



Y/SUB/01-006512/4

**Y-12 GROUNDWATER PROTECTION PROGRAM
CALENDAR YEAR 2000
GROUNDWATER MONITORING
DATA EVALUATION REPORT
FOR THE
UPPER EAST FORK POPLAR CREEK
HYDROGEOLOGIC REGIME
AT THE
U.S. DEPARTMENT OF ENERGY
Y-12 NATIONAL SECURITY COMPLEX,
OAK RIDGE, TENNESSEE**

**Y-12
NATIONAL
SECURITY
COMPLEX**

September 2001

Prepared by

**AJA TECHNICAL SERVICES, INC.
Under Subcontract No. 4300006512**

for the

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

Managed by

**BWXT Y-12, L.L.C.
for the U.S. Department of Energy
Under Contract No. DE-AC05-00OR22800**

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

UCN-13672 (10-00)

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List of Acronyms and Abbreviations

AJA	AJA Technical Services, Inc.
BCV	Bear Creek Valley
bgs	below ground surface
BJC	Bechtel Jacobs Company LLC
BT	buried tributary
BWXT Y-12	BWXT Y-12, L.L.C.
c12DCE	cis-1,2-dichloroethene
CE	counting error
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFU/ml	colony forming units per milliliter
CTET	carbon tetrachloride
CY	calendar year
DNAPL	dense, nonaqueous phase liquids
DO	dissolved oxygen
DOE	U.S. Department of Energy
DQO	data quality objective
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
ft	feet
gpm	gallons per minute
GWMR	Groundwater Monitoring Report
GWPP	(Y-12 Plant) Groundwater Protection Program
LRSPW	Lake Reality Spillway (sampling station)
MCL	maximum contaminant level (for drinking water)
MDA	minimum detectable activity
mgd	million gallons per day
µg/L	micrograms per liter
mg/L	milligrams per liter
msl	mean sea level
mV	millivolts
NPDES	National Pollution Discharge Elimination System
OF	outfall (storm drain)
ORR	Oak Ridge Reservation
PCE	tetrachloroethene
pCi/L	picoCuries per liter
RCRA	Resource Conservation and Recovery Act
REDOX	oxidation-reduction potential
RI	Remedial Investigation
SAIC	Science Applications International Corporation
SDWA	Safe Drinking Water Act
Tc-99	technetium-99
TCE	trichloroethene
TDS	total dissolved solids
t12DCE	trans-1,2-dichloroethene
U-234	uranium-234
U-238	uranium-238
UEFPC	Upper East Fork Poplar Creek

List of Acronyms and Abbreviations (continued)

UST	underground storage tank
UTL	upper tolerance limit
VC	vinyl chloride
VOC	volatile organic compound
WCPA	Waste Coolant Processing Area
WRRP	Water Resources Restoration Program
Y-12	Y-12 National Security Complex
11DCA	1,1-dichloroethane
11DCE	1,1-dichloroethene
111TCA	1,1,1-trichloroethane

1.0 INTRODUCTION

This report presents an evaluation of the groundwater and surface water monitoring data obtained during calendar year (CY) 2000 in the Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime). The East Fork Regime encompasses many confirmed and potential sources of groundwater and surface water contamination associated with the U.S. Department of Energy (DOE) Y-12 National Security Complex (hereafter referenced as Y-12) in Oak Ridge, Tennessee. Prepared under the auspices of the Y-12 Groundwater Protection Program (GWPP), this report addresses applicable provisions of DOE Order 5400.1 (*General Environmental Protection Program*) that require: (1) an evaluation of the quantity and quality of groundwater and surface water in areas that are, or could be, affected by Y-12 operations, (2) an evaluation of groundwater and surface water quality in areas where contaminants from Y-12 operations are most likely to migrate beyond the DOE Oak Ridge Reservation (ORR) property line, and (3) an evaluation of long-term trends in groundwater quality at Y-12. The following sections of this report contain relevant background information (Section 2.0); describe the results of the respective data evaluations required under DOE Order 5400.1 (Section 3.0); summarize significant findings of each evaluation (Section 4.0); and list the technical reports and regulatory documents cited for more detailed information (Section 5.0). Illustrations (maps and trend graphs) are presented in Appendix A. Brief data summary tables referenced in each section are contained within the text; supplemental information and extensive data tables are provided in Appendix B.

2.0 BACKGROUND INFORMATION

The boundaries of the East Fork Regime, which encompass all of the primary Y-12 operational facilities in Bear Creek Valley (BCV), extend along the base of Pine Ridge to the north, the base of Chestnut Ridge to the south, the eastern boundary of the Bear Creek watershed to the west, and the ORR property line along Scarboro Road to the east (Figure A.1). For the purposes of this report, the regime is divided into three major areas: the western Y-12 area between the Bear Creek watershed boundary and Y-12 grid coordinate easting 55,000; the central Y-12 area between grid coordinate eastings 55,000 and 62,000; and the eastern Y-12 area between grid coordinate easting 62,000 and the ORR property line (Figure A.2). The following discussion presents background information regarding the East Fork Regime, including an overview of the groundwater monitoring programs and the associated CY 2000 sampling and analysis activities, along with brief descriptions of the geology and groundwater flow system in BCV, the contaminant source areas within the regime, and the extent of groundwater contamination in the East Fork Regime and in Union Valley east of the regime.

2.1 MONITORING PROGRAMS AND CY 2000 SAMPLING AND ANALYSIS ACTIVITIES

Groundwater and surface water monitoring in the East Fork Regime during CY 2000 was performed primarily: (1) as needed to support the data-evaluation requirements specified under applicable provisions of DOE Order 5400.1, (2) in accordance with the requirements of Resource Conservation and Recovery Act (RCRA) post-closure corrective action monitoring defined in the RCRA post-closure permit for the East Fork Regime, and (3) as required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) record of decision for Union Valley and as needed for the purposes of CERCLA baseline and remedial effectiveness monitoring. The following discussion provides a brief overview of the CY 2000 sampling and analysis activities in the East Fork Regime, including the organizations responsible for monitoring at Y-12; the sampling locations, dates, and methods; and the field measurements and laboratory analyses. A more detailed description of these sampling and analysis activities is provided in the annual Groundwater Monitoring Report (GWMR) for CY 2000 (AJA Technical Services, Inc. [AJA] 2001a).

The Y-12 GWPP, which was managed by Lockheed Martin Energy Systems, Inc. until November 2000 when management was taken over by BWXT Y-12, L.L.C. (hereafter referenced as BWXT Y-12), implemented the groundwater sampling and analysis activities in the East Fork Regime that were needed to support the monitoring data evaluations specified under applicable provisions of DOE Order 5400.1. The Water Resources Restoration Program (WRRP) Organization, which is managed by Bechtel Jacobs Company LLC (hereafter referenced as BJC), implemented the sampling and analysis activities associated with the RCRA and CERCLA groundwater monitoring programs. Although performed separately, the respective CY 2000 sampling activities planned for Y-12 by the GWPP and WRRP were coordinated to achieve mutual programmatic objectives, including the use of functionally equivalent groundwater sampling procedures and laboratory analytical methods. Accordingly, the monitoring results obtained by the GWPP and the WRRP are suitable to the purposes of each organization.

As shown in the following summary (Table 1), 59 monitoring wells, four springs, one building sump, one process basin, and 13 surface water stations in the East Fork Regime (and surrounding areas) were sampled for the purposes of DOE Order 5400.1 monitoring, RCRA monitoring, and CERCLA monitoring during CY 2000.

Table 1. CY 2000 sampling locations in the East Fork Regime, north of Pine Ridge, and in Union Valley

Monitoring Driver	Monitoring Wells	Springs	Building Sumps	Process Basin	Surface Water Stations
DOE Order 5400.1	40	0	1	1	6
RCRA	5	0	0	0	0
CERCLA	17	4	0	0	7
Totals:	59	4	1	1	13

All but 14 of the CY 2000 sampling locations lie within the boundaries of the East Fork Regime (Figure A.2). Sampling locations outside the regime include six wells (GW-169, GW-170, GW-171, GW-172, GW-230, and GW-232) and three springs (SCR7.1SP, SCR7.18SP and SCR7.8SP) located in Union Valley east the ORR boundary (Figure A.2), and five surface water stations (NPR07.0SW, NPR10.0SW, NPR12.0SW, GHK2.51ESW, and GHK2.51NSW) located in drainage features along the ORR boundary north of Pine Ridge.

Samples were collected at least semiannually from all of the monitoring wells and springs, with sampling performed during seasonally wet and dry flow conditions (Table B.1). Samples also were obtained semiannually (wet and dry seasonal flow conditions) from each of the surface water stations except NPR10.0SW, which was dry during the seasonally dry sampling event (November 2000). Samples were collected only once from the designated sump in Building 9212 (9212-W-2-BSTM) and the process basin in Building 9215 (9215-STACK11).

Low-flow minimal drawdown sampling methods (hereafter referenced as low-flow sampling) were used to collect groundwater samples from all of the monitoring wells. Under low-flow sampling, which is intended to obtain representative groundwater samples that do not include stagnant water in the well casing, field personnel first pump the well at a flow rate that is low enough (<300 milliliters per minute) to minimize drawdown of the water level in the well (<0.1 feet [ft] per quarter-hour) and regularly check the pH, conductivity, temperature, oxidation-reduction potential (REDOX), and dissolved oxygen (DO) in the groundwater pumped from the well. Samples of the groundwater are collected immediately after the field measurements for each parameter show minimal variation over four consecutive readings. Additionally, filtered and unfiltered groundwater samples were collected by the Y-12 GWPP; only unfiltered groundwater samples were collected of the WRRP.

2.2 TOPOGRAPHY AND BEDROCK GEOLOGY

Ground elevations in BCV within the boundaries of the East Fork Regime range from about 1020 ft above mean sea level (msl) along the base of Pine Ridge and Chestnut Ridge in the western Y-12 area, to 900 ft msl along the axis of BCV in the exposed channel of Upper East Fork Poplar Creek (UEFPC) in the eastern Y-12 area downstream of Lake Reality (Figure A.3). Most of the regime is heavily industrialized and highly congested. A prominent local topographic feature is the gap in Pine Ridge cut by UEFPC northeast of Y-12. This gap roughly corresponds with a less prominent divide in Chestnut Ridge to the southeast of Y-12 and may indicate a structural or stratigraphic discontinuity near Scarboro Road.

Alternating sequences of clastic and carbonate strata that form the distinctive topography of the Valley and Ridge Physiographic Province comprise the bedrock geology in the East Fork Regime. Shale and siltstone beds of the Rome Formation form Pine Ridge to the north, limestone and shale formations of the Conasauga Group form BCV, and the primarily dolostone formations of the Knox Group form Chestnut Ridge to the south (Figure A.3). Strike and dip of bedding are generally N 55°E and 45°SE, respectively (as referenced to true north).

Bedrock is overlain by up to 40 ft of several unconsolidated materials, including man-made fill, alluvium, colluvium, fine-grained residuum from the weathering of the bedrock, and saprolite (weathered bedrock). Where undisturbed, the saprolite often retains primary textural features of the unweathered bedrock, including fractures (Solomon *et al.* 1992).

Extensive cut-and-fill areas within Y-12 have substantially altered the shallow subsurface throughout much of the East Fork Regime (Figure A.4). Most of the fill, which contains many voids and generally consists of a heterogeneous mixture of building debris and recompacted soil/residuum, was placed in the tributaries and main channel of UEFPC (Sutton and Field 1995). The numerous voids, heterogeneous composition, and varying thickness (5 to 25 ft) significantly influence shallow groundwater flow directions and contaminant migration patterns.

2.3 SURFACE WATER DRAINAGE

Surface water in the East Fork Regime is drained by UEFPC, which was extensively modified during construction of Y-12. The headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central Y-12 areas (Figure A.4), were filled and replaced with an extensive network of underground storm drains. For reference purposes, each buried tributary (BT) of UEFPC is designated with a value (e.g., BT-1) representing the tributary number counted downstream (west to east) from the headwaters. The underground network of storm drains in the western and central Y-12 areas direct surface runoff into the exposed portion of the UEFPC channel at a number of outfalls. The westernmost extent of the exposed portion of the UEFPC channel is Outfall (OF) 200, located about 6000 ft upstream of New Hope Pond/Lake Reality (Figure A.4). Also, drainage patterns in the eastern Y-12 area were extensively modified during construction and again during closure of New Hope Pond in 1988 and subsequent construction and operation of Lake Reality. New Hope Pond was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting Y-12. Lake Reality, a lined surface impoundment built to replace New Hope Pond, began operation in 1988.

During normal operations, flow in UEFPC is directed through a concrete-lined distribution channel located around the south and east side of Lake Reality. Also, a gravel and perforated pipe underdrain beneath portions of the distribution channel captures shallow groundwater. Until December 1996 when flow was rerouted to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was permanently diverted through the Lake Reality spillway (LRSPW), which discharges into the mainstream of UEFPC directly north of Lake Reality. Bypassing Lake Reality reduces mercury contributions to dry-weather flow in UEFPC.

About 70% of dry-weather flow in UEFPC, is attributable to once-through non-contact cooling water, condensate, and cooling tower blowdown, and the remaining 30% is from groundwater discharge (CDM Federal Programs Corporation 1994). Beginning in July 1996 a flow management program was implemented where raw water (i.e., Clinch River water from the intake lines to the DOE water treatment plant that supplies potable water to Y-12, the Oak Ridge National Laboratory, and the City of Oak Ridge) has been discharged near OF 200 to augment flow in UEFPC, which decreased from 10-15 million gallons per day (mgd) to about 2.5 mgd because of reduced operations at Y-12 in recent years. Flow management is needed to achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, where UEFPC exits the ORR downstream from Lake Reality. Flow management also allows compliance with NPDES toxicity requirements and helps lower the otherwise elevated water temperature in UEFPC.

2.4 GROUNDWATER SYSTEM

The following overview of the groundwater system in the East Fork Regime is based on the conceptual hydrogeologic models described in: *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE 1998), which is referenced hereafter as the Remedial Investigation (RI) report. This conceptual model incorporates: (1) the general hydrologic framework described in Solomon *et al.* (1992); (2) groundwater flow characteristics presented in Moore (1988 and 1989) and Moore and Toran (1992); (3) results of numerous hydrologic studies and investigations in BCV, including Dreier *et al.* (1987) and Shevenell (1994); and (4) findings of monitoring activities performed specifically for RI purposes (DOE 1998).

On the ORR in the vicinity of BCV, the Rome Formation, the Conasauga Group, and the Knox Group comprise two basic hydrogeologic units: (1) the aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Knox Group, and (2) the aquitard, consisting of the remaining Conasauga Group formations (Nolichucky Shale, Maryville Limestone, Rogersville Shale, Rutledge Limestone, and Pumpkin Valley Shale) and the Rome Formation (Figure A.3). The Maynardville Limestone functions as a hydrologic drain in BCV and provides the principal avenues for contaminant transport in the East Fork Regime. The aquitard formations underlie many of the contaminant source areas in the regime and are hydraulically upgradient of the aquifer.

Fractures provide the primary groundwater flowpaths in the aquitard and the aquifer, but dissolution of carbonates in the aquifer has enlarged fractures and produced solution cavities and conduits that greatly enhance its hydraulic conductivity relative to the aquitard. Although negligible in both units, flow through the rock matrix plays an important role in contaminant migration because of matrix diffusion processes. Most of the flow in both units is primarily parallel to bedding (along strike and dip), which in the aquitard may or may not coincide with the direction of maximum horizontal hydraulic gradient inferred from groundwater elevation isopleths. In the aquitard, the bulk of flow is thought to occur within the shallow bedrock interval less than 70 ft below ground surface (bgs). Flow across bedding occurs primarily along permeable zones formed by cross-cutting fractures or fracture zones (and possibly small faults). Some of these cross-cutting structures may act as barriers to lateral flow, causing groundwater from deeper intervals to upwell and discharge to the shallower flow system in each hydrogeologic unit. Others may serve as preferential pathways for migration of contaminants from the aquitard into the aquifer.

Most groundwater flow in the aquifer is thought to occur at shallow depths, typically less than 100 ft bgs in an extensively interconnected karst network of solution conduits and cavities. Flow in the shallow karst network is relatively rapid, and during rainfall may occur as “quickflow” recharge/discharge toward springs or nearby surface drainage features (Shevenell 1994). Below the shallow karst network, fractures provide the primary flowpaths, and there are important lithologic controls on groundwater flow (Goldstrand 1995). Lithologic characteristics differentiate seven distinct stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone. The more permeable zones lie at the bottom (Zone 2) and top (Zone 6) of the formation (Shevenell *et al.* 1993). Because of vugular porosity related to dissolution of gypsum nodules, Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the Maynardville Limestone (Goldstrand 1995).

