Y/SUB/94-EAQ10C/3/P2

Y-12

OAK RIDGE
Y-12
PLANT

MARTIN MARIETTA

CALENDAR YEAR 1993
GROUNDWATER QUALITY REPORT
FOR THE
CHESTNUT RIDGE HYDROGEOLOGIC REGIME
Y-12 PLANT, OAK RIDGE, TENNESSEE

1993 Groundwater Quality Data Interpretations and Proposed Program Modifications

September 1994

Prepared by:

HSW ENVIRONMENTAL CONSULTANTS, INC.
Under Purchase Order 70Y-EAQ10C

for the

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

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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under contract
DE-AC05-84OR21400

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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LIST OF ACRONYMS

AAS	Atomic Absorption Spectroscopy
ARAR	Appropriate, Relevant, and Applicable Requirement
BCV	Bear Creek Valley
bgs	Below Ground Surface
BNA	Base, Neutral, and Acid (extractable organic compounds)
BQR	Blank Qualification Result
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CVAA	Cold Vapor Atomic Absorption (spectroscopy)
CY	Calendar Year
DOE	U.S. Department of Energy
Ecotek	EcoTek Laboratory Services, Inc.
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
ft	Feet
GWPP	Groundwater Protection Program
GWQR	Groundwater Quality Report
ICP	Inductively Coupled Plasma (spectroscopy)
K-25	Oak Ridge K-25 Site (formerly the Oak Ridge Gaseous Diffusion plant)
MCL	Maximum Contaminant Level (for drinking water)
mg/L	milligrams per liter
MSL	Mean Sea Level
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OU	Operable Unit
PCE	Tetrachloroethene
pCi/L	picocuries per liter
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
SWDF	Solid Waste Disposal Facility (non-RCRA)
SWMU	Solid Waste Management Unit (RCRA)
TCE	Trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TSD	Treatment, Storage, and Disposal (unit)
TSS	Total Suspended Solids
μg/L	micrograms per liter
VOC	Volatile Organic Compound
1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane

LIST OF ACRONYMS (cont'd)

1,1-DCE	1,1-Dichloroethene
1,2-DCE	1,2-Dichloroethene
1,2-DCP	1,2-Dichloropropane
1,1,1-TCA	1,1,1-Trichloroethane
1,1,2,2-PCA	1,1-2,2-Tetrachloroethane

1.0 INTRODUCTION

This groundwater quality report (GWQR) contains an evaluation of the groundwater quality data obtained during the 1993 calendar year (CY) at several hazardous and non-hazardous waste management facilities associated with the U.S. Department of Energy (DOE) Y-12 Plant located on the DOE Oak Ridge Reservation (ORR) southeast of Oak Ridge, Tennessee (Figure 1). The groundwater quality data are presented in Part 1 of the GWQR submitted by Martin Marietta Energy Systems, Inc. to the Tennessee Department of Environment and Conservation (TDEC) in February 1994 (HSW Environmental Consultants, Inc. 1994a).

Groundwater quality data evaluated in this report were obtained at several hazardous and non-hazardous waste management sites located within the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge Regime). The Chestnut Ridge Regime encompasses a section of Chestnut Ridge south of the Y-12 Plant and is one of three hydrogeologic regimes defined for the purposes of groundwater quality monitoring at the plant (Figure 2). The Environmental Management Department of the Y-12 Plant Health, Safety, Environment, and Accountability Organization manages the groundwater monitoring activities in each regime as part of the Y-12 Plant Groundwater Protection Program (GWPP).

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

2.0 BACKGROUND INFORMATION

The Chestnut Ridge Regime is located south of the Y-12 Plant, and is flanked to the north by Bear Creek Valley (BCV) and to the south by Bethel Valley (directions in this report are in reference to the Y-12 Plant grid system). The regime encompasses a portion of Chestnut Ridge extending from a gap in the ridge located southeast of the eastern end of the Y-12 Plant to a drainage basin on the ridge located southwest of the western end of the Y-12 Plant (Figure 2).

Groundwater quality monitoring during CY 1993 in the Chestnut Ridge Regime was performed at three classes of waste-management facilities:

- sites scheduled for investigation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- hazardous waste treatment, storage, and disposal (TSD) units subject to regulation under RCRA; and
- nonhazardous solid waste disposal facilities (SWDFs).

Locations of these facilities are shown on Figure 3; detailed site descriptions, and discussions of the regulatory status and groundwater monitoring history of each site are included in Section 2.0 of the Part 1 GWQR.

2.1 CERCLA Operable Units

In January 1992, the DOE, the U.S. Environmental Protection Agency (EPA), and TDEC negotiated a Federal Facility Agreement (FFA) regarding environmental restoration at the ORR under CERCLA. This agreement changed the regulatory status of several RCRA TSD units and RCRA regulated solid waste management units (SWMUs) at the Y-12 Plant to CERCLA Operable Units (OUs). As such, the DOE appealed the applicability of RCRA post-closure care, corrective action, and groundwater monitoring requirements to CERCLA OUs.

In April 1993, the DOE, TDEC, and Martin Marietta Energy Systems, Inc. signed an Agreed Order for the S-3 Site RCRA post-closure permit, thereby resolving the appeal and formally agreeing to proceed with CERCLA as a lead regulatory program with RCRA as an appropriate, relevant, and applicable requirement (ARAR). Under this agreement, RCRA will be applied as an ARAR to the extent that post-closure maintenance and care of former TSD facilities will be conducted in compliance with the terms of RCRA post-closure permits, but corrective action under RCRA will be deferred to CERCLA. Groundwater monitoring is to be integrated with the CERCLA remedial investigation/feasibility study (RI/FS) programs. Groundwater monitoring data reporting will comply with RCRA post-closure permit conditions as well as RI/FS requirements.

Two types of OUs were established under the FFA: source control OUs and integrator OUs. Source control OUs are individual or groups of waste-management sites for which a RI/FS will be performed, including any interim actions and/or remedial actions. Integrator OUs encompass groundwater and surface water, and are considered separate from source control OUs that contribute to the contamination of these media. Integrator OUs were established because available data showed that contaminants from multiple sources had intermingled in the groundwater system and migrated through common surface and subsurface exit-pathways (U.S. Department of Energy 1992).

The FFA established four source control OUs that lie within the Chestnut Ridge Regime (Table 1): one former RCRA TSD unit (the Chestnut Ridge Security Pits) and three former RCRA SWMUs (Ash Disposal Basin, United Nuclear Corporation Site, and Rogers Quarry). Because there was no evidence of intermingling contaminant plumes from these sites, no integrator OU was established for the Chestnut Ridge regime and groundwater and surface water are addressed in the RI/FS for each source control OU.

2.2 RCRA Treatment, Storage, or Disposal Facilities

There are 4 RCRA-regulated hazardous waste TSD facilities in the Chestnut Ridge Regime (Table 1): the Chestnut Ridge Security Pits (Security Pits), the Chestnut Ridge Sediment Disposal Basin (Sediment Disposal Basin), Kerr Hollow Quarry, and the East Chestnut Ridge Waste Pile. The Security Pits have been designated as a CERCLA OU the latter three sites are Y-12 Study Areas. The Sediment Disposal Basin and Kerr Hollow Quarry are closed facilities granted RCRA interim status in 1986. The East Chestnut Ridge Waste Pile is a storage facility built and operated in accordance with an operating RCRA permit issued by the TDEC in 1987.

2.3 Solid Waste Disposal Facilities

There are 6 nonhazardous waste landfills in the Chestnut Ridge Regime (Table 1): five TDEC-permitted SWDFs (Industrial Landfills II, IV, and V, and Construction/Demolition Landfills VI and VII) and one temporary storage facility (Industrial Landfill III). The five permitted landfills are classified as either Class II or Class IV facilities, as defined in the most recent (July 1993) *Rules of the Tennessee Department of Environment and Conservation, Division of Solid Waste Management, Chapter 1200-1-7, Solid Waste Processing and Disposal.*

Groundwater quality monitoring at each of the SWDFs in the Chestnut Ridge Regime is performed in accordance with the requirements for detection monitoring contained in paragraph 1200-1-7-.02(7) of the TDEC solid waste regulations. Detection monitoring at some of the permitted SWDFs includes site-specific requirements (i.e., additional analytical parameters) specified in the operating permit for the site, as requested by the TDEC, or performed as a best-management practice of the Y-12 Plant GWPP.

Detection monitoring was initiated at Industrial Landfill II in 1982, at Industrial Landfill III in 1986, and at Industrial Landfill IV in 1987. Construction/Demolition Landfills VI and VII and Industrial Landfill V are newly permitted facilities. As required under the TDEC solid waste regulations and permit requirements, quarterly sampling to establish background water-quality conditions for detection monitoring purposes was initiated in May 1993 at Construction/Demolition Landfills VI and VII, and Industrial Landfill V. This background sampling was completed during CY 1993 at Construction/Demolition Landfill VI, and this site became operational in December 1993. However, the background monitoring protocols for the Industrial Landfill V were modified in early-1994 to comply with amendments to TDEC Rule 1200-1-7-.04(7), effective January 1, 1994, which require new and existing Class II landfills to complete 4, rather than 2, quarters of baseline (background) monitoring. Class II background monitoring requirements also were implemented at Construction/Demolition Landfill VII because of its proximity to Industrial Landfill V.

3.0 HYDROGEOLOGIC FRAMEWORK

This section contains a general description of the complex hydrogeologic system in the Chestnut Ridge Regime. It provides sufficient descriptive detail needed for RCRA assessment monitoring reporting requirements regarding evaluation of groundwater flow directions. The description is based on the conceptual framework and associated nomenclature presented in: *Status Report - A Hydrologic Framework for the Oak Ridge Reservation* (Solomon et al. 1992).

Groundwater at the Y-12 Plant occurs in two broad hydrologic units with fundamentally different hydrologic characteristics: the Knox Aquifer and the ORR Aquitards. The Knox Aquifer is comprised of the Knox Group and the underlying Maynardville Limestone formation of the Conasauga Group. Groundwater flow in the Knox Aquifer is controlled by solution conduits and the bulk permeability is ten times greater than that of the ORR Aquitards. The ORR Aquitards include the remaining Conasauga Group formations, the Rome Formation, and the strata of the Chickamauga Group. Groundwater flow in the ORR Aquitards is controlled by short, intersecting fractures in a relatively impermeable matrix, and the bulk of the groundwater flows in a shallow zone near the water table.

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

3.1 Geology

The geology in the area of the Y-12 Plant is generally characterized by sequences of south-dipping, fractured clastic (primarily shale and siltstone) and carbonate (limestone and dolostone) strata of Lower Cambrian to Lower Ordovician age (Figure 4). The primarily dolostone strata of the Knox Group form Chestnut Ridge, and the underlying interbedded limestone and shale formations of the Conasauga Group form BCV to the north. Strike and dip of bedding in the Chestnut Ridge Regime is generally N 55°E and 45°SE, respectively (not referenced to Y-12 Plant grid system).

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

The Knox Group consists of 2,500 to 3,000 ft of gray to blue-gray, thin- to thick-bedded cherty dolostone with interbeds of limestone (Figure 4). All but the southernmost portion of the Chestnut Ridge Regime is underlain by the Knox Group. The Chickamauga Group overlies the Knox Group disconformably and generally consists of thin- to medium-bedded argillaceous limestone and interbedded shale.

The most pervasive structural features in the Chestnut Ridge Regime are extensional, hybrid, and shear fractures (Solomon et al. 1992). Three major joint orientations are evident; one that roughly parallels bedding, one steeply dipping set that parallels geologic strike, and one steeply dipping set that trends perpendicular to strike (Dreier et al. 1987). Fracture densities ranging from about 1 to 60 per foot have been observed in rock outcrops near the Oak Ridge National Laboratory (ORNL) (Dreier et al. 1987; Sledz and Huff 1981). Most fractures are short, ranging from tenths of inches to a few feet in length (Solomon et al. 1992). Within a fracture, groundwater may flow either downdip, laterally, or in both directions. Changes in flow direction may occur at fracture splits and intersections and groundwater flow paths may locally resemble stairsteps in both plan and sectional views (Moore 1989).

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

3.2 Groundwater System

Solomon et al. (1992) divide the groundwater flow system in both the Knox Aquifer and the ORR Aquitards into four subsystems: (1) the stormflow zone, (2) the vadose zone, (3) the groundwater zone (subdivided into water-table, intermediate, and deep intervals), and (4) the aquiclude (Figure 5). The divisions are based on the amount of water transmitted by each subsystem (i.e., flux), which decreases with depth; the largest water flux occurs in the stormflow zone and the smallest in the aquiclude.

The groundwater flow system is vertically gradational with no discreet boundaries separating the subsystems. The stormflow zone occurs in regolith as does much of the vadose zone, although in some areas the vadose zone includes weathered and fresh rock. About 90% of subsurface flow occurs in the stormflow zone. In the groundwater zone, flow volumes decrease and solute residence times increase sharply with depth. The bulk (98%) of groundwater flow occurs at shallow depths (<100 ft below ground surface), and most (80%) of this flow occurs in the water-table interval. Below the water-table interval, groundwater flow occurs along permeable fractures (or possibly fractured regions) within a relatively impermeable matrix. Variations in the number and aperture of the fractures within these regions occur along flow paths, and these differences determine lateral and vertical flow directions. Additionally, the vertical spacing between the permeable regions increases with depth, and permeable regions at depth are poorly connected in three dimensions (Solomon et al. 1992).

3.2.1 Stormflow Zone

Investigations in Bethel Valley and Melton Valley near ORNL have shown that groundwater occurs intermittently above the water table in a near surface "stormflow zone" that extends from ground surface to a depth of about 6 ft (Moore 1989). As part of the RI/FS in progress for the integrator OU located in the Bear Creek Hydrogeologic Regime, stormflow tubes were installed at 6 sites (3 along the northern flank of Chestnut Ridge), all of which showed brief periods of soil saturation in response to rainfall. These findings suggest that stormflow is a widespread phenomenon at the Y-12 Plant (Science Applications International Corporation 1994).

Channels for lateral flow in the stormflow zone include macropores and mesopores, which are connected voids created by various processes, including biochanneling, cracking, and soil particle aggregation (Moore 1989). This zone is thicker and more permeable in forested areas than in grassy or brushy areas, and is more permeable near the land surface than at deeper levels (Moore 1989). However, a stormflow zone may not exist in areas that have undergone substantial modification, such as the capped portions of the waste-management areas.

Water is present in the stormflow zone during, and for short periods after, significant rainfall events; most of the water is lost to evapotranspiration and much of the remaining water discharges at nearby seeps, springs, and streams (Figure 6). Analysis of infiltrometer test results from Bethel Valley and Melton Valley suggest that the hydraulic conductivity of the stormflow zone averages about 29 feet per day (ft/day) near the top and 0.1 ft/day near the base (Moore 1989). Lateral flow in the stormflow zone is intermittent, lasting a few days to a few weeks after precipitation. Flow is fairly rapid when the zone is full of water but relatively slow when nearly drained (Moore 1989).

3.2.2 Vadose Zone

The vadose zone occurs between the stormflow zone and the water table. The geometric mean depth to the water table in the Knox Aquifer is about 100 ft. Water is added to the vadose zone by percolation from the stormflow zone and is removed by transpiration and recharge to the water table. The vadose zone is unsaturated except in the capillary fringe above the water table and within wetting fronts during periods of vertical percolation from the stormflow zone (Moore 1989). Most recharge through the vadose zone is episodic and occurs along discrete permeable fractures that became saturated even though surrounding micropores remain unsaturated (Solomon et al. 1992).

The hydraulic conductivity of the unsaturated residual soils on Chestnut Ridge has been determined from slug tests in wells located at the United Nuclear Corporation Site (Mishu 1982), and in areas several miles west of the Chestnut Ridge Regime (Woodward-Clyde Consultants, Inc. 1984). Little variation was observed with depth, but conductivities determined by field and laboratory tests varied by approximately two orders-of-magnitude for comparable depth intervals.

Mean field conductivities ranged from 0.0057 to 0.49 ft/day and mean laboratory conductivities ranged from 2.8×10^{-5} to 9.1×10^{-3} ft/day. Results of the slug tests are similar to those obtained from infiltrometer tests. Moore (1988) reported a geometric mean hydraulic conductivity of about 0.006 ft/day for residuum on Chestnut Ridge based on results of infiltrometer studies near ORNL reported by Watson and Luxmoore (1986) and Wilson and Luxmoore (1988).

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

3.2.3 Groundwater Zone

Solomon et al. (1992) divide the saturated zone in the Knox Aquifer and ORR Aquitards into water-table, intermediate, and deep intervals based on observed changes in hydrologic characteristics and groundwater geochemistry with depth (Figure 5).

3.2.3.1 Water-Table Interval

A permeable interval 3 to 15 ft thick usually occurs in the transitional horizon between regolith and unweathered bedrock. The water table often occurs within this permeable interval (Solomon et al. 1992). The saturated thickness of this interval changes with cyclic fluctuations in the water table elevation and the interval may be nearly drained during seasonal water table declines. It is postulated that the water-table interval transmits more than 80% of the flow that occurs below the stormflow zone.

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

3.2.3.2 Intermediate Interval

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

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

The hydraulic conductivity of the water-producing intervals in the Knox Aquifer is much greater than indicated by the straddle packer tests owing to an interconnected network of solution cavities and solutionally-enlarged fractures. For instance, groundwater flow rates determined from a tracer test performed by Ketelle and Huff (1984) ranged from about 490 to 1,250 ft/day. Preliminary results of a dye-tracer test performed by Geraghty & Miller, Inc. (1990) at the

Security Pits indicated flow rates of about 100 to 300 ft/day, although findings of the test were not confirmed by a second test performed at the site (Science Applications International Corporation 1993). However, results of the Ketelle and Huff (1984) and the Geraghty & Miller, Inc. (1990) tracer tests are within the range of conduit-flow rates typical in karst terrains (Quinlan and Ewers 1985).

3.2.3.3 Deep Interval

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

The transition from the intermediate interval to the deep interval in the ORR Aquitards is commonly indicated by a change from sodium-bicarbonate groundwater to sodium-chloride groundwater accompanied by a general increase in specific conductance and total dissolved solids (TDS). This change in groundwater geochemistry probably reflects longer residence times in the deep interval, and usually occurs at depths of more than 400 ft below the ground surface (Solomon et al. 1992). However, no such change in groundwater geochemistry is generally observed in the Knox Aquifer; calcium-magnesium-bicarbonate or calcium-sulfate groundwater occurs to depths of 1,000 ft below the ground surface (Dreier et al. 1993).

Evaluation of data obtained from straddle packer tests and slug tests, and slow-recovery analyses, indicates that the geometric mean hydraulic conductivity of the deep interval is about 0.001 ft/day (Solomon et al. 1992). The low conductivities may reflect reduced fracture apertures or increased fracture spacings (Solomon et al. 1992).

3.2.4 Aquiclude

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

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

3.3 Groundwater Flow Directions

Directions of groundwater flow in the Chestnut Ridge Regime were evaluated from static water level measurements obtained in January and September 1993. Water levels were determined in 82 monitoring wells during January 1993 (the seasonally high water table) and in 74 wells in September 1993 (the seasonally low water table); depth-to-water and water-level elevations for each well are presented in Appendix L of the Part 1 GWQR. Review of these data show that water level declines averaged about 8 ft in most of the wells, with the largest decreases (more than 20 ft) typically occurring in wells located along the crest of Chestnut Ridge. Additionally, the pattern of water level decrease was the same in all wells such that there were no significant changes in groundwater flow directions (i.e., no significant deviation of horizontal hydraulic gradients).

Groundwater elevations in the Chestnut Ridge Regime are illustrated on Figure 7. Monitoring wells were used for primary control for placement of elevation isopleths, but springs and streams also provided additional control. The water table in the Chestnut Ridge Regime generally reflects surface topography and radial groundwater flow directions; strike-parallel gradients range from 0.02 to 0.05 and strike-normal gradients range from 0.06 to 0.09.

Water level hydrographs prepared from average water level elevations in wells located at several of the waste-management sites in the regime are presented on Figure 8. Water levels in wells located along the crest of Chestnut Ridge (Industrial Landfill IV, the Security Pits, and the United Nuclear Corporation Site) show generally uniform and concurrent seasonal fluctuations. Average water level elevations in wells at other sites, however, particularly Kerr Hollow Quarry, show far more erratic, discordant fluctuations that appear less positively associated with seasonal water-table variations. Fluctuations in these wells may the result of direct surface or conduit connection or an artifact of purging at an adjacent well.

3.4 Groundwater Geochemistry

Groundwater geochemistry in the Chestnut Ridge Regime was evaluated through a review of dissolved concentrations of the principal cations (calcium, magnesium, sodium, and potassium) and total concentrations of the principal anions (bicarbonate, chloride, fluoride, nitrate, and sulfate) reported for each groundwater sample collected from each monitoring well. Dissolved cation concentrations exclude digested cations that do not contribute charge to the groundwater.

The accuracy of the data was checked by computing a relative percent difference (RPD) in the summed milliequivalent concentrations of the principal cations and anions using the following formula:

$$RPD = \left(\frac{\sum Cations - \sum Anions}{\sum Cations + \sum Anions}\right) X\ 100$$

The annual mean concentration of each ion (in millequivalents per liter) was used to determine the groundwater composition at each monitoring well. Samples for which the RPD exceeded ±10% were not used to determine annual mean concentrations. Based on this criterion, principal ion data reported for about 1% of the CY 1993 groundwater samples were not evaluated. Unusually low bicarbonate or high calcium and sodium concentrations typically caused positive RPDs greater than 10%. Unusually high alkalinity or low calcium concentrations typically caused negative RPDs greater than 10%. Charge balances for all groundwater samples collected in the Chestnut Ridge Regime during CY 1993 are included in Appendix G of the Part 1 GWQR.

Groundwater geochemistry in the Knox Aquifer is nearly uniform throughout the Chestnut Ridge Regime. The chemical composition is typical of water in contact with dolomite, having the characteristically equivalent molar concentrations of calcium and magnesium with bicarbonate as the predominant anion (Figure 9). However, atypical groundwater geochemistry was observed in samples from six wells: GW-295 at Industrial Landfill III; GW-539 at Industrial Landfill II; GW-303 at the Sediment Disposal Basin; GW-143 and GW-146 at Kerr Hollow Quarry; and GW-545 at Construction/Demolition Landfill VI (Figure 10).

Chloride concentrations in groundwater samples collected from well GW-295, located hydraulically downgradient from Industrial Landfill III (Figure 7), averaged 123 mg/L in 1993, which is substantially higher than chloride concentrations reported for samples from all other wells completed in the Knox Aquifer (Figure 9). Furthermore, the chloride concentrations in the well have steadily increased; concentrations averaged 75 mg/L in CY 1991, and 97 mg/L in CY 1992. The source of the elevated chloride has not been identified. However, during installation of GW-295 and a deeper well (GW-160) located nearby (Figure 10), substantial amounts of grout were required to set each well casing because of circulation losses through fractures and cavities. Calcium chloride-based additives that accelerate grout hardening were used to help reduce these losses to the formation. The two wells are about 25 ft apart, and both encountered a solution cavity between 137 to 140 ft below ground surface (bgs) that intercepts the monitored interval for well GW-295 (Jones et al. 1993). Elevated chloride concentrations observed in well GW-295 most likely result from localized chemical effects of the grout circulated into this cavity during the installation of well GW-160.

Atypical geochemistry also was identified in groundwater samples from well GW-539, the upgradient well at the Industrial Landfill II. Average chloride concentrations in samples from this well have steadily increased from 1991 (14 mg/L), to 1992 (21 mg/L), and to 1993 (28 mg/L). The reasons for the increasing chloride concentrations has not been identified.

Groundwater monitored by well GW-303 at the Sediment Disposal Basin has elevated sulfate (average 158 mg/L) and TDS (454 to 476 mg/L) in comparison to other wells at this site. Historically, the chemical composition of samples from this well has been fairly constant.

Elevated sulfate and TDS may reflect the local dissolution of disseminated sulfides in the Knox Group and the results for the samples probably reflect natural concentrations.

Samples from wells GW-143 and GW-146 at Kerr Hollow Quarry had higher average sodium, potassium, and sulfate concentrations than the samples from the wells with which they are paired (GW-144 and GW-145, respectively) (Figure 9). The chemistry of the samples from wells GW-143 and GW-146 probably reflects the quality of groundwater in less permeable zones within the Knox Aquifer. Wells GW-143 and GW-146 are completed with deeper monitored intervals than GW-144 and GW-145 and the water levels in GW-143 and GW-146 recover much more slowly after the wells are purged during sampling. The midpoint of the monitored interval for well GW-143 (about 229 ft bgs) is about 60 ft deeper than the midpoint in well GW-144 (about 171 ft bgs). Well GW-144, which intercepts a fracture at 170 ft bgs that yields over 20 gallons per minute (Jones et al. 1993), yields about 3 well volumes when purged and recovers relatively quickly. In contrast, well GW-143 yields only about one well volume before going dry and recovers more slowly. Similarly, well GW-146 is completed with a deeper monitored interval (190 to 220 ft bgs) than well GW-145 (86 to 110 ft bgs). Well GW-146 yields about one well volume before going dry and recovers very slowly, whereas GW-145 also yields about one well volume but recovers more rapidly. These relationships suggest that the higher average sodium, potassium, and sulfate concentrations in the groundwater monitored by wells GW-143 and GW-146 are a function of longer residence times in deeper aquifer zones with less direct hydraulic communication to shallower and more permeable zones in the Knox Aquifer.

Groundwater samples collected from well GW-545 at Construction/Demolition Landfill VI had higher average potassium concentrations (17.5 mg/L) than samples collected from other wells in the regime (Figure 9). The alkalinity in these samples also had comparatively high carbonate concentrations (average 36 mg/L) while bicarbonate was not detected. These atypical potassium and carbonate concentrations, coupled with the unusually high pH (field measurements of 10.3 to 11.0) of the samples from this well, suggests that groundwater quality near the well has been affected by the grout used to construct the well.

As indicated by the data reported for samples collected from wells at Rogers Quarry (GW-184, GW-186, GW-187, and GW-188), the chemical composition of groundwater in the Chickamauga Group differs from that in the Knox Aquifer. The sodium, potassium, and sulfate concentrations reported for the groundwater samples from these wells are usually higher than the concentrations typically found in the Knox Aquifer (Figure 9), and the range of calcium:magnesium ratios (5.8:1 to 0.8:1) differs from the nearly equal proportions common in the Knox Aquifer.

Groundwater samples from well GW-187 contained the highest average sodium (143 mg/L) and chloride (144 mg/L) concentrations of any well in the Chestnut Ridge Regime. The well is completed with a monitored interval at 139 to 162 ft bgs, but sodium- and chloride-enriched groundwater is usually encountered in the ORR Aquitards at greater depths (325 ft bgs). A fairly productive (25 gallons per minute) water-bearing fracture near the bottom of GW-187 (Jones et al. 1993) possibly may transmit this type of groundwater from deeper intervals. However, much lower sodium and chloride concentrations have been reported for well GW-186, which is completed with a monitored interval at a similar depth (142-171 ft bgs) and is located only about 900 ft east of GW-187.

Alternatively, the elevated sodium and chloride concentrations in samples from GW-187 may be caused by contamination with salt periodically used to de-ice Bethel Valley Road during the winter months. Well GW-186, which also in close proximity to the road, has lower sodium and chloride concentrations. An inadequate annular seal or other construction deficiency, or a potential hydrologic connection to the surface, could presumably produce this atypical geochemistry in GW-187.

3.5 Status of Hydrogeologic Studies

In addition to the groundwater quality monitoring activities in the Chestnut Ridge Regime, the Y-12 GWPP is responsible for several on-going hydrogeologic studies initiated to further characterize the groundwater flow system at the Y-12 Plant and provide a better understanding of contaminant fate and transport. Principal efforts in the Chestnut Ridge Regime have involved the performance of dye-tracer studies to identify discharge points for groundwater in the Knox Aquifer. Additional hydrogeologic studies at the Y-12 Plant are being performed primarily in the Bear Creek Regime, but the findings of several of these studies will be applicable to the Chestnut Ridge Regime as well. Brief descriptions of these studies are provided below.

3.5.1 Dye-Tracer Tests

In July 1990, a dye-tracer test was initiated with the injection of a fluorescein dye/water mixture into well GW-178 at the Security Pits. The objectives of this initial qualitative test were to determine groundwater flow directions in the saturated zone beneath the site and to identify natural discharge points for groundwater underlying the site. Approximately six months of weekly passive monitoring for the dye was conducted at 16 springs, 15 surface water sites, and eight monitoring wells. Results of the test suggested possible detection of the dye in several springs and streams located on the southern flank of Chestnut Ridge and at several points along Upper East Fork Poplar Creek northeast of the site (Geraghty & Miller, Inc. 1990).

