	EXP-SW		EXP-SW		EXP-SW		EXP-SW		EXP-SW	
Date Sampled	02/04/97	08/28/97	02/04/97	08/28/97	02/04/97	08/29/97	02/04/97	08/29/97	02/04/97	08/29/97
MISCELLANEOUS										
Water-Level Elevation	.	.	.	.	.	.	.	.	.	.
Water in Well (ft)	.	.	.	.	.	.	.	.	.	.
TSS (mg/L)	3.6	2	8	1	5.6	4	2.8	37	.	8
pH (Field)	7.8	6.5	7.5	6.7	7.5	7.9	7.6	7.2	8	7.8
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-8.7	-0.7	-11.2	-2.4	-10	-3.1	-9.6	-3.4	-10.6	-3.4
Calcium	28	51	34	56	40	66	48	74	59	37
Magnesium	7.1	15	8.1	13	7.7	14	8.2	18	9.2	5.8
Potassium	1.4	1.9	1.5	1.9	1.5	2.1	1.8	2.2	1.9	2
Sodium	3.7	4.3	4.3	5.6	5.9	7.3	8.5	7.7	12	4.9
Alkalinity-HCO3	92	160	110	170	110	188	118	200	130	120
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	8.28	5.29	10	9.27	15.1	11.4	20.6	12	26.3	4.45
Fluoride	0.11	0.12	0.13	0.15	0.18	0.17	0.27	0.24	0.39	0.17
Sulfate	15.7	27.3	14.2	14.1	18.2	21.6	27.9	22.2	30.5	4.24
Nitrate-N	2.16	2.1	3.61	5.68	7.7	9.43	10.6	10.3	17	.
METALS (mg/L)										
CLUSTER DESIGNATION	4	4	3	3	2	2	1	1	1	1
Aluminum	0.75	0.1	0.97	0.078	0.78	0.18	0.64	2	0.59	0.82
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.042	0.063	0.05	0.068	0.057	0.085	0.066	0.096	0.087	0.038
Beryllium	.	.	.	.	.	.	.	.	.	.
Boron	0.036	0.045	0.039	0.07	0.047	0.096	0.04	0.061	0.03	0.049
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	.	.	.	.	.	.	.	.	.	.
Cobalt	.	.	.	.	.	.	.	.	.	.
Copper	.	.	.	.	.	.	.	.	.	.
Iron	0.56	0.068	0.72	0.043	0.64	0.13	0.55	2	0.5	0.92
Lead (PMS)	.	.	.	.	.	.	.	0.0041	.	0.00083
Lithium	0.01	0.0086	0.012	0.013	0.016	0.017	0.01	0.014	0.0098	0.0064
Manganese	0.027	0.013	0.04	0.0086	0.048	0.02	0.06	0.08	0.16	0.024
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	.	.	.	.	.	.
Silver	.	.	0.026	.	.	.	.	.	.	.
Strontium	0.065	0.16	0.07	0.12	0.096	0.15	0.13	0.15	0.18	0.09
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.019	0.021	0.025	0.046	0.043	0.066	0.061	0.066	0.084	0.041
Vanadium	.	.	.	.	.	.	.	.	.	.
Zinc	0.004	0.0026	0.0051	0.0031	0.0061	.	0.0051	0.014	0.0061	0.0043
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	ND	ND	3	ND	6	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	3	.	5	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	3	.	5	.	.	.
Tetrachloroethene	.	.	.	.	.	.	1	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	.	.	.	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	11	13	19	22	21	32	28	48	18
Gross Beta	9	<MDA	17	<MDA	20	29	27	37	45	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	BCK-11.97		GW-040		GW-042		GW-043		GH-044	
Location	EXP-SW		BG		BG		OLF		OLF	
Date Sampled	02/04/97	08/29/97	01/22/97	09/02/97	01/31/97	09/02/97	01/23/97	08/13/97	01/23/97	08/11/97
MISCELLANEOUS										
Water-Level Elevation	.	.	990.45	986.46	984.30	981.50	991.60	987.25	996.25	991.21
Water in Well (ft)	.	.	15.35	11.36	12.55	9.75	21.8	17.45	55.95	50.91
TSS (mg/L)	1.2	.	2750	181	5.2	1	7.5	22	.	4
pH (Field)	7.2	7.7	6.5	5.3	6.5	5.5	6.1	5.9	6.6	6.7
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-10.9	-2.5	-8.5	-3.4	-8.8	-5.8	-0.7	-2	-1.2	-6.7
Calcium	61	220	6.4	7.3	3.8	4.2	14	18	44	46
Magnesium	7.7	27	9.9	12	4.7	5.1	2.5	3.3	3	3
Potassium	1.8	4.4	5.1	9.2	0.82	1.7	0.81	1.2	0.83	0.65
Sodium	12	33	11	12	3.5	3.4	7	6.7	5	5.1
Alkalinity-HCO3	114	208	38	36	34	34	50	64	132	142
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	27	39.4	2.16	1.97	2	1.76	1.08	1.01	0.83	1.15
Fluoride	0.2	0.62	0.3	0.31	0.25	0.19	.	.	.	0.1
Sulfate	27.4	29.7	26.8	30	5.76	6.2	9.48	6.86	6.8	6.54
Nitrate-N	25.3	135	.	0.07	.	0.2	.	.	.	0.03
METALS (mg/L)										
CLUSTER DESIGNATION	1	1	3	3	2	2	2	2	3	3
Aluminum	0.83	0.12	13	21	.	.	0.43	2	.	.
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.11	0.48	0.24	0.3	0.17	0.16	0.015	0.021	0.24	0.24
Beryllium	.	.	0.00066	0.0013	.	.	.	.	.	.
Boron	0.021	0.042	0.032	0.041	0.0071	0.011	0.0085	0.0086	0.009	0.0055
Cadmium	.	.	.	.	0.03	0.0053	.	.	.	.
Chromium	.	.	0.025	0.042	.	.	.	0.038	.	.
Cobalt	.	.	0.012	0.017	.	.	.	.	.	.
Copper	0.0092	.	0.017	0.02	0.012	.	.	.	.	0.0053
Iron	0.55	0.061	24	33	4.5	2.4	0.52	1.4	0.0076	0.017
Lead (PMS)	.	.	0.011	0.01	0.022	0.0034	0.0028	0.0087	0.00057	0.004
Lithium	0.0042	0.0065	0.042	0.052	0.021	0.023	0.0076	0.0084	0.0068	0.0099
Manganese	0.3	0.42	1.2	1.2	0.31	0.31	0.011	0.026	0.0031	0.015
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	0.013	0.029	0.041	0.014	0.016	.	0.019	.	.
Silver	.	.	.	.	0.008	.	.	0.007	.	.
Strontium	0.18	0.69	0.029	0.035	0.017	0.018	0.024	0.034	0.071	0.076
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.03	0.11	0.00054	.	.	.	.	.	.	.
Vanadium	.	.	0.024	0.035	.	.	.	.	.	.
Zinc	0.012	0.0025	0.056	0.07	0.063	0.015	0.0027	0.0072	0.0053	0.013
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethane	.	.	.	.	.	.	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
Tetrachloroethene	.	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	.	.	.	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	12	21	13	2.8	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Gross Beta	36	270	35	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-053		GW-056		GW-069		GW-079		GW-080	
Location	BG		EXP-A		BG		BG		BG	