In both the western Y-12 area and central Y-12 area, groundwater generally flows south (across strike) from the aquitard toward the aquifer (Maynardville Limestone) and eastward along strike in the Maynardville Limestone toward the east end of Y-12 (Figure A.5). However, the extensive network of basement dewatering sumps, storm drains, process lines, pipes, and outfalls in the shallow subsurface throughout much of the western

and central Y-12 areas strongly influences the movement and discharge of shallow groundwater, as well as the migration of groundwater contaminants. For instance, operation of sumps to suppress the local water table below the basement floor of Buildings 9204-4, 9201-5, and 9201-4, and possibly 9204-2 (Figure A.4) strongly influences local groundwater flow and contaminant transport patterns (DOE 1998). In the eastern Y-12 area, flow in the aquitard is more directly east (along strike) toward UEFPC, and flow in the aquifer is primarily to the east (along strike) toward Union Valley. However, groundwater flow directions at shallow depths in the Maynardville Limestone in the eastern Y-12 area are strongly influenced by the UEFPC distribution channel underdrain, which apparently functions as a highly permeable groundwater flow path and a constant head (recharge) boundary (Science Applications International Corporation [SAIC] 1998). Additionally, operation of the Lake Reality Sump, which is a 6-ft diameter, 20-ft deep sump installed to reduce hydraulic pressure on the synthetic liner in Lake Reality, creates an elongated cone of depression in the aquitard (Nolichucky Shale) oriented parallel with strike and decreases water levels in the aquifer (Maynardville Limestone) along the main channel of UEFPC. The sump is activated manually as required (very infrequently) to reduce pressure head and stop lake liner flotation. Once activated, the sump pump operates on an automatic level switch.

An aquifer pumping test and associated dye-trace test that were completed in July 1998 provide the most recent data regarding the hydrologic characteristics of the intermediate and deep groundwater flowpaths in the Maynardville Limestone, and the degree of hydraulic connection between the shallow and deep flow systems in the eastern Y-12 area (SAIC 1998). A stepped pump test was performed using a well (GW-845, monitored interval = 156.8 to 438.3 ft bgs) installed in the Maynardville Limestone about 250 ft southeast of New Hope Pond. Beginning on July 9, 1998, groundwater was continuously pumped from the well at progressively increased discharge rates: 25 gallons per minute (gpm) for 24 hours, 50 gpm for 24 hours, and 100 gpm for seven days (pumping stopped on July 18, 1998). Water level drawdown and recovery data obtained from nearby monitoring wells indicated: (1) rapid, large responses in wells located along strike to the east and across strike to the north of the pumping well, (2) more moderate responses in wells located oblique to strike near the contact with the Nolichucky Shale to the east of the pumping well, (3) weak responses in upgradient wells in the Maynardville Limestone to the west of the pumping well, and (4) little if any response in wells located adjacent to Lake Reality and the UEFPC distribution channel underdrain to the north and northeast of the pumping well. The maximum observed radius of influence from the pumping well encompassed the entire subcrop of the Maynardville Limestone in the eastern Y-12 area, with particularly strong anisotropies to the east (along strike) and north (up-dip) of the well and low-permeability boundary effects evident along the contact with the Nolichucky Shale. Additionally, the UEFPC distribution channel underdrain, the original UEFPC mainstream, and Lake Reality apparently represent constant head (recharge) sources to the shallow groundwater and may collectively function as a hydraulic boundary to the west and northwest of New Hope Pond. The UEFPC distribution channel underdrain in particular appears to function as a separate hydraulic system that may be at least partially connected to surface water flow in UEFPC (SAIC 1998).

In conjunction with the pumping test, orange eosine dye was injected in a shallow (60 ft bgs) well (GW-153) located about 450 ft southwest (upgradient) of the pumping well (GW-845) (Figure A.2). Rapid breakthrough of the dye observed in the pumping well clearly demonstrated the hydraulic connection between the shallow and intermediate/deep groundwater flowpaths along strike in the Maynardville Limestone. Additionally, confirmed detection of the dye in two shallow wells (GW-220 and GW-832) located about 600 ft northeast (across geologic strike) of the injection well (and about 300 ft northwest of the pumping well) suggests that the degree of hydrologic connection with the UEFPC distribution channel underdrain and groundwater movement along dip parallel or conjugate fracture flowpaths in the shallow flow system are strong enough to overcome the hydraulic capture zone created at the 100 gpm pumping rate in the intermediate to deep flow systems (SAIC 1998).

2.5 EXTENT OF GROUNDWATER CONTAMINATION

Sources of groundwater contamination in the East Fork Regime include: hazardous and nonhazardous waste treatment, storage, or disposal sites; bulk product transfer, storage, and use areas; former petroleum-fuel underground storage tanks (USTs) and associated dispensing facilities; industrial process buildings; waste and product spill areas; and the many process pipelines, effluent drains, and utilities associated with the industrial operations at Y-12. Also, operation of the S-3 Ponds, a closed RCRA regulated surface impoundment located in the Bear Creek Hydrogeologic Regime near the west end of Y-12, emplaced a large reservoir of contamination in the western Y-12 area. It is more difficult to conclusively identify other sources of groundwater contamination elsewhere in the regime because of extensive intermingling of contaminants, but groundwater contaminant signatures (i.e., specific contaminants or distinct groups of contaminants) can be related to one or more of the source areas. In any case, the overall extent of contamination in the regime reflects intermixing of contaminants from multiple sources (including dense, nonaqueous phase liquids [DNAPL] in the subsurface at several sites), and the substantial hydrologic influence exerted by the extensive areas of anthropogenic fill, subsurface drains and utilities, surface drainage conveyances, and operation of basement sumps in several of the process buildings (DOE 1998).

The following overview of the extent of groundwater and surface water contamination in the East Fork Regime is based on the comprehensive description presented in the RI report. Principal groundwater contaminants in the regime are inorganic compounds (primarily nitrate); trace metals (notably uranium); volatile organic compounds (VOCs), including chlorinated solvents and petroleum hydrocarbons; and several radionuclides, chiefly technetium-99 (Tc-99) and uranium isotopes. Intermingling of contaminants from multiple source areas has produced an extensive, essentially continuous groundwater contaminant plume of varying composition that extends from the western Y-12 area through the southern part of the central and eastern Y-12 areas and into Union Valley east of the ORR (Figure A.6).

A plume of nitrate contamination originating from the S-3 Ponds extends vertically in the aquitard at least 150 ft bgs and laterally at least 5,000 ft into the western Y-12 area. Nitrate (as N) concentrations (hereafter synonymous with “nitrate” concentrations) within the plume exceed 10,000 milligrams per liter (mg/L). Because it is chemically stable and highly mobile in groundwater, nitrate probably traces the overall migration pattern for other groundwater contaminants from the S-3 Ponds. The geometry of the nitrate plume indicates two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstream of UEFFPC; and (2) much slower migration along much longer strike-parallel pathways at greater depths in the bedrock toward basement sumps in Buildings 9204-4, 9201-4, and 9201-5 (DOE 1998).

The low pH groundwater of the contaminant plume adjacent to the S-3 Ponds contains a diverse mix of metal ions and/or ion-complexes (beryllium, cadmium, cobalt, manganese, mercury, and nickel) that are usually not mobile (or are more readily attenuated) in less acidic groundwater, as well as metals that are mobile under a wider range of groundwater pH conditions (barium, boron, strontium, and uranium). Some of these metals were entrained in the acidic wastes disposed at the site (e.g., uranium), and others were dissolved from the underlying saprolite and bedrock (e.g., barium). Trace metal concentrations within the plume exceed applicable maximum contaminant levels (MCLs) for drinking water by an order of magnitude or more. Similarly elevated concentrations of several other trace metals (including boron, cadmium, cobalt, copper, mercury, and uranium) occur in the groundwater elsewhere in the East Fork Regime, notably the S-2 Site, but available data do not indicate that extensive plumes of metal ions and/or ion-complexes have developed in the groundwater beyond the immediate vicinity of these sites.

Volatile organic compounds are the most pervasive groundwater contaminants in the East Fork Regime. Chloroethenes, primarily tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (c12DCE), 1,1-dichloroethene (11DCE), and vinyl chloride (VC), are the principal components of dissolved VOC plumes in the western Y-12 area and the central Y-12 area. Chloroethanes, primarily 1,1,1-trichloroethane (111TCA) and 1,1-dichloroethane (11DCA), are also major components of several plumes in the central Y-12 area. Chloromethanes (carbon tetrachloride [CTET], chloroform, and methylene chloride) are primary plume components in the eastern Y-12 area. Additionally, residual plumes of dissolved petroleum hydrocarbons (benzene, ethylbenzene, dimethylbenzene, and toluene) occur in shallow groundwater near former petroleum fuel USTs located in each Y-12 area. Concentrations of individual plume constituents in the aquitard near the Waste Coolant Processing Area (WCPA), Building 9212, and Tank 0134-U (Figure A.6) exceed 1,000 micrograms per liter ($\mu\text{g/L}$) and indicate the presence of DNAPL in the subsurface. Data for the existing network of aquifer monitoring wells generally define a relatively continuous plume of dissolved VOCs in the water table interval/shallow bedrock (<100 ft bgs) that extends eastward from the Fire Training Facility in the western Y-12 area, intermingles with plumes from several sources in the central Y-12 area, and extends underneath New Hope Pond in the eastern Y-12 area (Figure A.6). The extent of the plume at intermediate (>200 ft bgs) and deep (>400 ft bgs) intervals in the Maynardville Limestone is not well defined in the western and central Y-12 areas because of limited well coverage, but data from the network of wells in the eastern Y-12 area show that a plume of dissolved chloromethanes (primarily CTET), which is believed to originate from suspected DNAPL in the Maynardville Limestone west of New Hope Pond near Building 9720-6, extends vertically more than 400 ft bgs and laterally (parallel with geologic strike) into Union Valley at least 2,000 ft east of the ORR boundary (Figure A.6).

Groundwater with radiological contamination occurs primarily in the aquitard east of the former S-3 Ponds, at Tank 0134-U, Buildings 9204-4 and 9201-5, and the Salvage Yard. In the aquifer, radiological contamination occurs near the S-2 Site and upgradient of New Hope Pond (the uranium oxide vault, wells GW-605 and GW-606, and the former Oil Skimmer Basin) (Figure A.6). The S-3 Site is a principal source of uranium isotopes, primarily uranium-234 (U-234) and uranium-238 (U-238), and Tc-99; the migration of Tc-99 generally mirrors that of nitrate from the site. Gross alpha radioactivity levels within the plume exceed the 15 pCi/L drinking water MCL and beta radioactivity levels within the plume exceed the Safe Drinking Water Act (SDWA) screening level (50 pCi/L) for dose equivalent of 4 millirems per year (the drinking water MCL for gross beta radioactivity).

Relatively limited influx of radiological contamination directly into the aquifer (or extensive dilution) in the East Fork Regime is indicated by the greatly decreased gross alpha, gross beta, and isotopic uranium activity in the groundwater downgradient of source areas (e.g., S-2 Site and the former Oil Skimmer Basin).

3.0 DOE ORDER 5400.1 MONITORING DATA EVALUATIONS

The following sections provide an evaluation of the monitoring data for the network of CY 2000 sampling locations in the East Fork Regime, as reported in the CY 2000 GWMR (AJA 2001a). Each section addresses a corresponding requirement of DOE Order 5400.1. Section 3.1 (Surveillance Monitoring Data Evaluation) contains an evaluation of groundwater quality in areas that are, or could be, affected by Y-12 operations. Section 3.2 (Exit Pathway/Perimeter Monitoring Data Evaluation) contains an evaluation of surface water and groundwater quality where contaminants are most likely to migrate beyond the ORR property line. Section 3.3 (Contaminant Concentration Trend Evaluation) presents a review of long-term trends in groundwater quality near Y-12, as illustrated by data for selected sampling locations in the western, central, and eastern Y-12 areas. Each evaluation is based on historical and CY 2000 monitoring results that meet the applicable data quality objectives (DQOs) defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (SAIC 2000). Detailed descriptions of the DQO criteria and associated data screening process, along with summaries of the CY 2000 data that do not meet applicable DQOs, are provided in the CY 2000 GWMR.

3.1 SURVEILLANCE MONITORING DATA EVALUATION

The CY 2000 monitoring results reported for 41 monitoring wells, and one basement sump and one process basin in two process buildings in the East Fork Regime were evaluated for the surveillance monitoring purposes of DOE Order 5400.1. As shown in Table 2, 11 of these wells are located in the western Y-12 area, 17 of the wells (and both the basement sump and the process basin) are located in the central Y-12 area, and 13 wells are located in the eastern Y-12 area (Figure A.2).

Table 2. Network of wells used for CY 2000 Surveillance Monitoring in the East Fork Regime

Western Y-12 Area		Central Y-12 Area		Eastern Y-12 Area	
GW-108	GW-337	55-2C	GW-769	GW-153	GW-605
GW-109	GW-618	56-2C	GW-770	GW-154	GW-606
GW-192	GW-620	GW-193	GW-782	GW-222	GW-762
GW-251	GW-633	GW-204	GW-783	GW-223	GW-763
GW-253		GW-218	GW-788	GW-240	
GW-274		GW-219	GW-789	GW-380	
GW-275		GW-656	GW-791	GW-381	
		GW-690	GW-820	GW-382	
		GW-700		GW-383	

The following data evaluation is organized into separate discussions of the respective CY 2000 monitoring results obtained in the western, central, and eastern Y-12 areas.

3.1.1 Western Y-12 Area

Contaminants from operations at Y-12 were detected in at least one of the groundwater samples collected during CY 2000 from all of the wells in the western Y-12 area (Table 2). The general type(s) of groundwater

contaminant detected in each well, along with the hydrogeologic unit and monitored interval depth for each well, are shown in Table 3.

Table 3. Types of contaminants detected in monitoring wells in the western Y-12 area

CY 2000 Sampling Location	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Type of Groundwater Contaminant		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-108	41.0 - 58.6	. . .	!	!	!
GW-109	96.6 - 128.5	. . .	!	!	!
GW-192	6.5 - 17.5	. . .	.	!	.
GW-251	. . .	35.0 - 51.0	!	!	.
GW-253	. . .	36.2 - 50.0	!	!	!
GW-274	25.8 - 35.0	. . .	!	!	!
GW-275	53.3 - 65.5	. . .	!	!	.
GW-337	15.0 - 22.1	. . .	.	!	.
GW-618	. . .	26.0 - 37.0	.	!	.
GW-620	. . .	61.7 - 75.0	.	!	.
GW-633	3.5 - 15.0	. . .	!	!	!

The following evaluation of the CY 2000 monitoring results for these wells is organized into separate discussions for each major type of groundwater contaminant.

3.1.1.1 Inorganic Contaminants

Inorganic contaminants detected in the groundwater samples collected from the monitoring wells in the western Y-12 area during CY 2000 are barium, beryllium, cadmium, cobalt, copper, chloride, manganese, mercury, nickel, nitrate, potassium, sodium, strontium, sulfate, uranium, and zinc. Although there are several confirmed sources of these contaminants within the western Y-12 area, monitoring results obtained during CY 2000 primarily reflect contamination from the former S-3 Ponds (GW-108, GW-109, GW-274, GW-275, and GW-633) and the S-2 Site (GW-251 and GW-253). The following discussion of the CY 2000 monitoring results for these wells is presented in sequence from farthest upgradient (north and west) to farthest downgradient (south and east).

Aquitard monitoring well GW-633 is located near the southwest corner of the Y-12 Salvage Yard about 700 ft southeast of the S-3 Site (Figure A.2). Installed during April 1990 as part of an investigation of petroleum fuel USTs at the Rust Construction Garage Area, this well is completed at a very shallow depth (15 ft bgs) and a proportionately long (10 ft) screened interval that is intended to straddle the water table (in order to detect any immiscible petroleum products). Historical data show that this well yields highly contaminated groundwater samples containing many of the primary inorganic components of the contaminant plume emplaced during operation of the former S-3 Ponds, including barium, nitrate, and strontium. As shown in the following summary of data for these contaminants (Table 4), the respective CY 2000 results reflect substantially reduced concentrations compared to corresponding levels evident during the early 1990s.