To confirm the preliminary findings of the initial tracer study, a second study was initiated in March 1993 using two different dyes (Rhodamine WT and Fluorescent Brightener 28). Most of the same locations monitored during the first test were also monitored during the second test. The dyes were simultaneously injected into well GW-178, and passive monitoring was performed weekly until July 1993. Results of the second dye tracer test were inconclusive; none of the monitoring results could be characterized on a quantitative or qualitative basis as positively indicating the detection of either dye at any of the monitored locations (Science Applications International Corporation 1993). Options for additional dye tracer studies in the Chestnut Ridge Regime are currently being evaluated.

3.5.2 Multiport-Instrumented Monitoring

Research investigations using multiport-instrumented wells continued during CY 1993 for both exit-pathway studies and investigation of dense, non-aqueous phase liquids in the Bear Creek Regime. These wells are used to obtain detailed, three-dimensional hydraulic conductivity, potentiometric, and geochemical data from various depth intervals and thereby greatly enhance characterization of hydraulic and hydrochemical properties of the groundwater flow system. Although few of the multiport-instrumented wells are located within the Chestnut Ridge Regime, data obtained during these investigations, particularly the exit-pathway studies, are expected to provide a better understanding of groundwater flow and contaminant transport in the Knox Aquifer.

For the exit-pathway studies during CY 1993, 6 multiport-instrumented wells were used to monitor temporal changes in hydraulic head and conductivity, and to collect groundwater samples for volatile constituent and helium analyses. Results of the helium analyses provide information regarding the relative age of groundwater at various depths, which indicates groundwater residence time and, accordingly, helps define the depths of active groundwater flow. This data, and information from other wells, will be used to evaluate of the degree of hydraulic communication between the ORR Aquitards and the Maynardville Limestone. Identifying the flow paths across this geologic boundary is crucial to understanding the transport of contaminants into and through the Maynardville Limestone, which is the primary groundwater exit-pathway in Bear Creek Valley.

3.5.3 Colloidal Transport Study

In July 1993, the Y-12 Plant GWPP initiated a study to investigate contaminant transport via colloids. The study is focused on major ions and metals because these constituents are the most likely to adsorb onto colloids being transported within the active flow system. The study includes approximately 30 wells completed within the ORR Aquitards, Maynardville Limestone, and the Knox Group within the Bear Creek and Chestnut Ridge regimes. A wide range of geologic units and depths were selected to examine how colloidal transport of contaminants is related to these variables. Very slow pumping rates are used to sample the groundwater within each well. Various sizes of filters are used to filter the samples to obtain aliquots for analysis. The aliquots are analyzed to determine size fractions of colloidal particles. Approximately half of the subject wells have been sampled to date, and preliminary analytical results are being compiled.

Results of the study also provide information regarding colloidal movement as related to the rates at which groundwater is purged from monitoring wells before sampling. Current regulatory protocols require that a minimum of three casing volumes of water be removed from a monitoring well before groundwater is sampled. The relatively high pumping rate needed to efficiently achieve this purge-water volume may artificially induce colloidal movement into the well, resulting in the collection of non-representative samples. Additionally, the current purging requirements increase sampling and purge-water handling/disposal costs. Recent EPA guidance recommend alternative sampling protocols aimed at addressing these issues, and these protocols are currently undergoing phased implementation by the K-25 sampling personnel.

4.0 1993 GROUNDWATER PROTECTION PROGRAM

The following sections describe the groundwater sampling activities performed during CY 1993 in the Chestnut Ridge Regime under the lead of the Y-12 Plant GWPP. Included are details regarding the groundwater sampling locations, frequency, and procedures, analytical parameters, and results of quality assurance/quality control (QA/QC) sampling.

4.1 Sampling Locations

Groundwater monitoring during CY 1993 involved the collection of groundwater samples from 75 monitoring wells (Table 2). Locations of these wells are shown on Figure 10. Data regarding the elevation of the screened or open hole interval for the wells are summarized in Table 3; detailed well construction information is contained in Appendix C of the Part 1 GWQR. The monitoring wells were sampled for the purposes of four monitoring programs: (1) RCRA interim status assessment monitoring, (2) RCRA interim status detection monitoring, (3) SWDF detection monitoring, and (4) best-management practice monitoring. Descriptions of the monitoring well networks used for each program are provided in the following sections.

4.1.1 RCRA Interim Status Assessment Monitoring

Assessment monitoring during CY 1993 involved 11 monitoring wells at the Security Pits (Table 2). Assessment monitoring at the Security Pits has been in progress since 1987 and will be discontinued when a RCRA post-closure permit (which is expected to require RCRA corrective action monitoring) is issued for the site by the TDEC.

4.1.2 RCRA Interim Status Detection Monitoring

Detection monitoring in accordance with the RCRA interim status regulations was performed during CY 1993 at the Sediment Disposal Basin and Kerr Hollow Quarry, and included a total of 15 monitoring wells (Table 2). As required for interim status detection monitoring, results of selected indicator parameters (e.g., pH and specific conductance) were analyzed to identify any statistically significant changes in groundwater quality. Results of these statistical analyses were submitted to the TDEC in September 1993 (Energy Systems, Inc. 1993a,b) and February 1994 (Energy Systems, Inc. 1994a,b). The annual RCRA detection monitoring report for these facilities was submitted in February 1994. (Energy Systems, Inc. 1994c).

4.1.3 SWDF Detection/Background Monitoring

As noted in Section 2.3, groundwater monitoring in accordance with the TDEC solid waste management regulations is performed at all of the SWDFs in the regime. In CY 1993, 31 monitoring wells at the SWDFs were sampled for detection or background monitoring purposes (Table 2).

4.1.4 Best-Management Practice Monitoring

Groundwater samples were collected from 18 monitoring wells during CY 1993 as a best-management practice of the Y-12 Plant GWPP (Table 2). Best-management practice monitoring is performed at sites where regulation-driven monitoring is not required. For example, groundwater quality monitoring at the East Chestnut Ridge Waste Pile has been performed since 1987 even though this hazardous waste TSD unit is a lined facility exempt from RCRA groundwater monitoring requirements.

4.2 Sampling Frequency

Groundwater samples were collected during each quarter of CY 1993. First through fourth quarter sampling events were performed January 5 - March 30, April 1 - June 27, July 17 - September 30, and October 4 - December 19, respectively. Samples were collected during each quarterly sampling event from all but 10 of the 75 wells included in the previously described monitoring programs. Well GW-607 at the Security Pits was sampled only during the first quarter because the well was plugged and abandoned in March 1993. Installation of 5 monitoring wells at Industrial Landfill V and Construction/Demolition Landfill VII (GW-796, GW-797, GW-798, GW-799, and GW-801) was completed in March 1993. These new monitoring wells and 4 existing wells (GW-557, GW-560, GW-562, and GW-564) were incorporated into the quarterly sampling schedule beginning in the second quarter of the year.

Personnel from the Oak Ridge K-25 Site (K-25) Sampling and Environmental Support Department collected all the groundwater samples. Sampling was performed in accordance with the most recent version of the Standard Operating Procedure 8102 approved by the Y-12 Plant GWPP Manager. To minimize the potential for cross-contamination, samples were collected from the monitoring wells following a sequence that generally involved sampling from the least contaminated wells to the most contaminated wells at a site or in a sampling group (a series of monitoring wells grouped for sampling and data-tracking purposes). At sites where no groundwater contamination is present, samples were collected from the farthest upgradient wells first.

4.3 Laboratory Analysis

Groundwater samples collected from each monitoring well were analyzed for the parameters and constituents specified in Table 2. As shown in Table 2, samples from all of the wells were analyzed for a standard suite of analytes that included:

- trace metals and principal ions (total and dissolved concentrations);
- selected suite of volatile organic compounds (VOCs);
- gross alpha activity and gross beta activity;
- total suspended solids (TSS), TDS, and turbidity;
- field and laboratory determinations of pH and specific conductance; and
- field determinations of temperature, dissolved oxygen, and oxidation-reduction potential.

In addition to the standard suite of analyses, groundwater samples collected from wells at some sites in the Chestnut Ridge Regime were analyzed for other compounds or parameters as required by TDEC regulations or permits, as requested by the TDEC as a best management practice, or as deemed necessary based on previous monitoring results (Table 2). For example, samples collected from wells at Construction/Demolition Landfill VI were analyzed for additional organic compounds and other required parameters specified by the TDEC-approved operating permit. Samples from other wells, such as GW-295 at Industrial Landfill III, were analyzed for isotopic uranium and beta-emitting radionuclides because of elevated gross alpha and gross beta activity reported for samples collected from the well in CY 1992.

Analyses of the groundwater samples were performed by three different laboratories: the K-25 Analytical Chemistry Department, EcoTek Laboratory Services, Inc. (EcoTek), and the ORNL Chemistry Division. The bulk of the analyses were performed by the K-25 Analytical Chemistry Department. EcoTek performed the analyses for the additional organic compounds required by the TDEC for the SWDFs in the regime. Selected radiochemical analyses were performed by the ORNL Chemistry Division.

4.4 Quality Assurance/Quality Control Sampling

Quality assurance/quality control samples analyzed during CY 1993 included 115 laboratory blanks, 185 trip blanks, 75 equipment rinsates, and 47 duplicate groundwater samples. Similar numbers of QA/QC samples were analyzed during each quarterly sampling event: 75 to 36 laboratory blanks, 44 to 49 trip blanks, 15 to 23 equipment rinsates, and 11 to 13 duplicate samples.

Laboratory blanks were prepared using deionized water and analyzed along with the groundwater samples. Trip blanks were prepared in the laboratory using deionized water and transported unopened in coolers containing groundwater samples to be analyzed for VOCs. Equipment rinsates were obtained from the deionized water used to decontaminate the groundwater sampling equipment. Equipment rinsates were collected after a sampling team had completed sampling at a site or finished a sampling group (typically no more than 10 wells grouped for sampling and data-tracking purposes). If more than one team collected samples at a site or within a sampling group, each collected an equipment rinsate sample. Duplicate groundwater samples were collected at a frequency of at least one per sampling group, or one for every 10 monitoring wells, whichever was greater.

A modified equipment rinsate sampling protocol became effective in January 1993. Before then, all equipment rinsate samples were obtained from the final rinse of deionized water circulated through the air-piston pump used to purge the well and collect samples for inorganic analyses (samples for VOC analyses were collected with a pre-cleaned bailer). The rinsate samples were subsequently analyzed for both organic and inorganic compounds. Beginning in the first quarter of CY 1993, this protocol was followed only for rinsate samples scheduled for inorganic analyses (about 10% of the rinsate samples). The modified protocol required collecting a sample of the deionized water used to rinse the bailer before it was used to sample the well and conducting VOC analyses.

All of the laboratory blanks, trip blanks, and equipment rinsate samples were analyzed for the suite of VOCs listed on Table 2. Selected equipment rinsate samples also were analyzed for trace metals (Inductively Coupled Plasma analyses), gross alpha and gross beta activity, and radionuclides. Duplicate groundwater samples were analyzed for the constituents and parameters specified for the well from which the duplicate sample was collected. The analytical data for the QA/QC samples are summarized in Appendix I of the Part 1 GWQR.

4.4.1 Analytical Results

Detailed evaluation of the VOC results reported for laboratory blanks, trip blanks, and equipment rinsates was first presented in Part 2 of the 1991 GWQR for the Chestnut Ridge Regime (HSW Environmental Consultants, Inc. 1992). This initial evaluation was based on a collective analysis of the data for blanks and rinsates associated with monitoring wells in all three hydrogeologic regimes at the Y-12 Plant. However, because the data obtained in CY 1992 showed distinct differences in the types of compounds detected in the QA/QC samples associated with the wells in each regime, the QA/QC sample data for each regime were evaluated separately. This approach also was followed in evaluating the VOC data reported for CY 1993 QA/QC samples.

Percentages of each type of QA/QC samples containing VOCs were lower in 1993 than in 1992 (Figure 11). As summarized below, the percentage of laboratory blanks that contain at least one VOC steadily decreased after the fourth quarter of CY 1992; by the fourth quarter of

CY 1993 the percentage was the lowest since the first quarter of 1992. More erratic, but nonetheless decreasing, trends also are evident for the trip blanks and equipment rinsate samples. Overall, one or more VOCs were detected in 57% of the laboratory blanks, 53% of the trip blanks, and 49% of the equipment rinsate samples analyzed during CY 1993 as opposed to 61%, 74%, and 82%, respectively, for these sample types analyzed during CY 1992.

Year/Quarter		Percent of Samples Containing VOCs		
		Laboratory Blanks	Trip Blanks	Equipment Rinsates
1992	1	37	49	29
	2	55	83	100
	3	57	93	100
	4	89	71	100
1993	1	72	76	59
	2	50	32	25
	3	52	59	61
	4	46	45	53

Twenty-one VOCs were detected in the CY 1993 QA/QC samples, but methylene chloride, acetone, 4-methyl-2-pentanone, and 2-butanone were the most commonly detected compounds (Table 4). These compounds: (1) have been detected in each type of QA/QC sample collected since the first quarter of 1992, and (2) were the only compounds detected in second and fourth quarter 1993 trip blanks, and first and fourth quarter 1993 equipment rinsates. The persistent and frequent occurrence of these compounds, particularly in the laboratory blank samples, suggests that they are fairly ubiquitous in the K-25 Analytical Laboratory (which performed all VOC analyses in 1992 and 1993).

Efforts during CYs 1992 and 1993 to correct suspected contamination of the source of deionized water used to prepare the QA/QC samples appear to have been generally successful. Contamination of the deionized water used for laboratory blank samples was initially suspected from the 1992 data because 1,1,2,2-tetrachloroethane (1,1,2,2-PCA) and bromoform were frequently detected only in these samples. However, neither compound was detected in any of the 1993 laboratory blanks (or trip blanks and equipment rinsate samples).

Contamination of the deionized water used to prepare trip blanks and decontaminate sampling equipment was indicated by the frequent occurrence of chloroform and 1,2-dichloropropane (1,2-DCP) in the 1992 trip blanks and equipment rinsate samples (neither compound was detected in the 1992 laboratory blanks). Both compounds were detected in trip blanks and equipment rinsates analyzed during each quarter of 1992. In 1993, however, chloroform was detected in only 1% of the trip blanks and 7% of the equipment rinsates, and none of the trip blanks and only 4% of the equipment rinsates contained 1,2-DCP (Table 4).

The less frequent occurrence of VOCs in the equipment rinsate samples analyzed during CY 1993 also may reflect the modifications to equipment rinsate sampling protocol. In CY 1992, at least one VOC was detected in every equipment rinsate sample collected after the first quarter. The percentage of contaminated rinsate samples decreased to 25% by the second quarter of CY 1993, then increased to more than 50% in the third and fourth quarters. However, only common laboratory reagents were detected in the equipment rinsates collected during the first and fourth quarters CY 1993, and results for these compounds account for 31% and 68%, respectively, of the results reported for the second and third quarter samples. Moreover, none of the results for the equipment rinsate samples indicate potential deficiencies with equipment decontamination (i.e., compounds frequently detected in groundwater samples were not detected in the associated rinsates).

4.4.2 Data Screening

The laboratory blank and trip blank VOC data were used to identify VOC results reported for the associated groundwater samples that were considered probable artifacts of sampling and/or laboratory analysis (false positive results). False positives were "screened" (i.e., considered the same as "not detected" results) for the purposes of calculating the summed VOC concentration in each well (See Section 5.1). Using this approach, about 70% of the VOC results reported for the groundwater samples collected during CY 1993 were screened (Table 5).

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

Sixteen VOCs were detected in the groundwater samples collected from monitoring wells in the Chestnut Ridge Regime during 1993, and false positive results were identified for 11 of these compounds (Table 5):

- Methylene Chloride
- 4-Methyl-2-Pentanone
- 2-Butanone
- Acetone
- Benzene
- 1,1-Dichloroethene (1,1-DCE)
- 1,2-Dichloroethene (1,2-DCE)
- 2-Hexanone
- Tetrachloroethene (PCE)
- Trichloroethene (TCE), and
- Xylenes.

A total of 273 results for these compounds were reported for the groundwater samples, and 191 (70%) were screened as false positives. Most of the false positive results occurred for methylene chloride, 4-methyl-2-pentanone, acetone, and 2-butanone (Table 5); at least 95% of the groundwater sample results for each of these compounds were screened as false positives and the combined number of false positive results for these compounds (179) account for 94% of all false positive results identified in CY 1993 groundwater samples. These high percentages reflect the relatively large number of laboratory blanks and trip blanks that were contaminated with these compounds.

Results for compounds known to be present in the groundwater in the Chestnut Ridge Regime were rarely screened as false positives. The Security Pits are the principal source of dissolved VOCs in groundwater in the regime, and compounds most frequently detected in groundwater samples from wells at this site are 1,1,1-trichloroethane (1,1,1-TCA), PCE, 1,1-dichloroethane (1,1-DCA), 1,1-DCE, TCE, and 1,2-DCE. Of the 83 groundwater sample results reported for these compounds, only 4 were screened as false positives (one each for 1,1-DCE, 1,2-DCE, PCE, and TCE).

About 92% of the false positive results for CY 1993 groundwater samples were screened by BQRs determined from laboratory blank data (Table 5). Only 16 of the groundwater results were screened by BQRs determined from trip blank data, and 63% of these were false positives for methylene chloride or acetone. A similar pattern also occurred in CY 1992; 85% of the false positive results in the groundwater samples were screened by BQRs determined from laboratory blank data, and 70% of the results screened by BQRs determined from trip blank data were false positives for methylene chloride, acetone, 4-methyl-2-pentanone, and 2-butanone.

The number of false positive results screened from the groundwater data steadily increased throughout CY 1992, decreased in the first and second quarters of CY 1993, then increased through the end of the year (Figure 12). An explanation is not readily apparent for the general increase in the number of false positive VOC results in groundwater samples collected during the latter half of CYs 1992 and 1993. The increases do not appear to be related to the number of samples analyzed for VOCs each quarter, because substantial increases in the number of false positives occur independent of the number of samples for which VOCs are analyzed (which typically varied by less than 5% from one quarter to the next). Additionally, increases in the number of false positives do not appear directly related to the number of laboratory blank and trip blank samples that contained VOCs, including the common laboratory reagents. For example, at least one VOC was detected in 13 of the laboratory blanks analyzed in the second, third, and fourth quarters of CY 1993, but the number of false positive results identified by these samples increased more than 300% from 17 in the second quarter to 70 in the fourth quarter.

The concentration range for false positive VOC results is summarized in Table 6. About 97% of the false positives were less than 10 micrograms per Liter (µg/L). Only 6 of the false positive results exceeded 10 µg/L, and each of these were results for 2-butanone (the maximum screened concentration was 14 µg/L). Except for this false positive result for 2-butanone, all other screened results were less than the analytical detection limit for each compound (Table 6). False positive results identified during 1992 displayed a similar concentration distribution. About 91% were less than 10 µg/L; false positive results greater than or equal to 10 µg/L were identified only for common laboratory reagents (methylene chloride, acetone, and 2-butanone);

and most of the false positive results for each compound were less than analytical detection limits.

Based on analysis of the data screening employed since 1992, the following general observations have become evident:

- Groundwater samples and the associated laboratory blanks, trip blanks, and equipment rinsates often contain several common laboratory reagents (methylene chloride, acetone, 4-methyl-2-pentanone, and 2-butanone) that are apparently ubiquitous in the K-25 Analytical Chemistry Laboratory and results for these compounds are almost always screened as false positives;

- Compounds known to be present in the groundwater monitored in some areas of the Chestnut Ridge Regime are infrequently detected in QA/QC samples, and consequently few of the results for these compounds are screened as false positives;

- Because more than 90% of the false positive results in the groundwater samples are screened by BQRs determined from laboratory blank data, excluding trip blank data would not significantly impact the data screening process. The number of trip blanks analyzed each quarter could therefore be substantially reduced from current levels;

- There is a pronounced tendency for the number of false positive VOC results to increase in groundwater samples analyzed the third and fourth quarters of the year. The increase apparently occurs independent of the number of samples analyzed for VOCs and the number of QA/QC samples contaminated with VOCs. This finding suggests that the occurrence of false positive results is prone to idiosyncratic influences, such as different analytical instrumentation and operator techniques. Additional data tracking information (e.g., instrument number and operator identification) would be helpful in identifying these potential influences;

- Concentrations of false positive VOC results in the groundwater samples are typically less than 10 µg/L. False positive results for most compounds are almost always less than the analytical detection limits; and

- The data screening process, when applied to data obtained at the Y-12 Plant, appears to conservatively work to remove from consideration VOC data that are not likely representative of actual groundwater quality conditions and therefore is not prone to negate real evidence of VOC plume migration.

5.0 INTERPRETIVE ASSUMPTIONS

Evaluation of groundwater quality in the Chestnut Ridge Regime was based primarily on data collected during 1993, but historical (1986 - 1992) data were used to corroborate 1993 results, identify trends in the data, and define concentration distributions within contaminant plumes. The following sections contain a description of the interpretive assumptions used in the evaluation of the data for VOCs, trace metals, and radioactivity.

5.1 Less-than-Detection Limit Results

Less-than-detection limit results comprise substantial proportions of the analytical data for many of the inorganic and organic analytes (because of the reporting convention, less-than-detection limit results are rarely reported for radiological analyses). There are several approaches described in the technical literature and EPA guidance documents regarding how these data should be treated in quantitative evaluations. Each approach basically involves assuming a surrogate value, typically zero, the analytical detection limit, or a missing value (i.e. no analytical result), for the less-than detection limit results.

For the purposes of this report, less-than-detection limit results were: (1) assumed to equal zero for organic compounds, and (2) treated as missing values for inorganic compounds. Using zero as a surrogate value for organic constituents is appropriate because estimated concentrations below the specified analytical detection limit are often reported for these compounds. These estimated results, flagged by the analytical laboratory with a "J" qualifier, represent low but discernable responses from the analytical instrumentation. For inorganic compounds, missing values were used as surrogates instead of analytical detection limits because this is a more conservative approach that tends to skew calculations (e.g. mean concentrations) toward higher values.

5.2 Volatile Organic Compounds

Evaluation of groundwater quality in the Chestnut Ridge Regime, with respect to VOCs, was based on summed average concentrations of each VOC detected in samples from each monitoring well. Results reported as "not detected" were assumed to equal zero for the purposes of calculating the summed average VOC concentrations. In cases where elevated analytical detections limits were reported (i.e., diluted samples), the summed average VOC concentrations were considered qualitative.

In determining the summed average VOC concentrations, false positive VOC results and sporadic occurrences that were not considered representative of water quality at the sampling point (anomalous results) were considered the same as "not detected" results. Anomalous VOC results were identified by examining the frequency of occurrence of each VOC in water samples collected from each monitoring well. If a compound was detected in only 1 of at least 4 consecutive quarterly samples collected from a monitoring well, the result was assumed to be anomalous. If a well was not sampled during each quarter of 1993, data obtained during 1992 or preliminary data reported for samples collected during the first quarter of 1994 were used to identify anomalous results. Anomalous VOC results were not identified in samples for which elevated analytical detection limits were reported.

A total of 19 anomalous results were reported for 9 compounds (Table 7). The number of anomalous results varied throughout CY 1993, with the highest number (12) occurring in third quarter samples and the fewest (1) in first quarter samples (Figure 12). Anomalous results occurred in samples collected from at least one well at each of the waste-management sites in the regime except Industrial Landfill IV, but most frequently in samples collected from wells at Rogers Quarry and the East Chestnut Ridge Waste Pile.

Anomalous results most frequently occurred for methylene chloride and chloroform; anomalous results for these compounds account for about half (47%) of all the anomalous results screened from the 1993 groundwater data. Four anomalous results occurred for the VOCs that have been shown to be present in the groundwater in the regime (1,1,1-TCA, 1,1-DCE, and 1,2-DCE) (Table 7).

5.3 Trace Metals

Total concentrations reported for unfiltered groundwater samples were used to evaluate groundwater quality with respect to trace metals. Evaluation of these data was based on: (1) consideration of the analytical methods used by the K-25 Analytical Chemistry Department, (2) comparison to corresponding dissolved metal concentrations reported for filtered groundwater samples, (3) identification of concentrations for each metal that exceeded maximum contamination limits (MCLs) for drinking water, or screening levels calculated from data reported for upgradient monitoring wells, and (4) a review of the frequency at which metal concentrations exceeded MCLs or screening levels.

5.3.1 Analytical Methods

Four analytical methods were used to determine trace metal concentrations in the groundwater samples. Atomic absorption spectroscopy (AAS) was used for cadmium, chromium, and lead analyses. Mercury concentrations were determined by Cold Vapor Atomic Absorption (CVAA) spectroscopy. Total uranium concentrations were determined by fluorometry. Concentrations of aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, manganese, mercury, molybdenum, nickel, selenium, strontium, thorium, uranium, vanadium, and zinc were obtained from Inductively Coupled Plasma (ICP) analyses. The results for cadmium and chromium that were obtained by AAS were evaluated in lieu of ICP data because analytical interferences inherent to the ICP method can cause inaccurate results for these metals (U.S. Environmental Protection Agency 1986). Additionally, the ICP results for arsenic and selenium were considered unreliable because of these inherent analytical interferences. Historical results obtained with the AAS procedure show that total concentrations of these metals rarely exceed applicable standards.

5.3.2 Total/Dissolved Comparisons

As required by the TDEC, evaluation of groundwater quality with respect to trace metals was based on total concentrations reported for unfiltered groundwater samples. However, the dissolved metal concentrations reported for filtered groundwater samples collected from each well were compared to the corresponding total concentration as a qualitative check on the accuracy of the data. If the dissolved metal concentration exceeded the corresponding total concentration by an order-of-magnitude or more, both results were considered unusable. Such differences were reported for total and dissolved concentrations of 6 metals in filtered/unfiltered samples from 7 wells: aluminum and iron in the third quarter samples from well GW-161; boron in the second quarter samples from well GW-608 and third quarter samples from well GW-156; iron in the first quarter samples from well GW-300; manganese in first quarter samples from wells GW-292 and GW-144; and nickel and zinc in first and third quarter samples, respectively, from GW-514.

5.3.3 Identification of Elevated Concentrations

Evaluation of the trace metal data focused on total metal concentrations that exceeded: (1) federal maximum contaminant levels (MCLs) for drinking water that were adopted by the TDEC in July 1993, or (2) screening levels calculated from 1986-1993 data reported for monitoring wells located upgradient of waste-management sites in the Chestnut Ridge Regime. Concentrations that exceeded MCLs or screening levels (i.e. elevated concentrations) were further evaluated to determine if they represent impacts on groundwater quality.

Total concentrations of barium, cadmium, chromium, lead, and mercury reported for each unfiltered groundwater sample from each well were compared to their MCLs established for drinking water. As shown below, the revised federal drinking water standards increased the MCL for barium and chromium and reduced the MCL for cadmium relative to the MCLs used during previous assessments.

Metal	Drinking Water MCL (mg/L)	
	1986 - 1992	1993
Barium	1.0	2.0
Cadmium	0.01	0.005
Chromium	0.05	0.10
Lead	0.05	0.05
Mercury	0.002	0.002

Total concentrations of aluminum, antimony, beryllium, boron, cobalt, copper, iron, manganese, molybdenum, nickel, strontium, thorium, uranium, vanadium, and zinc were compared to screening levels assumed to represent the maximum concentrations expected for uncontaminated groundwater in the Knox Aquifer. Screening levels were determined from water quality data reported for unfiltered samples collected from 15 upgradient monitoring wells, including wells completed in the Knox Aquifer in the Chestnut Ridge Regime and wells completed within the top of the Maynardville Limestone in BCV near the base of Chestnut Ridge (Figure 13). However, excluded from the data sets were all results for samples with charge balance RPDs that exceeded 10%, and individual results obtained with elevated detection limits. Thus, data for varying numbers of samples were used to determine the screening level for each metal (Table 8).

Four methods were used to determine screening levels. Tolerance interval procedures were used if more than 50% of results for the metal exceeded the analytical detection limit; a parametric procedure if the data for the metal were normally or lognormally distributed, and a non-parametric procedure if the metal data were not normally or lognormally distributed. If less than 50% of the data for a metal exceeded the analytical detection limit, the screening level was assumed to equal the concentration at the 99th percentile of the ranked data. If a metal was not detected in any of the samples from the upgradient wells, the screening level was set at the analytical detection limit for the metal.

Parametric tolerance limits were determined using a procedure developed by the EPA (U.S. Environmental Protection Agency 1989). Following this procedure, means and standard deviations from the censored lognormally distributed data first were estimated using a procedure described by Helsel (1990). Normal scores were assigned to the data and a linear regression of the log concentration versus the normal score was computed for all observations reported above the detection limit. Estimates of values below the detection limit were then extrapolated from the regression coefficients, transformed into concentration units, and combined with results above the detection limit. Summary statistics were then computed and tolerance limits were established. This method was used to calculate screening levels for aluminum, iron, manganese, and zinc (Table 8).

Non-parametric tolerance limits were established by determining the sample size required for an upper 95% tolerance limit and randomly selecting this number of samples from the data for the metal. The maximum concentration in this sub-set of the data was used as the tolerance limit. This method was used to calculate screening levels for boron and strontium (Table 8).