Date Sampled	02/06/97	09/03/97	02/13/97	08/19/97	01/22/97	08/18/97	01/23/97	08/18/97	01/21/97	08/14/97
MISCELLANEOUS										
Water-Level Elevation	898.86	892.47	883.08	882.50	919.14	916.51	963.01	958.45	959.31	956.01
Water in Well (ft)	31.33	24.94	51.63	51.05	94.09	91.46	50.77	46.21	11.98	8.68
TSS (mg/L)	4.8	4	70	182	.	.	1.5	4	1206	292
pH (Field)	7	7	7.5	7.1	8.5	7.8	7.5	7.7	5.9	6
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-7	-6.7	-9	-4.8	-2.3	-6.8	0.9	-0.7	-0.8	-7
Calcium	120	120	96	110	10	13	38	36	3.8	4.9
Magnesium	13	14	18	20	5.7	6	3.7	3.7	5.4	4.4
Potassium	1.9	2.8	1.4	1.6	3.9	4.5	0.73	1.2	6.5	3.5
Sodium	7.2	8.2	57	53	64	59	4.4	4.8	6.5	7.8
Alkalinity-HCO3	334	344	304	312	126	148	110	110	36	38
Alkalinity-CO3	.	.	.	.	12	.	.	.	.	.
Chloride	28.4	27	117	65.5	46	56.8	0.91	0.9	0.6	1.19
Fluoride	.	.	0.11	.	0.11	0.12	.	0.11	0.1	0.14
Sulfate	23.2	20.8	29.7	26.5	1.67	2.06	6.87	7.25	10.4	14.6
Nitrate-N	0.05	.	0.137	0.2	.	.	.	.	.	.
METALS (mg/L)										
CLUSTER DESIGNATION	1	1	1	1	10	10	3	3	2	2
Aluminum	0.069	0.029	0.44	2	0.034	0.025	0.14	0.093	8.6	0.67
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	0.013	0.0054	.	.	.	.
Barium	0.21	0.21	0.1	0.16	0.37	0.37	0.17	0.16	0.11	0.035
Beryllium	.	.	.	.	.	.	0.00061	.	.	.
Boron	0.22	0.27	0.021	0.023	0.11	0.099	0.0077	0.0072	0.018	0.01
Cadmium	.	.	.	.	0.0035	.	.	.	0.0047	.
Chromium	.	.	.	0.021	.	.	.	.	0.019	.
Cobalt	.	.	.	.	0.0071	.	.	.	0.0059	.
Copper	.	.	.	0.0076	0.0074	.	0.0076	.	0.054	0.032
Iron	0.66	0.44	1.8	2.8	0.19	0.17	0.051	0.082	10	0.98
Lead (PMS)	0.0059	.	0.0046	0.014	0.0033	0.0014	0.0031	0.0035	0.015	0.0046
Lithium	0.3	0.38	0.0044	0.01	0.037	0.037	0.0056	0.0058	0.021	0.01
Manganese	0.09	0.082	0.24	0.37	0.0037	0.0085	0.055	0.047	0.087	0.06
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	0.017	0.02	0.06	0.07	.	.	.	.	0.017	.
Silver	.	.	.	.	.	.	.	.	0.015	.
Strontium	0.39	0.42	0.15	0.52	0.87	0.89	0.13	0.13	0.025	0.02
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.0013	0.0017	0.0081	0.0065	.	.	.	.	.	.
Vanadium	.	.	.	.	.	.	.	.	0.011	.
Zinc	0.0074	0.0023	0.019	0.069	0.0097	0.0024	0.019	0.0039	0.047	0.021
ORGANICS (ug/L)										
SUMMED VOCs	28	30	ND	ND	ND	3	ND	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	7	7	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	11	15	.	.	.	.	.	.	.	.
cis-1,2-Dichloroethene	11	15	.	.	.	.	.	.	.	.
Tetrachloroethene	1	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	3	2	.	.	.	.	.	.	.	.
Vinyl chloride	6	6	.	.	.	3	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	1.8	<MDA	<MDA
Gross Beta	<MDA	<MDA	10	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-084		GW-085		GW-115		GW-162		GW-276	
Location	OLF		OLF		S3		BG		S3	
Date Sampled	01/27/97	08/13/97	03/05/97	09/17/97	01/22/97	08/11/97	01/24/97	08/19/97	01/28/97	08/13/97
MISCELLANEOUS										
Water-Level Elevation	985.05	981.44	971.55	967.65	1046.60	1043.02	1022.94	1019.40	996.30	994.35
Water in Well (ft)	18.48	14.87	50.53	46.63	47.7	44.12	109.84	106.3	16	14.05
TSS (mg/L)	17.2	29	10	4.4	1	1	41	7	3.6	12
pH (Field)	7.9	7.5	6.6	7	7	6.2	8	8.1	4.5	4.7
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-3	-2.3	-1.6	0.5	-2.1	-4.5	-0.5	-6.3	-18.6	-11
Calcium	53	57	150	140	77	81	29	29	100	140
Magnesium	3.9	4.1	9.6	8.8	12	12	4.9	5	20	23
Potassium	1	0.76	1.9	1.4	2.2	1.7	2.6	2.9	11	13
Sodium	5.2	5.4	7.3	7.6	10	10	14	14	82	81
Alkalinity-HCO3	160	172	170	162	240	260	116	128	.	16
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	0.85	0.88	10.6	4.64	12.4	14.4	2.88	2.95	264	174
Fluoride	0.12	0.13	.	.	.	0.1	.	0.1	5.3	4.27
Sulfate	7.45	7.3	9.6	5.72	16.7	17.9	8.8	8.67	33	73.4
Nitrate-N	.	0.14	70.2	63	0.032	.	0.094	.	110	125
METALS (mg/L)										
CLUSTER DESIGNATION	3	3	3	3	3	3	3	3	3	3
Aluminum	0.37	0.75	0.8	0.33	0.027	0.025	0.52	0.028	11	11
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.16	0.17	0.4	0.34	0.22	0.21	0.27	0.29	0.4	0.42
Beryllium	.	.	.	.	.	.	.	.	0.0081	0.0082
Boron	0.0066	0.0056	0.014	0.0046	0.021	0.017	0.043	0.043	0.031	0.043
Cadmium	.	.	.	.	.	.	.	.	0.042	0.039
Chromium	.	.	0.011	.	.	.	.	.	.	.
Cobalt	.	.	.	.	.	.	.	.	0.17	0.15
Copper	.	.	.	.	.	.	0.028	.	0.023	0.018
Iron	0.63	0.64	0.61	0.22	0.33	0.43	13	1.7	0.15	0.34
Lead (PMS)	0.004	0.003	0.00071	0.00055	.	.	0.0061	0.0057	0.0028	0.003
Lithium	0.01	0.0095	0.015	0.014	0.016	0.018	0.041	0.039	0.027	0.031
Manganese	0.054	0.13	0.023	0.012	0.37	0.41	0.15	0.12	7.9	7.4
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	.	.	.	.	0.44	0.4
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	0.075	0.083	0.37	0.32	0.13	0.14	0.73	0.8	0.26	0.33
Thallium (PMS)	.	.	.	.	.	.	.	.	.	0.00094
Uranium (PMS)	.	.	.	.	.	.	.	.	0.78	1.3
Vanadium	.	.	.	.	.	.	.	.	.	.
Zinc	.	0.0036	0.0041	0.021	0.0057	0.0026	0.027	0.0024	0.14	0.13
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	ND	2	ND	ND	ND	ND	24	24
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	2	.	.	.	.	.	1
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
Tetrachloroethene	.	.	.	.	.	.	.	.	24	23
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	.	.	.	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	360	340
Gross Beta	<MDA	<MDA	38	38	<MDA	<MDA	<MDA	<MDA	680	790