Table 4. Selected data for inorganic groundwater contaminants detected in well GW-633, 1991-2000

Inorganic Groundwater Contaminant	Concentration (mg/L)				
	Conventional Sampling			Low Flow Sampling	
	March 1991	March 1992	March 1993	June 2000	October 2000
Barium	34	33	33	13.4	12.5
Nitrate	5,380	4,613	3,874	2,200	1,890
Strontium	17	16	15	6.7	6.37

Decreasing concentrations of these inorganic contaminants suggest that the center of mass of the S-3 Ponds contaminant plume in the Nolichucky Shale currently lies along strike to the east of well GW-633 (DOE 1998) or that the change in contaminant concentrations is an artifact of the concurrent change in sampling methodology. In contrast, the CY 2000 monitoring results reflect sharply increased concentrations of several organic contaminants in the shallow groundwater at this well (see Section 3.1.1.2).

Aquitard monitoring wells GW-108 and GW-109 are clustered in the Nolichucky Shale approximately 125 ft southeast of well GW-633. Both wells intercept strike-parallel migration pathways for the contaminant plume emplaced during operation of the former S-3 Ponds (DOE 1998). This well cluster is located about 800 ft northeast (hydraulically upgradient) of the former S-3 Ponds (Figure A.2). Data obtained from these wells during CY 2000 show that both continue to yield acidic (field pH 5.21 - 5.84) and highly mineralized groundwater samples (total dissolved solids [TDS] exceed 50,000 mg/L) characterized by very high concentrations of calcium (10,500 - 12,300 mg/L), nitrate (8,980 - 13,300 mg/L), magnesium (1,140 - 1,460 mg/L), sodium (501 - 620 mg/L), chloride (58.5 - 177 mg/L), and manganese (97.3 - 143 mg/L). The elevation of the static water level in each well indicate that the local vertical hydraulic gradient is consistently upward from the deeper (GW-109) to the shallower (GW-108) bedrock. Additionally, the CY 2000 data show that, with the notable exception of barium and manganese, the concentrations of most trace metals remain substantially higher in well GW-109 compared to well GW-108. For example, total cadmium concentrations in the unfiltered samples collected from well GW-108 in January and July 2000 do not exceed the associated reporting limit (0.001 mg/L), whereas a total cadmium concentration of 2.19 mg/L was reported for the unfiltered groundwater sample collected from well GW-109 in May 2000.

Based on comparison with historical nitrate levels in well GW-108, which effectively mirror the temporal fluctuations and long-term concentration trends for most of the inorganic contaminants in the groundwater at the well, the CY 2000 monitoring results show that nitrate concentrations in well GW-108 continue to decrease (Figure A.7). However, this decreasing trend incorporates substantial temporal concentration fluctuations. For instance, the nitrate level evident in February 1999 (11,800 mg/L) is 16% higher than the nitrate concentrations in July 1999 (9,880 mg/L), whereas the nitrate concentration evident in January 2000 (8,980 mg/L) is 37% lower than the nitrate level evident in July 2000 (13,300 mg/L). Nevertheless, the overall decrease in the nitrate levels over the long term probably reflects substantially reduced flux of nitrate following the closure/capping of the former S-3 Ponds, and may indicate that the center of mass of the Eastern S-3 Site Plume at shallow depths (<100 ft bgs) now lies to the east (along geologic strike) of well GW-108. Similarly, the CY 2000 results for deeper well GW-109 show that nitrate concentrations also remain very high (9,520 mg/L in October 2000) deeper in the bedrock, and comparison with historic data indicates a relatively stable long-term trend.

Aquitard monitoring wells GW-274 and GW-275 comprise a well cluster in the Nolichucky Shale near the southeast corner of the Y-12 Salvage Yard about 500 ft east-northeast of wells GW-108/GW-109 (Figure A.2). Respective historical data show that both wells intercept strike-parallel migration pathways for the contaminant plume emplaced during operation of the former S-3 Ponds (DOE 1998). Monitoring results obtained from these wells during CY 2000 show that both continue to yield acidic (field pH 5.53 - 6.68) and highly mineralized (TDS > 20,000 mg/L) groundwater samples characterized by very high concentrations of several major ions, notably calcium (5,070 - 8,900 mg/L), nitrate (3,890 - 7,160 mg/L), and magnesium (717 - 1,260 mg/L), along with elevated concentrations of several trace metals, including barium (35.7 - 125 mg/L) and strontium (15.6 - 67.6 mg/L). Pre-sampling groundwater elevations in these wells indicate that the local vertical hydraulic gradient is consistently upward from the shallow bedrock interval (GW-275) to water table interval (GW-274). Also, as illustrated by the following summary of barium and nitrate results (Table 5), the concentrations of inorganic contaminants remain much higher in well GW-275 compared to well GW-274, which may reflect upwelling of contaminated groundwater and dilution of contaminants in the shallow flow system (DOE 1998).

Table 5. Barium and nitrate results for wells GW-274 and GW-275, 1990-2000

Groundwater Contaminant	Monitoring Well	Concentration (mg/L)			
		Conventional Sampling Method		Low Flow Sampling Method	
		January 1990	October 1995	May 2000	October 2000
Barium	GW-274	83	37	35.7	34.3
	GW-275	120	96	123	125
Nitrate	GW-274	10,900	4,270	5,410	3,890
	GW-275	8,770	7,580	7,150	7,160

Although the concentration of most inorganic contaminants are now substantially lower than respective levels evident in each well during the late 1980s and early 1990's, the CY 2000 monitoring results suggest substantially slower concentration decreases in the groundwater at both wells. As shown in the preceding data summary, for instance, the barium and nitrate results obtained in October 2000 do not indicate any significant change from the corresponding concentrations evident in October 1995. Also, the CY 2000 monitoring data do not indicate any significant difference between the conventional sampling and the low-flow sampling results for the inorganic contaminants in each well.

Aquifer monitoring well GW-251 yields contaminated calcium-magnesium-bicarbonate groundwater from a relatively shallow depth (<50 ft bgs) in the upper Maynardville Limestone about 100 ft west of the S-2 Site (Figure A.2). Historical data show that nitrate and trace metals (notably cadmium) are the primary inorganic contaminants in the groundwater at the site. The CY 2000 sampling results for well GW-251 show that nitrate levels (26.3 - 63.2 mg/L) and total cadmium concentrations (0.0509 - 0.125 mg/L) remain well above respective MCLs (10 and 0.005 mg/L). These inorganic contaminants probably leach directly from the S-2 Site into the shallow groundwater in the Maynardville Limestone and are transported via karst flow downgradient (along strike) to the east and west (DOE 1998). This also explains the clearly seasonal fluctuations in the concentration of these inorganic contaminants, with higher concentrations typically evident during seasonally high flow (Figure A.8). For instance, monitoring results obtained during CY 2000 show that the nitrate concentration (63.2 mg/L) evident in May 2000 (seasonally high flow conditions) is more than double the nitrate concentration (26.3 mg/L) evident in October 2000 (seasonally low flow conditions). Along with the seasonal concentration fluctuations, historical nitrate results for well GW-251 reflect a generally decreasing long-term concentration trend (Figure A.8).

Aquifer well GW-253 monitors contaminated calcium-magnesium-bicarbonate groundwater from strike-parallel flowpaths in the shallow karst network immediately east of the S-2 Site (Figure A.2). Monitoring results obtained during CY 2000 show that the well continues to yield acidic (field pH 5.29 - 5.51) groundwater samples characterized by high concentrations of nitrate (>1000 mg/L), chloride (>100 mg/L), sulfate (> 70 mg/L), manganese (>50 mg/L), copper (>30 mg/L), zinc (>5 mg/L), cadmium (>4 mg/L), and nickel (>2mg/L). These results are consistent with historical data for the well and confirm that the highest concentrations within the contaminant plume occur to the east of the S-2 Site, although discharge from the shallow karst system into UEFPC, combined with dilution during transport, substantially reduces contaminant concentrations in the groundwater downgradient of the site (DOE 1998).

3.1.1.2 Volatile Organic Compounds

Excluding false-positive results, one or more of the following VOCs were detected in the groundwater samples collected during CY 2000 from 11 monitoring wells in the western Y-12 area (see Table 3): acetone, benzene, PCE, TCE, c12DCE, trans-1,2-dichloroethene (t12DCE), 11DCE, 11DCA, 111TCA, CTET, chloroform, methylene chloride, dimethylbenzene, toluene, and VC. Maximum summed VOC concentrations range between 9 and 7364 µg/L (Table B.2). The presence of dissolved VOCs in the groundwater at these monitoring wells reflects migration from the S-3 Ponds (GW-108 and GW-109), the Rust Garage Area (GW-633), the Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader (GW-192), the WCPA (GW-337), the S-2 Site (GW-251 and GW-253), the Fire Training Facility (GW-620), and a combination of these and other VOC source areas in the western Y-12 area (GW-274, GW-275, and GW-618). Moreover, as shown in Table 6, the CY 2000 monitoring data show that maximum concentrations of PCE, TCE, c12DCE, VC, CTET, and methylene chloride remain above the respective drinking water MCLs.

Table 6. Western Y-12 area: CY 2000 maximum VOC concentrations that exceed MCLs

Well	Maximum Concentration (µg/L)							
	PCE	TCE	c12DCE	11DCE	VC	CTET	Methylene Chloride	Benzene
GW-108	(2)	(4)	.	.	.	.	63	.
GW-109	170	5	.	.	.	.	15	.
GW-192	5	7	28	.	.	.	.	.
GW-251	300	150	10	.	.	6	.	.
GW-253	690	660	230	(3)	71	43	.	(1)
GW-274	650	12	7	.	.	.	57	50
GW-275	9	.	.	.	.	.	.	.
GW-337	860	940	4,900	160	63	33	.	.
GW-618	5	7	29	.	4	.	.	.
GW-620	23	9	20	.	.	.	.	.
GW-633	200	9	11	.	.	.	38	650
MCL (µg/L)	5	5	70	7	2	5	5	5
Note : Results for each monitoring well may be from more than one sampling event; “. ”= Not detected; () = Estimated concentration below the reporting limit; Bold = Exceeds MCL								

Groundwater samples collected from aquitard well GW-633 during CY 2000 contained a mixture of dissolved chloroethenes, chloromethanes, and petroleum hydrocarbons (Table B.2). The presence of VOCs in the shallow groundwater at well GW-633 reflects migration from multiple potential sources in the western Y-12 area, including the S-3 Site and former petroleum fuel USTs associated with the Rust Construction Garage

(DOE 1998). The types of VOCs detected in samples collected from the well during CY 2000 are generally consistent with historical data for the well, but as shown in the following summary (Table 7), the CY 2000 monitoring results reflect a substantial increase in the concentration of some compounds (see Section 3.3), particularly PCE and dissolved petroleum hydrocarbons (benzene, ethylbenzene, toluene, and dimethylbenzene), but little if any change in the concentration of other compounds, such as TCE and chloroform.

Table 7. Selected VOC data for aquitard well GW-633, 1991-2000

VOC	Concentration (µg/L)					
	Conventional Sampling				Low-Flow Sampling	
	March 1991	March 1992	March 1993	March 1994	June 2000	October 2000
PCE	70	91	60	57	200	170
TCE	8	11	7	(4)	9	8
1,2-DCE (total)	(2)	.	(3)	.	7	11
Chloroform	FP	40	24	12	26	24
Methylene Chloride	18	FP	18	FP	35	38
Benzene	(3)	(3)	6	6	650	560
Ethylbenzene	.	.	.	.	34	26
Toluene	(3)	(3)	(3)	5	150	55
Dimethylbenzene	5	.	(1)	.	250	190

Note: FP = False positive result; "." = Not detected; () = Estimated value below the reporting limit

Assuming the shallow groundwater at this well contains a fairly heterogeneous mixture of dissolved VOCs, it is not clear why the results for individual compounds exhibit such divergent concentration trends. Although coincident with the change from conventional sampling to low-flow sampling, this seems an unlikely cause of the sharp increase in the concentration of PCE and petroleum hydrocarbons considering the lack of any significant change in the concentration of the other VOCs in the well. Analytical errors likewise seem an unlikely explanation for sharp increase in the concentration of PCE and petroleum hydrocarbons indicated by the CY 2000 monitoring results. Perhaps these increased concentrations reflect greater relative flux of these compounds relative to the other VOCs in the shallow groundwater at this well.

Summed concentrations of VOCs detected in the groundwater samples collected from well GW-108 range from 90 µg/L in January 2000 to 358 µg/L in July 2000 (Table B.2), although the latter summed value is skewed high by results for bromomethane (170 µg/L) and chloromethane (79 µg/L), neither of which have a history of detection in well GW-108. Historical data show that chloroform and methylene chloride are the principal components of the dissolved VOC plume in the groundwater at the well (note from Table 6 that methylene chloride concentrations remain above the MCL). Compared to other components (e.g., nitrate) of the contaminant plume emplaced during operation of the former S-3 Ponds, the relatively low VOC concentrations in the shallow groundwater at well GW-108 probably reflect the smaller volume of organic wastes disposed at the site combined with lower relative mobility in the groundwater (DOE 1998). Although the concentrations remain relatively low, results for chloroform and methylene chloride indicate an increasing long-term concentration trend (see Section 3.3).

Summed concentrations of VOCs detected in the groundwater samples collected from well GW-109 range from 213 µg/L in October 2000 to 305 µg/L in June 2000 (note that both samples were collected during seasonally low flow conditions), and acetone and PCE are the dominant compounds. These results are consistent with VOC data obtained during CY 1999, which indicated little if any significant change in VOC concentrations since the previous sampling event in June 1995. For instance, the PCE concentrations evident in September 1999 (170 µg/L) and June 2000 (170 µg/L) are just slightly lower than the PCE concentration evident in June 1995 (180 µg/L). In contrast, the concentrations of the dissolved chloromethanes in the groundwater at this well reflect a clearly decreasing long-term trend (Figure A.7). For example, the concentrations of methylene chloride evident in January 1990 (58 µg/L) is more than twice the respective levels evident in the well in September 1999 (15 µg/L) and October 2000 (19 µg/L).

Several VOCs were detected in the groundwater samples collected from aquitard cluster wells GW-274 and GW-275 during CY 2000, but in contrast to the concentrations of inorganic groundwater contaminants in these wells (see Section 3.1.3.1), the dissolved VOC concentrations are substantially higher in the shallow groundwater from well GW-274 than evident in the deeper groundwater from well GW-275. This is clearly illustrated by the maximum concentration of PCE detected in well GW-274 (650 µg/L) and well GW-275 (9 µg/L) during CY 2000. Not only are the VOC concentrations much higher in well GW-274, but as shown in the following data summary (Table 8), the CY 2000 monitoring results for this well reflect a sharp increase in the concentration of PCE and benzene (see Section 3.3), but little if any change in the concentration of other VOCs in the well, such as chloroform and methylene chloride.

Table 8. Results for selected VOCs detected in well GW-274, 1990-2000

VOC	Concentration (mg/L)			
	Conventional Sampling Method		Low-Flow Sampling Method	
	January 1990	October 1995	May 2000	October 2000
PCE	(1)	36	500	650
TCE	6	6	10	12
12DCE (total)	.	(4)	5	7
Chloroform	21	17	25	28
Methylene chloride	51	37	49	57
Benzene	.	(2)	35	50

Note: "." = Not detected; () = Estimated value below analytical reporting limit; BOLD = Exceeds MCL

Note that chloroform and methylene chloride are primary organic components of the contaminant plume emplaced during operation of the former S-3 Ponds, and as noted in Section 3.1.1.1, the CY 2000 monitoring results for well GW-274 (and GW-275) show that concentrations of the primary inorganic components of the S-3 Ponds likewise reflect little if any change from respective levels evident in October 1995. As noted previously, the CY 2000 monitoring results for well GW-633, which is located about 575 ft west of well GW-274 (Figure A.2), also show minimal changes in the concentration of organic and inorganic components of the S-3 Ponds contaminant plume coincident with sharp increases in the concentrations of PCE and benzene (and other petroleum hydrocarbons). Taken together, the monitoring results for wells GW-274 and GW-633 may indicate mobilization of contaminants from nearby source areas other than the S-3 Site, such as the Rust Garage or the Y-12 Salvage Yard.

Several VOCs, primarily c12DCE, were detected in the groundwater samples collected from aquitard well GW-192 during CY 2000 (Table B.2). This well is paired with a shallow bedrock well (GW-191; not sampled in CY 2000) in the Maryville Limestone near the east side of the Beta-4 Security Pits (Figure A.2). The CY 2000 monitoring results for well GW-192 indicate that the maximum summed VOC concentration remains relatively low (40 µg/L), but as shown in Table 6, the highest concentration of TCE (7 µg/L) remains slightly above the MCL (5 µg/L). The Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader are the suspected sources of the dissolved chloroethenes in well GW-192 (DOE 1998), and the presence of dissolved chloroethenes in the shallower groundwater at this well suggests strike-parallel transport in the water table interval toward discharge areas in the upper reach of BT-1 (Figure A.4). Additionally, the preponderance of c12DCE relative to PCE and TCE suggests natural biodegradation. As shown in the following summary (Table 9), several geochemical characteristics of the groundwater, particularly the REDOX, are within the optimum range for biodegradation of dissolved chlorinated solvents.