More than 60% of the available upgradient water quality data reported for antimony, beryllium, cobalt, copper, molybdenum, nickel, uranium, and vanadium did not exceed the respective analytical detection limits. Screening levels for these metals were assumed to equal the 99th percentile of the ranked data for each metal (Table 8). Thorium was not detected in the samples from the upgradient wells and the screening level for this metal was assumed to equal the 0.2 mg/L analytical detection limit.

The above methods were first reported in Part 2 of the 1991 GWQR, and included 1986-1991 data reported for 36 upgradient wells completed in the Knox Aquifer and ORR Aquitards. Data for each of the metals except copper, manganese, and strontium were collectively evaluated to ensure that the screening levels were calculated from the largest available population of upgradient water quality data (HSW Environmental Consultants, Inc. 1992). Copper, manganese, and strontium screening levels were determined only from 1986-1991 data reported for Knox Aquifer wells because results of a t-test showed that concentrations of these metals were statistically different (at the 95% confidence level) from those reported for ORR Aquitard wells (Mercier 1992). For the purposes of the 1993 assessment, these methods were used to recalculate the screening levels with the additional data obtained during 1992 and 1993. However, data reported for the ORR Aquitard wells were not used in the recalculations because statistical evaluation of the revised data sets showed significant differences between

Knox Aquifer and ORR Aquitard concentrations of most of the metals (Paradigm Data Services, Inc. 1994a).

As shown below, recalculating the trace metal screening levels from data sets that included the 1992 and 1993 upgradient data and excluded data reported for the ORR Aquitard wells: (1) decreased the screening levels for antimony, cobalt, copper, manganese, and uranium; (2) had no effect on screening levels for beryllium, molybdenum, nickel, thorium, and vanadium; and (3) increased the screening levels for aluminum, boron, iron, strontium, and zinc:

Metal	**Screening Level (mg/L)**		**Percent Change**
	1986-1991 Data	**1986-1993 Data**	
Antimony	0.11	0.058	-47
Manganese	0.49	0.32	-35
Uranium	0.01	0.007	-30
Copper	0.11	0.10	-9
Cobalt	0.012	0.011	-8
Beryllium	0.0066	0.0066	0
Molybdenum	0.023	0.023	0
Nickel	0.18	0.18	0
Thorium	0.20	0.20	0
Vanadium	0.064	0.064	0
Iron	13.91	14.0	1
Aluminum	8.3	9.5	14
Boron	1.1	1.3	18
Zinc	0.14	0.18	29
Strontium	1.5	2.8	87

Changes in the upgradient data set affected only the method used to determine the screening level for copper; less than 50% of 1986-1993 upgradient copper data exceeded the analytical detection limit, so instead of the parametric tolerance procedure used previously (more than 50% of the

1986-1991 data exceeded the detection limit), the updated screening level was set at the 99th percentile (note that there was little difference between the screening level determined with either method). Significant differences in the screening levels determined from the two upgradient data sets occurred only for antimony, manganese, uranium, zinc, and strontium. These differences may be at least partially attributable to elimination of influences imparted by the data for the ORR Aquitard wells. Additionally, the methods used to determine the screening level for each of these metals (99th percentile and non-parametric tolerance interval) are sensitive to data outliers (Paradigm Data Services, Inc. 1994a), and statistical testing to identify and exclude outliers was not performed.

5.3.4 Frequency Review

Historical monitoring data show that total metal concentrations that exceed MCLs or screening levels (i.e. elevated concentrations) have been reported for unfiltered samples collected from about one-third of the monitoring wells in the Chestnut Ridge Regime. Unfiltered samples collected from a few of these wells are typically characterized by total concentrations of one or two metals that consistently exceed MCLs or screening levels (i.e. elevated concentrations), but samples from most of the wells are characterized by sporadically elevated concentrations of a varying number of metals. However, no common causal relationships or readily apparent spatial and temporal patterns have been identified which would indicate that the sporadically elevated concentrations reported for these samples reflect transitory contaminant migration through seasonally active groundwater flow paths within the Knox Aquifer. A study of the feasibility of correlating precipitation events with elevated metals concentrations and/or TSS levels was initiated during CY 1993. However, preliminary results of the study indicate that groundwater conduits, flow paths, and velocities are too poorly constrained to formulate a meaningful evaluation (or attain any conclusive information) within the current scope of operations.

Instead of a case-by-case evaluation of these sporadically elevated concentrations, an approach generally followed in previous GWQRs, a detailed review of the 1990-1993 data was performed to quantify the frequency at which elevated metal concentrations have occurred in unfiltered samples from each monitoring well in the regime. If the total concentration of a metal exceeded the MCL or screening level in only 1 out of every 4 unfiltered samples from a well, the result was considered anomalous and assumed to reflect analytical errors or interferences, sampling artifacts, or other extraneous factors unrelated to groundwater quality. This approach enables evaluation of trace metal concentrations within the context of the monitoring history of each well, many of which have been sampled during every quarter of the last 4 years.

Elevated concentrations of every trace metal analyte except barium and thorium have been reported for unfiltered groundwater samples collected since 1990. Elevated concentrations of strontium have been reported for the most samples (43), and elevated manganese concentrations have been reported for the most wells (19). Review of the frequency at which elevated concentrations of each metal have occurred shows that anomalous results account for all of the elevated concentrations reported for boron and antimony, at least 50% of the elevated concentrations reported for beryllium, boron, copper, cadmium, iron, manganese, mercury, and nickel, but less than 25% of the elevated concentrations reported for uranium, molybdenum, and strontium (Table 9).

Total concentrations reported for at least 1 metal analyte have exceeded MCLs or screening levels for at least 1 unfiltered groundwater sample collected from 34 of the 91 monitoring wells in the Chestnut Ridge Regime sampled between 1990 and 1993 (Table 9). However, anomalous results account for all of the elevated metal concentrations reported for samples from 22 of the 34 wells (Table 9). Moreover, total concentrations of 11 metals (most often copper, lead, manganese, and zinc) exceeded MCLs or screening levels in unfiltered samples collected from 5 wells (GW-160, GW-178, GW-305, GW-521, and GW-522) that were used to determine screening levels and are located upgradient of potential sources of contamination in the regime. However, all the elevated concentrations reported for each of these wells except GW-178 were identified as anomalous. The occurrence of anomalous elevated metal concentrations in samples from these wells, which are the least likely to be affected by contaminant releases in the regime, further supports disregarding these results as attributable to influences unrelated to actual groundwater quality conditions.

5.4 Radiochemical Parameters

The radiochemical quality of the groundwater in the Chestnut Ridge Regime was evaluated with respect to annual average levels of gross alpha and gross beta activity that exceeded 15 and 50 picocuries per liter (pCi/L), respectively (HSW Environmental Consultants, Inc. 1994a). These are Safe Drinking Water Act screening values for gross alpha activity and gross beta activity above which analyses for specific radioisotopes are needed.

The gross alpha and gross beta activity reported for a particular sample represents the total activity minus the background activity associated with the analytical laboratory and the analytical instrument. In the case of samples with activities below background, the resulting net activity is reported as a negative value. Variation in the background activity can be large for gross alpha activity and gross beta activity and can greatly complicate data interpretation.

A degree of uncertainty is associated with the determination of gross alpha and gross beta activity, and is expressed by the counting error (two standard deviations from the mean) reported for each result. Sometimes the counting error exceeds the reported activity, but the reported activity is nonetheless valid; the high counting error implies only that there is a higher degree of uncertainty associated with the reported result.

The annual average gross alpha and beta activities were determined for each well using the individual activities for each quarterly sample, including negative activities and results with high counting errors. Data obtained during 1992 (if available) were used to calculate mean activities for wells not sampled during each quarter of 1993. The mean counting error **(e)** for the samples from each well was calculated using the following formula from Evans (1955):

$$\varepsilon = \sqrt{\frac{E_1^2}{n^2} + \frac{E_2^2}{n^2} + \frac{E_3^2}{n^2} + \frac{E_4^2}{n^2}}$$

where $\mathbf{E}_1$, $\mathbf{E}_2$, $\mathbf{E}_3$ and $\mathbf{E}_4$ are the individual errors reported for each sample, and **n** is the number of samples. This formula is appropriate for calculating the mean error of a series of errors.

6.0 GROUNDWATER QUALITY EVALUATION

Volatile organic compounds are the primary groundwater contaminants in the Chestnut Ridge Regime, and releases of VOCs to the groundwater system have been confirmed only at the Security Pits. The 1993 groundwater quality data generally show only isolated occurrences of other contaminants (i.e., metals and radioactivity) at the Security Pits and other sites in the regime.

6.1 Volatile Organic Compounds

Previous monitoring results have shown that VOCs are pervasive in groundwater only at the Security Pits. Although the focus of groundwater monitoring at this waste-management site has, for the past few years, shifted toward plume boundary monitoring, and consequently fewer wells in the interior of the plume have been sampled, results obtained during CY 1993 generally support this assertion. Excluding results screened as false positives or anomalous, VOCs that cannot reasonably be attributed to releases from the Security Pits were repeatedly detected only in samples collected from two wells at Kerr Hollow Quarry.

VOC results for all but the following wells were screened as false positives or anomalous: GW-175, GW-177, GW-608, GW-609, and GW-611 at the Security Pits; GW-305 at Industrial Landfill IV; GW-514 at the Ash Disposal Basin; GW-796 at Industrial Landfill V; and GW-142 and GW-144 at Kerr Hollow Quarry. Summed average VOC concentrations were highest in samples from the wells at the Security Pits, ranging from 4 µg/L in GW-608 to 33 µg/L in GW-177 (Table 10). However, historical data from interior plume wells indicate summed VOC concentrations exceed 500 µg/L in groundwater at the site. Summed average concentrations in samples from wells GW-142, GW-144, GW-305, GW-514, and GW-796 were 3 µg/L were or less.

Based on average concentrations, frequency of detection, and areal distribution, the primary components of the VOC plume at the Security Pits are 1,1,1-TCA, 1,1-DCA, 1,1-DCE, and PCE. Secondary VOCs at the site are 1,2-DCE, TCE, and 1,2-dichloroethane (1,2-DCA). The distribution of these VOCs shows that 1,1,1-TCA, 1,1-DCA, and 1,1-DCE are the principal compounds in the VOC plume in the western part of the site and that PCE is the major component of the plume in the eastern part of the site (Figure 14). This distinct difference in the composition of the VOC plume may be directly related to differences in the types of wastes disposed of in the eastern and western disposal trenches at the site, or possibly differences between the solubilities of these compounds.

Summed VOC concentrations have steadily decreased in groundwater samples collected since 1989 from all wells at the Security Pits except GW-177 (Table 11). Annual average summed VOC concentrations in samples from well GW-177 decreased to about 19 µg/L in 1990, but have since increased by about 75% to 33 µg/L in 1993 (although the summed concentrations are still lower than 1989 levels). Review of 1987-1994 data reported for the two primary VOCs detected in the samples from GW-177 (1,1,1-TCA and 1,1-DCA) shows: (1) substantial decreases in the concentrations of both compounds after closure of the site in 1988 and construction of the multilayer cap in 1989; (2) a corresponding increase in the depth to the static water level in the well; and (3) distinctive cyclic fluctuations in 1,1,1-TCA and 1,1-DCA concentrations that generally mirror seasonal water level fluctuations in the well (Figure 15).

The horizontal extent of the VOC plume at the Security Pits is generally defined to the north and south. However, the horizontal extent of the plume at deeper intervals along strike, to the east and west is not fully delineated. For instance, data from wells GW-173 and GW-609 suggest that movement of the VOCs along strike to the east may be occurring at deep intervals in the aquifer (Figure 16). The elevation of the screened interval in well GW-173, which is located about 200 ft east of the site, is between 948 and 959 ft mean sea level (MSL); GW-609 is screened between 840 and 853 ft MSL. This well is located approximately 800 ft east of well GW-173, and the summed average concentration of VOCs in samples from the well (28 µg/L) has been significantly greater than that in the samples from well GW-173 for three consecutive years, or since the installation of GW-609, even though GW-173 was not sampled in 1993. Tetrachloroethene is the primary compound detected in the samples from both wells, suggesting that the wells monitor the VOC plume originating from the eastern disposal trenches at the site. These findings indicate that the VOC plume may extend further eastward, below the shallower wells adjacent to the disposal trenches.

The maximum depth of the VOC plume down-dip of the Security Pits is defined by monitoring wells GW-742 and GW-743 installed in December 1991 south of the area where groundwater samples contain the highest summed average VOC concentrations (Figure 16). Only low concentrations of common laboratory reagents (acetone, 4-methyl-2-pentanone, and methylene chloride) were detected in the samples collected from these wells in 1992 and 1993, and each of these results were screened as false positives. The maximum depth of the VOC plume along strike has not been defined (Figure 16).

The primary component of the VOC plume at the western end of the Security Pits, 1,1,1-TCA, was detected in groundwater samples collected from well GW-514 at the Ash Disposal Basin, well GW-796 associated with Industrial Landfill V, and well GW-305 at Industrial Landfill IV. Each of these wells except GW-305 are hydraulically downgradient from the Security Pits (Figure 7).

Low concentrations of 1,1,1-TCA reported for samples collected from wells GW-796 and GW-514 (Table 10) may indicate down-dip migration from the source area at the western end of the Security Pits. Samples collected from GW-796 in the second, third, and fourth quarters of 1993 contained 1,1,1-TCA concentrations of 2 µg/L. This well is located about 500 ft south of the western disposal trenches at the Security Pits. Low concentrations (less than 1 µg/L) of 1,1,1-TCA were detected in samples collected from well GW-514 during the first, second, and third quarters of CY 1993. This compound also was detected at low concentrations in the samples collected from the well during CYs 1991 and 1992. However, 1,1,1-TCA was not detected in samples collected from shallower wells (GW-512 and GW-513) clustered with GW-514 and all three wells are hydraulically upgradient of the Ash Disposal Basin, suggesting that the Ash Disposal Basin is not the source of the 1,1,1-TCA in the well. Well GW-514 is located about 900 ft south of the western disposal trench at the Security Pits, and 1,000 ft southwest of well GW-796. The repeated occurrence of low concentrations of 1,1,1-TCA in the groundwater samples collected from these wells likely indicates down-dip transport from the Security Pits.

Concentrations of 1,1,1-TCA reported for samples collected from well GW-305 during CY 1993 ranged from 2 µg/L in the first quarter sample to 4 µg/L in the fourth quarter sample. This well has been sampled since the first quarter of CY 1988 and 1,1,1-TCA was first detected in the samples collected during CY 1992, ranging from 0.6 µg/L in the first quarter to 2 µg/L in the fourth quarter. Although the 1,1,1-TCA concentrations reported for the 1992 and 1993 samples were below the analytical detection limit of 5 µg/L, the concentrations nonetheless suggest a continued increasing trend. Neither 1,1,1-TCA nor any other VOC (excluding false positive results for common laboratory reagents) has been detected in samples from the other wells at Industrial Landfill IV, and the only confirmed source of 1,1,1-TCA is the western end of the Security Pits. However, well GW-305 is located about 4,500 west of the Security Pits (Figure 14), and the average water-level elevations in the well (and other wells at Industrial Landfill IV) are more than 20 ft higher than the seasonally high and low water-level elevations in wells at the Security Pits (Figure 8).

Cross contamination was suggested in Part 2 of the 1992 GWQR as a potential source of the 1,1,1-TCA in samples from well GW-305 because: (1) the well was sampled with the same equipment previously used to sample wells at the Security Pits which contained 1,1,1-TCA; and (2) the compound was detected in several of the equipment rinsates analyzed during CY 1992 (HSW Environmental Consultants, Inc. 1993). However, results obtained during CY 1993 do not support this observation; none of the wells sampled before well GW-305 contained 1,1,1-TCA and this compound was not detected in any of the CY 1993 equipment rinsate samples. Thus, the source of the 1,1,1-TCA in the samples from this well has not been conclusively identified.

Low carbon tetrachloride concentrations (3 µg/L) were detected in the groundwater samples collected from well GW-144 at Kerr Hollow Quarry during the third and fourth quarters of 1993. Concentrations have ranged from 1 to 6 µg/L in each groundwater sample collected from the well since the third quarter of 1990 except samples collected in the first quarters of 1991, 1992 and 1993 and the second quarter of 1992. Carbon tetrachloride has not been detected in samples collected from other wells at the site. Chloroform, a degradation product of carbon tetrachloride, was detected in samples collected from GW-142 in the second (4 µg/L) and third (1 µg/L) quarters of 1993. Low chloroform concentrations (0.7 µg/L) also were reported for samples collected from wells GW-143 and GW-144 in the third quarter of 1993, but these results were screened as anomalous. Although the concentrations of carbon tetrachloride and chloroform are typically less than their respective analytical detection limits, they have been detected with some regularity and the possibility that Kerr Hollow Quarry may be the source of these VOCs cannot be totally discounted.

6.2 Semi-Volatile and Other Organic Compounds

Groundwater samples collected from wells at the Sediment Disposal Basin and Rogers Quarry were analyzed for base, neutral, and acid (BNA) extractable organic compounds; analytical results are provided in Appendix E of the Part 1 GWQR. Only 6 BNA compounds were detected: phthalates in samples from wells at both sites, and isophorone in a sample from one well (GW-158) at the Sediment Disposal Basin (Table 12). Because many of these compounds were detected in only one sample from the wells, the results were probably analytical artifacts and were screened as anomalous.

Phthalates were detected in samples collected from 8 wells at the Sediment Disposal Basin (GW-156, GW-158, GW-159, GW-241, GW-303, GW-304, GW-731, and GW-732) and 4 wells at Rogers Quarry (GW-184, GW-186, GW-187, and GW-188). However, the concentrations of these compounds were very low (estimated values below the practical quantitation limit) and were commonly detected in associated laboratory blank samples (Table 12). The phthalates detected in samples from these wells also were probably analytical artifacts and were screened as either false positive or anomalous results.

Samples from the monitoring wells at Industrial Landfills II, III, IV, and V and Construction/Demolition Landfills VI (first quarter only) and VII were analyzed for the additional organic compounds listed in Table 2. Groundwater samples from monitoring wells at Construction/Demolition Landfills VI and VII also were analyzed for trans-1,2-dichloroethene. None of these compounds were detected in any of the samples from these wells.

6.3 Trace Metals

As noted in Section 5.2.4, elevated trace metal concentrations reported for most wells in the Chestnut Ridge Regime were discounted as anomalous based on the sporadic frequency at which they occurred. Excluding anomalous results, total metal concentrations that exceed MCLs or screening levels have been reported for at least 2 samples collected since 1990 from 12 monitoring wells in the Chestnut Ridge Regime (Table 13). Evaluation of these results indicates that they may be divided into the following categories: inconclusive, biased, and consistent. The characteristics of each category are described in the following paragraphs.

Inconclusive results were defined as elevated concentrations that occurred sporadically, but at a frequency just above what would be considered anomalous. These results were reported primarily for samples collected from 4 wells: GW-165 at Industrial Landfill III, GW-731 at the Sediment Disposal Basin, and wells GW-178 and GW-742 at the Security Pits (Table 13). Elevated concentrations of all the metals in these samples except those reported for manganese, iron, and zinc were discounted as anomalous. However, continued sampling of these wells (GW-165 and GW-178 were not sampled during CY 1993) would probably demonstrate that these elevated manganese, iron, and zinc concentrations also are anomalous results that do not reflect actual groundwater quality conditions monitored by the wells.

Elevated metal concentrations reported for unfiltered samples collected from 3 wells were categorized as biased: 1086 at Industrial Landfill II (which was plugged and abandoned in June 1992), GW-295 at Industrial Landfill III, and GW-545 at Construction/Demolition Landfill IV. The elevated total metal concentrations reported for samples from well GW-546 also would be similarly classified, except all of the results for this well were identified as anomalous. Unfiltered samples from these wells are characterized by sporadically elevated total concentrations of as many as 11 different metals (Table 13). However, there is often a direct correlation between TSS and total concentrations of several metals in these samples (Figure 17). Elevated metals concentrations are biased by metal ions mobilized from the suspended materials when the pH of the unfiltered sample is reduced by the acid preservative. Additionally, the TSS in the unfiltered samples from these wells is typically highest when the water column in the wells is lowest (Figure 18). This relationship documents that turbid, unfiltered samples are more likely to result when water levels are low and particulates in the bottom of these wells are disturbed during sampling. Thus, sporadically elevated total metal concentrations reported for these wells were considered sampling artifacts.

Biased total concentrations of chromium, iron, manganese, and nickel in unfiltered groundwater samples from well GW-295 also may be the result of well screen corrosion. This well was constructed with type 304 stainless steel well casing and screen, which is less resistant than other types of stainless steel to corrosion by halogen salts, especially chlorides (Driscol 1986). Chlorides enhance the dissolution of metal constituents in the steel, particularly chromium, because it easily penetrates the corrosion-resistant monomolecular film that forms on the surface of the steel (Driscol 1986). Chloride concentrations in samples from well GW-295 have ranged from 60 to 160 mg/L (Figure 19). Nine of the 16 unfiltered groundwater samples collected from the well since 1990 have contained elevated concentrations of each of chromium, iron, manganese, and nickel (12 samples have contained chromium concentrations in excess of the 0.01 mg/L MCL). Chloride concentrations higher than those in well GW-295 have been reported only for samples from well GW-187 at Rogers Quarry. Well GW-187 has a polyvinylchloride well screen and total metal concentrations in these samples have not exceeded MCLs or screening levels (Figure 19). These findings strongly suggest that unfiltered samples collected from GW-295 are biased by corrosion products in the well. Potential corrosion products combined with the biased results attributable to probable sampling artifacts related to TSS, indicate that few if any of the elevated total metal concentrations reported for these samples are representative of groundwater quality monitored by the well.

Results categorized as consistent occur in unfiltered groundwater samples collected from 5 wells: GW-541 at Industrial Landfill II; GW-303 near the Sediment Disposal Basin; and GW-142, GW-145, and GW-146 at Kerr Hollow Quarry (Table 13). All of these wells except GW-541 have been sampled each quarter since 1990. Discounting anomalous results, elevated concentrations of as many as 2 metals have been reported for at least half of the samples from each well; molybdenum in well GW-541 (10 samples), strontium in wells GW-146 (16 samples) and GW-303 (8 samples), uranium in well GW-142 (8 samples), and strontium and uranium in well and GW-145 (16 samples).

Total molybdenum concentrations exceeded the 0.023 mg/L screening level in all of the unfiltered groundwater samples collected from GW-541 during CY 1993 (Table 13), as well as in all of the unfiltered samples collected from the well since the third quarter of CY 1991 (Figure 20). Concentrations have remained fairly constant, fluctuating between 0.03 and 0.038 mg/L. Elevated total molybdenum concentrations have been reported for unfiltered samples from wells located elsewhere in the regime (1 sample from wells GW-142, GW-301, and

GW-145, and 5 samples from GW-295 and GW-545), but their infrequent occurrence in these diversely located wells suggest that these results do not indicate contaminant migration from a common source area. Conversely, the consistent occurrence of elevated molybdenum concentrations only in the unfiltered samples from well GW-541 suggests a well-specific source, perhaps residual traces of a molybdenum-based lubricant used on drill rod joints during installation of the well.

Total strontium concentrations have exceeded the 2.8 mg/L screening level in 8 of the 16 unfiltered samples collected from well GW-303 since the first quarter of 1990 (Figure 20), including 3 of the 4 samples collected from the well in 1993 (Table 13). However, the concentrations have consistently ranged from just below (2.6 mg/L) to slightly above (3.1 mg/L) the screening level, concentrations that warrant further monitoring but may not reflect groundwater contamination.

Total strontium concentrations have exceeded the screening level in every sample collected from wells GW-145 and GW-146 since the first quarter of 1990, including all samples collected from the wells in 1993 (Table 13). Concentrations in samples from both wells have fluctuated very little, ranging from 6.7 to 9.4 mg/L in samples from well GW-145 and from 6.3 to 8.7 mg/L in samples from well GW-146 (Figure 20). Total strontium concentrations in the unfiltered samples from the other wells at Kerr Hollow Quarry have been substantially lower, ranging from less than 1 mg/L in wells GW-142, GW-144, and GW-231 to about 2 mg/L in wells GW-143 and GW-147. Wells GW-145 and GW-146 comprise a well cluster located downgradient of Kerr Hollow Quarry and the consistently elevated strontium concentrations in these wells may be related to waste disposal at the site.

Total uranium concentrations have exceeded the 0.07 mg/L screening level in 8 of the 16 unfiltered samples collected from well GW-142, and in all of the 16 samples collected from well GW-145 (Table 13). Concentrations in samples from both wells are fairly consistent (Figure 20). However, gross alpha activity in samples from both wells is low (i.e. less than 15 pCi/L), which suggests that the total uranium concentrations reported for these wells may reflect natural concentration variations within the Knox Aquifer.

6.4 Radioactivity

The annual average gross alpha and gross beta activity in groundwater samples from all wells in the regime, except GW-295, were below their respective Safe Drinking Water Act screening levels of 15 and 50 pCi/L. Gross alpha and gross beta activities averaged 42.8 ± 14.7, and 57.4 ± 16.5 pCi/L, respectively, in the samples collected from GW-295. Annual average gross alpha and gross beta activities determined for samples from this well have exceeded 15 and 50 pCi/L each year since 1990, but each annual average activity was skewed by unusually high results reported for one or two quarterly samples. Review of historical (1990-1993) gross alpha and beta activities reported for GW-295 show the same relationships with TSS and water level that are evident with the total metal concentrations. Elevated alpha and beta activities are associated with elevated TSS levels in unfiltered samples collected when the water levels in the well are lowest (Figure 21). This association with TSS levels is important, because excessive amounts of particulates in the sample can significantly affect analyses of gross alpha and gross beta activity.

Because of the elevated gross beta activities reported for samples collected from GW-295 during CY 1992, samples collected from the well in CY 1993 were analyzed for specific beta-emitting isotopes (strontium, technetium, and tritium) to determine if the samples from the well exceed the MCL for beta activity (4 millirems/year cumulative dose). Dose equivalents were calculated using dose factors proposed by the EPA (Federal Register, Vol. 56 No. 138, July 18, 1991). These dose factors represent the radionuclide activity that will deliver a 4 millirem/year dose equivalent to a critical organ or to the total body assuming a 2-Liter per day intake of the affected water. As shown in the following table, results of these calculations show that the cumulative dose calculated from the CY 1993 data for GW-295 is substantially below the MCL.

Parameter	Dose Factor	Mean Activity	Dose Equivalent
Gross Beta	-	57.4 ± 16.5	-
Strontium	42	11.1	1.05
Technetium	3,790	-114.6	0
Tritium	60,900	-4.3	0
Cumulative Dose			**1.05**

The essentially negligible activities reported for the beta-emitting radionuclides further indicate that the elevated gross beta activities reported for unfiltered samples from the well are analytical artifacts probably resulting from analyses of turbid samples.

7.0 CONCLUSIONS

Contaminant releases to the groundwater system in the Chestnut Ridge Regime have occurred at the Security Pits and VOCs are the principal contaminants. The 1993 groundwater quality data generally show only isolated occurrences of other contaminants (i.e., metals and radiochemical parameters) at other sites in the regime.

Groundwater samples and the associated laboratory blanks, trip blanks, and equipment rinsates often contain several common laboratory reagents (methylene chloride, acetone, 4-methyl-2-pentanone, and 2-butanone) that are apparently ubiquitous in the K-25 Analytical Chemistry Laboratory. However, compounds known to be present in the groundwater in some areas of the Chestnut Ridge Regime are infrequently detected in QA/QC samples. Nevertheless, there is a pronounced tendency for the number of false positive VOC results to increase in groundwater samples collected during the third and fourth quarters of the year. The increase apparently occurs independent of the number of samples analyzed for VOCs and the number of QA/QC samples contaminated with VOCs. This finding suggests that the occurrence of false positive VOC results is prone to idiosyncratic influences, such as different analytical instrumentation and operator techniques.

Volatile organic compounds occur in groundwater primarily at the Security Pits, and data obtained during 1993 are similar to historical results. The primary VOCs in groundwater at the site are 1,1,1-TCA, 1,1-DCA, 1,1-DCE, and PCE. Historical data indicate that summed average VOC concentrations are highest (>100 µg/L) in samples collected from monitoring wells (GW-176, GW-322, and GW-612) located south (down-dip) of the site, and well GW-179 located north (up-dip) of the site. The 1993 data confirm previous findings of a general decrease in VOC concentrations at the site; summed VOC concentrations in some wells have decreased by more than 60% since 1989. Additionally, concentrations of 1,1,1-TCA and 1,1-DCA in samples collected since 1986 from a well (GW-177) located adjacent to disposal trenches at the site show substantial decreases following closure of the site in 1988 and installation of the impermeable cap in 1989. Moreover, the depth to water in well GW-177 increased substantially after closure and capping the site, and seasonal water level fluctuations are mirrored by concentrations of 1,1,1-TCA and 1,1-DCA. Horizontal boundaries of the VOC plume at the site are essentially defined to the north and south, but not along strike to the east or west. The 1993 data reported for two wells (GW-742 and GW-743) installed at the site in 1991 to help delineate the vertical boundaries of the VOC plume suggest that the maximum depth of the VOC plume at the site is less than 500 ft below the ground surface.