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-287		GW-311		GW-315		GW-363		GW-372	
	BG		RS		SPI		OLF		BG	
Date Sampled	02/06/97	09/03/97	03/04/97	09/19/97	03/05/97	09/16/97	01/29/97	08/14/97	01/27/97	08/14/97
MISCELLANEOUS										
Water-Level Elevation	918.89	917.35	978.77	959.65	1002.66	985.72	953.91	952.22	968.97	961.21
Water in Well (ft)	6.79	5.25	22.64	3.52	61.86	44.92	73.5	71.81	40.7	32.94
TSS (mg/L)	92.8	2	.	39	.	.	.	2	.	.
pH (Field)	5.5	6.4	7.2	7	6.9	6.3	9.2	7.7	7.6	7.5
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	5.2	27.4	-0.1	3.8	1.2	3	-2.5	0.1	-0.9	-1.7
Calcium	9.1	20	81	110	86	120	3	2.2	57	56
Magnesium	3	3.8	6.1	7.6	16	12	1.3	0.83	10	10
Potassium	1.2	1.6	1.7	3.2	1.9	3.6	1.6	1.5	1	1.8
Sodium	3.6	5.2	2.5	2.3	1.5	7.9	84	110	9.2	9
Alkalinity-HCO3	20	62	222	232	262	242	180	198	172	178
Alkalinity-CO3	.	.	.	.	.	.	16	40	.	.
Chloride	3.65	3.72	1.93	1.98	2.57	14.5	1.68	0.92	2.31	1.95
Fluoride	.	.	0.11	.	.	.	0.17	0.27	0.19	0.18
Sulfate	8.58	7.25	3.14	3.74	5.59	39.7	7.04	7.44	25.9	26.2
Nitrate-N	0.37	0.07	0.33	0.45	2.24	11.4	.	0.03	.	.
METALS (mg/L)										
CLUSTER DESIGNATION	3	3	3	3	1	1	10	10	3	3
Aluminum	3	0.22	0.088	11	.	0.049	.	0.42	0.023	0.034
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.089	0.076	0.02	0.046	0.035	0.052	0.09	0.059	0.076	0.067
Beryllium	0.00034	.	.	0.00091	.	.	.	.	.	.
Boron	0.015	0.021	0.0056	0.0066	0.01	0.008	0.25	0.3	0.011	0.013
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	1.2	.	.	0.087	.	.	.	.	.	.
Cobalt	.	.	.	0.013	.	.	.	.	.	.
Copper	0.025	0.0043	.	0.096	.	.	.	.	.	.
Iron	5	0.11	0.15	17	.	0.011	0.16	0.88	0.15	0.17
Lead (PMS)	0.0083	.	0.00096	0.13	.	.	.	.	0.00076	.
Lithium	.	0.0046	.	0.016	.	.	0.036	0.039	0.014	0.014
Manganese	0.39	0.11	0.0058	0.51	.	0.0016	0.0019	0.0069	0.03	0.033
Molybdenum	0.019	.	.	.	.	.	.	.	.	.
Nickel	0.029	.	.	0.065	.	.	.	.	.	.
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	0.033	0.048	0.076	0.092	0.1	0.2	0.12	0.084	0.16	0.16
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.00098	.	.	0.0012	.	0.0019	.	.	.	.
Vanadium	0.0067	.	.	0.024	.	.	.	.	.	.
Zinc	0.083	0.0074	0.0066	0.15	0.0032	0.023	0.0027	.	0.009	.
ORGANICS (ug/L)										
SUMMED VOCs	5	3	1	14	24	31	ND	ND	ND	ND
Carbon tetrachloride	.	.	1	1	.	.	.	.	.	.
Chloroform	.	.	.	1	.	FP2	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	4	5	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	4	5	.	.	.	.
Tetrachloroethene	5	3	.	.	14	19	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	FP2	12	6	7	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	5	< CE	<MDA	<MDA	<MDA	<MDA	< CE
Gross Beta	9.9	<MDA	<MDA	<MDA	<MDA	25	<MDA	<MDA	<MDA	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-373		GW-537		GW-613		GW-614		GW-621	
Location	BG		OLF		S3		S3		EXP-B	
Date Sampled	01/27/97	08/20/97	03/04/97	09/17/97	01/22/97	08/11/97	01/27/97	08/14/97	02/17/97	08/21/97
MISCELLANEOUS										
Water-Level Elevation	965.83	964.78	971.87	968.90	1001.92	999.44	1010.95	1007.15	913.52	913.42
Water in Well (ft)	143.08	142.03	20.98	18.01	33.72	31.24	91.75	87.95	30.95	30.85
TSS (mg/L)	8.8	6	.	.	.	2	.	.	3	43
pH (Field)	9.1	9.1	6.7	6.9	6.7	6.8	7.9	7.5	7.9	7.5
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-2	0.1	-11.1	-4.9	-1.2	-6	-1.4	-0.9	-6.2	-11.8
Calcium	1.4	1.5	930	900	26	29	45	50	54	64
Magnesium	0.15	0.17	72	62	2.7	2.8	9.3	9.9	9.8	11
Potassium	.	0.94	3.9	2.9	0.74	.	2.1	1.5	0.87	2.4
Sodium	110	120	35	32	3.3	3.5	9.2	9.5	1.9	3
Alkalinity-HCO3	176	188	288	278	82	92	172	176	180	176
Alkalinity-CO3	40	40	.	.	.	.	.	.	.	.
Chloride	1.91	2.88	38.7	29.3	0.85	1.06	0.63	0.65	4.44	15.2
Fluoride	1.53	1.47	.	.	.	0.12	.	.	.	.
Sulfate	28.7	28.1	4.37	4.52	5.51	5.63	11.5	11.4	4.6	43.7
Nitrate-N	.	.	782	696	0.033	0.03	.	.	4.07	5.68
METALS (mg/L)										
CLUSTER DESIGNATION	10	10	3	3	2	2	3	3	3	3
Aluminum	0.19	0.22	.	0.22	.	0.026	0.024	0.15	0.21	5.3
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.046	0.056	2.4	2	0.056	0.056	0.14	0.16	0.022	0.045