Table 9. Geochemical indicators for biodegradation of chlorinated solvents in aquitard well GW-192

Geochemical Parameter/ Optimum Range (Wilson <i>et al.</i> 1996)	May/June 1999	November 1999	May 2000	October 2000
Nitrate < 1 mg/L	<0.028	0.0477	<0.028	0.0294
Iron (II) > 1 mg/L	6.61 *	5.85 *	2.67 *	5.98 *
Sulfate < 20 mg/L	3.58	4.83	4.15	4.87
DO <0.5 parts per million	0.25**	1.25**	0.89**	2.98**
REDOX < 50 millivolts (mV)	5 **	-44 **	93 **	-23 **
pH 5 < pH < 9	6.6 **	7.03 **	6.36 **	6.88 **

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

Several factors influence this process, including the availability of electron donors (e.g., hydrogen), and the efficiency of the process differs under methanogenic, sulfate-reducing, iron-reducing, and nitrate-reducing conditions (Chapelle 1996). The apparent lack of VC in the groundwater at well GW-192 suggests that the VC is oxidized to carbon dioxide or that the strongly reducing (methanogenic) conditions necessary to transform 12DCE isomers to VC do not occur (Wilson *et al.* 1996).

Aquitard well GW-337, which is completed at a screened interval less than 25 ft bgs in the Nolichucky Shale near the southwest corner of the WCPA (Figure A.2), monitors calcium-magnesium-bicarbonate groundwater with some of the highest dissolved VOC concentrations (>5,000 µg/L) in the East Fork Regime. Shallow groundwater at the site contains a heterogeneous mixture of chloroethenes, with c12DCE, TCE, and PCE being the primary compounds, along with lesser amounts of 111TCA and 11DCA. The high summed concentrations of VOCs in the groundwater at well GW-337 potentially indicate the local presence of DNAPL in the subsurface, which would provide a fairly stable long-term source of dissolved VOCs downgradient of the site (DOE 1998). Nevertheless, the CY 2000 monitoring results generally continue the long-term decreasing concentration trends indicated by historical VOC data for the well (Figure A.9), although the rate of decrease appears to have slowed considerably. For example, the concentration of 12DCE (total) decreased by almost 50% between July 1991 (11,000 µg/L) and May 1995 (5,700 µg/L), but decreased by less than 15% between May 1995 and October 2000 (4,959 µg/L). Also, the monitoring data for this well generally do not indicate geochemical conditions for biotic degradation of the dissolved VOCs in the groundwater. For instance, the CY 2000 results show that total iron concentrations (<0.01 mg/L) and REDOX (113-163 mV) are not within the respective optimal anaerobic ranges (Wilson *et al.* 1996). Also, historical data for the chloroethanes in the well

generally indicate a concurrent, overall decrease in the concentration of the parent compound (111TCA) and degradation products (e.g., 11DCA and 11DCE) (Figure A.9). Thus, it appears that hydrologic (e.g., dilution and dispersion) rather than biological mechanisms are the primary natural attenuation processes working to decrease dissolved VOC concentrations in the shallow groundwater at well GW-337.

Historical data show that aquifer well GW-251 monitors the plume of dissolved chloroethenes (primarily PCE and TCE) and chloromethanes (CTET and chloroform) that originates from the S-2 Site (DOE 1998). The VOC results obtained during CY 2000 are consistent with the historical data for the well and show: (1) higher summed maximum concentrations of chloroethenes (460 µg/L) relative to chloromethanes (16 µg/L), (2) substantially higher maximum concentrations of PCE (300 µg/L) and TCE (150 µg/L) relative to c12DCE (10 µg/L), and (3) a higher summed VOC concentration (476 µg/L) during seasonally high groundwater flow (May 2000) compared to the summed VOC concentration (104 µg/L) evident during seasonally low flow (October 2000). Seasonally variable concentrations suggest flushing of VOCs from the shallow karst network during seasonally and/or episodically high flow conditions in the Maynardville Limestone (DOE 1998). This may at least partially explain the substantial short-term VOC concentration fluctuations indicated by historical data for the well and account for the relatively indeterminate long-term VOC concentration trend (Table B.3).

Aquifer well GW-253 also monitors the plume of dissolved chloroethenes and chloromethanes originating from the S-2 Site. Moreover, considering that the summed maximum concentration of the VOCs detected in well GW-253 during CY 2000 (1,739 µg/L) is substantially higher than the summed maximum concentration of the VOCs detected in well GW-251 (476 µg/L), the results for well GW-253 suggest greater strike-parallel flux of VOCs to the east rather than west of the site. The CY 2000 monitoring results also indicate that the maximum concentrations of CTET (43 µg/L), PCE (690 µg/L), TCE (660 µg/L), c12DCE (230 µg/L), and VC (71 µg/L) remain above respective MCLs (see Table 6). Additionally, the VOC results obtained during CY 2000 confirm the CY 1999 results which showed a substantial increase in VOC concentrations since the well was last sampled in June 1996 (see Section 3.3).

Relatively low (<50 µg/L) summed concentrations of chloroethenes (PCE, TCE, c12DCE, and VC) were detected in the groundwater samples collected from aquifer well GW-618 during CY 2000, and only the maximum concentration of TCE (7 µg/L in May 2000) exceeds the applicable MCL. This well intercepts bedrock interval migration pathways for a plume of dissolved chloroethenes originating from one or more upgradient sources in the western Y-12 area (DOE 1998). Comparison with historical data indicates relatively steady or indeterminate long-term VOC concentration trends in the groundwater at well GW-618 (Table B.3).

Historical results show that aquifer well GW-620 monitors a plume of dissolved chloroethenes, along with lesser amounts of chloroethanes and petroleum hydrocarbons, that originates from former burn areas in the western part of the Fire Training Facility (DOE 1998). Several of these compounds, such as c12DCE and VC, are probably present as biodegradation products of parent compounds (e.g., PCE or TCE) used at the site. As illustrated by the summed concentrations, VOCs detected in the groundwater samples collected from the well in May 2000 (52 µg/L) and October 2000 (11 µg/L) continue the decreasing long-term trend indicated by historical monitoring results (Figure A.10). This decreasing trend clearly reflects the natural (biotic and abiotic) attenuation of VOCs in the Maynardville Limestone following closure of the burn areas at the Fire Training Facility.

3.1.1.3 Radioactivity

Monitoring results obtained during CY 2000 for gross alpha and gross beta radioactivity that exceed the minimum detectable activity (MDA) and the corresponding counting error (CE) were reported for nine of the 11 monitoring wells in the western Y-12 area. As shown in the following summary (Table 10), elevated levels of radioactivity in the groundwater, as determined by gross alpha activity above 15 pCi/L and/or gross beta activity above 50 pCi/L, is evident in five of the wells that were sampled during CY 2000.

Table 10. Western Y-12 area: elevated CY 2000 gross alpha and gross beta results

Well Number	Date Sampled	Gross Alpha (pCi/L)			Gross Beta (pCi/L)		
		MDA	Activity ± CE		MDA	Activity ± CE	
GW-108	01/11/00	143.99	333.3	± 156.16	90.42	8,642.12	± 198.95
GW-108	07/18/00	193.69	<MDA		164.99	9,025.39	± 307.06
GW-109	05/25/00	100	<CE	130	610	7,300	± 800
GW-109	10/19/00	240	<MDA		830	7,400	± 910
GW-253	05/23/00	5.9	86.59	± 10.61	4.65	34.13	± 5.33
GW-253	11/02/00	25.82	73.63	± 24.27	19.1	36.6	± 14.1
GW-274	05/30/00	260	<MDA		750	7,800	± 870
GW-274	10/18/00	157	<MDA		394	12,200	± 1,000
GW-633	06/08/00	17	<MDA		150	6,100	± 340
GW-633	10/24/00	26	34	± 25	79	4,100	± 200

Note: Bold = Activity exceeds MCL = 15 pCi/L (gross alpha) or SDWA screening level = 50 pCi/L (gross beta)

The highest radioactivity levels (>5,000 pCi/L) are reported for samples from wells located within the contaminant plume emplaced during operation of the former S-3 Ponds (GW-108, GW-109, GW-274, and GW-633). Table 10 also illustrates the more widespread distribution of beta radioactivity in the western Y-12 area compared to alpha radioactivity. The distribution of beta radioactivity in the groundwater, particularly the very high levels evident in wells GW-108, GW-109, GW-274, and GW-633, primarily reflect Tc-99 activity from the contaminant plume emplaced during operation of the former S-3 Ponds (DOE 1998). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee *et al.* 1983). Thus, temporal changes in Tc-99 concentrations potentially mirror temporal changes in the total flux of Tc-99 in the groundwater, especially in the shallow flow system where oxidizing conditions are most likely to occur. This is of particular interest considering the diverging long-term gross beta concentration trends in these wells (Table B.3). Clearly increasing long-term concentration trends are evident in the shallow groundwater, as indicated by gross beta results for wells GW-108, GW-274, and GW-633 (see Section 3.3), whereas clearly decreasing gross beta trends are evident in the deeper groundwater, as indicated by data for wells GW-109 and GW-275 (Figure A.11). The significance of these diverging gross beta trends is not clear from the available data, but may reflect continued upwelling of contaminant mass from deeper to shallower groundwater intervals (see Section 3.3).

Uranium isotopes are the source of the alpha and beta radioactivity in the groundwater near the S-2 Site (DOE 1998). As indicated in the data summarized on Table 10, the CY 2000 monitoring results indicate higher levels of gross alpha and gross beta radioactivity in well GW-253 relative to well GW-251. This relationship also is evident between the concentrations of other groundwater contaminants in these wells, and likewise reflects greater flux of uranium isotopes (and other contaminants) along groundwater flowpaths to the east of the site. Aside from this relationship, however, the gross alpha and gross beta results for these wells indicate relatively stable or indeterminate long-term trends (Table B.3).

3.1.2 Central Y-12 Area

Contaminants from operations at Y-12 were detected in at least one of the water samples collected during CY 2000 from one building sump, one process basin, and 13 of the 17 monitoring wells located in the central Y-12 area. The general type(s) of contaminants detected in each building sump, process basin and well, along with the hydrogeologic unit and monitored interval depth for each well, are shown in the following summary (Table 11).

Table 11. Types of contaminants detected in monitoring wells and building sumps in the central Y-12 area

CY 2000 Sampling Location	Hydrogeologic Unit/ Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
55-2C	69.0 - 75.9	. . .	!	!	.
56-2C	71.0 - 77.3	. . .	.	!	.
9212-W-2-BSMT	. . .	. . .	.	!	.
9215-STACK 11	. . .	. . .	!	!	!
GW-193	. . .	5.5 - 18.4	!	!	.
GW-204	6.5 - 17.3	. . .	!	.	!
GW-219	. . .	4.3 - 11.3	!	.	!
GW-656	8.3 - 21.5	. . .	!	!	.
GW-690	. . .	40.8 - 52.8	!	!	.
GW-700	. . .	19.0 - 31.0	!	!	.
GW-769	48.2 - 60.3	. . .	.	!	.
GW-770	7.5 - 19.0	. . .	.	!	.
GW-782	23.8 - 35.9	. . .	.	!	!
GW-791	57.5 - 70.6	. . .	.	!	.
GW-820	. . .	? - 17.3	!	!	.

The following evaluation of the CY 2000 monitoring results for these sampling locations is organized into separate discussions for each major type of contaminant.

3.1.2.1 Inorganic Contaminants

Inorganic contaminants detected in the groundwater samples collected during CY 2000 from the building sump, process basin, and monitoring wells located in the central Y-12 area are: barium, chromium, copper, chloride, manganese, nickel, nitrate, potassium, sodium, strontium, and uranium. As shown in the preceding summary (Table 11), one or more of these inorganic contaminants were detected in samples from one of the building sumps and eight of the monitoring wells, with chloride, sulfate, and uranium being the most frequently detected inorganic contaminants.

Aquitard well 55-2C is located about 500 ft directly east (parallel with geologic strike) of the WCPA (Figure A.2). The deepest well of a three-well cluster installed in August 1983 as part of an investigation of mercury contamination at Y-12, well 55-2C is completed in the Nolichucky Shale at a depth of about 76 ft bgs. Historical data show that the well monitors VOC-contaminated (see Section 3.1.2.2), moderately acidic and mineralized (TDS >1,000 mg/L), sodium-enriched, calcium-magnesium bicarbonate groundwater distinguished by elevated concentrations of the nitrate, barium, and strontium. The CY 2000 monitoring results confirm the historical data, with maximum concentrations of nitrate (154 mg/L), barium (1.33 mg/L), and strontium (4.49

mg/L) indicating respectively increasing long-term concentration trends (see Section 3.3.2). Elevated nitrate, barium, and strontium concentrations in this well reflect the eastward, strike-parallel migration of the more mobile components of the contaminant plume emplaced during operation of the former S-3 Ponds (DOE 1998).

Elevated concentrations of chloride (>20 mg/L) and/or sulfate (>30 mg/L) were reported for at least one water sample collected during CY 2000 from the process basin 9215-STACK11 and from monitoring wells GW-193, GW-204, GW-656, GW-690, GW-700, and GW-820. Elevated levels of chloride and sulfate in the shallow groundwater at many of these locations probably reflect impacts from numerous non-specific sources (including chlorinated once-through cooling water blowdown), such as leaking industrial process lines, sanitary sewers, or storm drains. However, sulfur leached from the coal stockpile overlying the Coal Pile Trench is the most likely source of the very high sulfate concentrations reported for the groundwater samples collected from aquifer wells GW-690 (368-460 mg/L) and GW-700 (106-111 mg/L). Well GW-690 is completed at a fairly shallow depth (53 ft bgs) in the lower Maynardville Limestone about 200 ft directly east (hydraulically downgradient) of the coal stockpile, and well GW-700 also is shallow (31 ft bgs) and is located about 900 ft southeast from well GW-690 (Figure A.2).

In November 2000, as part of the programmatic efforts to address DOE Order 5400.1 surveillance monitoring requirements, the Y-12 GWPP collected an unfiltered water sample for the first time from 9215-STACK11, which is the sampling point designation for a subsurface process basin located beneath the stack for a ventilation system in Building 9215 (Figure A.2). The static water level in the basin was 7.5 ft below grade when the water was sampled, and the analytical results for the sample indicate that the basin contains moderately mineralized (TDS >400 mg/L) calcium-magnesium-bicarbonate water with elevated sulfate (75.8 mg/L) and extremely high total uranium (15.4 mg/L). In groundwater, stable species of uranium include uranyl cations (+6 valence) that tend to form pH-dependent complexes with several inorganic anions, and soluble complexes with carbonate are possible under the neutral pH (field measurement of 7.49) and oxidizing (REDOX = 243 mV) conditions indicated by the November 2000 sampling results (Fetter 1993). Thus, the extremely high total uranium concentrations evident in the water in this process basin, if confirmed, may reflect the presence of mobile uranyl carbonate complexes originating from ongoing operations in Building 9215. Additional investigations into the potential for groundwater and/or surface water contamination related to 9215-STACK11 are being performed in CY 2001.

Aquitard well GW-204 is a shallow well (17.5 ft bgs) that was installed into the pit from which a petroleum fuel UST (Tank 0134-U) was excavated and removed in August 1988 (DOE 1998). The CY 2000 monitoring results for the well, which is located next to Building 9204-2 about 500 ft southeast (hydraulically downgradient) of 9215-STACK11 (Figure A.2), show that it continues to yield samples of calcium-magnesium-bicarbonate groundwater distinguished by elevated total uranium concentrations; 16 of the 18 unfiltered groundwater samples collected from the well between June 1990 (0.06 mg/L) and October 2000 (0.117 mg/L) had total uranium levels that exceed the federal MCL for drinking water (0.03 mg/L). The specific source of the elevated uranium levels (and alpha radioactivity) in the shallow groundwater at this well has not been determined, but Building 9204-2 is a likely candidate (DOE 1998). If so, then limited downgradient transport of the uranium (and/or substantial attenuation) in the shallow flow system is indicated by the much lower uranium levels evident in aquitard well GW-656, which is less than 100 ft southeast (hydraulically downgradient) of well GW-204 and is less than 50 ft east of Building 9204-2 (Figure A.2).