One of the primary components of the VOC plume at the Security Pits (1,1,1-TCA) was consistently detected in samples collected from two wells (GW-514 and GW-746) located directly downgradient of the Security Pits, and one well (GW-305) located about 4,000 ft along strike to the west of the site. The 1,1,1-TCA results reported for GW-514 and GW-746 indicate potential down-dip migration from the Security Pits. Results reported for well GW-305 are not easily attributable to migration from the Security Pits because the well is hydraulically upgradient of the site.

Low concentrations of several phthalates were detected in samples from wells located at the Sediment Disposal Basin and Rogers Quarry. However, the low concentration (typically <5 µg/L) and sporadic occurrence (i.e., detected in only one of four samples from the wells) of these compounds suggest that the results were probably analytical artifacts.

Groundwater quality with respect to trace metal concentrations was evaluated based on a comparison of the total metal concentrations reported for unfiltered groundwater samples to drinking-water MCLs, if applicable, or to screening levels determined from statistical analysis of 1986-1993 trace metal data for wells completed in the Knox Aquifer upgradient of waste-management facilities in the Chestnut Ridge Regime. A detailed review and evaluation of the data obtained between 1990 and 1993 indicate that elevated total metal concentrations have been reported for unfiltered samples collected from 34 of the 91 monitoring wells in the regime. The elevated concentrations reported for 22 of these wells were anomalous results probably caused by extraneous factors unrelated to groundwater quality (e.g., analytical interferences and sampling artifacts).

Elevated concentrations of some metals reported for many of the wells are probably biased by outside factors and are not representative of actual groundwater quality. Concentrations of some metals are often associated with high TSS levels in the unfiltered samples from the wells, indicating that the elevated concentrations are biased by metal ions mobilized from the suspended materials when the pH of the unfiltered sample is reduced by the acid preservative. Additionally, turbid, unfiltered samples were usually collected when water levels in the wells were lowest, indicating that these turbid samples were probable artifacts resulting when sediment in the bottom of the wells was disturbed during sampling.

Evaluation of the data for one well in the regime (GW-295 at Industrial Landfill III) indicates a correlation between the chloride concentrations and total concentrations of some metals, particularly chromium. This correlation may indicate that the concentrations of some metals observed in this well are biased by chloride-induced corrosion of the stainless steel well screen.

Excluding the anomalous elevated trace metal concentrations, only 5 wells in the regime consistently yield unfiltered samples with total metal concentrations that exceed screening levels: GW-142 (uranium), GW-145 (uranium and strontium), and GW-146 (strontium) at Kerr Hollow Quarry; GW-303 (strontium) near the Sediment Disposal Basin; and GW-541 (molybdenum) at Construction/Demolition Landfill VI. However, the elevated concentrations of these metals do not necessarily reflect impacts on groundwater quality at these sites.

Annual average gross alpha activity and gross beta activity exceeded Clean Water Act screening levels of 15 and 50 pCi/L, respectively, only in samples collected from well GW-295. However, the annual average activities determined for this well were skewed over the respective screening levels by anomalously high results reported for one sample from the well. These anomalously high activities show a positive correlation with TSS levels in the unfiltered samples from the well. Excessive amounts of particulates can significantly affect analyses for gross alpha and gross beta activities, and the anomalously high activities reported for well GW-295 were assumed to reflect analytical artifacts. This assumption was supported by the low activities reported for beta-emitting radionuclides in the samples from the well.

8.0 PLANNED AND PROPOSED MONITORING CHANGES

Changes to the groundwater monitoring program in the Chestnut Ridge Regime are currently planned by the Y-12 Plant GWPP for implementation in CY 1995. Planned changes primarily involve the sampling frequency for some wells, and continued collection of groundwater samples from a spring located near Industrial Landfill V. Other modifications also are proposed based on the results of the 1993 groundwater quality monitoring program.

8.1 Sampling Locations, Frequency, and Analytical Parameters

Requirements of the monitoring programs under which groundwater in the Chestnut Ridge Regime is sampled have not changed, and thus few changes to the monitoring well network are planned for CY 1995 (Figure 22). A total of 73 monitoring wells will be sampled for the purposes of the following programs:

- 10 wells for RCRA interim status assessment monitoring at the Security Pits, 1 less than in CY 1993 (GW-607 was plugged and abandoned);
- 15 wells for RCRA detection monitoring programs at Kerr Hollow Quarry and the Sediment Disposal Basin (all of which were sampled during CY 1993);
- 30 wells used during CY 1993 for detection and background monitoring at Industrial Landfills II, III, IV, and V, and at Construction/Demolition Landfills VI and VII; and
- 18 wells located at the United Nuclear Corporation Site, the East Chestnut Ridge Waste Pile, the Ash Disposal Basin, and Rogers Quarry will be sampled as a best-management practice of the Y-12 Plant GWPP.

Groundwater samples will be collected each quarter of 1995 from only 48 of the monitoring wells. The remaining 25 wells will be sampled semiannually, including 4 at the East Chestnut Ridge Waste Pile, 7 at Industrial Landfill III, 4 at the Ash Disposal Basin, 4 at Rogers Quarry, and 6 at Construction/Demolition Landfill VI (Table 14). Wells included in each sampling event will be sampled in the sequence shown on Table 14 and the samples will be analyzed for the specified constituents and parameters. In addition to the monitoring wells, samples of the groundwater discharging from a spring located near Industrial Landfill V will be collected semiannually (Figure 22).

Groundwater samples collected during CY 1995 from the monitoring wells at each site except those at the Sediment Disposal Basin and Rogers Quarry will be analyzed for the same suite of analytes used in previous years. Samples from wells at the Sediment Disposal Basin and Rogers Quarry will not be analyzed for BNAs during CY 1995. The analytical results reported for these wells over the past few years indicate that BNAs are infrequently detected and such results are probably analytical artifacts. The specific list of analyses for samples from each well are identified in *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant During Calendar Year 1995* (HSW Environmental Consultants, Inc. 1994b).

8.2 Proposed Modifications

Based on the findings obtained during 1993, the following modifications to the groundwater monitoring program for the Chestnut Ridge Regime are proposed for consideration:

(1) Well GW-295 at Industrial Landfill III, and wells GW-545 and GW-546 at Construction/Demolition Landfill VI should no longer be sampled for water quality monitoring purposes. Review of the data for these wells strongly indicates that they do not yield representative groundwater samples. However, the wells are suitable for water level monitoring, so plugging and abandonment of the wells may not be necessary.

(2) All available records should be reviewed to help identify the suspected well-specific source of elevated total molybdenum concentrations that have been consistently reported for unfiltered groundwater samples collected from well GW-541 at Construction/Demolition Landfill VI. If necessary, downhole video inspection of the well should be performed.

(3) A thorough inspection of well GW-187 at Rogers Quarry should be performed to determine if an inadequate annular grout seal is responsible for the elevated sodium and chloride concentrations in samples from the well (possibly caused by infiltration of surface runoff containing dissolved salt used in de-icing Bethel Valley Road).

(4) Historical data should be reviewed to identify wells that may potentially yield groundwater samples with total metal concentrations that are potentially biased by corrosion products from stainless steel well casing and screens. A preliminary review of the data performed during this assessment indicated that total concentrations of chromium, manganese, nickel, and iron are usually higher in wells with: (1) stainless steel well screens; (2) chloride concentrations that exceed 8 mg/L; and (3) static water levels that are below the top of the monitored interval (Paradigm Data Services, Inc. 1994b). The data tracking procedure should, therefore, be modified to flag results reported for unfiltered samples from wells that meet these criteria. More rigorous evaluation of the potential effects of well screen corrosion could then be focused on these wells. Two common methods of predicting the corrosive tendencies of water are the Langelier and the Ryznar Stability Indices (Driscol 1986). Data needed for these calculations (TDS, methyl orange alkalinity, and calcium hardness) are currently available or may be determined from available data.

(5) Screening levels for non-drinking water metals should be recalculated after excluding statistical outliers from the 1986-1994 dataset for each metal. Methods used to calculate the screening levels are sensitive to outliers, which may skew the screening levels toward higher concentrations.

(6) Additional data tracking information (such as instrument number and analyst identification) should be obtained to help identify the source or cause of the increase in the number of false positive VOC results identified from third and fourth quarter QA/QC samples.

(7) Groundwater samples from selected wells should be speciated for selected metals to identify the common forms (i.e. free ions, or inorganic and organic complexes) in which trace these metals are most likely to occur in groundwater in the regime. Such information is needed to evaluate the relative mobility of potential metal contaminants.

(8) Analysis of recent (CY 1993 and 1994) cadmium and chromium data should be performed to determine if differences between ICP and AAS results reported for these metals are statistically significant. If no such differences are evident, AAS analyses of these metals could be discontinued.

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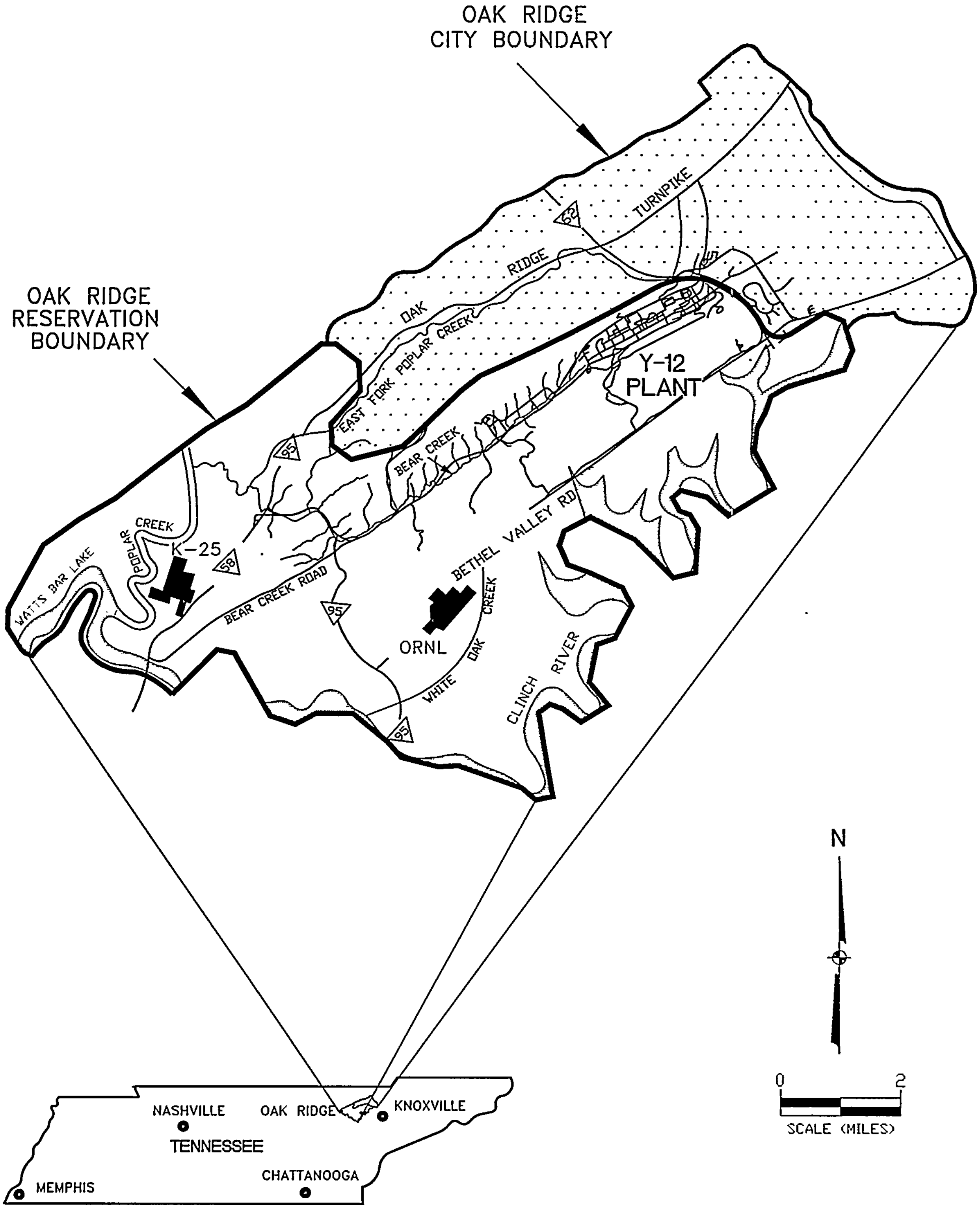
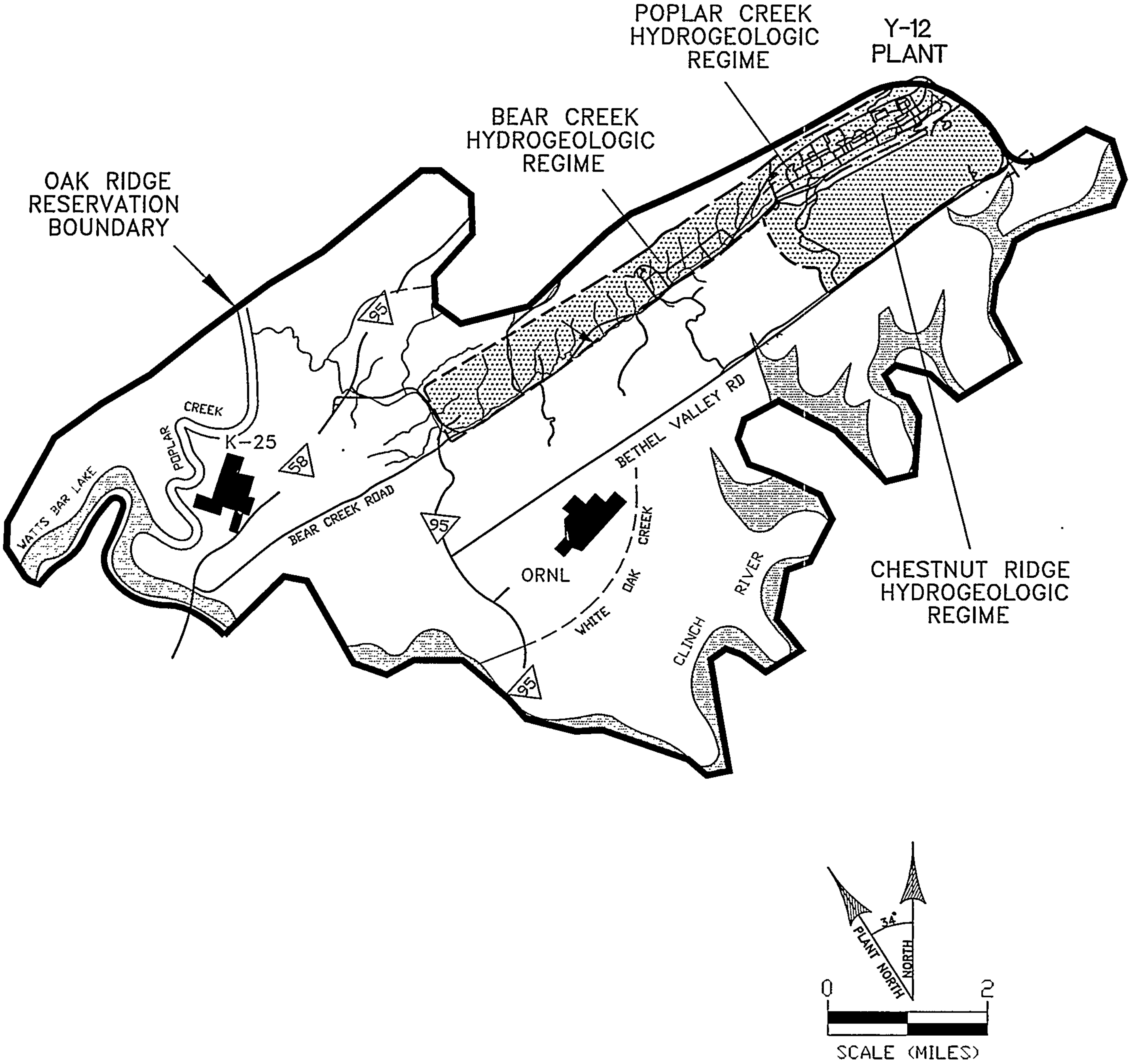
APPENDIX A

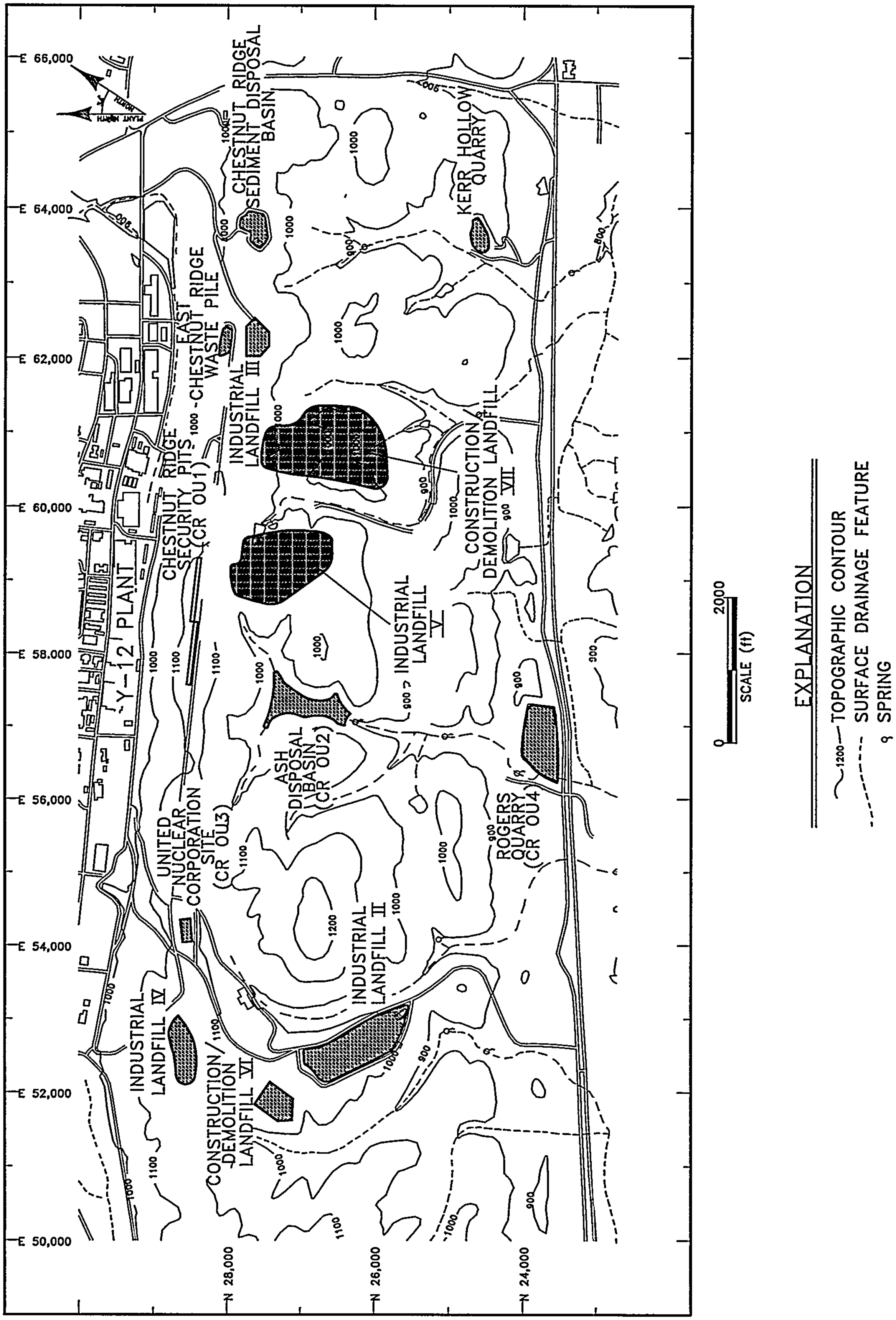
FIGURES



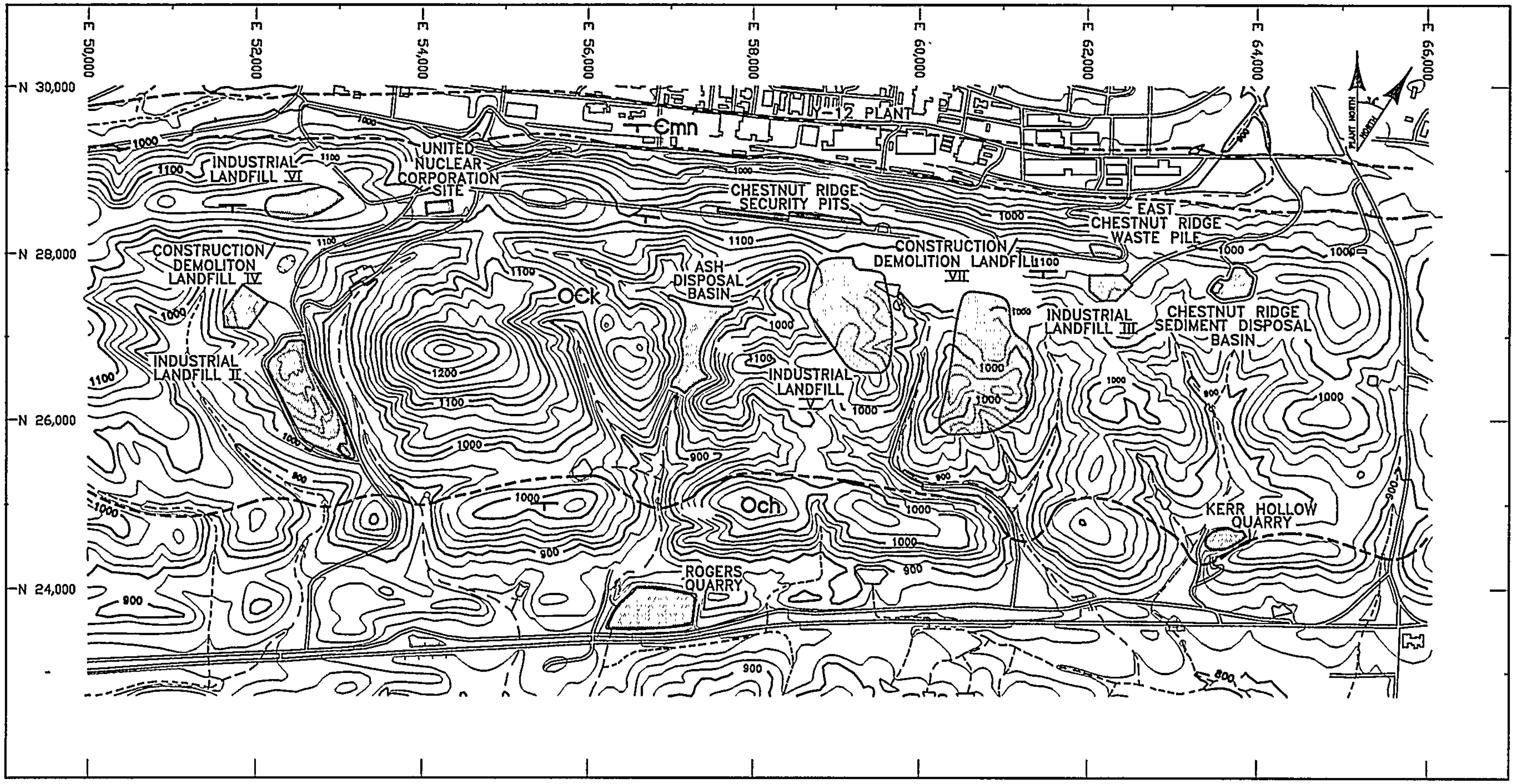
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 1
DATE:	8-25-94	REGIONAL LOCATION OF THE Y-12 PLANT
DWG ID.:	OR250-HC	



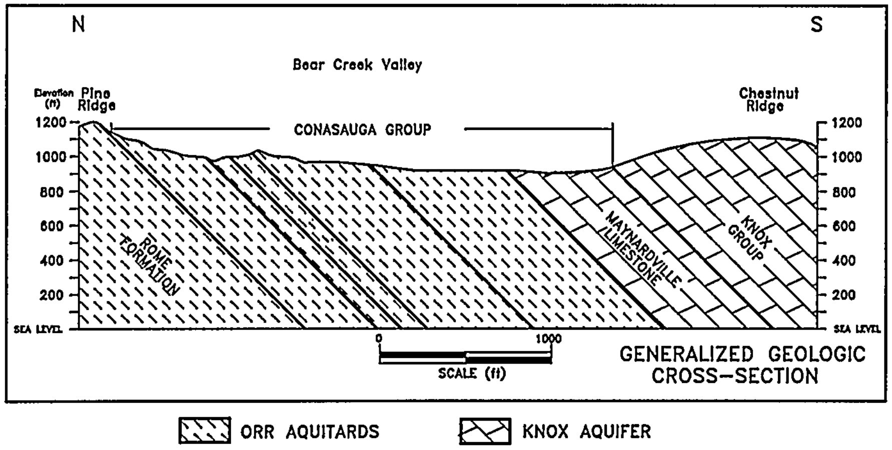
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 2
DATE:	8-26-94	HYDROGEOLOGIC REGIMES AT THE Y-12 PLANT
DWG ID.:	OR321-HC	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 3
DATE:	8-25-94	WASTE-MANAGEMENT SITES AND CERCLA OPERABLE UNITS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR210-HC	



SOURCE: King and Haase, 1987



GENERALIZED GEOLOGIC CROSS-SECTION

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

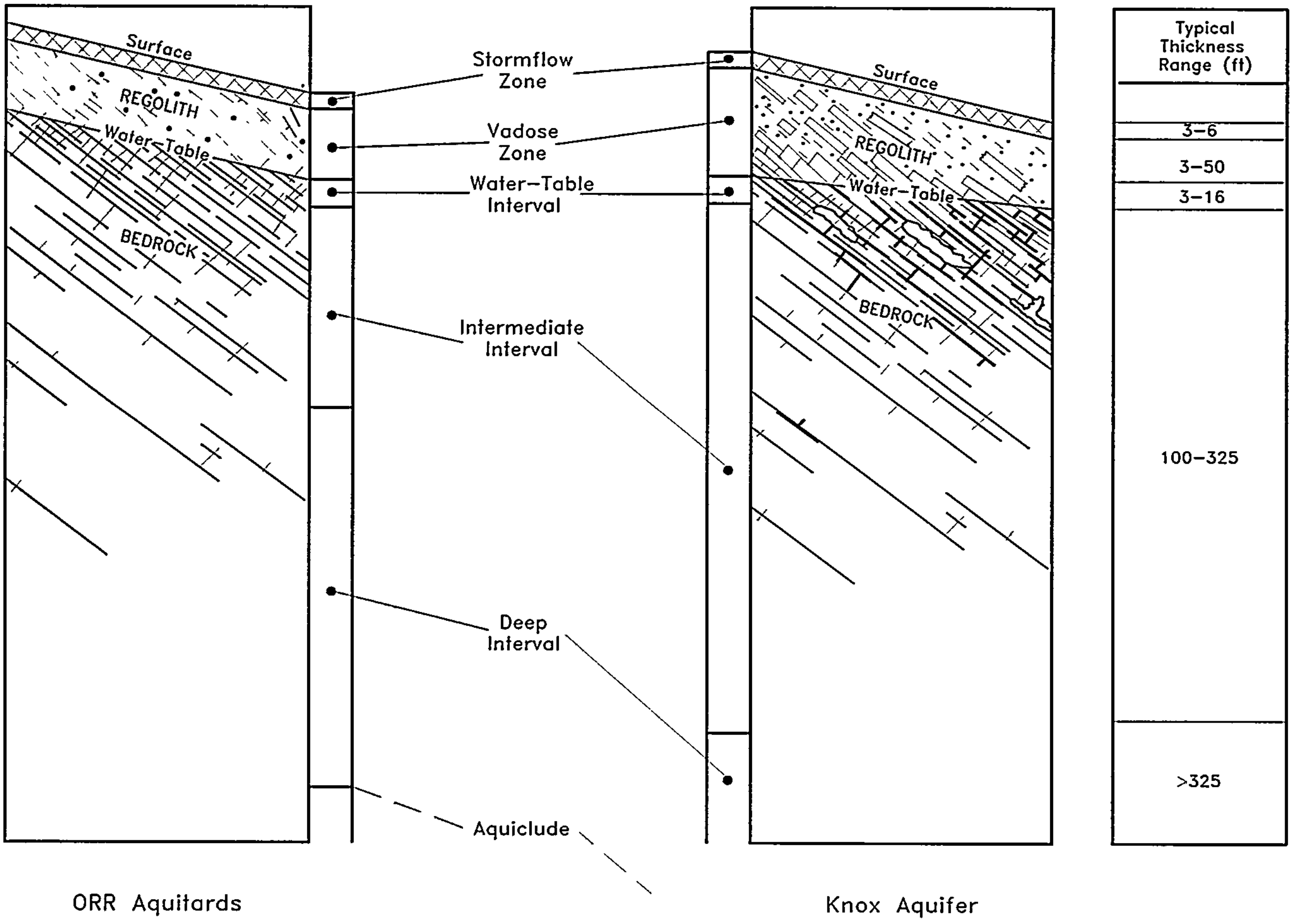
LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DATE:	8-25-94
DWG ID.:	OR211-HC