Beryllium	.	.	.	.	.	.	.	.	.	.
Boron	0.12	0.17	0.026	0.021	.	0.0052	0.059	0.021	0.013	0.031
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	.	.	.	.	.	.	.	.	0.027	0.07
Cobalt	.	.	.	.	.	.	.	.	.	.
Copper	0.015	.	.	.	.	.	.	.	.	0.0059
Iron	0.54	2.2	.	0.034	.	.	0.093	0.12	0.48	3.8
Lead (PMS)	0.0018	0.00053	.	.	.	.	.	.	0.00087	0.003
Lithium	0.033	0.036	0.043	0.034	0.0042	0.0058	0.011	0.012	0.0078	0.0078
Manganese	0.0055	0.013	.	.	.	.	0.012	0.014	0.053	0.21
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	.	.	.	.	0.02	0.062
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	0.061	0.069	3	2.4	0.044	0.05	0.55	0.61	0.059	0.075
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	.	.	0.0012	0.0014	.	.	.	.	0.0024	0.0049
Vanadium	.	.	.	.	.	.	.	.	.	0.0057
Zinc	0.0073	.	.	0.13	0.0022	.	0.0055	.	0.0037	0.013
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	2	2	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	2	2	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
Tetrachloroethene	.	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	.	.	.	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	5.5	<MDA
Gross Beta	<MDA	<MDA	420	550	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-627		GW-642		GW-653		GW-683		GW-684	
Location	BG		BG		BG		EXP-A		EXP-A	
Date Sampled	02/08/97	09/09/97	01/21/97	08/14/97	02/06/97	09/03/97	02/17/97	08/21/97	02/18/97	08/21/97
MISCELLANEOUS										
Water-Level Elevation	920.90	918.85	996.05	992.74	911.92	907.80	883.41	883.42	883.27	883.31
Water in Well (ft)	250.51	248.46	21.05	17.74	22.07	17.95	110.76	110.77	116.14	116.18
TSS (mg/L)	.	2	7	.	6.8	.	1	.	2	2
pH (Field)	9.1	8.9	6.6	5.6	5	4.9	7.4	8.4	7.4	7.4
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-5.3	-4.5	-10	-5.5	-5.3	-2.8	-6.6	-5.8	-6.4	-6.4
Calcium	0.9	1	7.6	7.7	2.2	2.2	43	62	40	59
Magnesium	0.21	0.22	8	8.5	1.2	1.1	15	17	13	17
Potassium	1.1	1.5	2.3	1.9	.	.	1.1	1.9	7.5	8.5
Sodium	300	300	7.6	7.5	2.6	2.5	4	6.8	4.8	7.5
Alkalinity-HCO3	564	520	72	68	14	14	158	190	158	174
Alkalinity-CO3	64	80	.	.	.	.	.	.	.	.
Chloride	40	35.9	1.07	1.13	0.89	0.82	8.1	12.4	15.6	19.1
Fluoride	5.03	4.98	0.29	0.37	.	.	0.17	0.14	0.2	0.18
Sulfate	32.3	30.3	9.36	9.51	2.36	2.15	14.3	29.9	12.8	31.9
Nitrate-N	.	.	0.066	.	.	.	3.41	10.1	3.14	9.15
METALS (mg/L)										
CLUSTER DESIGNATION	10	10	2	2	2	2	4	4	1	1
Aluminum	.	.	0.024	0.023	0.2	.	.	0.048	0.036	0.21
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.046	0.042	0.12	0.14	0.037	0.035	0.062	0.092	0.07	0.1
Beryllium	.	.	.	.	.	.	.	.	.	.
Boron	0.49	0.48	0.01	0.014	0.0042	0.0048	0.022	0.048	0.025	0.048
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	.	.	.	0.011	.	.	.	.	.	.
Cobalt	.	.	.	.	.	.	.	.	.	.
Copper	.	.	0.006	.	0.0062	.	.	.	.	.
Iron	0.61	0.18	3.1	4.1	0.12	0.009	0.034	0.038	0.091	0.21
Lead (PMS)	0.0022	0.00085	0.0014	.	.	.	.	0.00051	.	.
Lithium	0.088	0.087	0.037	0.038	.	.	0.0047	0.0076	0.014	0.019
Manganese	0.0075	0.0059	1.2	1.3	0.0065	0.0016	0.0011	0.0021	0.005	0.0083
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	.	.	.	.	.	.
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	0.077	0.076	0.023	0.025	0.019	0.019	0.072	0.12	0.09	0.14
Thallium (PMS)	.	0.0005	.	.	.	.	.	.	.	.
Uranium (PMS)	.	0.0006	.	.	.	.	0.031	0.034	0.025	0.034
Vanadium	.	.	.	.	.	.	.	.	.	.
Zinc	0.019	0.0091	0.0053	0.0022	0.0083	0.0026	0.0023	.	0.0054	0.0056
ORGANICS (ug/L)										
SUMMED VOCs	110	108	ND	ND	35	6	ND	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	8	7	.	.	2	.	.	.	.	.
1,1-Dichloroethene	3	1	.	.	1	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	26	6	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	26	6	.	.	.	.
Tetrachloroethene	83	84	.	.	3	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	1	.	.	.	.	.
Trichloroethene	16	15	.	.	2	.	.	.	.	.
Vinyl chloride	.	1	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	15	<MDA	<MDA	<MDA	16	19	13	13
Gross Beta	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	26	<MDA	38