Aquifer well GW-219 is completed at a depth of about 11 ft bgs in the Maynardville Limestone about 50 ft east-northeast of the Uranium Oxide Vault (Figure A.2). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater with elevated total and dissolved uranium concentrations; total uranium concentrations reported for the unfiltered samples collected from the well in June 2000 (0.494 mg/L)

and October 2000 (0.449 mg/L) exceed the drinking water MCL by more than an order-of-magnitude. However, these very high uranium levels contrast with the substantially lower uranium concentrations evident in aquifer well GW-218, which is completed at a depth of about 28 ft bgs in the Maynardville Limestone less than 100 ft east of the Uranium Oxide Vault (Figure A.2). Monitoring results obtained from well GW-218 during CY 2000 show that this well yields calcium-magnesium-bicarbonate groundwater with total uranium concentrations near 0.005 mg/L, which is well below the uranium MCL and more than two orders-of-magnitude lower than the uranium concentrations evident in well GW-219. This suggests limited transport of the uranium (and/or substantial attenuation) in the shallow flow system downgradient of the well GW-219.

3.1.2.2 Volatile Organic Compounds

Excluding false-positive results, VOCs were detected in at least one of the water samples collected during CY 2000 from the building sump, the process basin, and 11 of the monitoring wells in the central Y-12 area (Table 11). These VOCs are primarily chloroethenes (PCE, TCE, c12DCE, t12DCE, 11DCE, and VC) with less frequently detected and lower concentrations of chloroethanes (111TCA and 11DCA), chloromethanes (CTET and chloroform), benzene, and miscellaneous compounds (Table B.2). Maximum summed VOC concentrations range from less than 10 µg/L in samples from sumps 9215-STACK 11 and 9212-W-2-BSTM to more than 5,000 µg/L in samples from wells GW-656 and GW-820 (Table B.2). As shown in the following data summary (Table 12), the maximum concentrations of PCE, TCE, c12DCE, 11DCE, VC, CTET, and benzene exceed respective MCLs for drinking water.

Table 12. Central Y-12 area: CY 2000 maximum VOC concentrations that exceed MCLs

Monitoring Well	Maximum Concentration (µg/L)						
	PCE	TCE	c12DCE	11DCE	VC	CTET	Benzene
55-2C	580	310	1,600	38	33	.	.
56-2C	2,600	1,100	760	15	20	.	.
GW-193	.	.	.	.	.	.	20
GW-656	70	4,500	160	600	9	.	.
GW-690	180	34	71	.	.	.	.
GW-700	190	20	66	.	.	.	.
GW-769	12	(3)	(3)	.	.	75	.
GW-782	220	63	14	33	2	.	.
GW-791	1,200	(3)	.	.	.	.	.
GW-820	3,500	560	1,200	6	110	.	.
MCL (µg/L)	5	5	70	7	2	5	5
Note: Results for each well may be from more than one CY 2000 sampling date; "." = Not detected; () = Estimated concentration below the reporting limit; Bold = Exceeds MCL							

The following discussion of the CY 2000 VOC results for these monitoring wells is presented in sequence from north and west (hydraulically upgradient) to south and east (hydraulically downgradient).

As noted previously, aquitard well 55-2C is completed at a depth of 76 ft bgs in the Nolichucky Shale about 500 ft directly east of the WCPA (Figure A.2). Monitoring results obtained during CY 2000 show that this well continues to yield groundwater samples containing a mixture of dissolved chloroethenes and chloroethanes dominated by 12DCE (>1,000 µg/L), PCE (>500 µg/L), and TCE (>300 µg/L) with lesser amounts (<50 µg/L)

of 11DCE, 111TCA, 11DCA, and VC. Dissolved components (and degradation products) of the DNAPL in the aquitard near the WCPA seems a likely source of the VOCs in the groundwater at this well. The dissolved plume of VOCs in the shallow groundwater at the WCPA is characterized by similar proportions of each compound detected in the groundwater at well 55-2C (see VOC data for well GW-337 on Table 6). Therefore, the WCPA also seems a likely source area for contaminants at well 55-2C assuming that the dissolved VOCs in the well share the predominately eastward, strike-parallel transport pattern that is traced by the more mobile inorganic components (nitrate, barium, and strontium) of the contaminant plume emplaced during operation of the former S-3 Ponds. As shown in the following data summary (Table 13), the CY 2000 monitoring results for well 55-2C reflect generally decreasing long-term VOC concentration trends.

Table 13. VOC data for aquitard well 55-2C, 1996-2000

VOC	Concentration (µg/L)			
	Conventional Sampling Method		Low-Flow Sampling Method	
	June 1996	March 1997	June 1998	May 2000
PCE	640	550	390	580
TCE	350	340	220	310
12DCE (total)	2,700	2,121	1,800	1,616
VC	<200	50	35	33

Also, these results do not indicate any clear difference between VOC results obtained from conventional sampling and low-flow sampling.

Aquitard well 56-2C is located near the southwest corner of Building 9201-4 about 1,000 ft east (downgradient and along strike) of well 55-2C (Figure A.2). Part of a three-well cluster installed in August 1983 during an investigation of mercury contamination at Y-12, well 56-2C is completed at a depth of about 77 ft bgs in the uppermost Nolichucky Shale near the contact with the Maynardville Limestone. Monitoring results obtained during CY 2000 show that this well yields sodium-bicarbonate groundwater samples containing a mixture of dissolved chloroethenes dominated by PCE (>2,000 µg/L), TCE (>1,000 µg/L), and c12DCE (>750 µg/L) with lesser concentrations (<25 µg/L) of t12DCE, 11DCE, and VC. These results are generally consistent with historical data for well 56-2C and, based on available VOC data for the shallower wells (56-2A and 56-2B) with which it is clustered, indicate that the maximum summed VOC concentration in the deeper bedrock at well 56-2C (4,559 µg/L) remain substantially higher than evident in the shallower bedrock (39 ft bgs) at well 56-2B (<1,000 µg/L) and in the water table interval (15 ft bgs) at well 56-2A (<100 µg/L). Additionally, historical monitoring data show an upward hydraulic gradient from the deeper bedrock to the shallow bedrock (0.015 between 56-2C and 56-2B) and a downward hydraulic gradient from the water table to the shallow bedrock (0.014 from 56-2A and 56-2B). Thus, dissolved chloroethenes in the deeper flow system, where the very high levels of PCE in well 56-2C suggest the presence of DNAPL, probably discharge upward into the more permeable flow system in the shallow bedrock (AJA 1999). The source of the dissolved VOCs in the groundwater at this well cluster is believed to be spills and leaks of chlorinated solvents during historical production and machining operations in Building 9201-4 and Building 9201-5 (DOE 1998).

As noted in Section 3.1.2.1, aquifer well GW-690 is completed at a depth of about 50 ft bgs in the lower Maynardville Limestone about 200 ft directly east (hydraulically downgradient) of the Coal Pile Trench and approximately 250 ft southwest of aquitard well 56-2C (Figure A.2). As shown in the following data summary (Table 14), analytical results for the groundwater samples collected from well GW-690 during CY 2000 confirm

the historical data for this well, which was sampled only once previously (June 1996), and show that it monitors groundwater containing a plume of dissolved chloroethenes dominated by PCE.

Table 14. VOC data for aquifer well GW-690, 1996-2000

VOC	Concentration (µg/L)		
	Conventional Sampling Method	Low-Flow Sampling Method	
	June 1996	June 2000	October 2000
PCE	720	66	180
TCE	26	6	34
12DCE (total)	44	12	71

Comparison with the June 1996 monitoring results suggests an overall decrease in the concentration of PCE concurrent with an overall increase in the concentrations of TCE and (total) 12DCE. These divergent concentration trends are probably not artifacts of the change from conventional sampling to low-flow sampling, which would be expected to influence the results for each VOC. Also, the monitoring results obtained during CY 2000 suggest wide temporal concentration fluctuations, with the summed VOC concentration in June 2000 (84 µg/L) about 70% lower than the summed VOC concentration in October 2000 (285 µg/L). The specific source of the VOCs in the well is not known, but if the elevated sulfate in the shallow groundwater at this well reflects strike-parallel transport of sulfate derived from the Coal Pile Trench (see Section 3.1.2.1) and assuming the same transport pattern for the dissolved VOCs in the well, then the source(s) of the VOCs likewise may lie along geologic strike to the west of the well.

Aquifer well GW-700 is completed at a shallow depth (31 ft bgs) above the Maynardville Limestone about 800 ft southeast of well GW-690 (Figure A.2). The CY 2000 monitoring results for this well, which was sampled only once previously (June 1996), show that it yields sulfate-enriched (contaminated) calcium-magnesium-bicarbonate groundwater. Samples collected during CY 2000 from well GW-700 contain a suite of dissolved chloroethenes very similar to that observed in well GW-690 and dominated by PCE. As shown in the following data summary (Table 15), comparison with the monitoring results obtained in June 1996 suggest an overall decrease in the concentration of PCE concurrent with little significant change, if not a slight increase, in the respective concentrations of TCE and 12DCE.

Table 15. VOC data for aquifer well GW-700, 1996-2000

VOC	Concentration (µg/L)		
	Conventional Sampling Method	Low-Flow Sampling Method	
	June 1996	June 2000	October 2000
PCE	360	150	190
TCE	15	11	20
12DCE (total)	46	66	63

Also, the VOC results for well GW-700 are very similar to those reported for aquifer well GW-690, which suggests that both wells may monitor a contiguous plume of dissolved chloroethenes in the Maynardville Limestone. The extent of this plume may reflect influx of VOCs transported from sources within the

catchments of the buried tributaries that discharge into the Maynardville Limestone upgradient of well GW-690 (BT-2) and well GW-700 (BT-3).

The production complex in the vicinity of Building 9212 is the suspected source of the dissolved PCE in the groundwater at aquitard well GW-791, which is south of Building 9212 about 300 ft west of Building 9215 (Figure A.2). Historical data for this well, which yields calcium-magnesium-bicarbonate groundwater from less than 75 ft bgs in the Maryville Limestone, show maximum PCE concentrations above 1,000 µg/L and indicate the presence of DNAPL (DOE 1998). Monitoring results for the well also reflect an overall lack of PCE degradation products, indicating little if any natural biodegradation of the PCE. Minimal biotic degradation of the PCE is supported by microbiologic sampling results obtained in May 2000 (see Appendix F of the CY 2000 GWMR), which suggest minimal microbiological activity in the groundwater at this well. Also, presampling groundwater elevations in well GW-791 and a shallower well (GW-792) with which it is paired (GW-792 was not sampled during CY 2000) show strong upward vertical hydraulic gradients (Figure A.12), which indicate that dissolved PCE migrates upward from the shallow bedrock (GW-791) into the water table interval (GW-792). The presampling groundwater elevations in each wells also show a fairly sudden increase in CY 1996 that may reflect a significant leak from a cooling tower located in the northeast corner of the 9212 complex (Jones 2000).

Historical monitoring data show a substantial disparity between the conventional and low-flow sampling results for PCE in well GW-791, but little if any difference between the conventional sampling and low-flow sampling results for PCE in well GW-792 (AJA 2000). To evaluate this phenomenon, the Y-12 GWPP used each sampling method to obtain samples from well GW-791 on consecutive days during each semiannual (seasonal) sampling event in CY 2000, with the low-flow sampling method used one day and conventional sampling used the next. As shown in the following summary (Table 16), analytical results for these samples confirm that the PCE concentrations in the groundwater samples from this well are strongly influenced by the sampling method, with substantially higher PCE levels evident in samples obtained with the conventional sampling method.

Table 16. PCE results obtained for aquitard well GW-791 using conventional sampling and low-flow sampling methods

Groundwater Sampling Method	PCE (µg/L)			
	May 2, 2000	May 3, 2000	October 3, 2000	October 4, 2000
Conventional Sampling	.	1,200	.	730
Low-Flow Sampling	40	.	21	.

These results show that purging the well for conventional sampling induces inflow of PCE into the well, which in turn suggests the potential for significant advective flux of dissolved PCE along the groundwater flowpaths intercepted by the well. The disparity between these PCE results suggests that either the conventional sampling method does not provide representative information with regard to dissolved PCE concentrations evident in well GW-791 under ambient hydrologic conditions, or the low flow sampling method may not provide representative information due to inadequate purging of the well. Nevertheless, the conventional and low-flow sampling results for well GW-791 (including the CY 2000 data) reflect a clearly decreasing long-term PCE concentration trend and strongly seasonal concentration fluctuations (Figure A.12), with higher concentrations during the seasonally high flow (winter and spring) and lower concentrations during seasonally low flow (summer and fall).

Aquitard well GW-656 is completed at a shallow depth (<25 ft bgs) in the Nolichucky Shale near the southeast corner of Building 9204-2 (Figure A.2). Historical data show that this well, which was last sampled in

September 1993, yields moderately acidic, chloride- and sulfate-enriched, calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved chlorinated solvents dominated by TCE and 11DCE, with lesser amounts of PCE, 12DCE, 111TCA, and 11DCA. Monitoring results obtained during CY 2000 are consistent with these historical findings and show that TCE and 11DCE remain the primary compounds in the groundwater at well GW-656, with the very high levels of TCE (>4,000 µg/L) indicating the continued presence of DNAPL (DOE 1998). The suite of dissolved VOCs in the well, with TCE rather than PCE as the dominant compound, is fairly unique compared to other wells that monitor VOC-contaminated groundwater in the East Fork Regime. This suggests a distinct (local) source area, possibly Building 9204-2 (DOE 1998). Also, the well is located near several subsurface storm drains, which may provide preferential avenues for advective transport of dissolved VOCs from an upgradient source area (HSW Environmental Consultants, Inc. 1993). In any case, the following data summary (Table 17) shows that although summed VOC concentrations reflect a substantial overall decrease from levels evident in the early 1990s, the analytical results for individual compounds reflect clearly divergent concentration trends.

Table 17. VOC data for aquitard well GW-656, 1991-2000

VOC	Concentration (µg/L)					
	Conventional Sampling Method				Low-Flow Sampling Method	
	June 1991	September 1993	June 1993	September 1993	June 2000	October 2000
PCE	.	.	99	81	61	70
TCE	17,000	14,000	11,000	10,000	4,500	4,300
1,2-DCE (total)	.	400	340	230	182	192
c12DCE	NR	NR	NR	NR	150	160
t12DCE	NR	NR	NR	NR	32	32
11DCE	2,400	2,000	1,700	1,500	420	600
VC	.	.	.	.	9	9
111TCA	430	.	.	.	2	2
11DCA	190	.	.	.	25	33
SUMMED VOCS:	21,000	16,400	13,139	11,811	5,239	5,236

Note: “.” = Not detected; NR = Not reported

For example, TCE concentrations decreased more than 50% between September 1993 and October 2000, whereas PCE concentrations decreased less than 15% over this same period. Additionally, the apparent rate of concentration decrease appears to have slowed considerably. Decreasing concentrations of the dissolved VOCs in the shallow groundwater at this well also may reflect biological degradation because, as shown in the following data summary (Table 18), the geochemical conditions (aside from the elevated sulfate levels) are favorable to the biotic degradation of chlorinated solvents.

Table 18. Geochemical indicators for biodegradation of chlorinated solvents in aquitard well GW-656

Geochemical Parameter/ Optimum Range (Wilson <i>et al.</i> , 1996)	June 1991	June 1993	June 2000
Nitrate < 1 mg/L	<0.02	0.33	0.0685
Iron (II) > 1 mg/L	4.4 *	7.1*	1.11 *
Sulfate < 20 mg/L	67	61	52.6
REDOX < 50 mV	3.3 **	9.0**	-12.0**
pH 5 - 9	6.8 **	6.5**	6.54 **

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

Moreover, results of microbiologic sampling performed by the GWPP in June 2000 indicated the presence of slime-forming bacteria (50,000 colony forming units per milliliter [CFU/ml]) in the shallow groundwater at this well (see Appendix F in the CY 2000 GWMR). Also, as noted in Section 3.1.1.2, biodegradation of dissolved chlorinated solvents is strongly influenced by the availability of electron donors. Well GW-656 is less than 100 ft downgradient of a former petroleum fuel UST (Tank 0134-U) and petroleum hydrocarbons that leaked from this UST may have served as electron donors. If so, the biodegradation of the chlorinated solvents may have slowed as the reservoir of petroleum hydrocarbons was depleted following removal of UST (petroleum hydrocarbons were not detected in any of the groundwater samples collected from the well after December 1991).

Aquitard well GW-782 is completed at a depth of 36 ft bgs in the upper Nolichucky Shale about 100 ft southwest of Building 9731 (Figure A.2). Historical data show that the well monitors calcium-magnesium-bicarbonate groundwater containing a mixed plume of dissolved chloroethenes, chloroethanes, and chloromethanes that is believed to originate from one or more sources in the vicinity of Building 9204-2 and Building 9731 (DOE 1998). The CY 2000 VOC results are consistent with historical data for the well, which has been sampled on a continuous quarterly or semiannual frequency since June 1994, and as illustrated by the following summary of CY 1999 and CY 2000 VOC data (Table 19), indicate that summed VOC concentrations remain above 400 µg/L with PCE and 11DCA being the dominant compounds.