FIGURE 4

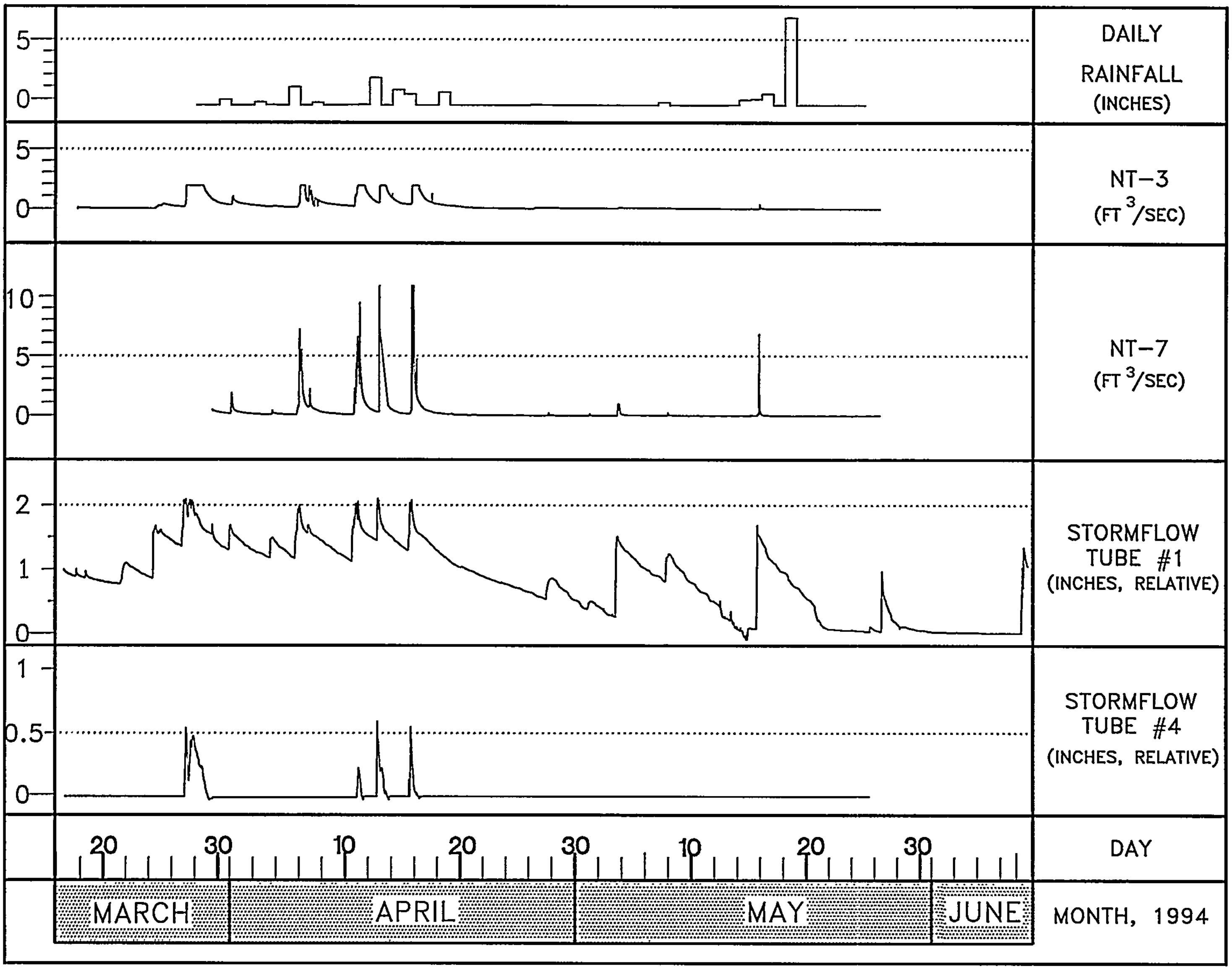
TOPOGRAPHY AND BEDROCK GEOLOGY IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME

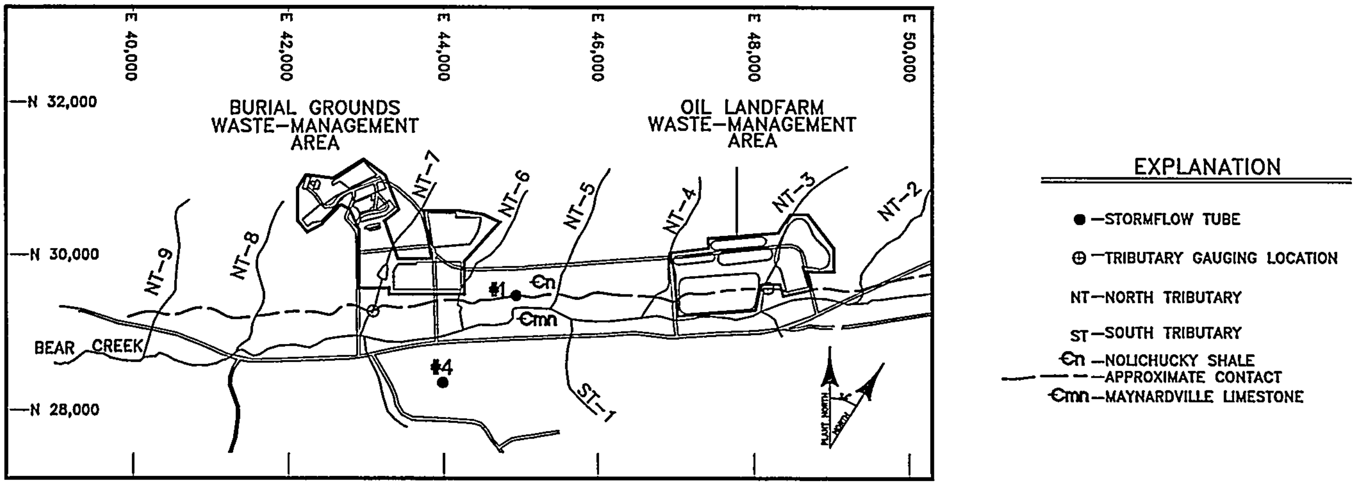
HYDROSTRATIGRAPHIC UNITS

PROPOSED BY SOLOMON *et al.* (1992)

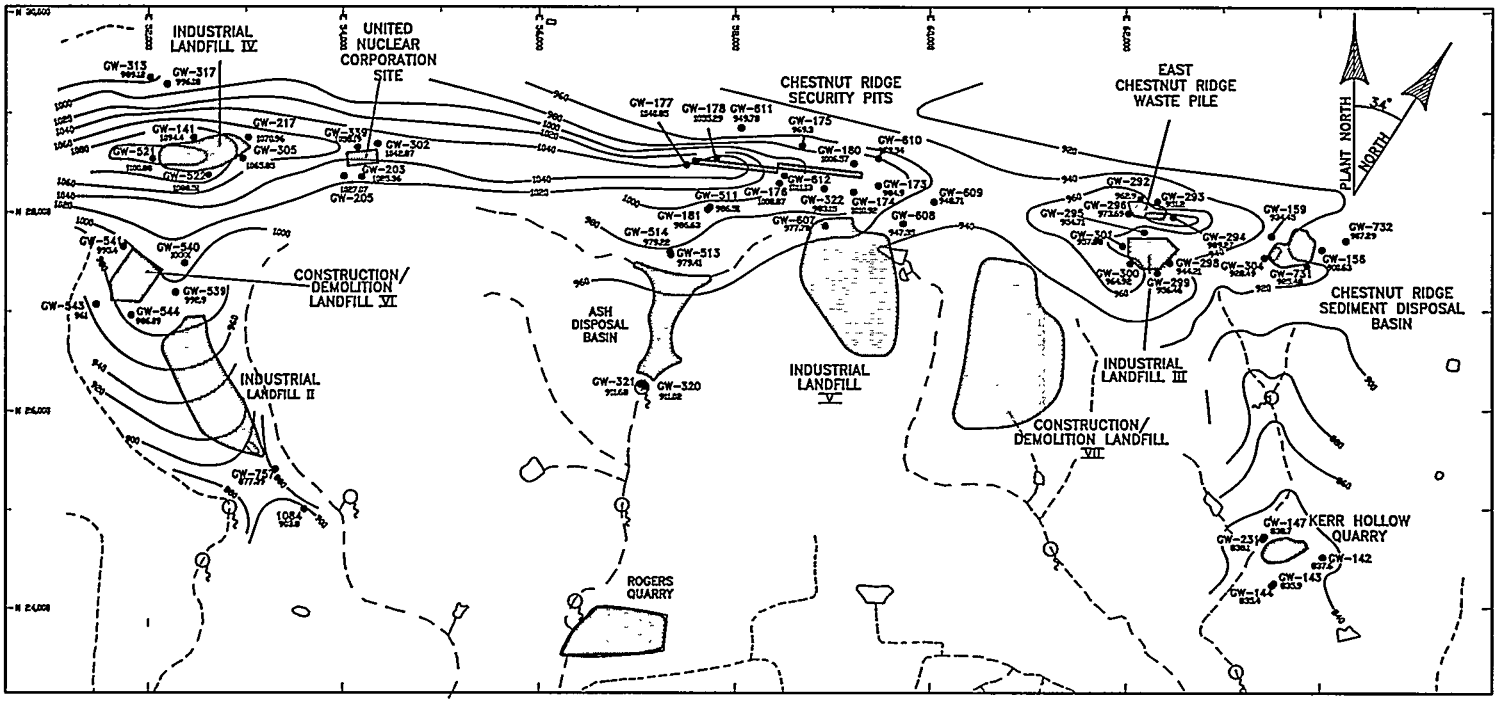


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 5
DATE:	8-25-94	SCHEMATIC PROFILE OF HYDROSTRATIGRAPHIC UNITS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR213-HC	

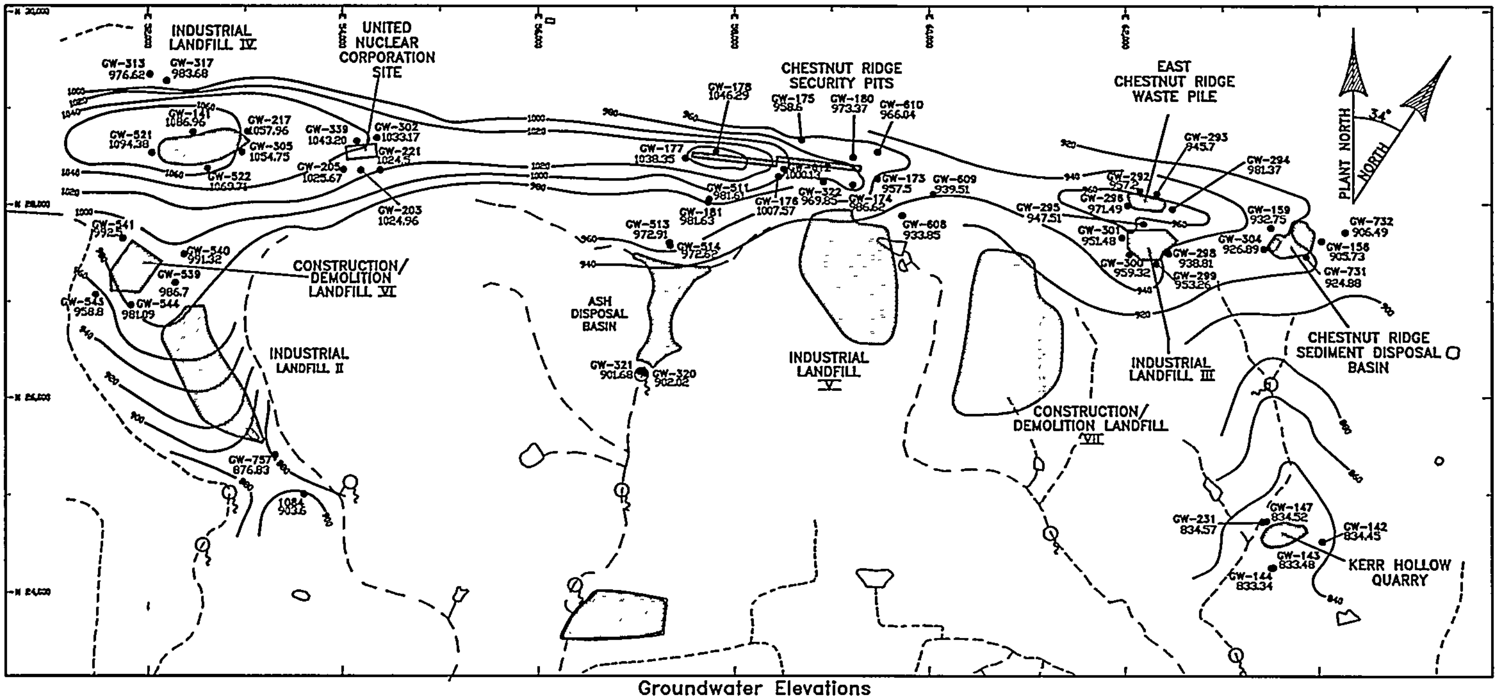




LOCATION:	Y−12 PLANT OAK RIDGE, TN.	FIGURE 6
DATE:	8−15−94	RAINFALL RESPONSES IN THE STORMFLOW ZONE
DWG ID.:	OR414−HC	



Groundwater Elevations
January 11–22, 1993



Groundwater Elevations
September 1–7, 1993

EXPLANATION

GW-732 906.49 ● Bedrock Monitoring Well

920 Water-Level Isopleth (ft msl) (dashed where inferred)

Surface Drainage Feature

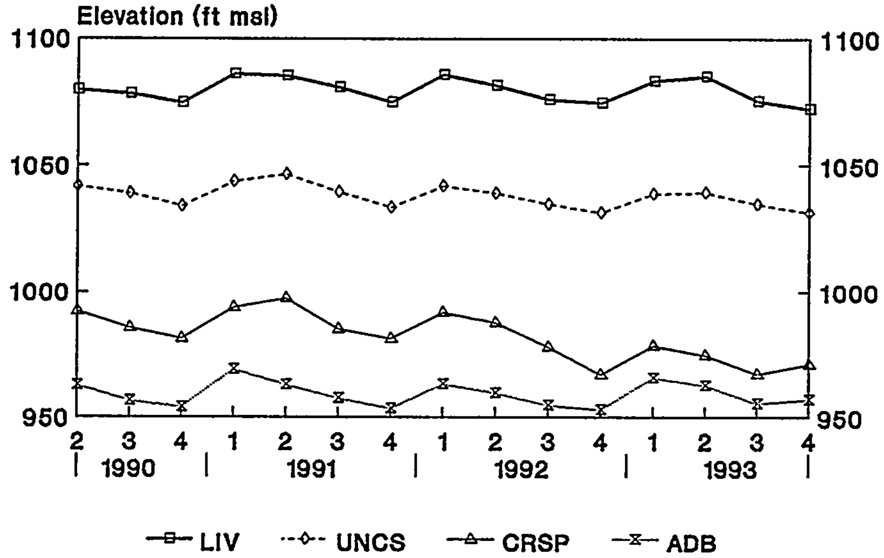
Spring

0 2000
SCALE (ft)

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 7
DATE:	8-25-94	GROUNDWATER ELEVATIONS IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR319-HC	

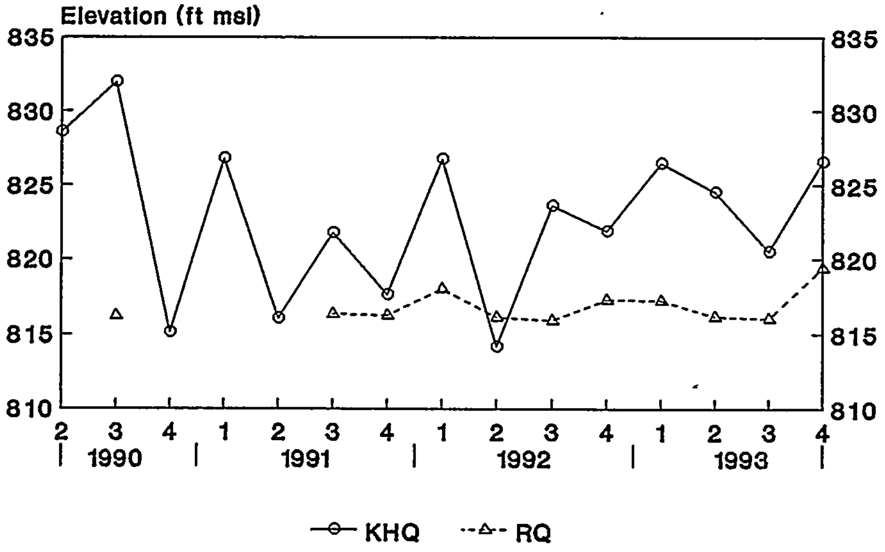
Upgradient Sites

Recharge



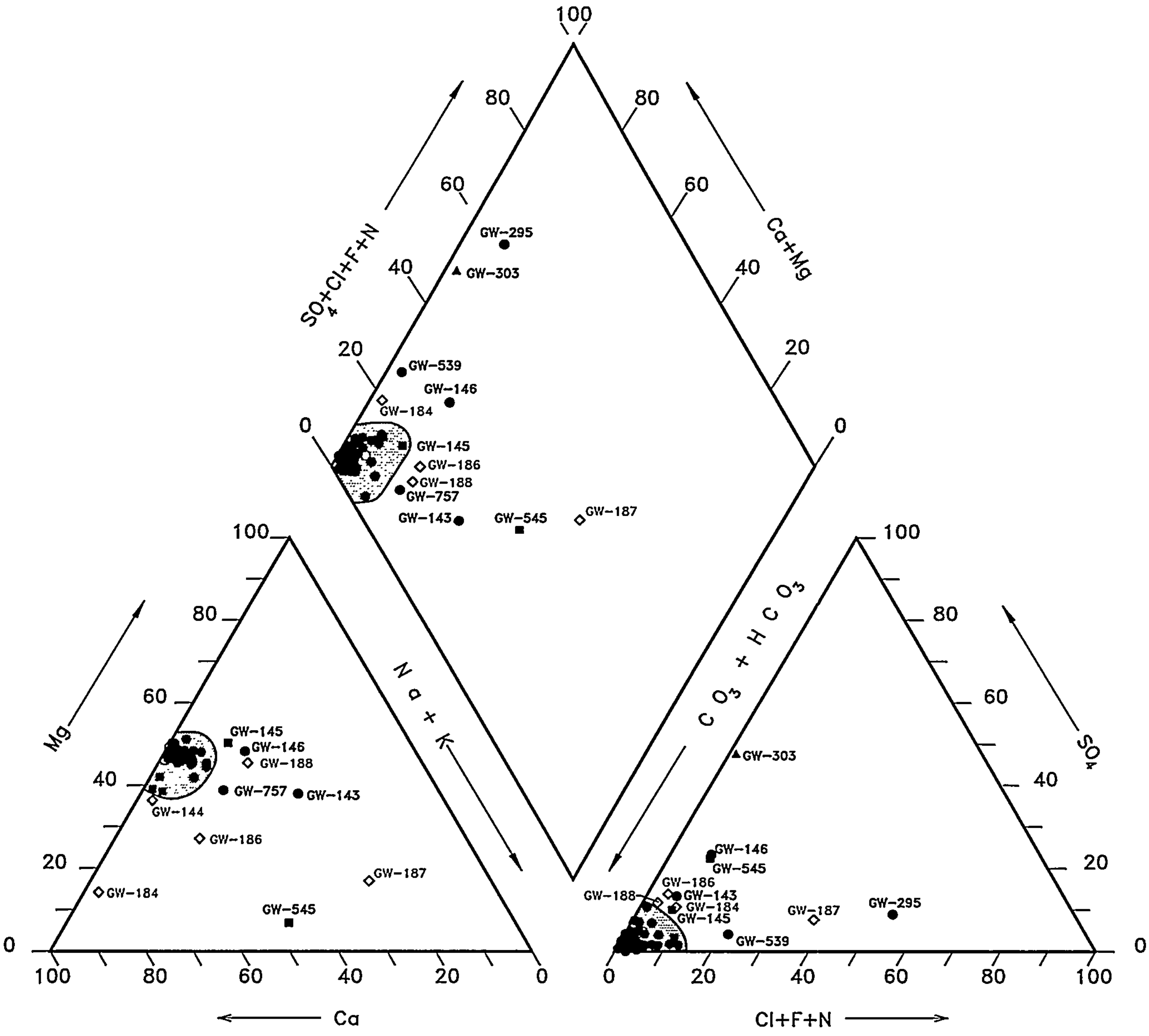
Downgradient Sites

Discharge



Quarterly Average Groundwater Elevations

LOCATION:	Y–12 PLANT OAK RIDGE, TN.	FIGURE 8
DATE:	7–28–94	WATER LEVEL HYDROGRAPHS FOR SELECTED SITES IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	A–8	



EXPLANATION

▨ — GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS, 75 WELLS PLOTTED ON DIAGRAM

GW-545 ■ — WATER-TABLE MONITORING WELL

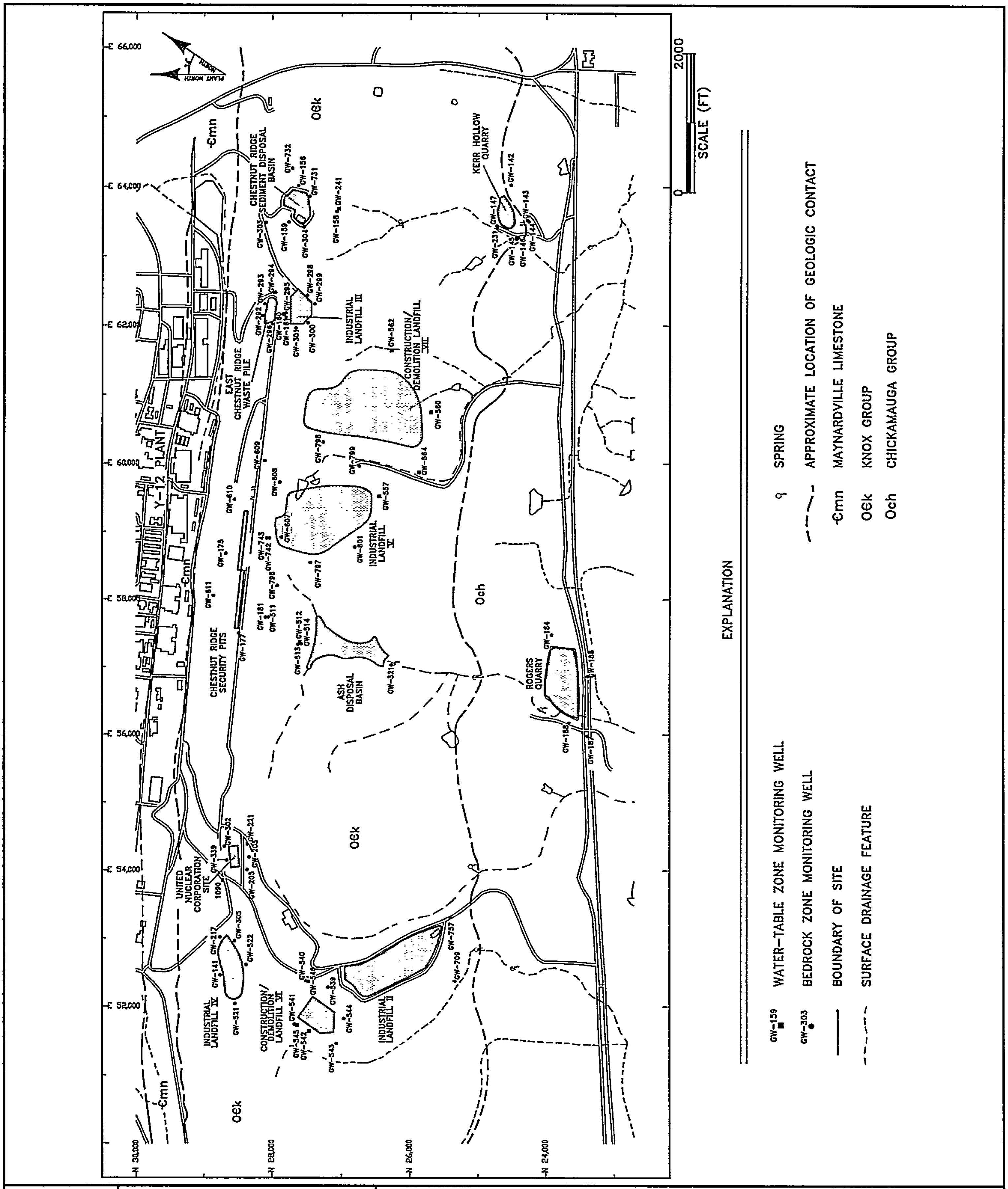
GW-755 ○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP

GW-143 ● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP

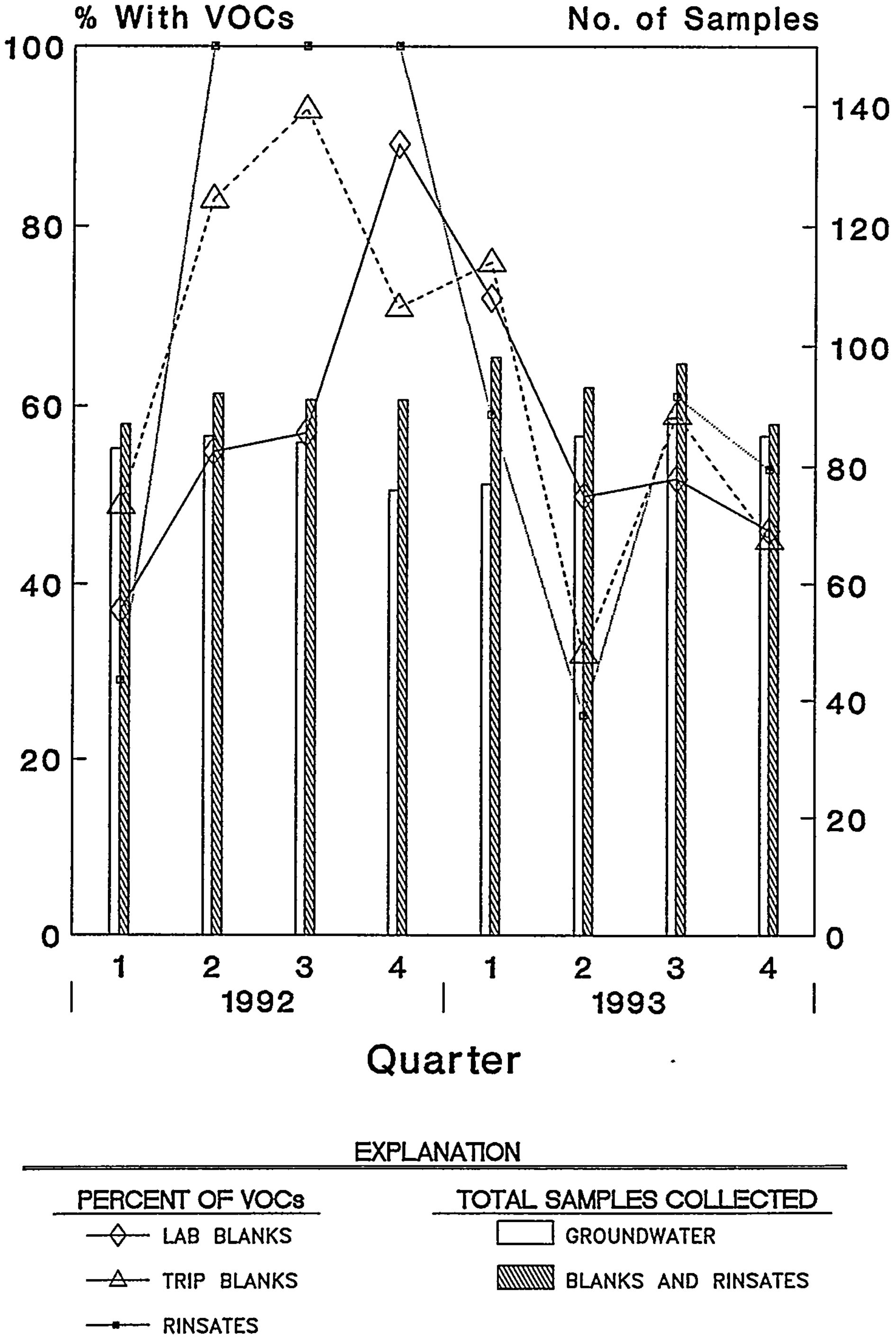
GW-303 ▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