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-685		GW-695		GW-703		GW-704		GW-706	
Location	EXP-A		EXP-B		EXP-B		EXP-B		EXP-B	
Date Sampled	02/12/97	08/20/97	02/17/97	08/19/97	02/19/97	08/27/97	02/19/97	08/28/97	02/21/97	09/03/97
MISCELLANEOUS										
Water-Level Elevation	884.28	885.16	914.18	910.95	917.30	911.36	916.13	910.03	917.72	910.37
Water in Well (ft)	133.3	134.18	39.56	36.33	147.5	141.56	230.14	224.04	174.44	167.09
TSS (mg/L)	11	2	102	57	3	3	2	15	.	2
pH (Field)	7.6	7.3	8.1	8	7.6	8.2	7.4	7.3	7.3	7.3
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-8.4	-5.7	-7.2	1.3	-3.9	-1.4	-2.6	-3.3	-5.1	-3.6
Calcium	71	81	37	39	65	62	63	64	81	96
Magnesium	24	22	18	19	29	28	31	31	17	20
Potassium	1.4	1.8	5.6	4.6	1.5	2	1.5	1.7	2.6	3.1
Sodium	24	21	31	18	9.4	9.6	13	14	11	13
Alkalinity-HCO3	304	260	202	186	202	212	208	218	182	252
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	57.7	42.4	11.5	11.5	22	17.3	32.6	30	23.5	29.2
Fluoride	0.12	0.11	0.12	0.11	0.16	0.17	0.19	0.19	0.4	0.35
Sulfate	19.9	36.6	11.9	13.5	22.2	21.6	24.5	21.3	39	27.8
Nitrate-N	2.21	5.89	8.81	1.5	16.5	15.6	17.2	16.5	18.1	33.1
METALS (mg/L)										
CLUSTER DESIGNATION	1	1	1	1	1	1	1	1	1	1
Aluminum	0.4	0.18	4.3	0.34	.	0.023	.	0.046	.	0.05
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.1	0.094	0.031	0.029	0.086	0.071	0.087	0.094	0.1	0.14
Beryllium	.	.	.	.	.	.	.	.	.	.
Boron	0.039	0.043	0.042	0.031	0.065	0.047	0.079	0.074	0.042	0.11
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	.	.	.	0.014	.	.	.	.	.	.
Cobalt	.	.	.	.	.	.	.	.	.	.
Copper	.	.	.	.	.	.	.	.	.	.
Iron	4.3	0.57	1.2	0.14	0.28	0.75	1.5	5.6	0.16	0.7
Lead (PMS)	0.00093	0.001	0.0022	0.00097	.	.	.	.	.	.
Lithium	0.0086	0.0076	0.015	0.0099	0.014	0.015	0.017	0.017	0.013	0.018
Manganese	0.15	0.086	0.004	0.0019	0.029	0.034	0.013	0.03	0.0078	0.026
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	.	.	.	.	.	.
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	0.11	0.13	0.06	0.064	0.21	0.22	0.43	0.44	0.24	0.28
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.0043	0.0084	0.0037	0.0022	0.0051	0.0048	0.001	0.001	0.13	0.11
Vanadium	.	.	.	.	.	.	.	.	.	.
Zinc	0.022	0.0084	0.0061	0.0023	0.0075	0.0055	0.0074	0.013	0.0026	0.005
ORGANICS (ug/L)										
SUMMED VOCs	1	2	10	5	8	17	16	115	2	16
Carbon tetrachloride	.	.	.	.	.	.	2	2	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	1	1	.	.
1,1-Dichloroethene	.	.	.	.	3	.	8	7	.	.
1,2-Dichloroethene	1	1	3	.	5	3	3	3	2	5
cis-1,2-Dichloroethene	1	1	3	.	5	3	3	3	2	5
Tetrachloroethene	.	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	2	2	.	.
Trichloroethene	.	1	7	5	FP2	14	FP2	100	FP1	11
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	5.5	<MDA	5.4	<MDA	<MDA	<MDA	<MDA	45	29
Gross Beta	<MDA	15	<MDA	18	<MDA	40	<MDA	<MDA	73	67