Table 19. Selected VOC results for aquitard well GW-782, 1999-2000

VOC and Associated Reporting Limit (µg/L)	Concentration (µg/L)			
	May 1999	October 1999	May 2000	October 2000
PCE 5	180	170	220	160
TCE 5	62	46	63	49
c12DCE 5	15	12	12	14
VC 10/2	(2)	(3)	.	2
111TCA 5	5	15	.	8
11DCA 5	110	160	92	150
11DCE 5	32	43	24	33
SUMMED VOCs:	415	457	411	416

Note: “.” = Not detected; () = Estimated concentration below the reporting limit, reporting limit for VC changed from 10 µg/L to 2 µg/L in CY 2000

The concentrations of dissolved VOCs in the shallow groundwater at this well also may reflect the varying influence of natural attenuation processes. For instance, abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), might at least partially account for the preponderance of 11DCA and 11DCE relative to 111TCA in the well. This is consistent with microbiologic sampling results obtained by the Y-12 GWPP in May 2000, which indicate low (presumably) numbers of iron-related bacteria (100 CFU/ml), slime-forming bacteria (<100 CFU/ml), and sulfate-reducing bacteria (1,000 CFU/ml).

Aquifer well GW-193 yields calcium-magnesium-bicarbonate groundwater from less than 20 ft bgs in the lower Maynardville Limestone about 200 ft north of the UEFPC channel near the eastern end of Building 9201-1 (Figure A.2). Shallow groundwater in this well, which has an extensive quarterly (March 1991 - November 1993) and semiannual (March 1997 - July 2000) sampling history, contains a plume of dissolved petroleum hydrocarbons (benzene, chlorobenzene, dimethylbenzene, ethylbenzene, and toluene) originating from a former petroleum fuel UST (Tank 2331-U) that was excavated and removed in December 1988 (DOE 1998). Aside from benzene in the sample collected in January 2000 (20 µg/L), no other VOCs were detected in the groundwater samples collected from the well during CY 2000. Moreover, the groundwater sample collected from the well in July 2000 is the only one obtained from the well that has not contained benzene. This is consistent with the clearly decreasing long-term concentration trend indicated by historical data for the well. For example, benzene concentrations ranged from about 1,200 to 6,200 µg/L from 1991 to 1993, then decreased to about 100 µg/L through 1998, and dropped below 50 µg/L for the first time in July 1999. Nevertheless, the persistence of the dissolved petroleum hydrocarbons in the shallow groundwater at this well is somewhat surprising considering their high mobility in groundwater (particularly benzene), the cumulative affects of dilution and dispersion over the past 10 years, and the propensity for biological degradation.

Aquifer well GW-820 is located near the southwest (upgradient) corner of Building 9201-2 about 250 ft east-southeast of well GW-193 (Figure A.2). Available well construction data indicate that this well is completed at a shallow depth (<25 ft bgs) in the Maynardville Limestone. As shown in the following data summary (Table 20), the CY 2000 monitoring results for this well, which was sampled only three times previously (March 1997, March 1998, and September 1999), show that it monitors a plume of dissolved chloroethenes dominated by PCE concentrations that equal or exceed 1% of pure-phase solubility (1,500 µg/L).

Table 20. Selected VOC results for aquifer well GW-820, 1997-2000

VOC	Concentration (µg/L)				
	Conventional Sampling Method	Low Flow Sampling Method			
	March 1997	March 1998	September 1999	April 2000	November 2000
PCE	5	7,300	1,500	3,500	2,600
TCE	600	590	250	560	480
c12DCE	5,000	870	940	1,000	1,200
t12DCE	Not Reported	6	16	5	8
VC	Not Reported	65	130	89	110
SUMMED VOCs:	5,605	8,831	2,836	5,154	4,398

These monitoring results indicate that PCE may be present as DNAPL in the subsurface near the western (upgradient) end of Building 9201-2. Additionally, natural biodegradation of the PCE is suggested by the high and generally increasing concentrations of c12DCE and VC, the latter of which substantially exceeds the MCL for drinking water (2 µg/L). Moreover, the CY 2000 monitoring results continue the apparently divergent seasonal concentration variations indicated by the previous monitoring results. As shown in the preceding data summary, for example, in April 2000 (i.e., seasonally high flow conditions) the concentration of PCE is about 25% higher than evident in November 2000 (i.e., seasonally low flow conditions), whereas the concentration of c12DCE in April 2000 is about 25% lower than evident in November 2000. The mechanism(s) governing these temporal concentration fluctuations are not clearly characterized by available data. Additionally, the operation of de-watering sumps in the basement of Building 9201-2 may effectively capture the bulk of the contaminant mass in the shallow flow system near this well (DOE 1998).

Aquitard well GW-770, which is completed at a shallow depth (<20 ft bgs) in the Nolichucky Shale, forms a well cluster with shallow bedrock well GW-769 (60 ft bgs) near the northeast corner of Building 9201-2 (Figure A.2). Historical data show that both of these wells yield calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved chloroethenes (PCE, TCE, and c12DCE) and chloromethanes (CTET and chloroform). The CY 2000 monitoring results for well GW-769 are consistent with historical VOC data, with CTET (25 and 75 µg/L), chloroform (3 µg/L), PCE (8 and 12 µg/L) each detected in the groundwater samples collected from the well in April and October 2000 (note that the CTET and PCE levels exceed respective MCLs). Also, these results continue the relatively stable or indeterminate long-term concentrations trends indicated by historical data for the well (Table B.3). The CY 2000 monitoring results for well GW-770 also are consistent with historical VOC data, with low levels of chloroform and CTET (<10 µg/L) detected in the groundwater samples collected from the well in April and October 2000. These results likewise continue the relatively stable or indeterminate long-term concentrations trends indicated by historical data for the well (Table B.3). Because basement sumps in Building 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) of these VOCs may be located to the north of the well, possibly Buildings 9202, 9203, and 9205 where large amounts of CTET were used to convert uranium trioxide to uranium tetrachloride (DOE 1998).

3.1.2.3 Radioactivity

Monitoring results obtained during CY 2000 support historical monitoring data and do not indicate widespread radiological contamination in the central Y-12 area. As shown in the following summary (Table 21), elevated levels of radioactivity (gross alpha activity above 15 pCi/L and/or gross beta activity above 50 pCi/L) were reported only for the process basin and three monitoring wells, with the highest radioactivity levels (>1,000 pCi/L) reported for the water sample collected from process basin 9215-STACK11.

Table 21. Central Y-12 area: elevated CY 2000 gross alpha and gross beta results

Sampling Point	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
		MDA	Activity ± CE	MDA	Activity ± CE
9215-STACK11	11/30/00	2.8	5,100 ± 86	6.5	2,800 ± 45
GW-204	06/07/00	2.3	28 ± 5.8	10	11 ± 6.7
GW-204	10/24/00	2.8	71 ± 10	7.4	34 ± 6.7
GW-219	06/06/00	2.4	100 ± 11	8	89 ± 9.5
GW-219	10/30/00	3.5	26 ± 6.1	8.5	24 ± 6.6
GW-782	05/01/00	3.2	62 ± 8.7	7.7	10 ± 5.2
GW-782	10/03/00	5.6	54 ± 10	7	7.5 ± 4.6

Note: Bold = Activity exceeds MCL (gross alpha) or SDWA screening level (gross beta)

The following discussion of the CY 2000 radiological results is presented in the same sequence as listed in the preceding data summary.

As noted in Section 3.1.2.1, the Y-12 GWPP sampled the water in subsurface process basin 9215-STACK11 for the first time in November 2000. Analytical results for this sample indicate very high levels of alpha and beta radioactivity that substantially exceed the drinking water MCL (15 pCi/L) and the SDWA screening level (50 pCi/L), respectively. Additionally, results of isotopic analyses show that U-234 (870 ± 160 pCi/L) and U-238 (5,800 ± 1,000 pCi/L) are the primary radionuclides in the basin water.

Data obtained during CY 2000 support previous findings of elevated gross alpha radioactivity (i.e., >15 pCi/L) in the shallow groundwater at aquitard well GW-204 east of Building 9204-2 (Figure A.2). Neither of the groundwater samples collected from the well during CY 2000 were analyzed for specific radionuclides, but historical results show that uranium isotopes (primarily U-234 and U-238) are the primary source of the alpha and beta radioactivity in the shallow groundwater at this well. Additionally, the CY 2000 gross alpha results (28 - 71 pCi/L) are somewhat less than the result for September 1999 (95 pCi/L) and are similar to the quarterly sampling results for well GW-204 in CY 1993 (30.7 - 102 pCi/L). Building 9204-2 is the presumed source of the uranium isotopes in the well (DOE 1998).

Aside from 9215-STACK 11, the highest levels of gross alpha radioactivity (100 ± 11 pCi/L) and gross beta radioactivity (89 ± 9.5 pCi/L) in the central Y-12 area were reported for the groundwater sample collected from well GW-219 in June 2000. As noted in previously, this well is completed at a shallow depth (11 ft bgs) in the Maynardville Limestone near the Uranium Oxide Vault and it typically yields groundwater samples with elevated (i.e., >MCL) total uranium concentrations. Moreover, results of isotopic analyses confirm the presence of uranium isotopes in the shallow groundwater at this well, with the October 2000 sampling results for U-234 (20 pCi/L) and U-238 (140 pCi/L) indicating a slight decrease from the respective levels of U-234 (31 pCi/L) and U-238 (220 pCi/L) evident in December 1999. These uranium isotopes may be from a relatively nearby source (possibly the Uranium Oxide Vault) because they probably occur as uranyl cations, which are prone to pH-sensitive sorption reactions and consequently are not usually highly mobile in groundwater (Fetter 1993).

The CY 2000 results showing elevated gross alpha activity in the groundwater at aquitard well GW-782, located southwest of Building 9731 (Figure A.2), are consistent with historical results, including data obtained during the RI identifying U-234 as the principal alpha-emitting isotope in the well (DOE 1998). In contrast, historical

data (including RI results) show essentially background levels (i.e., <MDA) of gross alpha activity in the shallower (GW-783) and deeper (GW-781) wells clustered with GW-782. Background gross alpha levels in the shallower and deeper groundwater suggest stratabound (strike- or dip-parallel) migration of uranium isotopes and associated daughter products along the groundwater flowpaths intercepted by well GW-782. Additionally, historical results for well GW-782 show a frequently inverse relationship between gross alpha activity and the pre-sampling groundwater elevation in the well, including a notably sharp activity decrease and water level increase following a 1.8-inch rainfall in March 1995 (AJA 1996). Also, a generally increasing long-term trend is indicated by a time-series plot of the gross alpha results for well GW-782, but this upward trend appears to be an artifact of the change from conventional sampling to low-flow sampling. For example, excluding alpha activity “spikes” in February 1996 (52 pCi/L) and May 1997 (44 pCi/L), the conventional sampling results range between 10 and 30 pCi/L and reflect a relatively stable or indeterminate trend (Figure A.13); the low-flow sampling results for gross alpha reflect a similarly indeterminate trend at slightly higher levels ranging between 43 pCi/L in May 1998 and 64 pCi/L in October 1999. In any case, the source of the uranium isotopes in the well is believed to be historical spills and leaks from nearby process buildings where large amounts of radionuclides were routinely handled (DOE 1998).

3.1.3 Eastern Y-12 Area

As shown in the following summary (Table 22), groundwater samples collected during CY 2000 from 12 of the 13 monitoring wells in the eastern Y-12 area contained one or more inorganic, organic, and radiological contaminants.

Table 22. Types of contaminants detected in monitoring wells in the eastern Y-12 area

Well Number	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-153	. . .	45.0 - 60.0	.	!	.
GW-154	. . .	4.7 - 11.2	!	.	!
GW-222	. . .	18.0 - 25.0	!	!	!
GW-223	. . .	79.0 . 90.5	!	!	.
GW-240	. . .	21.0 - 29.5	.	!	.
GW-381	. . .	49.3 - 60.4	!	!	.
GW-382	. . .	125.0 - 173.0	!	!	.
GW-383	16.6 - 23.6	. . .	.	!	.
GW-605	. . .	28.2 . 39.9	!	!	!
GW-606	. . .	155.0 - 171.0	!	!	.
GW-762	46.4 - 58.7	. . .	.	!	.
GW-763	4.0 - 16.0	. . .	!	!	.

The following evaluation of the CY 2000 monitoring results for these wells is organized into separate discussions for each major type of groundwater contaminant.

3.1.3.1 Inorganic Contaminants

One or more inorganic contaminants were detected in groundwater samples collected during CY 2000 from eight wells in the eastern Y-12 area: GW-154, GW-222, GW-223, GW-381, GW-382, GW-605, GW-606, and

GW-763. Inorganic contaminants detected in these samples were chloride, iron, nitrate, sulfate, and uranium. The following evaluation of the CY 2000 monitoring results for these wells is presented in sequence from westernmost wells to the easternmost wells (i.e., from farthest upgradient to farthest downgradient).

Aquifer wells GW-605 and GW-606 comprise a well cluster in the lower Maynardville Limestone about 1,400 ft west (hydraulically upgradient) of New Hope Pond (Figure A.2). The extensive historical data for these wells, which have been sampled on a continuous quarterly or semiannual frequency since August 1991, show that both yield moderately mineralized (TDS >400 mg/L) calcium-magnesium-bicarbonate groundwater containing elevated levels (>25 mg/L) of chloride and sulfate. Atypically high concentrations of chloride and sulfate in these wells may reflect contamination in the groundwater (and surface water) from multiple industrial sources (e.g., leaking process lines or subsurface drains) within Y-12 upgradient of the wells, although the elevated chloride concentrations also may be at least partially attributable to in-situ degradation of dissolved chlorinated solvents in the groundwater.

Groundwater samples from well GW-605 are distinguished by elevated total concentrations of elemental uranium (and uranium isotopes). The specific source(s) of the uranium in the groundwater at this well, which is completed at a depth of about 40 ft bgs, has not been identified, but the well may penetrate fill material containing low-level radioactive materials potentially derived from historical uranium enrichment activities performed in Buildings 9201-1, 9201-2, and 9201-3 (DOE 1998). The CY 2000 monitoring results show that the total uranium levels in the well remain above the MCL (0.03 mg/L), with the highest uranium concentrations reported for the groundwater sample collected in July 2000 (0.0897 mg/L). These uranium results reflect a partial rebound toward the much higher uranium level evident in March 1998 (0.33 mg/L). The sharp decrease and subsequent recovery of the uranium concentrations potentially reflects the influence of the stepped pumping test described in Section 2.4. Manual water level monitoring in well GW-605 during the pumping test showed only a slight water level decrease (0.11 ft) at the end of the 7-day 100 gpm pumping interval, which may indicate constant head recharge from UEFPC (SAIC 1998). If so, increased recharge from UEFPC in response to the pumping test may have diluted the uranium levels in the shallow flow system near the well, with the CY 2000 uranium results reflecting a continued rebound toward the uranium concentrations that were evident in the well before the pumping test.

Although significantly below the MCL (10 mg/L), nitrate concentrations reported for the groundwater samples collected from aquifer well GW-606 in January 2000 (2.65 mg/L) and July 2000 (6.3 mg/L) exceed background levels (<1 mg/L) in the Maynardville Limestone. These nitrate results support the similarly elevated nitrate concentrations reported for the samples collected from this well in March 1998 (4.8 mg/L), July 1998 (4.69 mg/L), February 1999 (5.1 mg/L), and July 1999 (4.6 mg/L). Additionally, the maximum nitrate concentrations during each of these years are more than double the previous maximum nitrate concentration (1.7 mg/L in March 1995). This disparity with historical nitrate data coincides with the change from conventional sampling to low-flow sampling, which suggests that purging the well for conventional sampling may induce greater inflow of uncontaminated groundwater that effectively dilutes the nitrate levels in the well. Nevertheless, the presence of nitrate in the relatively deep groundwater at this monitoring well, which is completed at a depth of about 175 ft bgs, potentially indicates substantial (>5,000 ft) strike-parallel migration at depth in the Maynardville Limestone from the contaminant plume(s) emplaced during operation of the S-2 Site or the former S-3 Ponds. Alternatively, nitrate concentrations in the groundwater at this well may reflect nitrate contamination from a stockpile of urea formerly located about 400 ft southwest (upgradient) of well GW-606 (Figure A.2).