GW-188 ◇ — BEDROCK MONITORING WELL, CHICKAMAUGA GROUP

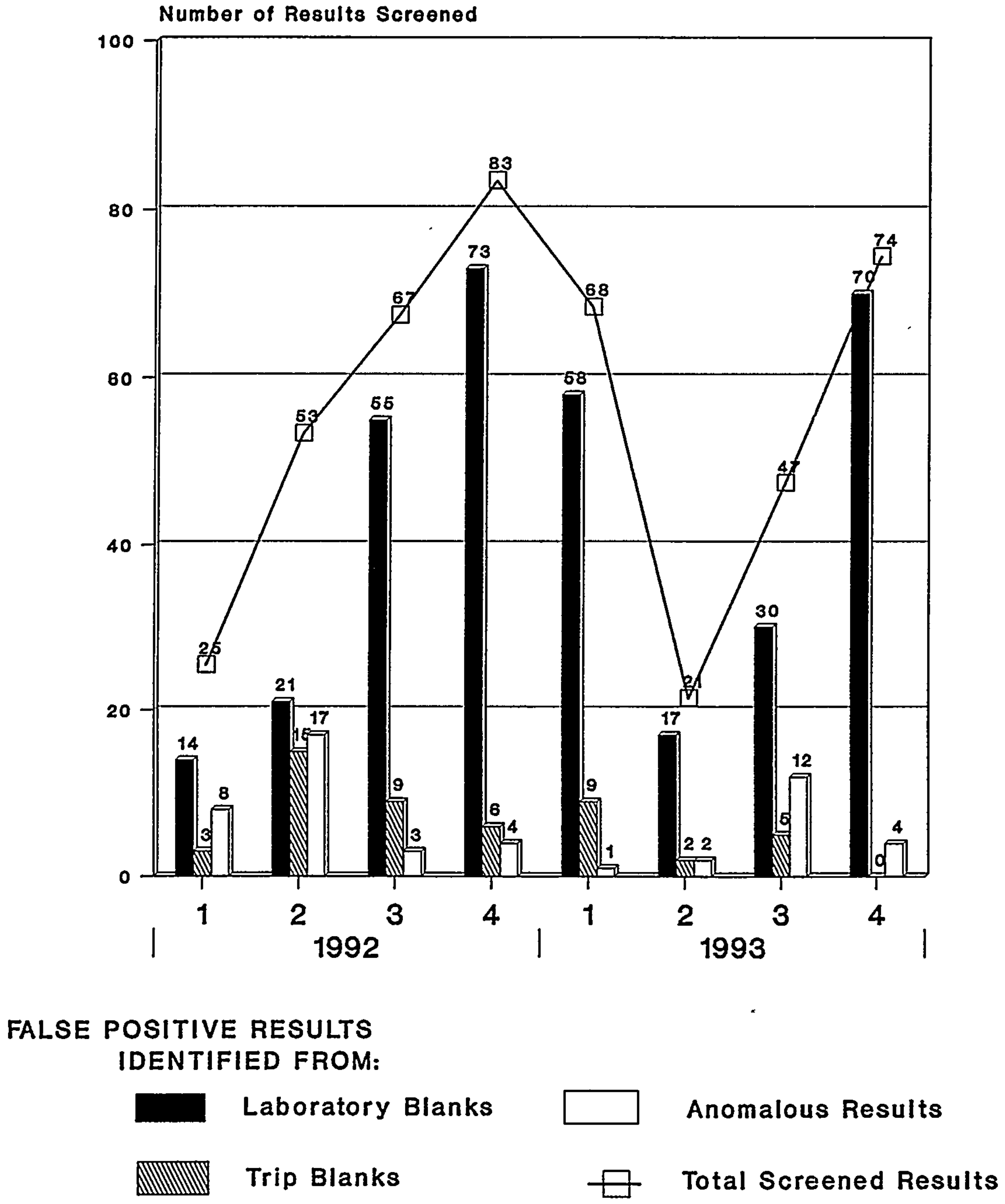
LOCATION:	Y-12 PLANT OAK RIDGE, TN	FIGURE 9
DATE:	7-26-94	GROUNDWATER GEOCHEMISTERY IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME
DWG ID.:	OR365-HC	



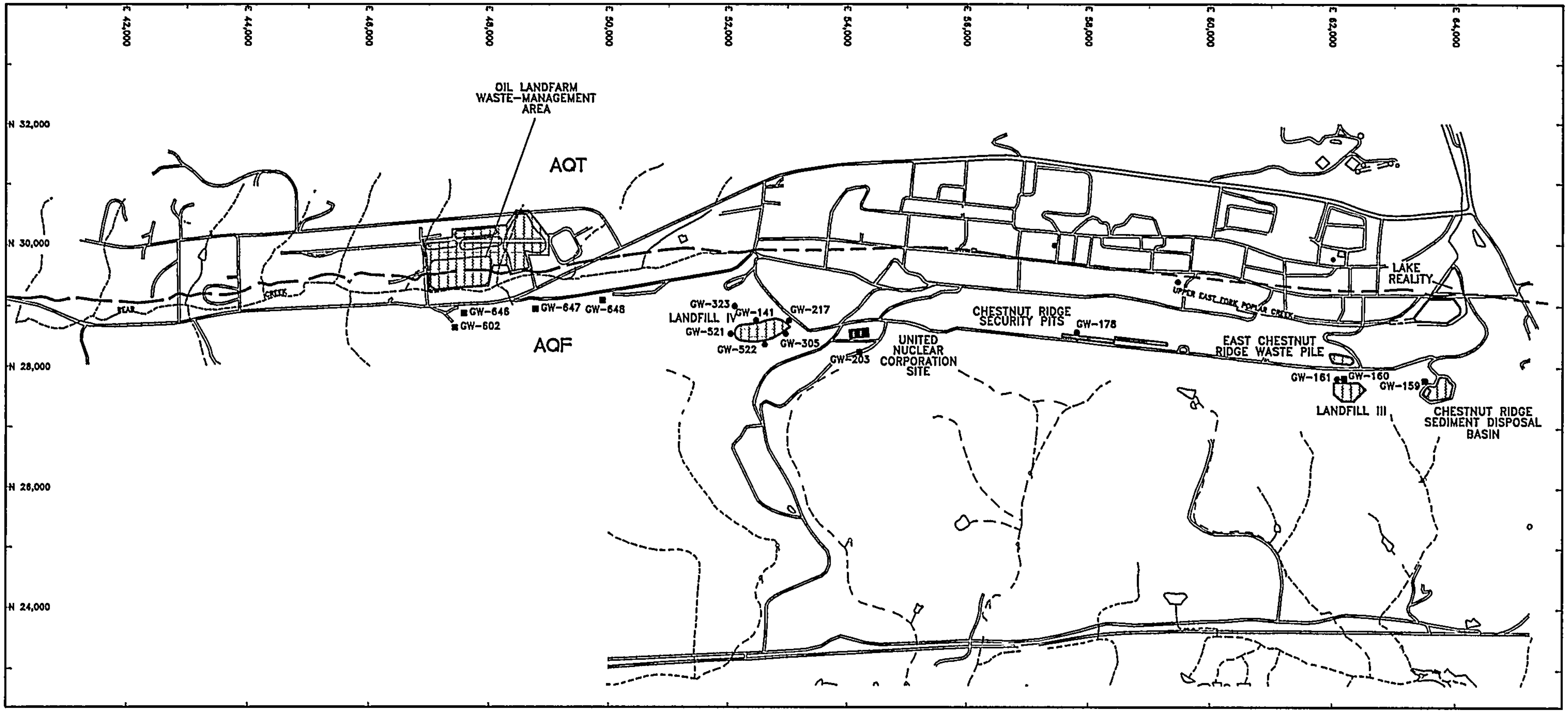
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 10
DATE:	8-26-94	MONITORING WELLS SAMPLED DURING 1993
DWG ID.:	OR307-HC	



LOCATION:	Y–12 PLANT OAK RIDGE, TN.	FIGURE 11 BLANK SAMPLES CONTAINING VOCs, 1992-1993
DATE:	8–26–94	
DWG ID.:	A–11	

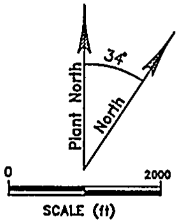


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 12
DATE:	7-28-94	NUMBER OF FALSE POSITIVE VOC RESULTS IDENTIFIED IN 1992 AND 1993 GROUNDWATER SAMPLES
DWG ID.:	A-12	

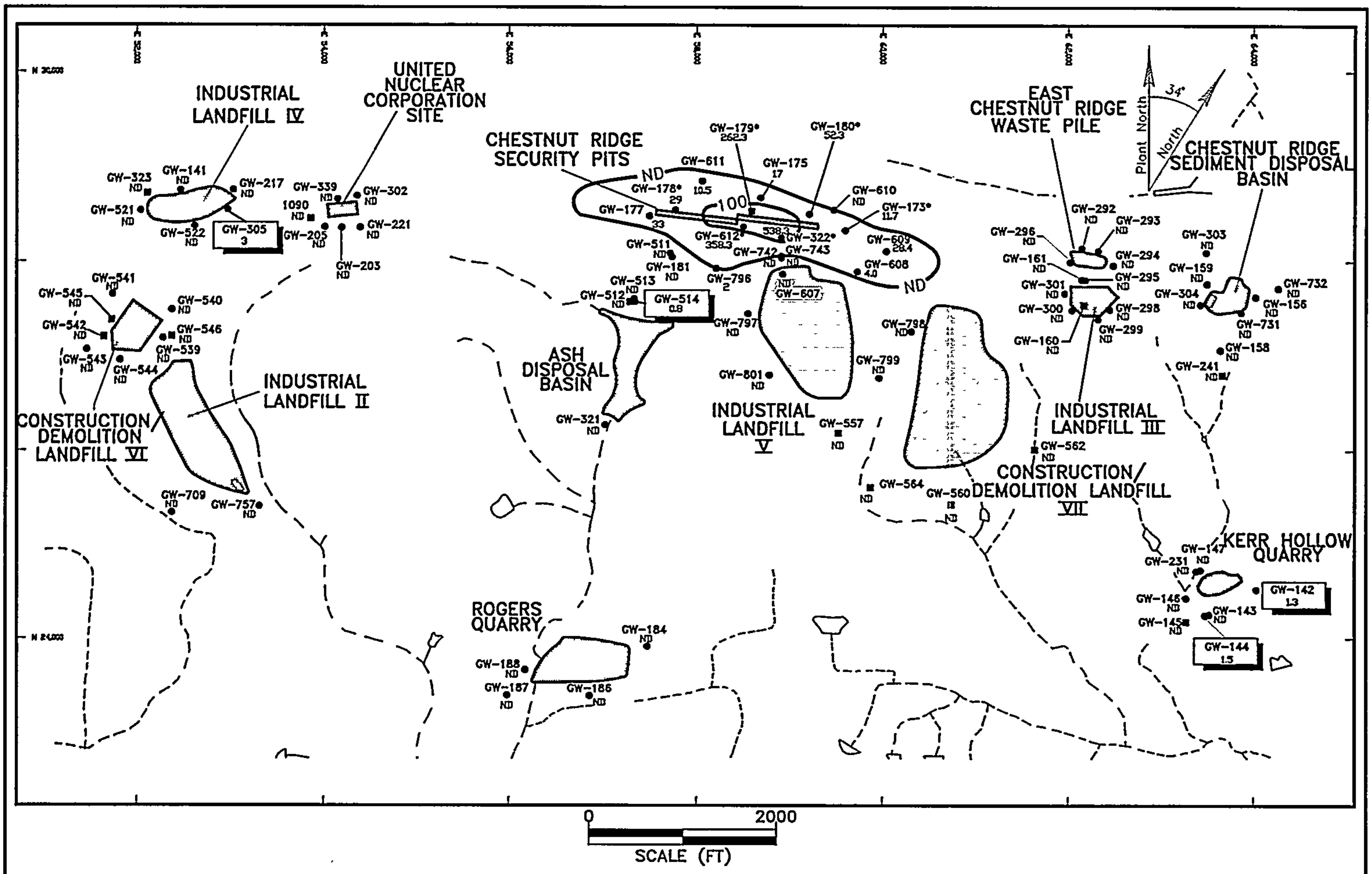


EXPLANATION

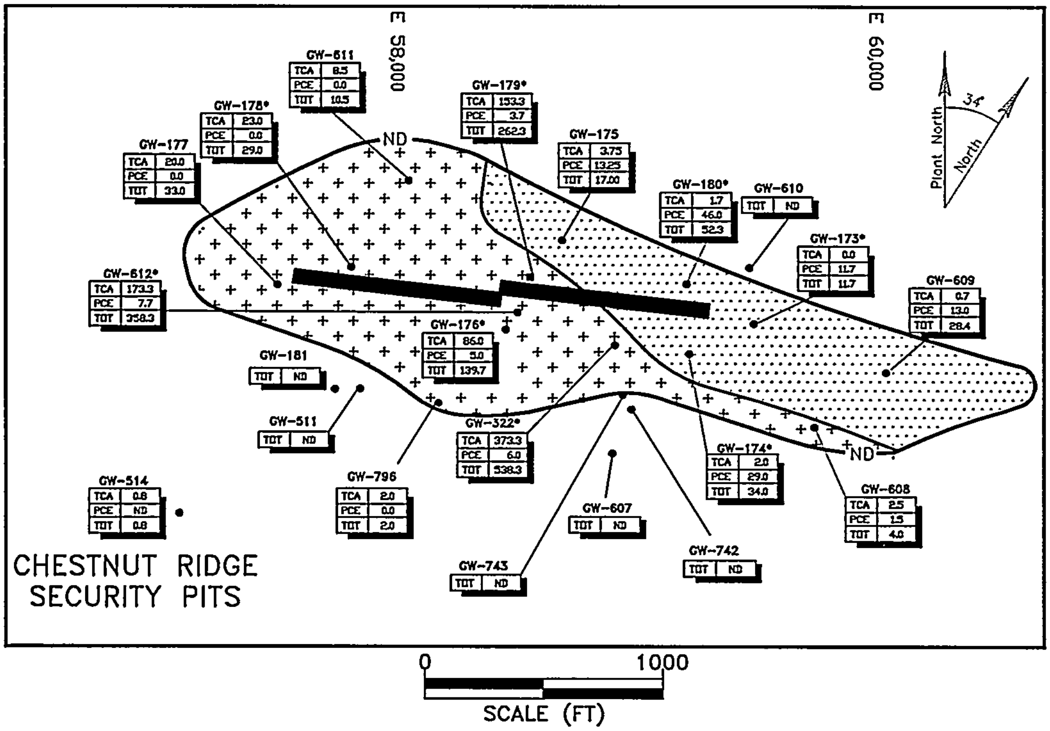
GW-325 ■ — WATER TABLE INTERVAL MONITORING WELL
GW-613 ● — BEDROCK INTERVAL MONITORING WELL
— — — — — SURFACE DRAINAGE FEATURE
AQT — OAK RIDGE RESERVATION AQUITARDS
— — — — APPROXIMATE NOLICHUCKY SHALE\MAYNARDVILLE LIMESTONE CONTACT
AQF — KNOX AQUIFER



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 13
DATE:	8-26-94	LOCATION OF MONITORING WELLS USED TO DETERMINE TRACE METAL SCREENING LEVELS
DWG ID.:	OR415-HC	



DISTRIBUTION OF VOCs



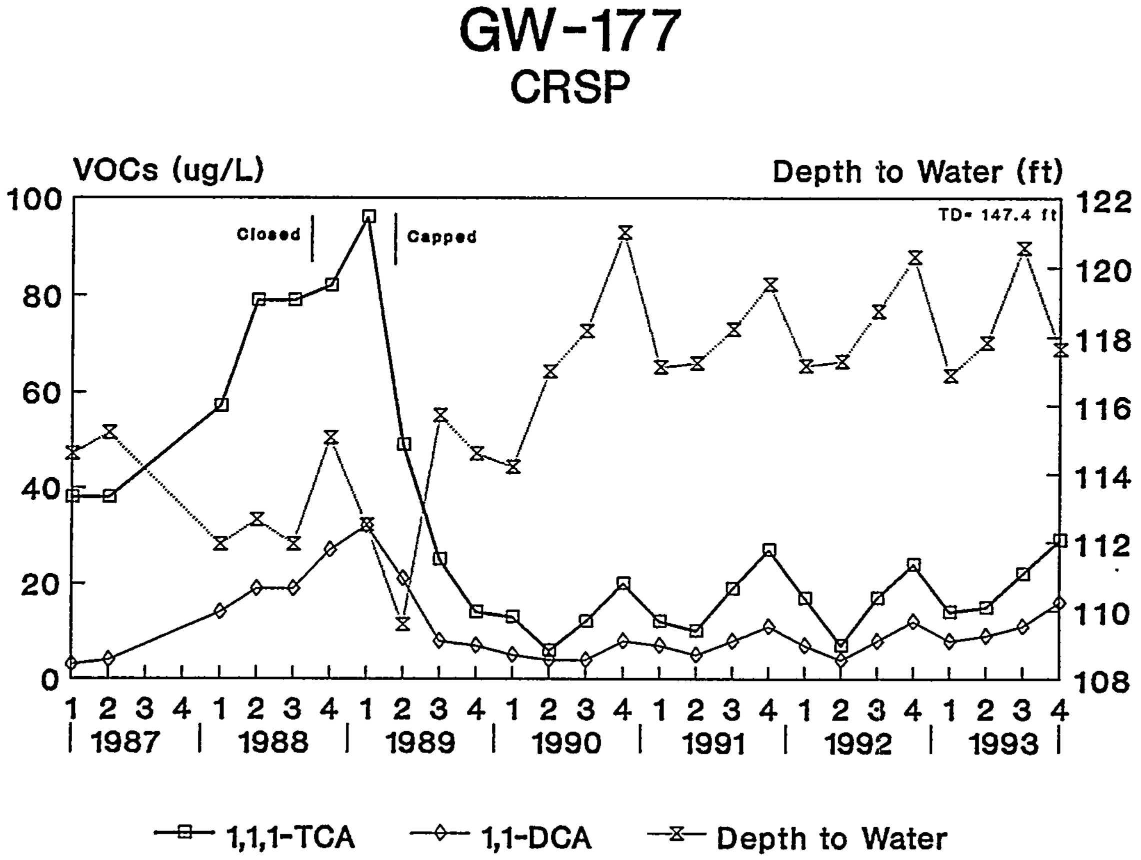
EXPLANATION

- — — — Surface Drainage Feature
- GW – ■ — Water Table Monitoring Well
- GW – ● — Bedrock Monitoring Well
- * — Qualitative Data, Well Sampled in 1992
- ND — Not Detected
- 4.5 — Summed Average VOC Concentration (ug/L)
- GW-144 3.0 — Summed Average VOC Concentration Exceeding Detection Limit Outside Defined Plume Boundary
- 100 — Line of Equal Concentration

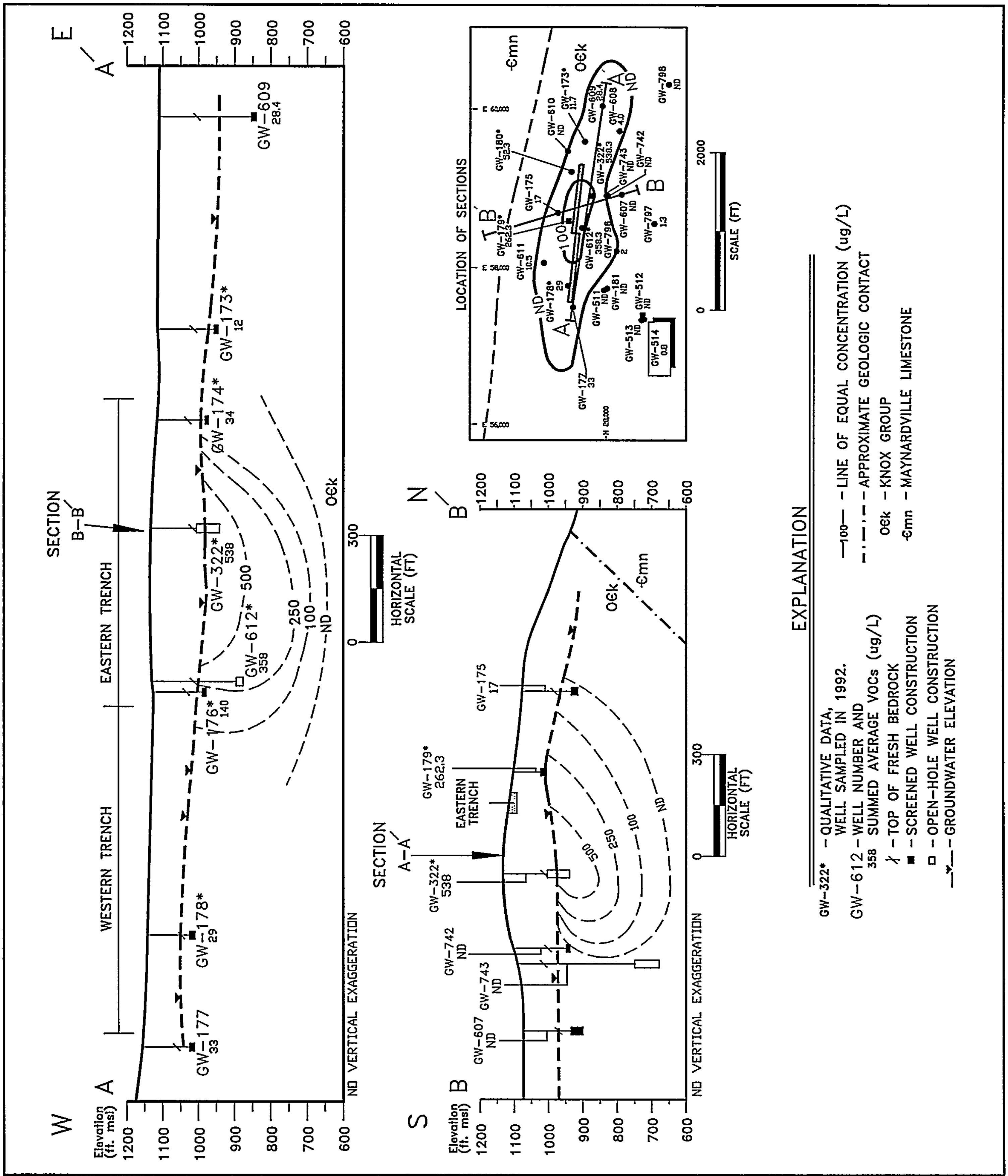
DISTRIBUTION OF VOCs

- TCA — 1,1,1-Trichloroethane (ug/L)
- PCE — Tetrachloroethene (ug/L)
- TOT — Sum of all VOCs (ug/L)
- ▨ — PCE > 50% of TOT
- + — TCA > 50% of TOT

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	**FIGURE 14**
DATE:	8-26-94	**HORIZONTAL EXTENT OF VOCs IN GROUNDWATER IN THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME**
DWG ID.:	OR374-HC	

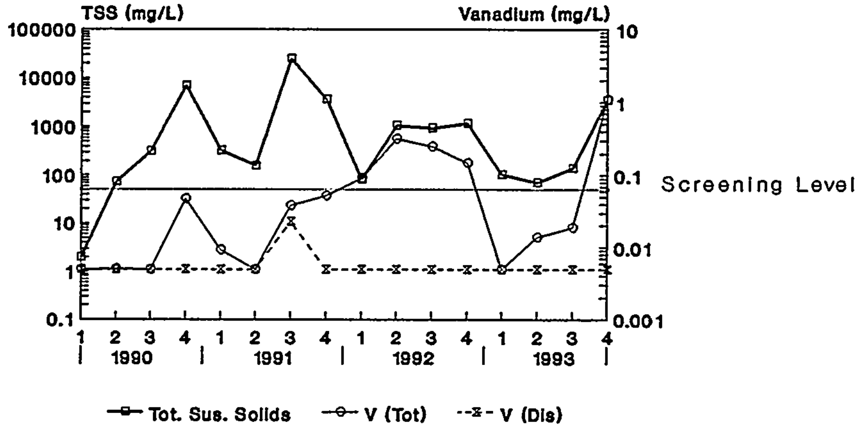


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 15
DATE:	8-25-94	CONCENTRATIONS OF 1,1,1-TCA AND 1,1-DCA IN SAMPLES COLLECTED FROM WELL GW-177, 1987-1993
DWG ID.:	A-15	

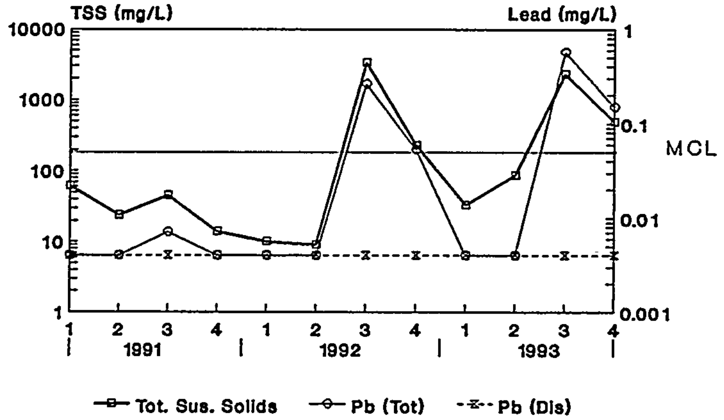


LOCATION:	Y-12 PLANT OAK RIDGE, TN	FIGURE 16
DATE:	8-15-94	VERTICAL EXTENT OF VOC's IN GROUNDWATER AT THE CHESTNUT RIDGE SECURITY PITS
DWG ID.:	OR375-HC	

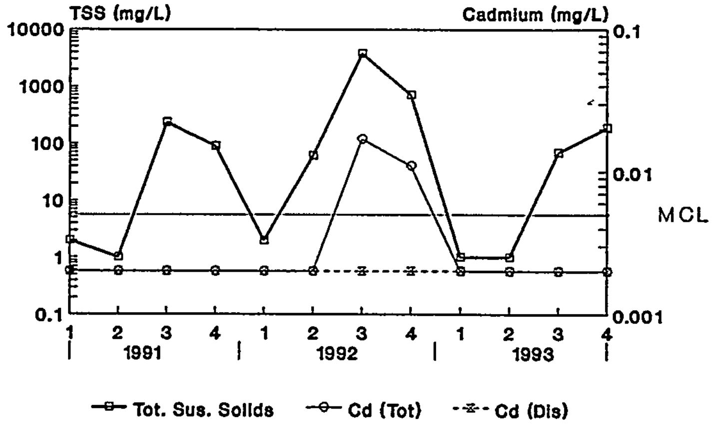
GW-295
Industrial Landfill III



GW-545
Construction/Demolition Landfill VI

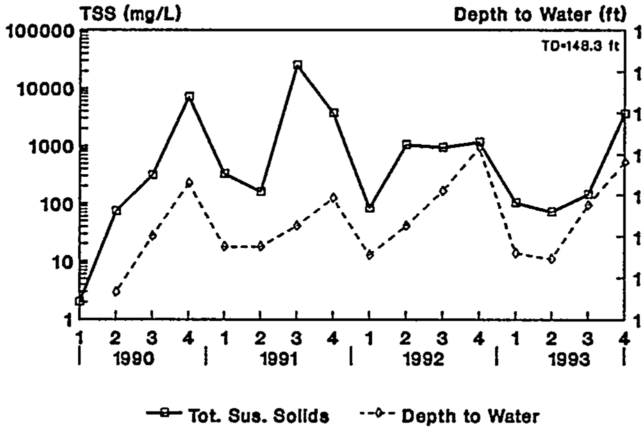


GW-546
Construction/Demolition Landfill VI

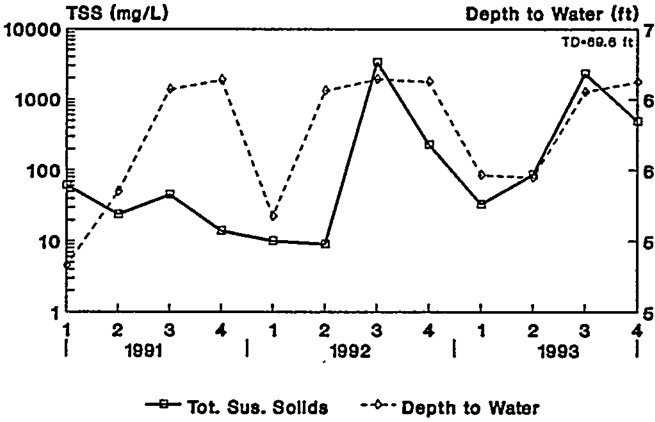


LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 17
DATE:	8-15-94	RELATIONSHIP BETWEEN TSS LEVELS AND TOTAL CONCENTRATIONS OF SELECTED METALS IN WELLS GW-295, GW-545, AND GW-546, 1990-1993
DWG ID.:	A-17	