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-710		GW-711		GW-712		GW-713		GW-714	
Location	EXP-W		EXP-W		EXP-W		EXP-W		EXP-W	
Date Sampled	02/02/97	08/28/97	01/31/97	08/26/97	02/02/97	08/26/97	02/02/97	08/27/97	02/03/97	08/27/97
MISCELLANEOUS										
Water-Level Elevation	848.71	843.56	844.05	838.95	847.14	842.54	846.13	840.12	849.58	844.27
Water in Well (ft)	685.18	680.03	608.29	603.19	431.03	426.43	283.5	277.49	122.28	116.97
TSS (mg/L)	345	15	22	4	2	2	.	4	.	6
pH (Field)	7.6	6.9	8.1	7	7.7	7.8	7.8	7.7	7	7.9
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-7.3	-62.9	-7.7	1.8	-0.6	-4.6	-8.9	-4.1	-11	-4.6
Calcium	510	600	430	490	71	70	51	60	55	57
Magnesium	170	180	190	200	34	34	25	30	21	22
Potassium	9.8	8.4	23	23	1.3	2.1	2	2.6	1.1	1.3
Sodium	200	230	1100	1200	17	17	7.7	11	3.3	3.8
Alkalinity-HCO3	170	164	160	162	194	212	218	206	236	214
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	408	1750	2020	1990	21.5	14.2	15.3	14.2	11	9.3
Fluoride	1.5	1.73	1.54	1.71	0.48	0.53	0.5	0.53	0.14	0.18
Sulfate	1970	8970	1870	1570	129	139	67.2	84.2	21	25.4
Nitrate-N	.	.	.	.	0.072	0.15	0.734	0.1	3.57	2.62
METALS (mg/L)										
CLUSTER DESIGNATION	1	1	1	1	1	1	1	1	3	3
Aluminum	.	0.24	.	0.14	.	0.035	.	0.026	0.059	0.24
Antimony	.	.	.	0.1	.	.	.	.	.	.
Arsenic (PMS)	0.034	0.01	0.055	0.036	0.008	.	.	.	.	.
Barium	0.0035	0.0072	0.0094	0.011	0.042	0.044	0.029	0.044	0.057	0.066
Beryllium	.	.	.	.	.	.	.	.	.	.
Boron	0.34	0.25	1.2	1.2	0.085	0.086	0.071	0.059	0.072	0.059
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	.	.	.	.	0.069	.	.	.	.	.
Cobalt	.	.	.	.	.	.	.	.	.	.
Copper	.	.	0.012	.	0.0053	.	.	.	.	.
Iron	23	9.5	18	4.3	1.4	1.1	0.72	1.2	1.6	1.2
Lead (PMS)	.	.	.	.	.	.	.	.	0.0012	0.00073
Lithium	0.14	0.14	0.7	0.68	0.012	0.014	0.0099	0.013	0.0082	0.0093
Manganese	0.33	0.23	0.34	0.024	0.035	0.018	0.023	0.035	0.026	0.015
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	.	.	.	.	0.028	.	.	.	.	.
Silver	.	.	.	0.017	.	.	.	0.007	.	.
Strontium	7.6	8.9	12	12	1.2	1.3	1.1	1.5	0.19	0.2
Thallium (PMS)	.	.	.	0.0065	.	0.0014	.	.	.	.
Uranium (PMS)	.	.	.	.	0.00094	0.00055	0.0052	.	0.0031	0.0032
Vanadium	.	.	.	.	.	.	.	.	.	.
Zinc	0.0071	0.088	.	0.071	.	0.0024	0.0066	0.0066	0.0069	0.0081
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
cis-1,2-Dichloroethene	.	.	.	.	.	.	.	.	.	.
Tetrachloroethene	.	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	.	.	.	.	.	.	.
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	4.7
Gross Beta	<MDA	63	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point Location	GW-715		GW-724		GW-725		GW-738		GW-740	
	EXP-W		EXP-C		EXP-C		EXP-C		EXP-C	
Date Sampled	02/03/97	08/27/97	02/27/97	09/05/97	02/28/97	09/05/97	02/25/97	09/04/97	02/24/97	09/04/97
MISCELLANEOUS										
Water-Level Elevation	849.47	845.55	952.92	947.84	953.15	947.66	956.48	951.92	953.20	947.64
Water in Well (ft)	21.3	17.38	277.9	272.82	137.39	131.9	64.12	59.56	126.2	120.64
TSS (mg/L)	49.6	.	7.5	21	7	4	7.5	21	7.8	7.4
pH (Field)	6.7	7.1	7.5	7.6	7	6.9	7.2	7	7.8	7.4
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	-12	-4.4	-3.9	-3.6	-6.6	-2.2	-2.9	-1.2	-4.1	0.8
Calcium	74	79	96	100	190	170	110	120	61	65
Magnesium	15	12	42	43	40	32	24	26	31	33
Potassium	1.8	2	2.7	1.7	3	3	2.5	3.3	1.5	1.5
Sodium	16	17	25	28	25	23	6.1	6.6	1.8	2
Alkalinity-HCO3	268	252	238	236	328	326	324	326	272	272
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	48.1	35.1	87.6	85.6	113	67.9	13.7	10.8	12.9	6.86
Fluoride	.	.	0.23	0.21	0.12	0.17	.	.	0.17	0.22
Sulfate	6.68	6.54	24	25.1	34.7	39.3	28.1	24.6	7.64	13.2
Nitrate-N	0.524	0.34	35.7	36.3	76.1	47.5	11	10.4	3.41	3.64
METALS (mg/L)										
CLUSTER DESIGNATION	1	1	1	1	1	1	1	1	4	4
Aluminum	0.074	.	0.063	0.033	.	0.055	0.67	4.3	0.03	.
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.08	0.071	0.17	0.19	0.31	0.27	0.051	0.063	0.08	0.09
Beryllium	.	.	.	.	.	.	.	0.00036	.	.
Boron	0.023	.	0.069	0.078	0.048	0.024	0.017	0.035	0.015	0.027
Cadmium	.	.	.	.	.	.	.	.	.	.
Chromium	1.4	.	.	.	.	.	.	.	.	.
Cobalt	0.012	.	.	.	.	.	.	.	.	.
Copper	0.07	.	.	.	.	.	.	.	.	.
Iron	21	0.21	0.14	10	0.081	1.3	0.99	2.9	0.28	0.24
Lead (PMS)	.	.	.	.	.	.	0.0011	0.0023	.	.
Lithium	.	.	0.02	0.019	0.0067	0.0056	0.0059	0.0091	0.014	0.015
Manganese	0.095	0.014	0.0082	0.11	0.23	0.39	0.029	0.056	0.012	0.0091
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	0.4	0.12	.	.	.	.	.	.	.	.
Silver	.	0.0069	.	.	.	.	.	.	.	0.06
Strontium	0.086	0.086	1.2	1.4	0.83	0.67	0.11	0.12	0.048	0.055
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.0007	.	.	.	0.0044	0.0058	0.0022	0.0021	.	.
Vanadium	0.0063	.	0.0052	.	.	.	.	.	.	.
Zinc	0.0086	0.0036	0.0041	0.023	0.0033	0.025	0.0065	0.017	0.0029	0.0051
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	36	45	7	16	46	39	70	78
Carbon tetrachloride	.	.	.	.	.	.	.	1	2	2
Chloroform	.	.	.	.	.	.	1	FP2	FP2	FP2
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	1	.	.	.	2	2	3	3
cis-1,2-Dichloroethene	.	.	1	.	.	.	2	2	3	3
Tetrachloroethene	.	.	.	.	.	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	35	45	7	16	43	36	65	73
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Gross Beta	<MDA	<MDA	47	30	27	28	<MDA	22	<MDA	13