Aquifer wells GW-381 and GW-382 are part of a three-well cluster (along with well GW-380) in the Maynardville Limestone about 1,000 ft east (hydraulically downgradient) of wells GW-605/GW-606 and approximately 400 ft west (hydraulically upgradient) of New Hope Pond (Figure A.2). Wells GW-381 and GW-

382, each of which have an extensive sampling history, yield calcium-magnesium-bicarbonate groundwater distinguished by very high chloride and (total) iron concentrations. Chloride levels exceed 40 mg/L in both wells, with maximum concentrations of total iron exceeding 4 mg/L in well GW-382 and 10 mg/L in well GW-381. The source of the elevated chloride levels is not known and may be one or more of a number of industrial sources in the eastern Y-12 area upgradient of the well, including chloride from biotic degradation of dissolved chlorinated solvents in the groundwater. Also, the unusually high iron levels in these wells may be from corrosion of the well casing in each well, both of which are constructed with carbon steel casing (American Petroleum Institute Grade F25) and open-hole monitoring intervals (Lockheed Martin Energy Systems 1998).

Aquifer wells GW-154, GW-222, and GW-223 comprise a three-well cluster in the Maynardville Limestone adjacent to the preconstruction channel of UEFPC on the western side of New Hope Pond about 250 ft east of Building 9720-6 (Figure A.2). Well GW-154 is completed at a depth of about 11 ft bgs, well GW-222 is completed at a depth of 25 ft bgs, and well GW-223 is completed at a depth of about 90 ft bgs. Groundwater samples were collected from wells GW-154 and GW-223 during CY 1999, but groundwater in well GW-222 was last sampled in November 1996. Respective historical data show that each well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater containing elevated concentrations of elemental uranium. The historical data also show that total uranium concentrations in the shallower groundwater at wells GW-154 and GW-222 are substantially higher than evident in the deeper groundwater at well GW-223. As shown in the following summary (Table 23), uranium results obtained during CY 2000 are consistent with the respective historical monitoring data and indicate that concentrations in wells GW-154 and GW-222 exceed the MCL for drinking water (0.03 mg/L) and remain significantly higher than evident in well GW-223.

Table 23. Selected total uranium results for aquifer wells GW-154, GW-222, and GW-223, 1986-2000

Monitoring Well	Total Uranium (mg/L)									
	Conventional Sampling						Low-Flow Sampling			
	1986		1990		1996		1999		2000	
	1 ST QTR.	3 RD QTR.	1 ST QTR.	3 RD QTR.	1 ST QTR.	3 RD QTR.	1 ST QTR.	3 RD QTR.	2 ND QTR.	3 RD /4 TH QTR.
GW-154	0.021	0.022	2.35	0.751	0.4	0.2	0.267	0.286	0.766	0.609
GW-222	0.029	0.012	0.099	0.364	0.28	0.083	NS	NS	0.136	0.0812
GW-223	0.009	0.009	0.001	0.004	0.012	0.02	NS	0.0236	0.0221	0.0221

Note: BOLD = Exceeds MCL (0.03 mg/L); NS= Not sampled

Following closure of New Hope Pond in 1988, total uranium concentrations in the groundwater at monitoring wells GW-154 and GW-222 generally decreased before increasing sharply in CY 2000 to the highest levels evident in either well since September 1990 (GW-154) and March 1996 (GW-222). Uranium levels in the deeper groundwater at well GW-223, although substantially lower than in either of the shallower wells, also increased after New Hope Pond was closed but have remained relatively unchanged since August 1996 (see Table 23). These divergent uranium concentration trends generally correspond with distinctive changes in the groundwater elevations in these wells. Before New Hope Pond was closed and flow in UEFPC was diverted into Lake Reality, pre-sampling groundwater elevations in wells GW-154 and GW-223 reflected consistently upward vertical hydraulic gradients (Figure A.14). Following closure of New Hope Pond and initial operation of Lake Reality, the pre-sampling groundwater elevations in these wells have reflected downward vertical hydraulic gradients. The reversal of the vertical hydraulic gradients may be a direct consequence of the closure

of the former Oil Skimmer Basin because visual evidence of a direct hydraulic connection with the basin was observed during installation of wells GW-154 and GW-222 (Geraghty & Miller, Inc. 1989). The Oil Skimmer Basin, which was a 25 x 40 ft sediment-accumulation basin located near the inlet to New Hope Pond, is considered the most likely source of a distinctive contaminant signature characterized by elevated uranium concentrations along with alpha and beta radioactivity (DOE 1998).

Aquitard well GW-383 is completed at a depth of about 24 ft bgs in the Nolichucky Shale near the southwest (upstream) end of Lake Reality (Figure A.2). Monitoring data for this well, which has an extensive 10-year quarterly (1991-1996) and semiannual (1997-2001) sampling history, show that it yields chloride-enriched calcium-magnesium-bicarbonate groundwater containing a plume of dissolved chlorinated solvents (see Section 3.1.3.2). The CY 2000 monitoring results are consistent with the historical data, with elevated levels of chloride reported for the samples collected from the well in May (45 mg/L), August (45.4 mg/L), and October 2000 (43.5 mg/L). Unusually high chloride concentrations in the shallow groundwater at this well may reflect transport from one or more upgradient sources in Y-12, such as leaking sanitary sewers, but also may at least partially result from the degradation of dissolved chlorinated solvents in the groundwater.

3.1.3.2 Volatile Organic Compounds

Excluding false-positive results, one or more chloromethanes (CTET and chloroform), chloroethenes (PCE, TCE, c12DCE, t12DCE, 11DCE, and VC), and chloroethanes (111TCA and 11DCA) were detected in at least one groundwater sample collected during CY 2000 from 11 of the 13 monitoring wells in the eastern Y-12 area (Table B.2). As shown in Table 24, the maximum concentrations of either PCE, TCE, c12DCE, 11DCE, VC, or CTET in the samples collected from each of these eleven monitoring wells exceed the respective drinking water MCL.

Table 24. Eastern Y-12 area: CY 2000 maximum VOC concentrations that exceed MCLs

Well Number	CY 2000 Maximum Concentration (µg/L)					
	PCE	TCE	c12DCE	11DCE	VC	CTET
GW-153	7	.	.	.	.	280
GW-222	110	29	45	.	(1)	28
GW-223	110	31	95	.	3	.
GW-240	.	.	.	.	.	6
GW-381	7	.	(4)	.	.	1000
GW-382	17	(2)	(3)	.	.	1400
GW-383	610	200	150	(3)	2	.
GW-605	54	57	100	.	.	62
GW-606	7	.	.	.	.	75
GW-762	2400	150	66	51	6	.
GW-763	62	14	150	5	13	.
MCL (µg/L)	5	5	70	7	2	5

Notes: “.” = Not detected; () = Estimated concentration below the reporting limit; Bold = Exceeds MCL

The following discussion of the CY 2000 VOC results for these monitoring wells is presented in sequence from west and north (hydraulically upgradient) to south and east (hydraulically downgradient) of New Hope Pond/Lake Reality.

As noted previously, aquifer well GW-605 is located about 1,400 ft west (hydraulically upgradient) of New Hope Pond (Figure A.2). Monitoring results obtained during CY 2000 support historical data showing that the groundwater in this well contains a mixture of dissolved chlorinated solvents, including chloroethenes (PCE, TCE, and c12DCE) and chloromethanes (CTET and chloroform). These monitoring results are consistent with previous VOC data reported for samples obtained from the well with the low-flow sampling method, which reflect a substantial divergence from the historical VOC data reported for samples obtained from the well with the conventional sampling method. As shown in the following data summary (Table 25), results of low-flow sampling show generally higher concentrations of PCE, TCE, and c12DCE relative to the corresponding conventional sampling data, whereas the results of conventional sampling show generally higher concentrations of CTET and chloroform relative to the corresponding low-flow sampling data.

Table 25. Selected VOC data for aquifer well GW-605, 1995-2000

VOC	Concentration (µg/L)											
	Conventional Sampling						Low-Flow Sampling					
	Mar. 1995	Sep. 1995	Feb. 1996	June 1996	Mar. 1997	Aug. 1997	Mar. 1998	July 1998	Feb. 1999	July 1999	Jan. 2000	July 2000
PCE	15	65	21	14	(3)	7	.	35	12	27	15	54
TCE	4	25	8	5	(1)	(2)	.	43	14	30	16	57
c12DCE	12	54	21	13	(3)	5	.	79	24	55	27	100
CTET	200	320	190	250	100	170	(4)	42	10	25	11	62
Chloroform	18	35	26	23	FP	16	.	11	12	11	7	10

Notes: () = Estimated concentration below analytical reporting limit; "." = Not detected; FP = False positive

Note also that c12DCE concentrations are about twice the PCE concentrations reported for samples obtained using the low-flow sampling method, while the concentrations of these compounds were nearly equal for samples collected using the conventional method. Assuming that the groundwater in the well contains a heterogeneous mixture of dissolved VOCs, it is unclear why the change from conventional sampling to low-flow sampling would yield data that reflect such divergent concentration trends (see Section 3.3). Also, results obtained from well GW-605 with both sampling methods reflect substantial short-term concentration fluctuations, as illustrated by the PCE results obtained from low-flow sampling in January (15 µg/L) and July 2000 (54 µg/L) and from conventional sampling in March (15 µg/L) and September 1995 (65 µg/L). These short-term temporal variations in the VOC concentrations dominate the long-term concentration trends and potentially reflect widely variable flux of these compounds along the groundwater flowpaths intercepted by well GW-605. Although the long-term concentration trends for chloromethanes and chloroethenes are slightly decreasing or indeterminate, the concentration trends indicated by respective low-flow sampling results are generally increasing (see Section 3.3).

The CY 2000 VOC results for aquifer well GW-606 are consistent with historical data showing that CTET and chloroform, along with low levels of PCE, are the principal components of the dissolved VOC plume at intermediate depths in the Maynardville Limestone upgradient (west) of New Hope Pond/Lake Reality. Although maximum CTET and PCE concentrations in well GW-606 remain above respective MCLs during CY 2000 (see Table 24), these results nevertheless continue the decreasing (CTET) and indeterminate (PCE) long-term concentration trends indicated by historical data for the well (Figure A.15). These trends are accompanied by widely fluctuating but generally increasing concentrations of chloroform (see Section 3.3), with the chloroform concentration reported for the sample collected from the well in July 2000 (430 µg/L) being the

highest reported for the well since August 1992 (440 µg/L). Also, chloroform concentrations have exceeded CTET concentrations since low-flow sampling began, and the increasing concentration of chloroform and the concurrently decreasing concentration of CTET may be least partially attributable to biotic and/or abiotic degradation in the groundwater.

As noted previously, aquifer wells GW-381 and GW-382 are clustered in the Maynardville Limestone west (hydraulically upgradient) of New Hope Pond about 1,000 ft east (hydraulically downgradient) of aquifer wells GW-605/GW-606 (Figure A.2). Historical data show that the groundwater in shallow bedrock well GW-381 (60 ft bgs), which was last sampled in May 1995, has contained very high levels of CTET (>5,000 µg/L) and chloroform (>500 µg/L), with the CTET concentrations potentially indicative of DNAPL in the subsurface south of Building 9720-6 (SAIC 1998). The CY 2000 monitoring data show the continued presence of both compounds in the shallow groundwater at this well, although the levels of CTET (130 µg/L) and chloroform (63 µg/L) detected in the sample collected in October 2000 are not only substantially lower than the concentrations evident in May 2000 (1,000 µg/L and 280 µg/L, respectively), but are the lowest levels ever reported for the well. Additionally, as illustrated in the following data summary (Table 26), these monitoring results continue the steadily decreasing long-term concentration trend for CTET and the more widely fluctuating long-term concentration trend for chloroform.

Table 26. Selected results for CTET and chloroform in aquifer well GW-381, 1991-2000

VOC	Concentration (µg/L)						
	Conventional Sampling					Low-Flow Sampling	
	May 1991	April 1992	April 1993	May 1994	May 1995	May 2000	October 2000
CTET	6,700	5,900	4,800	2,500	1,900	1,000	130
Chloroform	680	700	380	640	2,200	280	63

The sharp decrease (an order of magnitude) in the CTET and chloroform concentrations indicated by the October 2000 sampling results, if confirmed by future sampling, may be a direct consequence of the efforts to capture the CTET-dominated VOC plume in the Maynardville Limestone before it exits the regime. The capture zone pumping well (GW-845) began operating in October 2000 shortly before well GW-381 was sampled (see Section 3.2.1). This finding is consistent with results of the aquifer pumping test described in Section 2.4, because groundwater elevations in well GW-381 exhibited direct responses to the stepped pumping rates (25, 50, and 100 gpm) in well GW-845, which is located about 2,500 ft east (along geologic strike) of well GW-381 (Figure A.2).

A mixture of several dissolved chloroethenes dominated by PCE (>10 µg/L), along with substantially higher concentrations of chloroform (>500 µg/L) and CTET (>1,000 µg/L) were detected in the groundwater samples collected from well GW-382 during CY 2000. The very high concentrations of CTET in the well, which is completed at a depth of 173 ft bgs, potentially indicate the presence of DNAPL at depth in the Maynardville Limestone south of Building 9720-6 (SAIC 1998). As shown in the following data summary (Table 27), these monitoring results generally continue the long-term decrease in the concentration of CTET and the concurrent overall increase in the concentration of chloroform in the well, but also reflect a sharp drop in the concentration of PCE in the well.

Table 27. Selected results for CTET, chloroform, and PCE in aquifer well GW-382, 1991-2000

VOC	Concentration (µg/L)							
	Conventional Sampling				Low-Flow Sampling			
	May 1991	Aug. 1991	April 1993	Aug. 1993	May 1995	Sep. 1999	May 2000	Sep. 2000
CTET	6,500	6,800	5,500	6,500	4,500	1,900	1,400	1,300
Chloroform	180	200	380	330	270	920	540	610
PCE	210	260	250	230	200	110	17	13

Unlike the sampling results for well GW-381, the CY 2000 VOC results for well GW-382 do not reflect any potential response to the efforts to capture the dissolved VOC-plume in the Maynardville Limestone because the groundwater in the well was sampled before the plume-capture pumping well (GW-845) began operating in October 2000. Thus, assuming a fairly heterogeneous mixture of dissolved VOCs in the groundwater at well GW-382, it is not clear from the available monitoring data why the CTET, chloroform, and PCE results reflect such divergent long-term concentration trends. Chloroform is a product of the biotic and abiotic degradation of CTET, which may account for both the decreasing concentration of CTET and the increasing concentration of chloroform in the well (see Section 3.3). Degradation of the PCE in the groundwater, however, seems a less likely explanation for the sharp concentration decrease indicated by the PCE results obtained during CY 2000, which represent the lowest PCE concentrations ever reported for the well. Moreover, these PCE results do not appear to be an artifact of the change to low-flow sampling because, as illustrated by the preceding data summary (Table 27), the PCE concentration evident from low-flow sampling in September 1999 (110 µg/L) is similar to the previous conventional sampling results for PCE. Also, the lack of concurrent changes in the concentrations of other VOCs in the well (e.g., chloroform) tends to discount sampling or analytical errors as the likely cause of the sharply lower PCE concentrations.

Aquifer wells GW-153 and GW-240 comprise a well cluster located directly south of New Hope Pond about 750 ft east (hydraulically downgradient) of the GW-381/GW-382/GW-383 well cluster (Figure A.2). Historical monitoring data show that both of these wells, which are completed in the Maynardville Limestone at respective depths of 60 ft and 29.5 ft bgs, yield calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved VOCs dominated by CTET. Monitoring results obtained for each well during CY 2000 are generally consistent with respective historical data, with CTET and chloroform detected in the samples collected from each well, and PCE detected in the samples collected from well GW-153. Additionally, as shown in the following data summary (Table 28), dissolved VOC concentrations in the deeper groundwater at well GW-153 are substantially higher than evident in the shallower groundwater at well GW-240.

Table 28. Selected results for CTET, chloroform, and PCE in aquifer wells GW-153 and GW-240, 1991-2000

Monitoring Well/ VOC	Concentration (µg/L)								
	Conventional Sampling						Low-Flow Sampling		
	Apr./May 1991	Nov. 1992	Apr./May 1993	Nov. 1994	May 1995	Nov. 1996	May 2000	Oct. 2000	
GW-153	CTET	120	NS	NS	100	180	270	270	280
	Chloroform	7	NS	NS	8	7	10	12	12
	PCE	5	NS	NS	(4)	6	8	7	7
GW-240	CTET	8	14	8	9	14	17	5	6
	Chloroform	.	FP	(0.8)	(1)	(2)	(3)	.	(3)
	PCE	.	FP	(0.6)	.	(1)	.	.	.