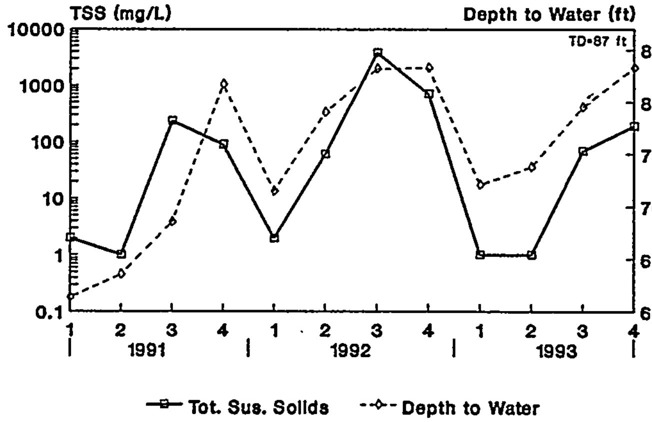
GW-295
Industrial Landfill III



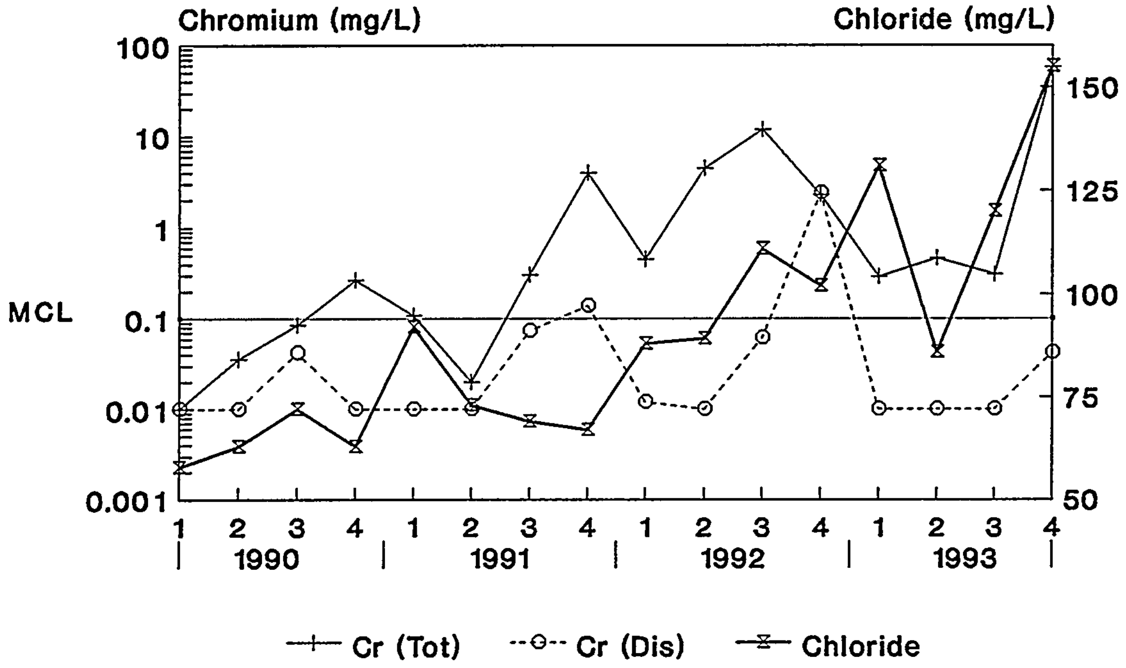
GW-545
Construction/Demolition Landfill VI



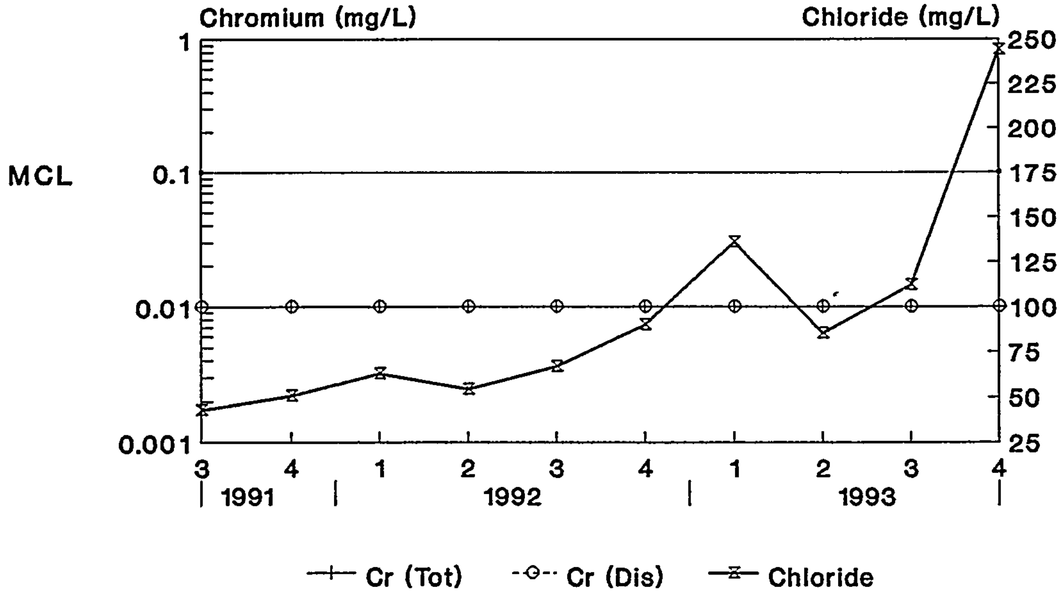
GW-546
Construction/Demolition Landfill VI



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 18
DATE:	8-15-94	RELATIONSHIP BETWEEN TSS LEVELS AND DEPTH TO WATER IN WELLS GW-295, GW-545, AND GW-546, 1990-1993
DWG ID.:	A-18	

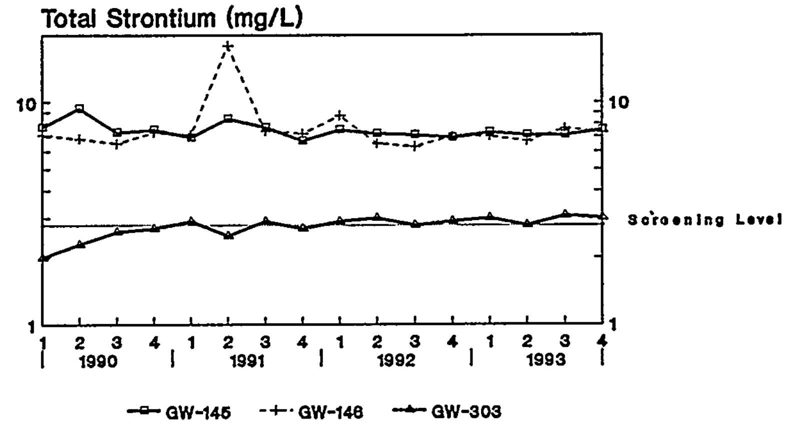


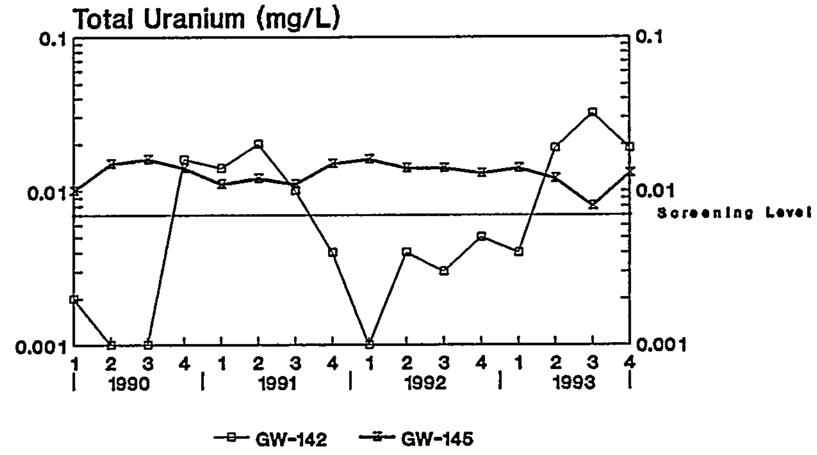
GW-295
Industrial Landfill III

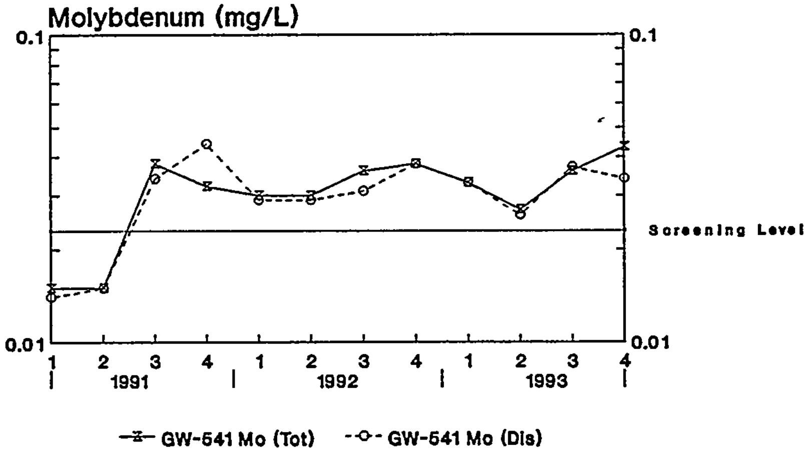


GW-187
Rogers Quarry

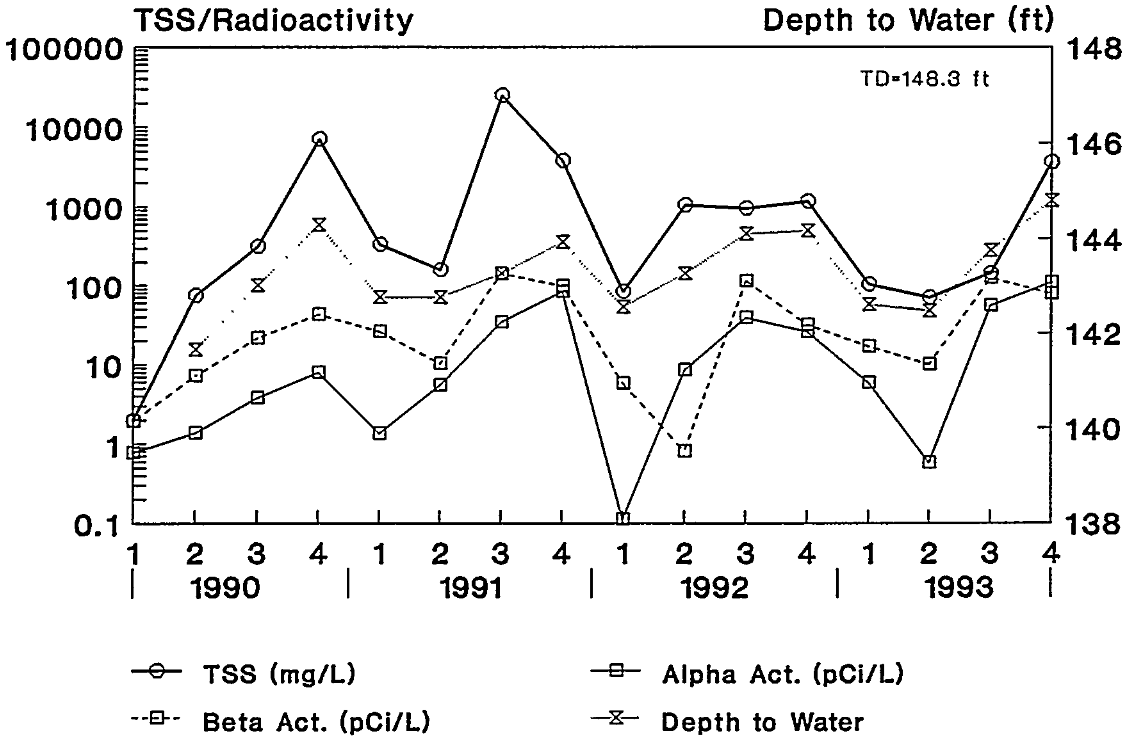
LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 19
DATE:	8-15-94	RELATIONSHIP BETWEEN CHLORIDE AND CHROMIUM CONCENTRATIONS IN WELLS GW-295 AND GW-187, 1990-1993
DWG ID.:	A-19	



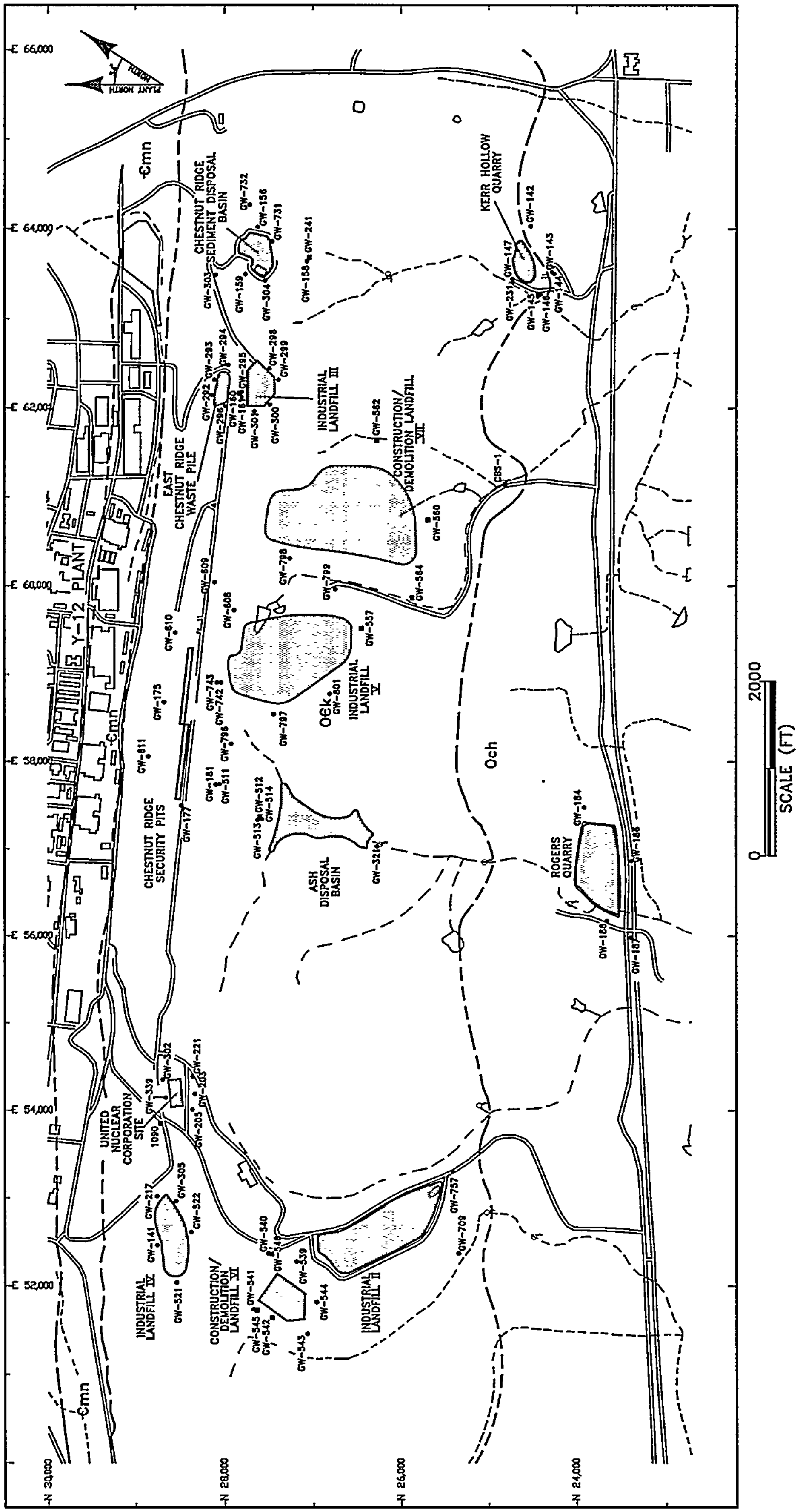




LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 20
DATE:	7-28-94	TRACE METAL CONCENTRATIONS IN SELECTED WELLS, 1990-1993
DWG ID.:	A-20	



LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 21
DATE:	8-15-94	RELATIONSHIP BETWEEN TSS AND GROSS ALPHA AND GROSS BETA ACTIVITY IN WELL GW-295, 1990-1993
DWG ID.:	A-21	



EXPLANATION

GW-■ — WATER-TABLE ZONE MONITORING WELL

GW-● — BEDROCK ZONE MONITORING WELL

—— — BOUNDARY OF SITE

- - - — SURFACE DRAINAGE FEATURE

CBS-1■ — SPRING SAMPLING LOCATION

ɋ — SPRING

— - — APPROXIMATE LOCATION OF GEOLOGIC CONTACT

Ꞓmn — MAYNARDVILLE LIMESTONE

OꞒk — KNOX GROUP

Och — CHICKAMAUGA GROUP

LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 22
DATE:	8-12-94	PROPOSED MONITORING-WELL NETWORK FOR GROUNDWATER MONITORING IN 1995
DWG ID.:	OR307-HC	

APPENDIX B

TABLES

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

Site	Regulatory Classification	
	Historical[1]	Current[2]
Chestnut Ridge Sediment Disposal Basin	TSD Unit	Study Area/ TSD Unit
East Chestnut Ridge Waste Pile	TSD Unit	Study Area/TSD Unit
Kerr Hollow Quarry	TSD Unit	Study Area/TSD Unit
Chestnut Ridge Security Pits	TSD Unit	CR OU 01/ TSD Unit
Ash Disposal Basin	SWMU	CR OU 02
United Nuclear Corporation Site	SWMU	CR OU 03
Rogers Quarry	SWMU	CR OU 04
Industrial Landfill II	SWDF	SWDF
Industrial Landfill III	SWDF	SWDF[3]
Industrial Landfill IV	SWDF	SWDF
Industrial Landfill V	N/A	SWDF
Construction Debris Landfill VI	N/A	SWDF
Construction Debris Landfill VII	N/A	SWDF

Notes:

1 Regulatory classification before the 1992 Federal Facility Agreement.

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

2 Modified from: *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (U.S. Department of Energy 1992)

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

3 Not permitted by TDEC

Table 2. Monitoring Wells Sampled During Calendar Year 1993

Monitoring Program	Well No.	Location[1]	Quarters Sampled[2]	Analytical Parameters
RCRA Interim Status Assessment Monitoring				
	GW-175	CRSP	4	STD[3]
	GW-177	CRSP	4	STD
	GW-181	CRSP	4	STD
	GW-511	CRSP	4	STD
	GW-607	CRSP	1	STD
	GW-608	CRSP	4	STD
	GW-609	CRSP	4	STD
	GW-610	CRSP	4	STD
	GW-611	CRSP	4	STD
	GW-742	CRSP	4	STD
	GW-743	CRSP	4	STD
RCRA Interim Status Detection Monitoring				
	GW-142[a]	KHQ	4	STD, REP[4], PHEN[5]
	GW-143[a]	KHQ	4	STD, REP, PHEN
	GW-144	KHQ	4	STD, REP, PHEN
	GW-145	KHQ	4	STD, REP, PHEN
	GW-146[a]	KHQ	4	STD, REP, PHEN
	GW-147	KHQ	4	STD, REP, PHEN
	GW-156	CRSDB	4	STD, REP, BNA[6]
	GW-158[a]	CRSDB	4	STD, REP, BNA
	GW-159[a]	CRSDB	4	STD, REP, BNA
	GW-231	KHQ	4	STD, REP, PHEN
	GW-241	CRSDB	4	STD, REP, BNA
	GW-303[b]	CRSDB	4	STD, REP, BNA
	GW-304	CRSDB	4	STD, REP, BNA

Table 2 (cont'd)

Monitoring Program	Well No.	Location[1]	Quarters Sampled[2]	Analytical Parameters
RCRA Interim Status Detection Monitoring (cont'd)				
	GW-731	CRSDB	4	STD, REP, BNA
	GW-732	CRSDB	4	STD, REP, BNA
SWDF Detection and Background Monitoring				
	GW-141[a]	LIV	4	STD, AOC[7], ORP[8]
	GW-160[a]	LIII	4	STD, AOC, ORP
	GW-161[a]	LIII	4	STD, AOC, ORP
	GW-217[a]	LIV	4	STD, AOC, ORP
	GW-295	LIII	4	STD, AOC, ORP, U[9], BETA[10]
	GW-298	LIII	4	STD, AOC, ORP
	GW-299	LIII	4	STD, AOC, ORP
	GW-300	LIII	4	STD, AOC, ORP
	GW-301	LIII	4	STD, AOC, ORP
	GW-305[a]	LIV	4	STD, AOC, ORP
	GW-521[a]	LIV	4	STD, AOC, ORP
	GW-522[a]	LIV	4	STD, AOC, ORP
	GW-539	LII	4	STD, AOC, ORP, U, OMP
	GW-540	CDLVI	4	STD, AOC, ORP
	GW-541	CDLVI	4	STD, AOC, ORP
	GW-542	CDLVI	4	STD, AOC, ORP
	GW-543	CDLVI	4	STD, AOC, ORP
	GW-544	CDLVI	4	STD, AOC, ORP
	GW-545	CDLVI	4	STD, AOC, ORP
	GW-546	CDLVI	4	STD, AOC, ORP
	GW-557	LV	3	STD, AOC, ORP, U, OMP[11]
	GW-560	CDLVII	3	STD, AOC, ORP, U, OMP, TPH[12]

Table 2 (cont'd)

Monitoring Program	Well No.	Location[1]	Quarters Sampled[2]	Analytical Parameters
SWDF Detection and Background Monitoring (cont'd)				
	GW-562	CDLVII	3	STD, AOC, ORP, U, OMP, TPH
	GW-564	CDLVII	3	STD, AOC, ORP, U, OMP, TPH
	GW-709	LII	4	STD, AOC, ORP
	GW-757	LII	4	STD, AOC, ORP
	GW-796	LV	3	STD, AOC, ORP, U, OMP
	GW-797	LV	3	STD, AOC, ORP, OMP
	GW-798	CDLVII	3	STD, AOC, ORP, OMP
	GW-799	LV	3	STD, AOC, ORP, OMP, TPH
	GW-801	LV	3	STD, AOC, ORP, OMP
Best Management Practice Monitoring				
	1090	UNCS	4	STD, Ra[13], U
	GW-184	RQ	4	STD, BNA
	GW-186	RQ	4	STD, BNA
	GW-187	RQ	4	STD, BNA
	GW-188	RQ	4	STD, BNA
	GW-203	UNCS	4	STD, Ra, U
	GW-205	UNCS	4	STD, Ra, U
	GW-221	UNCS	4	STD, Ra, U
	GW-292	ECRWP	4	STD
	GW-293	ECRWP	4	STD
	GW-294	ECRWP	4	STD
	GW-296	ECRWP	4	STD
	GW-302	UNCS	4	STD, Ra, U
	GW-321	ADB	4	STD, TOC[14], TOX[15]
	GW-339	UNCS	4	STD, Ra, U

Table 2 (cont'd)

Monitoring Program	Well No.	Location[1]	Quarters Sampled[2]	Analytical Parameters
Best Management Practice Monitoring (cont'd)				
	GW-512	ADB	4	STD, TOC, TOX
	GW-513	ADB	4	STD, TOC, TOX
	GW-514	ADB	4	STD, TOC, TOX

Notes:

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

2 The number of quarterly sampling events in which samples were collected during CY 1993.

3 STD - Standard suite of analytical parameters; includes the following:

- Inductively Coupled Plasma (ICP) Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Magnesium
Manganese
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Strontium
Thorium
Vanadium
Zinc

Table 2 (cont'd)

Notes: (cont'd)

3 STD - Standard suite of analytical parameters (cont'd)

- Atomic Absorption Spectroscopy (AAS) Metals
    - Cadmium
    - Chromium
    - Lead

- Other Metals
    - Mercury (Cold Vapor Atomic Absorption Spectroscopy)
    - Uranium (Flourometric Analysis)

- Volatile Organic Compounds
    - Acetone
    - Benzene
    - Bromodichloromethane
    - Bromoform
    - Bromomethane
    - 2-Butanone
    - Carbon disulfide
    - Carbon tetrachloride
    - Chlorobenzene
    - Chlorodibromomethane
    - Chloroethane
    - Chloroform
    - Chloromethane
    - 1,1-Dichloroethane
    - 1,2-Dichloroethane
    - 1,1-Dichloroethene
    - 1,2-Dichloroethene
    - 1,2-Dichloropropane
    - cis-1,3-Dichloropropene
    - trans-1,3-Dichloropropene
    - Ethylbenzene
    - 2-Hexanone
    - 4-Methyl-2-pentanone
    - Methylene chloride
    - Styrene
    - 1,1,2,2-Tetrachloroethane
    - Tetrachloroethene
    - Toluene
    - 1,1,1-Trichloroethane
    - 1,1,2-Trichloroethane
    - Trichloroethene
    - Vinyl acetate
    - Vinyl chloride
    - Xylenes

- Anions
    - Alkalinity - Carbonate
    - Alkalinity - Bicarbonate
    - Chloride
    - Nitrate (as N)
    - Fluoride
    - Sulfate

Table 2 (cont'd)

Notes: (cont'd)

3 STD - Standard suite of analytical parameters (cont'd)

- Radiological Parameters
  - Gross Alpha Activity
  - Gross Beta Activity

- Miscellaneous Parameters
  - pH
  - Specific Conductance
  - Total Suspended Solids
  - Total Dissolved Solids
  - Turbidity

- Field Measurements
  - Static Water Level
  - pH
  - Temperature
  - Dissolved Oxygen
  - Specific Conductance
  - Oxidation - Reduction Potential

4 REP - Four replicate analyses of:

pH
Specific Conductivity
TOC
TOX

5 PHEN - Phenols

6 BNA - Base/Neutral/Acid Extractable Organic Compounds:

Acenaphthene
Acenaphthylene
Anthracene
Benzo (A) Anthracene
Benzo (A) Pyrene
Benzo (B) Fluoranthene
Benzo (G,H,I) Perylene
Benzo (K) Fluoranthene
Nitrobenzene
Pentachlorophenol
Phenol
Phenanthrene
Pyrene
4-Bromophenyl Phenyl Ether
2-Chloronaphthalene
2-Chlorophenol

Table 2 (cont'd)

Notes: (cont'd)

6 BNA - Base/Neutral/Acid Extractable Organic Compounds: (cont'd)

Benzoic Acid
Benzyl Alcohol
Bis (2-Chloroethoxy) Methane
Bis (2-Chloroethyl) Ether
Bis (2-Chloroisopropyl) Ether
Bis (2-Ethylhexyl) Phthalate
Butyl Benzyl Phthalate
Chrysene
Dibenzofuran
Dibenzo (A,H) Anthracene
Diethylphthalate
Dimethylphthalate
Di-N-Butylphthalate
Di-N-Octylphthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Ideno(1,2,3-CD) Pyrene
Isophorone
N-Nitrosodi-N-Propylamine
N-Nitrosodiphenylamine
Naphthalene

4-Chlorophenyl Phenyl Ether
4-Chloro-3-Methylphenol
4-Chloroaniline
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2,4-Dinitrotoluene
2,6-Dinitrotoluene
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
3,3-Dichlorobenzidine
4,6-Dinitro-2-Methylphenol
2-Methylnaphthalene
2-Methylphenol
4-Methylphenol
2-Nitrophenol
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
4-Nitrophenol
1,2,4-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

7 AOC - Additional Organic Compounds

Acrolein
Acrylonitrile
2-Chloroethyl vinyl ether
Dibromomethane
1,4-Dichloro-2-butene
Dichlorodifluoromethane

Ethanol
Ethyl methacrylate
Iodomethane
Trichlorofluoromethane
1,2,3-Trichloropropane

Table 2 (cont'd)

Notes: (cont'd)

8 ORP - Other Required Parameters

Chemical Oxygen Demand
Cyanide
Total Organic Carbon (TOC)
Total Organic Halogen (TOX)

9 U - Isotopic Uranium (^{234}U, ^{235}U, ^{238}U)

10 BETA - Beta-emitting isotopes:
- Strontium (total)
- Technetium (^{99}Tc)
- Tritium (^{3}H)

11 OMP - Other Miscellaneous Parameters:

Trans-1,2-dichloroethene
Ammonia (as N)
Gamma Activity; reported as activity of one or more of the following:
- Cesium
- Neptunium (^{237}Np)
- Potassium (^{40}K)
- Protactinium
- Ruthenium (^{106}Ru)
- Thorium (^{234}Th)

12 TPH - Total Petroleum Hydrocarbons

13 Ra - Radium (total)

14 TOC - Total Organic Carbon

15 TOX - Total Organic Halogen

a Background/Upgradient monitoring well

Table 3. Construction Information for Monitoring Wells Sampled During 1993[1]