(CONTINUED)

APPENDIX C.1
Screened Data Summary, 1997

Sampling Point	GW-829		NT-01		SS-1		SS-4		SS-5	
Location	OLF		EXP-SW		EXP-SW		EXP-SW		EXP-SW	
Date Sampled	03/04/97	09/16/97	02/03/97	10/13/97	02/03/97	10/13/97	02/03/97	08/29/97	02/03/97	08/29/97
MISCELLANEOUS										
Water-Level Elevation	974.98	972.34	.	.	.	.	.	.	.	.
Water in Well (ft)	107.66	105.02	.	.	.	.	.	.	.	.
TSS (mg/L)	580	248	4.5	13	.	35	8	2	.	2
pH (Field)	8.7	7.9	7.1	6.8	7.2	7.5	7.5	7.1	7.3	7.4
MAJOR IONS (mg/L)										
CHARGE BALANCE (RPD)	0	-0.8	-7.5	-5	-7.7	-6.7	-10.8	-1.8	-8.5	-3.6
Calcium	33	23	50	520	220	170	66	110	36	72
Magnesium	12	7.9	7.8	62	17	14	15	22	12	16
Potassium	8.9	5.3	1.7	8.4	3.9	4.4	1.7	3.1	0.94	1.8
Sodium	110	120	7.2	78	27	31	8.8	15	3.1	7.7
Alkalinity-HCO3	180	180	84	258	310	336	198	234	146	200
Alkalinity-CO3	.	.	.	.	.	.	.	.	.	.
Chloride	3.16	3.3	9.75	103	95.5	101	22.8	26	7.42	12.8
Fluoride	0.48	0.34	0.32	1.37	0.22	0.49	0.35	0.43	0.15	0.19
Sulfate	15.137	17.5	13.7	39	258	66.1	31.6	23.3	9.92	24.1
Nitrate-N	33.9	54.1	25.3	382	12.4	14.6	11.3	42	2.09	11.4
METALS (mg/L)										
CLUSTER DESIGNATION	10	10	1	1	1	1	1	1	1	1
Aluminum	18	1.4	0.43	0.21	0.066	0.14	0.25	0.059	0.094	0.13
Antimony	.	.	.	.	.	.	.	.	.	.
Arsenic (PMS)	.	.	.	.	.	.	.	.	.	.
Barium	0.83	0.69	0.094	1.2	0.075	0.078	0.09	0.17	0.044	0.088
Beryllium	0.0011	.	.	.	.	.	.	.	.	.
Boron	0.28	0.26	0.019	0.061	0.054	0.054	0.036	0.11	0.022	0.06
Cadmium	.	.	.	0.043	.	.	.	.	.	.
Chromium	0.027	.	.	.	.	.	.	.	.	.
Cobalt	0.0078	.	.	0.013	.	.	.	.	.	.
Copper	0.015	0.0056	.	.	.	.	.	.	.	.
Iron	9.1	0.75	0.3	0.05	0.033	0.26	0.41	0.1	0.047	0.086
Lead (PMS)	0.0065	0.001	.	0.0012	.	0.0019	.	.	.	.
Lithium	0.07	0.061	.	0.006	0.0052	0.0072	0.012	0.024	0.0042	0.01
Manganese	0.14	0.022	0.44	9.2	0.03	0.086	0.24	0.02	0.0036	0.0049
Molybdenum	.	.	.	.	.	.	.	.	.	.
Nickel	0.018	.	0.011	0.16	.	.	.	.	.	.
Silver	.	.	.	.	.	.	.	.	.	.
Strontium	1.4	1.3	0.15	1.3	0.81	0.78	0.17	0.32	0.052	0.15
Thallium (PMS)	.	.	.	.	.	.	.	.	.	.
Uranium (PMS)	0.0025	0.0012	0.004	0.32	0.047	0.039	0.1	0.13	0.019	0.07
Vanadium	0.011	.	.	.	.	.	.	.	.	.
Zinc	0.033	0.0093	0.01	0.043	0.01	0.0034	0.0078	0.0032	TOT<DIS	0.0037
ORGANICS (ug/L)										
SUMMED VOCs	ND	ND	ND	21	2	ND	4	15	ND	3
Carbon tetrachloride	.	.	.	.	.	.	.	.	.	.
Chloroform	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethane	.	.	.	.	.	.	.	.	.	.
1,1-Dichloroethene	.	.	.	.	.	.	.	.	.	.
1,2-Dichloroethene	.	.	.	1	.	.	.	5	.	.
cis-1,2-Dichloroethene	.	.	.	1	.	.	.	5	.	.
Tetrachloroethene	.	.	.	19	2	.	.	.	.	.
1,1,1-Trichloroethane	.	.	.	.	.	.	.	.	.	.
Trichloroethene	.	.	.	1	.	.	4	10	.	3
Vinyl chloride	.	.	.	.	.	.	.	.	.	.
RADIOACTIVITY (pCi/L)										
Gross Alpha	6.1	<MDA	<MDA	100	20	14	43	50	9.3	18
Gross Beta	<MDA	<MDA	71	920	20	42	32	100	11	34