Well No.	Location[2]	Aquifer[3]		Monitored Interval[4]	
		Zone	Unit	Depths	Elevations
1090	UNCS	WT	OCk	unknown - 96.7	unknown - 1,004.88
GW-141[a]	LIV	BDR	OCk	141.0 - 156.0	1,042.5 - 1,027.5
GW-142[b]	KHQ	BDR	OCk	248.5 - 295.0	719.8 - 673.3
GW-143[b]	KHQ	BDR	OCk	205.0 - 253.0	706.0 - 658.0
GW-144	KHQ	BDR	OCk	148.0 - 195.0	762.5 - 715.5
GW-145	KHQ	WT	OCk	86.0 - 110.0	751.3 - 727.3
GW-146[b]	KHQ	BDR	OCk	190.0 - 220.0	647.0 - 617.0
GW-147	KHQ	BDR	OCk	52.0 - 69.0	796.4 - 779.4
GW-156	CRSDB	BDR	OCk	146.0 - 157.0	900.9 - 889.9
GW-158[b]	CRSDB	BDR	OCk	356.0 - 441.0	625.2 - 540.2
GW-159[a]	CRSDB	BDR	OCk	146.0 - 157.0	902.8 - 891.8
GW-160[a,b]	LIII	WT	OCk	205.0 - 235.0	885.7 - 855.7
GW-161[a,b]	LIII	BDR	OCk	350.0 - 400.0	740.9 - 690.9
GW-175	CRSP	BDR	OCk	148.3 - 166.7	933.6 - 915.2
GW-177	CRSP	BDR	OCk	132.0 - 145.0	1,023.5 - 1,010.5
GW-181[b]	CRSP	BDR	OCk	155.0 - 168.0	935.6 - 922.6
GW-184	RQ	BDR	Och	101.5 - 130.0	823.2 - 794.7
GW-186	RQ	BDR	Och	142.0 - 171.0	686.3 - 657.3
GW-187	RQ	BDR	Och	139.0 - 162.0	692.6 - 669.6
GW-188	RQ	BDR	Och	49.0 - 68.0	785.3 - 766.3
GW-203[a]	UNCS	BDR	OCk	144.0 - 156.0	958.3 - 946.3
GW-205	UNCS	BDR	OCk	154.0 - 164.0	947.5 - 937.5
GW-217[a]	LIV	BDR	OCk	165.2 - 180.0	1,009.1 - 994.3
GW-221	UNCS	BDR	OCk	147.0 - 158.0	956.4 - 945.4
GW-231	KHQ	BDR	OCk	22.8 - 35.0	824.1 - 811.9

Table 3 (cont'd)

Well No.	Location[2]	Aquifer[3]		Monitored Interval[4]	
		Zone	Unit	Depths	Elevations
GW-241	CRSDB	WT	OCk	78.0 - 103.0	902.8 - 877.8
GW-292	ECRWP	BDR	OCk	172.1 - 186.0	898.0 - 884.1
GW-293[b]	ECRWP	BDR	OCk	197.0 - 214.0	864.7 - 847.7
GW-294	ECRWP	BDR	OCk	113.0 - 128.0	968.7 - 953.7
GW-295	LIII	BDR	OCk	130.4 - 146.0	960.0 - 944.4
GW-296	ECRWP	BDR	OCk	134.4 - 147.0	953.9 - 941.3
GW-298	LIII	BDR	OCk	171.1 - 190.0	875.3 - 856.4
GW-299	LIII	BDR	OCk	153.0 - 168.0	898.3 - 883.3
GW-300	LIII	BDR	OCk	132.0 - 147.0	938.7 - 923.7
GW-301	LIII	BDR	OCk	148.5 - 163.5	935.4 - 920.4
GW-302	UNCS	BDR	OCk	121.5 - 134.8	1,018.1 - 1,004.8
GW-303[b]	CRSDB	BDR	OCk	300.0 - 321.0	704.4 - 683.4
GW-304	CRSDB	BDR	OCk	148.5 - 167.0	894.3 - 875.8
GW-305[a]	LIV	BDR	OCk	165.3 - 179.6	1,015.8 - 1,001.5
GW-321	ADB	BDR	OCk	84.0 - 98.6	839.1 - 824.5
GW-339	UNCS	BDR	OCk	101.0 - 114.0	1,021.2 - 1,008.2
GW-511	CRSP	BDR	OCk	140.0 - 153.7	950.7 - 937.0
GW-512	ADB	WT	OCk	48.0 - 61.0	951.0 - 938.0
GW-513	ADB	BDR	OCk	111.0 - 125.3	888.0 - 873.7
GW-514[b]	ADB	BDR	OCk	174.0 - 195.0	824.7 - 803.7
GW-521[a]	LIV	BDR	OCk	123.2 - 136.0	1,056.3 - 1,043.5
GW-522[a]	LIV	BDR	OCk	183.0 - 195.3	989.0 - 976.7
GW-539	LII	BDR	OCk	136.4 - 156.0	954.0 - 934.4
GW-540	CDLVI	BDR	OCk	158.5 - 171.5	910.9 - 897.9
GW-541	CDLVI	BDR	OCk	86.7 - 104.5	969.1 - 951.3
GW-542	CDLVI	WT	OCk	59.0 - 76.5	990.0 - 972.5

Table 3 (cont'd)

Well No.	Location[2]	Aquifer[3]		Monitored Interval[4]	
		Zone	Unit	Depths	Elevations
GW-543	CDLVI	BDR	OCk	76.2 - 93.6	945.0 - 927.6
GW-544	CDLVI	BDR	OCk	91.0 - 109.3	951.5 - 933.2
GW-545	CDLVI	WT	OCk	55.2 - 67.0	1,000.2 - 988.4
GW-546	CDLVI	WT	OCk	66.2 - 84.4	1,003.0 - 985.2
GW-557	LV	WT	OCk	112.9 - 138.0	965.7 - 940.6
GW-560	CDLVII	WT	OCk	45.2 - 69.0	891.0 - 867.2
GW-562	CDLVII	WT	OCk	36.0 - 60.0	895.9 - 871.9
GW-564	CDLVII	WT	OCk	52.0 - 81.0	883.1 - 854.1
GW-607	CRSP	BDR	OCk	138.0 - 151.3	934.9 - 921.6
GW-608[b]	CRSP	BDR	OCk	148.0 - 220.0	923.0 - 851.0
GW-609	CRSP	BDR	OCk	256.4 - 269.0	853.3 - 840.7
GW-610	CRSP	BDR	OCk	105.1 - 117.4	951.7 - 939.4
GW-611	CRSP	BDR	OCk	101.5 - 121.6	943.9 - 923.8
GW-709	LII	BDR	OCk	68.7 - 80.6	835.1 - 823.2
GW-731	CRSDB	BDR	OCk	164.0 - 178.7	881.8 - 867.1
GW-732	CRSDB	BDR	OCk	178.3 - 190.0	882.4 - 870.7
GW-742[b]	CRSP	BDR	OCk	350.0 - 420.0	747.8 - 677.8
GW-743	CRSP	BDR	OCk	150.1 - 161.1	948.6 - 937.6
GW-757	LII	BDR	OCk	134.0 - 166.7	824.7 - 792.0
GW-796	LV	BDR	OCk	122.9 - 136.5	925.9 - 912.3
GW-797	LV	BDR	OCk	118.0 - 134.1	938.1 - 922.0
GW-798	CDLVII	BDR	OCk	122.0 - 135.4	864.6 - 851.2
GW-799	CDLVII	BDR	OCk	78.7 - 92.0	899.4 - 886.1
GW-801	LV	BDR	OCk	175.8 - 188.9	918.2 - 905.1

Table 3 (cont'd)

Notes:

1 Well construction information compiled from: *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation* (Jones et al. 1993).

2	ADB	-	Ash Disposal Basin
	CDLVI	-	Construction Debris Landfill VI (formerly Industrial Landfill II Expansion)
	CDLVII	-	Construction Debris Landfill VII
	CRSDB	-	Chestnut Ridge Sediment Disposal Basin
	CRSP	-	Chestnut Ridge Security Pits
	ECRWP	-	East Chestnut Ridge Waste Pile
	KHQ	-	Kerr Hollow Quarry
	LII	-	Industrial Landfill II
	LIII	-	Industrial Landfill III
	LIV	-	Industrial Landfill IV
	LV	-	Industrial Landfill V
	RQ	-	Rogers Quarry
	UNCS	-	United Nuclear Corporation Site

3	WT	-	Water Table
	BDR	-	Bedrock
	Och	-	Chickamauga Group
	OCk	-	Knox Group

4 Depth in feet from the ground surface.
Elevation in feet above mean sea level.

a Background/Upgradient Well

b Open borehole well construction.

Table 4. VOCs Detected in 1993 Laboratory Blanks, Trip Blanks, and Equipment Rinsate Samples

Compound	Laboratory Blanks				Trip Blanks				Equipment Rinsate				Total			
	No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples	
	92	93	92	93	92	93	92	93	92	93	92	93	92	93	92	93
Methylene Chloride	45	49	0.33	0.43	49	67	0.30	0.36	16	26	0.24	0.35	110	142	0.30	0.38
Acetone	36	28	0.28	0.24	34	50	0.21	0.27	17	14	0.26	0.19	87	92	0.24	0.25
4-Methyl-2-Pentanone	33	26	0.25	0.23	33	28	0.20	0.15	11	9	0.17	0.12	77	63	0.21	0.17
2-Butanone	10	18	0.08	0.16	9	19	0.06	0.10	6	15	0.09	0.20	25	52	0.07	0.14
2-Hexanone	21	7	0.16	0.06	3	1	0.02	<0.01	2	0	0.03	·	26	8	0.07	0.02
Benzene	1	1	<0.01	<0.01	2	4	0.01	0.02	0	2	·	0.03	3	7	<0.01	0.02
Chloroform	0	0	·	·	43	2	0.26	0.01	45	5	0.68	0.07	88	7	0.24	0.02
Bromodichloromethane	1	0	<0.01	·	2	0	0.01	·	7	5	0.11	0.07	10	5	0.03	0.01
1,2-Dichloropropane	0	0	·	·	47	0	0.29	·	29	3	0.44	0.04	76	3	0.21	<0.01
Trichloroethene	1	0	<0.01	·	2	3	0.01	0.02	0	0	·	·	3	3	<0.01	<0.01
Styrene	0	2	·	0.02	0	1	·	<0.01	0	0	·	·	0	3	·	<0.01
Xylenes	1	1	<0.01	<0.01	2	1	0.01	<0.01	0	1	·	0.01	3	3	<0.01	<0.01
Tetrachloroethene	1	1	<0.01	<0.01	1	1	<0.01	<0.01	2	0	0.03	·	4	2	0.01	<0.01
Toluene	6	0	0.05	·	8	2	0.05	0.01	0	0	·	·	14	2	0.04	<0.01
Carbon Disulfide	1	0	<0.01	·	3	0	0.02	·	0	1	·	0.01	4	1	0.01	<0.01
Chlorobenzene	1	0	<0.01	·	1	1	<0.01	<0.01	0	0	·	·	2	1	<0.01	<0.01
1,2-Dichloroethane	0	0	·	·	1	0	<0.01	·	0	1	·	0.01	1	1	<0.01	<0.01

Table 4. (cont'd)

Compound	Laboratory Blanks				Trip Blanks				Equipment Rinsate				Total			
	No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples		No. of Samples[1]		% of Samples	
	92	93	92	93	92	93	92	93	92	93	92	93	92	93	92	93
1,1-Dichloroethene	0	0	·	·	1	1	<0.01	<0.01	0	0	·	·	1	1	<0.01	<0.01
1,2-Dichloroethene	0	0	·	·	1	1	<0.01	<0.01	0	0	·	·	1	1	<0.01	<0.01
Ethylbenzene	1	0	<0.01	·	2	1	0.01	<0.01	1	0	<0.01	·	4	1	0.01	<0.01
1,1,2,2-Tetrachloroethane	23	0	0.18	·	1	0	<0.01	·	1	0	<0.01	·	25	0	0.07	·
Total[1]	80	65	0.61	0.57	121	98	0.74	0.52	54	37	0.82	0.49	255	200	0.70	0.53

Note:

1 Total number of samples in which one or more VOCs were detected:

Total samples analyzed:

	1992	1993
Laboratory Blanks:	131	115
Trip Blanks:	164	185
Equipment Rinsates:	66	75
Total:	361	375

Table 5. Summary of False Positive VOC Results for 1993 Groundwater Samples

Compound	Groundwater Sample Results[1]	False Positive Results Identified From[2]		Total False Positive Results	Percent of Groundwater Sample Results
		Laboratory Blanks	Trip Blanks		
Methylene Chloride	81	67 (39)	10 (9)	77	95
4-Methyl-2-Pentanone	38	38 (20)	0	38	100
Acetone	34	32 (18)	1 (1)	33	97
2-Butanone	32	31 (16)	0	31	97
Benzene	5	5 (1)	0	5	100
2-Hexanone	2	2 (2)	0	2	100
Xylenes	1	0	1 (1)	1	100
Trichloroethene	5	0	1 (1)	1	20
1,2-Dichloroethene	6	0	1 (1)	1	17
1,1-Dichloroethene	7	0	1 (1)	1	14
Tetrachloroethene	13	0	1 (1)	1	8
1,1,1-Trichloroethane	28	0	0	0	.
1,2-Dichloroethane	8	0	0	0	.
Chloroform	7	0	0	0	.
Carbon Tetrachloride	4	0	0	0	.
Carbon Disulfide	2	0	0	0	.
Total Results:	**273**	**175**	**16**	**191**	**70**

Notes:

1 The number of samples in which the compound was detected.

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

Table 6. Concentration Range of False Positive VOC Results for 1993 Groundwater Samples

Compound	Det. Limit[1] (µg/L)	MCL[2] (µg/L)	Concentration of False Positive Result						Max.[3] (µg/L)
			≤ 1 (µg/L)		1 - 10 (µg/L)		> 10 (µg/L)		
			No.	%	No.	%	No.	%	
Methylene Chloride	5	-	56	73	21	27	0	-	4
4-Methyl-2-Pentanone	10	-	11	29	27	71	0	-	4
2-Butanone	10	-	1	3	24	77	6	20	14
Acetone	10	-	2	6	31	94	0	-	10
Benzene	5	5	5	100	0	-	0	-	1
1,1-Dichloroethene	5	7	1	100	0	-	0	-	1
1,2-Dichloroethene	5	-	1	100	0	-	0	-	1
2-Hexanone	10	-	2	100	0	-	0	-	1
Tetrachloroethene	5	5	1	100	0	-	0	-	1
Trichloroethene	5	-	0	-	1	100	0	-	3
Xylenes	5	10,000	0	-	1	100	0	-	2
Total:	**-**	**-**	**80**	**42**	**105**	**55**	**6**	**3**	**-**

Notes:

1 - Analytical detection limit.
2 - Maximum Contaminant Level for drinking water.
3 - Maximum concentration of false positive result.

Table 7. Anomalous VOC Results for 1993 Groundwater Samples

Compound	Det. Limit (µg/L)	MCL[1] (µg/L)	Sampling Point	Location[2]	Date Sampled	Anomalous Result (µg/L)
Acetone	10	-	GW-798[a]	CDLVII	08/29/93	5.7
Methylene Chloride	5	-	GW-542	CDLVI	03/16/93	1.0
			GW-293	ECRWP	04/06/93	1.0
			GW-147	KHQ	08/24/93	1.0
			GW-540	CDLVI	08/21/93	1.0
2-Butanone	10	-	GW-203	UNCS	07/26/93	9.0
Chloroform	5	-	GW-293	ECRWP	04/06/93	0.7
			1090	UNCS	07/27/93	0.7
			GW-143	KHQ	08/27/93	0.7
			GW-144	KHQ	08/26/93	0.7
			GW-339	UNCS	07/27/93	0.6
1,1-Dichloroethene	5	7	GW-175	CRSP	12/19/93	0.6
1,2-Dichloroethene	5	-	GW-177	CRSP	12/19/93	0.6
Carbon Tetrachloride	5	5	GW-143	KHQ	08/27/93	0.8
			GW-608	CRSP	12/18/93	0.2
Trichloroethene	5	-	GW-143	KHQ	08/27/93	1.0
			GW-798	CDLVII	08/29/93	2.3
Carbon Disulfide	5	-	GW-797[a]	LV	08/29/93	0.3
			GW-304	CRSDB	11/29/93	3.0

Notes:

1 Maximum Contaminant Level for drinking water.

2 CDLVI - Construction/Demolition Landfill VI
CDLVII - Construction/Demolition Landfill VII
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
ECRWP - East Chestnut Ridge Waste Pile
KHQ - Kerr Hollow Quarry
LV - Industrial Landfill V
UNCS - United Nuclear Corporation Site

a Well sampled during first, second, and third quarters of 1993; first quarter 1994 data used to identify result as anomalous.

Table 8. Trace Metal Screening Levels

Metal[1]	Number of Samples[2]	Detection Limit (mg/L)	Percent Detected[3]	Screening Level[4] (mg/L)		
				Upper 95% Tolerance Limit		99th Percentile
				Parametric	Nonparametric	
Iron	304	0.005	97	14.0	-	-
Zinc	304	0.001	90	0.18	-	-
Manganese	304	0.001	87	0.32	-	-
Aluminum	304	0.02	85	9.5	-	-
Strontium	304	0.0004	94	-	2.8	-
Boron	304	0.004	86	-	1.3	-
Copper	304	0.004	38	-	-	0.10
Beryllium	308	0.0003	22	-	-	0.0066
Uranium (Fluor.)	314	0.001	22	-	-	0.007
Nickel	308	0.01	21	-	-	0.18
Vanadium	308	0.005	18	-	-	0.064
Cobalt	304	0.005	7	-	-	0.011
Molybdenum	304	0.01	3	-	-	0.023
Antimony	304	0.05	1	-	-	0.058
Thorium	309	0.2	0	-	-	-

Note:

1 Results obtained by the ICP spectroscopy unless otherwise noted.

2 Number of groundwater samples used to determine screening level.

3 Percent of samples in which the total metal concentration exceeded the analytical detection limit.

4 Based on evaluation of 1986-1993 data. Values represent the maximum total concentration (in mg/L) that would be expected in uncontaminated, unfiltered groundwater samples collected from monitoring wells completed in the Knox Aquifer upgradient from waste-management sites at the Y-12 Plant.

Table 9. Anomalous Total Metal Concentrations, 1990-1993

METALS

Metal	Elevated Concentrations[1]			Metal	Elevated Concentrations[1]		
	Total	Anomalous	%		Total	Anomalous	%
Boron	1	1	100	Chromium	23	11	48
Antimony	2	2	100	Lead	34	16	47
Copper	19	14	74	Aluminum	17	7	41
Cadmium	7	5	71	Cobalt	21	7	33
Mercury	5	3	60	Zinc	31	11	35
Beryllium	10	6	60	Vanadium	10	3	30
Nickel	20	11	55	Uranium	29	6	21
Iron	28	15	54	Molybdenum	23	3	13
Manganese	42	22	52	Strontium	43	3	7

MONITORING WELLS

Well	Elevated Concentrations[1]			Well	Elevated Concentrations[1]		
	Total	Anomalous	%		Total	Anomalous	%
1085	2	2	100	GW-293	1	1	100
1091	1	1	100	GW-298	7	7	100
GW-143	1	1	100	GW-300	1	1	100
GW-147	7	7	100	GW-301	9	9	100
GW-156	1	1	100	GW-302	9	9	100
GW-158	2	2	100	GW-305	5	5	100
GW-160	7	7	100	GW-322	1	1	100
GW-177	1	1	100	GW-521	3	3	100
GW-179	2	2	100	GW-522	5	5	100
GW-188	2	2	100	GW-539	6	6	100
GW-241	2	2	100	GW-546	20	20	100

Table 9. (cont'd)

MONITORING WELLS (cont'd.)

Well	Elevated Concentrations[1]			Well	Elevated Concentrations[1]		
	Total	Anomalous	%		Total	Anomalous	%
GW-545	25	16	64	GW-142	8	1	13
GW-178	8	5	63	GW-541	11	1	9
GW-731	12	6	50	1086	34	3	9
GW-742	3	1	33	GW-295	100	8	8
GW-146	21	5	24	GW-165	2	0	0
GW-145	38	6	16	GW-303	8	0	0

Note:

1 Total concentrations in unfiltered groundwater samples that exceeded MCLs or screening levels (see Table 8).

Total - total number of samples with elevated metal concentrations

Anomalous - elevated metal concentrations reported for fewer than 1 out of every 4 unfiltered samples

Table 10. Annual Average VOC Concentrations in 1993 Groundwater Samples

	Average VOC Concentration[2] (µg/L)									
Sampling Point	**GW-142**	**GW-144**	**GW-175**	**GW-177**	**GW-305**	**GW-514**	**GW-608**	**GW-609**	**GW-611**	**GW-796**
Location[1]	**KHQ**	**KHQ**	**CRSP**	**CRSP**	**LIV**	**ADB**	**CRSP**	**CRSP**	**CRSP**	**LV**
Carbon Tetrachloride	0	1.5	0	0	0	0	0	0	0	0
Chloroform	1.3	0	0	0	0	0	0	0	0	0
1,1-Dichloroethane	0	0	0	11.0	0	0	0	0.8	1.0	0
1,1-Dichloroethene	0	0	0	2.0	0	0	0	0	1.0	0
1,2-Dichloroethene	0	0	0	0	0	0	0	13.0	0	0
Tetrachloroethene	0	0	13.25	0	0	0	1.5	13.0	0	0
1,1,1-Trichloroethane	0	0	3.75	20.0	3.0	0.8	2.5	0.7	8.5	2.0
Trichloroethene	0	0	0	0	0	0	0	1.0	0	0
Summed Average VOCs	**1.3**	**1.5**	**17.0**	**33.0**	**3.0**	**0.8**	**4.0**	**28.5**	**10.5**	**2.0**

Notes:

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

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

Table 11. Annual Average Summed VOC Concentrations in Groundwater at the Chestnut Ridge Security Pits, 1989-1993

Well Number	Summed Average VOCs[1] (µg/L)					Percent Decrease
	1989	1990	1991	1992	1993	
GW-173	17.0	13.5	11.8	11.7	NS	31
GW-174	47.8	48.5	43.7	34.0	NS	29
GW-175	31.8	38.5	31.0	29.5	17.0	47
GW-176	285.3	233.5	170.5	139.7	NS	51
GW-177	66.7	18.8	26.3	25.5	33.0	51
GW-178	43.4	40.0	34.0	29.0	NS	32
GW-179	838.0	455.0	328.3	262.3	NS	69
GW-180	145.8	99.5	74.2	52.3	NS	64
GW-322	696.0	730.3	633.0	538.3	NS	23
GW-607	NS	16.9	ND	ND	ND	100
GW-608	NS	14.8	15.5	4.5	4.0	73
GW-609	NS	78.0	67.5	35.5	28.4	64
GW-610	NS	1.0	0.5	ND	ND	100
GW-611	NS	16.0	9.0	13.5	10.5	34
GW-612	NS	505.8	451.3	358.3	NS	29

Note:

1 µg/L - micrograms per Liter
NS - Not Sampled
ND - Not Detected

Table 12. Base, Neutral, and Acid Extractable Organic Compounds in 1993 Groundwater Samples

Compound	Sampling Point	Location[1]	Concentration[2] (µg/L)			
			1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
di-n-butylphthalate	GW-158	CRSDB	[5]	-	1	-
	GW-159	CRSDB	0.3	-	-	-
	GW-184	RQ	-	NS	[9]	-
	GW-186	RQ	-	[4]	[2]	-
	GW-187	RQ	-	NS	[14]	-
	GW-188	RQ	-	NS	[5]	-
	GW-241	CRSDB	-	[5]	-	[17]
	GW-303	CRSDB	-	[6]	-	[14]
	GW-731	CRSDB	[0.3]	-	-	-
bis (2-Ethylhexyl) phthalate	GW-156	CRSDB	[1]	-	-	-
	GW-158	CRSDB	[1]	[2]	[11]	-
	GW-159	CRSDB	[6]	-	-	-
	GW-187	RQ	-	NS	1	-
	GW-188	RQ	-	NS	2	-
	GW-241	CRSDB	-	[1]	[0.7]	-
	GW-304	CRSDB	[2]	-	-	-
	GW-731	CRSDB	[3]	-	-	-
	GW-732	CRSDB	[2]	-	-	-
Butylbenzylphthalate	GW-158	CRSDB	-	-	0.6	-
	GW-184	RQ	-	NS	2	-
Diethylphthalate	GW-158	CRSDB	0.7	-	0.5	-

Table 12. (cont'd)

Compound	Sampling Point	Location[1]	Concentration[2] (µg/L)			
			1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
di-n-octylphthalate	GW-158	CRSDB	-	-	0.2	-
Isophorone	GW-158	CRSDB	[2]	-	-	-

Notes:

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

2 µg/L - Micrograms per Liter
\- - Less than the reported detection limit
NS - Not Sampled
[ ] - Compound detected in the associated laboratory blank sample

Table 13. Elevated Total Metal Concentrations, 1990-1993

Well Number	Total Number of Samples[1]	Elevated Metal Concentrations[2] 1990-1993		1993 Total Metal Concentration (mg/L)[3]				
		Number of Samples	Number of Metals	Metal	1st	2nd	3rd	4th
INCONCLUSIVE RESULTS								
GW-165	5	2	1	Fe	NS	NS	NS	NS
GW-742	7	2	1	Mn	-	-	-	-
GW-178[a]	8	3	1	Zn	NS	NS	NS	NS
GW-731	10	3	2	Fe	15	-	-	-
				Mn	0.4	0.38	-	-
BIASED RESULTS								
1086[b]	6	5	10		NS	NS	NS	NS
GW-545	12	5	2	Mo	-	-	0.061	0.033
				Pb	-	-	0.57	0.15
GW-295	16	12	11	Cr	0.29	0.47	0.31	58
				Co	-	-	0.039	0.39
				Fe	-	-	21	470
				Pb	-	-	0.051	1.7
				Mn	-	-	0.73	11
				Zn	-	0.2	-	3.8

Table 13. (cont'd)

Well Number	Total Number of Samples[1]	Elevated Metal Concentrations[2] 1990-1993		1993 Total Metal Concentration (mg/L)[3]				
		Number of Samples	Number of Metals	Metal	1st	2nd	3rd	4th
CONSISTENT RESULTS								
GW-142	16	8	1	U	-	0.019	0.032	0.019
GW-303	16	8	1	Sr	3.0	-	3.1	3.0
GW-541	12	10	1	Mo	0.033	0.027	0.036	0.043
GW-146	16	16	1	Sr	7.0	6.7	7.6	7.3
GW-145	16	16	2	Sr	7.3	7.1	7.1	7.5
				U	0.014	0.012	0.008	0.013

Note:

1 Total number of samples collected during 1990 - 1993.

2 Total concentrations that exceed MCLs or screening levels (excluding anomalous elevated concentrations).

3 NS - Not sampled during 1993
- - Concentration less than MCL or screeing level

a Upgradient monitoring well (used to determine screening levels).

b Plugged and abandoned monitoring well.

Table 14. Sampling Frequency and Well Sampling Sequence for CY 1995

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

Table 14 (cont'd)

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-4 (cont'd)	ECRWP	GW-292	BMP
CR-5	LIII	GW-161[a]	SDM
(Q1,Q3)	LIII	GW-160[a]	SDM
	LIII	GW-301	SDM
	LIII	GW-300	SDM
	LIII	GW-299	SDM
	LIII	GW-298	SDM
	LIII	GW-295[b]	SDM
CR-6	CRSDB	GW-159[a]	RDM
	CRSDB	GW-304	RDM
	CRSDB	GW-731	RDM
	CRSDB	GW-732	RDM
	CRSDB	GW-156	RDM
	CRSDB	GW-303	RDM
	CRSDB	GW-241	RDM
	CRSDB	GW-158	RDM
CR-7	KHQ	GW-142	RDM
	KHQ	GW-147	RDM
	KHQ	GW-231	RDM
	KHQ	GW-146	RDM
	KHQ	GW-143	RDM
	KHQ	GW-144	RDM
	KHQ	GW-145	RDM

Table 14 (cont'd)

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-8	ADB	GW-321	BMP
(Q2, Q4)	ADB	GW-513	BMP
	ADB	GW-512	BMP
	ADB	GW-514	BMP
CR-9	RQ	GW-184	BMP
(Q1, Q3)	RQ	GW-188	BMP
	RQ	GW-187	BMP
	RQ	GW-186	BMP
CR-10	LII	GW-539[a]	SDM
(Q1,Q3)	LII	GW-709	SDM
	LII	GW-757	SDM
CR-11	CDLVI	GW-540	SDM
(Q2, Q4)	CDLVI	GW-546	SDM
	CDLVI	GW-541	SDM
	CDLVI	GW-545	SDM
	CDLVI	GW-542	SDM
	CDLVI	GW-543	SDM
	CDLVI	GW-544	SDM
CR-12	CDLVII	GW-560	SDM
(Q2,Q4)	CDLVII	GW-562	SDM
	CDLVII	GW-564	SDM
	LV	GW-557	SDM
	LV	GW-799	SDM

Table 14 (cont'd)

Sample Group[1] (frequency)	Location[2]	Sampling Point[3]	Monitoring Program[4]
CR-12 (cont'd)	CDLVII	GW-798	SDM
	LV	GW-797	SDM
	LV	GW-796	SDM
	LV	GW-801	SDM
	LV	CBS-1	SDM

Notes:

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

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

3 CBS - Spring Sampling Location

4 AMP - RCRA Assessment Monitoring
BMP - Best-Management Practice Monitoring
RDM - RCRA Detection Monitoring
SDM - SWDF Detection Monitoring

a Background well.

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