APPENDIX C.2
Screened Isotopic Data Summary, CY 1997

Sampling Point	BCK-11.97		GW-040		GW-042		GW-043		GW-044	
Location	EXP-SW		BG		BG		OLF		OLF	
Date Sampled	08/29/97	09/12/97	01/22/97	09/02/97	01/31/97	09/02/97	01/23/97	08/13/97	01/23/97	08/11/97
ACTIVITY (pCi/L)										
Gross Alpha	21	.	13	2.8	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Gross Beta	270	.	35	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Americium 241	<MDA	.	0.4	<MDA	<MDA	< CE	< CE	<MDA	<MDA	0.28
Neptunium 237	0.42	.	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 238	<MDA	.	<MDA	<MDA	<MDA	0.32	<MDA	<MDA	<MDA	<MDA
Plutonium 239	<MDA	.	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Radium 223/224/226	<MDA	.	8.2	<MDA	<MDA	<MDA	<MDA	1	<MDA	1.3
Technetium 99	450	.	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 234	17	.	<MDA	<MDA	< CE	<MDA	<MDA	0.14	<MDA	<MDA
Uranium 235	1.3	.	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 238	32	.	<MDA	0.17	<MDA	<MDA	<MDA	<MDA	<MDA	0.31

(CONTINUED)

Sampling Point	GW-069		GW-079		GW-080		GW-084		GW-115	
Location	BG		BG		BG		OLF		S3	
Date Sampled	01/22/97	08/18/97	01/23/97	08/18/97	01/21/97	08/14/97	01/27/97	08/13/97	01/22/97	08/11/97
ACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	1.8	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Gross Beta	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Americium 241	<MDA	0.19	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Neptunium 237	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 238	0.4	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 239	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Radium 223/224/226	<MDA	<MDA	<MDA	<MDA	5.1	<MDA	<MDA	<MDA	<MDA	<MDA
Technetium 99	<MDA	<MDA	<MDA	<MDA	13	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 234	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	< CE	<MDA	<MDA
Uranium 235	<MDA	<MDA	<MDA	<MDA	<MDA	0.12	<MDA	<MDA	<MDA	<MDA
Uranium 238	<MDA	0.25	<MDA	0.29	<MDA	0.37	<MDA	<MDA	< CE	<MDA

(CONTINUED)

Sampling Point	GW-162		GW-276		GW-363		GW-372		GW-373	
Location	BG		S3		OLF		BG		BG	
Date Sampled	01/24/97	08/19/97	01/28/97	08/13/97	01/29/97	08/14/97	01/27/97	08/14/97	01/27/97	08/20/97
ACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	360	340	<MDA	<MDA	<MDA	< CE	<MDA	<MDA
Gross Beta	<MDA	<MDA	680	790	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Americium 241	0.12	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Neptunium 237	<MDA	<MDA	20	19	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 238	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 239	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Radium 223/224/226	<MDA	<MDA	0.94	5.4	<MDA	<MDA	39	<MDA	0.95	<MDA
Technetium 99	<MDA	<MDA	920	760	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 234	<MDA	<MDA	190	19	<MDA	0.28	<MDA	<MDA	0.15	<MDA
Uranium 235	<MDA	<MDA	8.8	1.2	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 238	<MDA	<MDA	410	46	<MDA	0.17	<MDA	0.29	0.15	<MDA

(CONTINUED)

APPENDIX C.2
Screened Isotopic Data Summary, CY 1997

Sampling Point	GW-613		GW-614		GW-642		GW-710		GW-711	
Location	S3		S3		BG		EXP-W		EXP-W	
Date Sampled	01/22/97	08/11/97	01/27/97	08/14/97	01/21/97	08/14/97	02/02/97	08/28/97	01/31/97	08/26/97
ACTIVITY (pCi/L)										
Gross Alpha	<MDA	<MDA	<MDA	<MDA	15	<MDA	<MDA	<MDA	<MDA	<MDA
Gross Beta	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	63	<MDA	<MDA
Americium 241	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Neptunium 237	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	< CE	<MDA
Plutonium 238	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 239	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	< CE	4	<MDA	<MDA
Radium 223/224/226	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	8.6	8.6	2.8	4.7
Technetium 99	<MDA	14	<MDA	<MDA	13	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 234	<MDA	0.12	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 235	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 238	<MDA	0.36	<MDA	0.26	<MDA	0.2	<MDA	<MDA	<MDA	0.2

(CONTINUED)

Sampling Point	GW-712		GW-713		GW-714		GW-715	
Location	EXP-W		EXP-W		EXP-W		EXP-W	
Date Sampled	02/02/97	08/26/97	02/02/97	08/27/97	02/03/97	08/27/97	02/03/97	08/27/97
ACTIVITY (pCi/L)								
Gross Alpha	<MDA	<MDA	<MDA	<MDA	<MDA	4.7	<MDA	<MDA
Gross Beta	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Americium 241	<MDA							
Neptunium 237	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	< CE
Plutonium 238	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Plutonium 239	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	0.24	<MDA
Radium 223/224/226	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Technetium 99	<MDA	<MDA	<MDA	<MDA	8.5	<MDA	<MDA	<MDA
Uranium 234	0.67	0.72	0.42	0.47	0.74	0.87	0.25	0.23
Uranium 235	<MDA	< CE	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Uranium 238	0.26	0.31	<MDA	<MDA	1.3	1.3	0.3	0.57