Note: NS = Not sampled; () = Estimated value below reporting limit; FP = False positive; "." = Not detected

The CY 2000 monitoring results also show that the concentrations of the VOCs detected in each well have changed little from the respective levels evident when each well was last sampled in November 1996; these results likewise reflect little if any difference between VOC concentrations reported for samples obtained with conventional and low-flow sampling methods. Note also that the VOC results reported for the groundwater samples collected from each well in October 2000 do not indicate any clear response to the continuous pumping of well GW-845, which is located about 600 ft east of wells GW-153/GW-240 (Figure A.2).

The DNAPL believed to be present in the subsurface near Building 9720-6 is the suspected source of the dissolved plume of chlorinated solvents in the groundwater at aquitard wells GW-762 and GW-763 (DOE 1998). As noted in Section 3.1.3.1, these wells are clustered in the Nolichucky Shale about 500 ft west of New Hope Pond (Figure A.2), with well GW-762 completed in the shallow bedrock interval (about 60 ft bgs) and well GW-763 completed in the water-table interval (16 ft bgs). Historical monitoring data show that PCE and associated degradation products (primarily 12DCE) are the principal dissolved VOCs in the groundwater at both wells, although the concentrations in well GW-762 are at least an order-of-magnitude higher than evident in well GW-763. The CY 2000 VOC results for these wells are generally consistent with respective historical data and show that the summed maximum VOC concentrations in the shallow groundwater at well GW-763 (177 µg/L) remain substantially lower than the summed VOC concentrations evident in the deeper groundwater at well GW-762 (2,700 µg/L). Because the presampling groundwater elevations in these wells consistently show downward vertical hydraulic gradients, the lower VOC concentrations in well GW-763 probably at least partially reflect greater dilution from recharge to the shallow flow system. Additionally, more efficient biotic degradation in the shallower flow system also may account for the lower VOC concentrations in well GW-763 because the geochemical characteristics of the groundwater in this well, including the very high total iron concentrations (>25 mg/L), appear to be more favorable for biodegradation of dissolved chlorinated solvents than the geochemical conditions evident in the deeper groundwater at well GW-762.

Another distinctive characteristic of the VOC monitoring data for aquitard wells GW-762 and GW-763 is that there is little if any difference between the VOC results obtained from well GW-762 using either conventional or low-flow sampling methods, whereas substantial differences are evident between the VOC concentrations reported for samples obtained from well GW-763 with these sampling methods. To further evaluate this

phenomenon, the Y-12 GWPP used each sampling method to obtain samples from well GW-763 on consecutive days in May 2000 (seasonally high flow) and October 2000 (seasonally low flow), with the low-flow sampling method used the first day and conventional sampling used the next. In May 2000, VOCs were not detected in the sample collected using the low-flow sampling method, but several compounds dominated by PCE and c12DCE were detected in the sample obtained with the conventional sampling method the next day. As shown in Table 29, each of these same VOCs except 11DCA were detected in the groundwater samples obtained with each sampling method in October 2000, and there is not any significant difference between the respective concentrations of VOCs reported for either of these groundwater samples.

Table 29. VOC results obtained for aquitard well GW-763 using conventional sampling and low-flow sampling methods in May and October 2000

VOC	Concentration (µg/L)			
	May 10, 2000 Low-Flow Sampling	May 11, 2000 Conventional Sampling	October 10, 2000 Low-Flow Sampling	October 11, 2000 Conventional Sampling
PCE	.	62	28	20
TCE	.	14	7	7
c12DCE	.	150	98	90
11DCA	.	(2)	.	.
11DCE	.	5	.	.
VC	.	13	5	8

Note: “.” = Not detected; () = Estimated concentration below the analytical reporting limit

Excluding sampling and/or analytical errors, which are not indicated by the available data, it is not clear why VOCs were not detected in the groundwater sample obtained from low-flow sampling in May 2000. Perhaps this observed trend is related in some way to the hydraulic performance of the well. For instance, considering the very high total iron concentrations in the well (>25 mg/L), it is likely that the groundwater contains iron-related bacteria (Driscoll 1986). Iron-related bacteria in the groundwater oxidize and precipitate dissolved iron and manganese and produce accumulations of a gel-like material that, in combination, can effectively plug the openings in the well screen (along with the pores in surrounding filter pack material) within a short time (Driscoll 1986). Potentially, the pumping rate used for low-flow sampling in May 2000 was too low to induce inflow through the clogged well screen/filter pack and, as a consequence, a sample of the relatively stagnant water column in the well casing, rather than the VOC-contaminated groundwater outside the well, may have been obtained. Conversely, purging the well during conventional sampling the next day appears to have not only induced inflow of the VOC-contaminated groundwater into the well, but also to have at least partially unclogged the well screen/filter pack to the extent that the low pumping rate used for low-flow sampling in October 2000 was sufficient to induce inflow of VOC-contaminated groundwater into the well.

As noted previously, aquifer wells GW-222 and GW-223 are clustered (along with well GW-154) in the Maynardville Limestone next to the preconstruction channel of UEFPC on the western side of New Hope Pond (Figure A.2). Respective historical data show that both wells monitor groundwater containing a mixture of dissolved chloroethenes (PCE, TCE, and 12DCE isomers) and chloromethanes (CTET and chloroform). Monitoring results obtained during CY 2000 support the historical data for each well with respect to the types of compounds detected, and continue the generally decreasing concentration trends evident since the mid-1990s (following a sharp increase associated with closure of New Hope Pond in CY 1988). As illustrated by the summed VOC concentrations included in the following data summary (Table 30), VOC levels in both wells increased substantially after New Hope Pond was closed and capped in late-1988, but then appear to have

generally decreased, with the summed concentrations of VOCs detected in samples collected from each well in October 2000 reflecting the lowest levels evident in either well since October 1987, when summed VOC concentrations were 20 µg/L in well GW-222 and 107 µg/L in well GW-223.

Table 30. Summed VOC concentrations in aquifer wells GW-222 and GW-223, 1986-2000

Monitoring Well	Summed VOC Concentration (µg/L)									
	Conventional Sampling							Low-Flow Sampling		
	1986	1989	1991	1995		1996		1999	2000	
	2 ND QTR.	2 ND QTR.	1 ST QTR.	2 ND QTR.	4 TH QTR.	2 ND QTR.	4 TH QTR.	3 RD QTR.	2 ND QTR.	4 TH QTR.
GW-222	18	831	22	470	515	50	175	NS	217	25
GW-223	78	1,859	288	381	311	245	619	243	179	136

Note: NS= Not sampled

Moreover, the concentrations of VOCs detected in samples from well GW-222 reflect particularly acute short-term concentration fluctuations, regardless of sampling method. For instance, low-flow sampling results reflect a substantially higher PCE concentration in June 2000 (110 µg/L) than in October 2000 (6 µg/L); a similarly sharp difference is evident between the PCE concentrations obtained from conventional sampling in November 1995 (280 µg/L) and March 1996 (13 µg/L). These wide short-term fluctuations dominate and effectively mask the long-term concentration trends for VOCs detected in well GW-222, whereas the concentrations of VOCs detected in the samples from well GW-223 reflect much less temporal variability and generally decreasing long-term concentration trends (Figure A.14).

The DNAPL believed to be present in the subsurface near Building 9720-6 is the suspected source of the dissolved chloroethenes in the shallow (<25 ft bgs) groundwater at aquitard well GW-383, which is located adjacent to the original UEFPC channel near Building 9720-6 about 350 ft north-northeast (hydraulically downgradient) of wells GW-153 and GW-222 (Figure A.2). The extensive database of historical monitoring results for well GW-383 show that it monitors groundwater containing a plume of dissolved chlorinated solvents, primarily PCE, TCE, and 12DCE. Monitoring results obtained during CY 2000 are consistent with the historical data, with maximum concentrations of PCE (610 µg/L), TCE (200 µg/L), and c12DCE (150 µg/L) equal to or greater than respective maximum levels evident during CY 1999. Moreover, the CY 2000 monitoring results continue the generally increasing chloroethene concentration trend evident since August 1988 (see Section 3.3).

3.1.3.3 Radioactivity

Monitoring results obtained during CY 2000 support historical monitoring data and do not indicate widespread radiological contamination in the eastern Y-12 area. Elevated levels of radioactivity in the groundwater, as determined by gross alpha activity above 15 pCi/L and/or gross beta activity above 50 pCi/L, is evident only in three of the wells that were sampled during CY 2000: one well located about 1,200 ft west (hydraulically upgradient) of New Hope Pond (GW-605) and two wells (GW-154 and GW-222) clustered adjacent to the preconstruction channel of UEFPC on the western side of New Hope Pond. Gross alpha and gross beta

activity reported for the groundwater samples collected from these wells during CY 2000 are summarized below (Table 31).

Table 31. Eastern Y-12 area: elevated CY 2000 gross alpha and gross beta results

Well	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
		MDA	Activity ± CE	MDA	Activity ± CE
GW-154	05/17/00	2.29	496 ± 14.74	2.62	97.23 ± 4.03
GW-154	08/22/00	1.54	572 ± 12.1	1.48	171.56 ± 3.49
GW-222	06/13/00	3.5	35 ± 7	5.9	21 ± 5
GW-222	10/26/00	2.4	100 ± 11	7.2	74 ± 8.7
GW-605	01/12/00	2.12	48 ± 4.22	2.79	14.87 ± 3.08
GW-605	07/17/00	1.74	49 ± 3.74	1.99	11.64 ± 1.93

Note: Bold = Activity exceeds 15 pCi/L MCL (gross alpha) or 50 pCi/L SDWA screening level (gross beta)

Aquifer well GW-605 monitors groundwater in the Maynardville Limestone that contains a distinctive plume of radiological contamination originating from an unidentified but presumably nearby source area (see Section 3.1.3.1). Historical monitoring data show that the radioactivity (alpha and beta) in the well is from uranium isotopes (U-234 and U-238) in the groundwater (isotopic analyses were not performed on the groundwater samples collected from the well during CY 2000). The CY 2000 monitoring results show that alpha radioactivity in the well remains above the MCL and reflect a slight increase from the maximum gross alpha activity evident during CY 1998 (29 pCi/L) and CY 1999 (39 pCi/L). However, these gross alpha results are substantially below the gross alpha level evident in March 1998 (130 pCi/L). This rapid decrease and subsequent slow rebound in the level of alpha radioactivity corresponds with a similar trend in the concentration of total uranium in the well (see Section 3.1.3.1) and may likewise reflect the influence of the aquifer pumping test described in Section 2.3.

As shown in the preceding data summary (Table 31), the highest levels of gross alpha and gross beta radioactivity in the eastern Y-12 area during CY 2000 were reported for the groundwater samples collected from aquifer wells GW-154 and GW-222. Groundwater samples obtained from well GW-154 in May and August 2000 were analyzed for uranium isotopes, and results of these analyses show that the alpha and beta radioactivity in the shallow groundwater at this well is primarily from U-234 (454 and 438 pCi/L) and U-238 (312 and 185 pCi/L). Although isotopic analyses of the groundwater samples obtained from well GW-222 were not performed, uranium isotopes also are the likely source of the alpha and beta radioactivity in this well considering the high levels of U-234 and U-238 in the shallower groundwater at well GW-154, the downward vertical hydraulic gradients indicated by the pre-sampling groundwater elevations in these wells, and the elevated concentrations (i.e., >0.03 mg/L MCL) of total uranium in well GW-222 (see discussion in Section 3.1.3.1). As illustrated by the CY 2000 monitoring results (Table 31), alpha and beta radioactivity in each well exhibit substantial temporal variability. For example, the gross beta result reported for the sample collected from well GW-222 in November 2000 (74 pCi/L) may be another beta radioactivity “spike” similar to those evident in October 1989 (138 pCi/L), August 1990 (116 pCi/L), February 1995 (72 pCi/L), and November 1995 (54 pCi/L). Also, as with elemental uranium, the substantially reduced beta radioactivity compared to the respective levels evident in these wells during CY 1989 (see data for GW-154, Figure A.14) is probably a direct consequence of the closure of the former Oil Skimmer Basin (see discussion in Section 3.1.3.1).

3.1.4 Union Valley

The CY 2000 monitoring results reported for six wells (GW-169, GW-170, GW-171, GW-172, GW-230, and GW-232) and three springs (SCR 7.1SP, SCR7.18SP, and SCR7.8SP) located in Union Valley east of Y-12 (Figure A.2) were evaluated for the surveillance monitoring purposes of DOE Order 5400.1. Each monitoring well yields groundwater from the Maynardville Limestone; well depths range from less than 40 ft bgs (GW-169 and GW-171) to more than 400 ft bgs (GW-230 and GW-232). Based on their respective locations relative to the (presumed) subcrop geology, springs SCR7.1SP and SCR7.18SP discharge groundwater from the Maynardville Limestone and spring SCR7.8SP discharges groundwater from the lower Knox Group.

As illustrated in Table 32, known or suspected inorganic, organic, and radiological contaminants were not detected in any of the groundwater samples collected from spring SCR7.8SP and monitoring wells GW-171, GW-172, and GW-232 during CY 2000, but several VOCs were detected in the groundwater samples collected from wells GW-169, GW-170, and GW-230 and from springs SCR7.1SP and SCR7.18SP.

Table 32. Types of contaminants detected in CY 2000 sampling locations in Union Valley

Sampling Location	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
Monitoring Wells					
GW-169	. . .	28.7 - 34.7	.	!	.
GW-170	. . .	104.0 - 156.9	.	!	.
GW-171	. . .	26.0 - 31.2	.	.	.
GW-172	. . .	105.0 . 133.8	.	.	.
GW-230	. . .	341.0 - 406.4	.	!	.
GW-232	. . .	401.0 - 411.7	.	.	.
Springs					
SCR7.1SP	!	.
SCR7.18SP	!	.
SCR7.8SP

Aquifer wells GW-169 and GW-170 are clustered (along with well GW-232) near the base of Chestnut Ridge about 1,500 ft east of the ORR boundary along Scarborough Road (Figure A.2). Historical data show that these wells both yield calcium-magnesium-bicarbonate groundwater containing dissolved chlorinated solvents, including PCE, TCE, 12DCE, CTET, chloroform, and methylene chloride. Trace levels (2 µg/L) of PCE were detected in the groundwater samples collected from well GW-169 in May and August 2000; similarly low concentrations of PCE (all below the 5 µg/L MCL for drinking water) were detected in 22 of the 23 samples previously collected from this well between March 1991 (4 µg/L) and September 1999 (1 µg/L). In addition to PCE, traces (2 - 4 µg/L) of TCE and CTET along with low levels (12 -14 µg/L) of chloroform were detected in the groundwater samples obtained from well GW-170 during each quarter of CY 2000. These quarterly monitoring results are consistent with the respective historical data for each compound except CTET. As shown in the following summary (Table 33), the CY 2000 monitoring results for CTET reflect an order-of-magnitude decrease from the CTET concentrations previously evident in the well.

Table 33. Selected VOC results for aquifer well GW-170, 1996-2000

VOC	Concentration (µg/L)										
	Conventional Sampling			Low-Flow Sampling							
	Mar. 1996	June 1996	Sep. 1997	June 1998	July 1998	Feb. 1999	Aug. 1999	Jan. 2000	May 2000	Aug. 2000	Nov. 2000
CTET	81	68	56	40	97	57	31	(3)	(2)	(2)	(4)
Chloroform	7	FP	17	14	8	14	12	13	13	10	11
PCE	(4)	5	(4)	(4)	6	(4)	(2)	(2)	(4)	(2)	(2)
TCE	(3)	(4)	(3)	(3)	(3)	(3)	(2)	(2)	(3)	(2)	(2)
Benzene	.	.	.	.	.	.	.	(3)	(4)	(3)	(4)

Note: “.” = Not detected; FP = False positive; () = Estimated value below reporting limit.

Moreover, the preceding data summary shows that traces of benzene were detected in each of the groundwater samples collected from the well during CY 2000. This, too, differs from the historical data, because benzene was not detected in any of the 23 groundwater samples previously collected from this well. An explanation for the decrease in the concentration of CTET and concurrent detection of benzene is not apparent from the monitoring results, especially considering the lack of any similarly significant changes in the concentrations of the other VOCs in the well, particularly chloroform. The change from conventional sampling to low-flow sampling does not appear to have influenced the sampling results for either compound, as illustrated by the lack of benzene in the samples obtained from previous low-flow sampling and the close similarity between the CTET concentrations reported for samples previously obtained using each sampling method. However, the sharply reduced levels of CTET and the repeated detection of benzene coincide with conspicuous changes in the geochemical characteristics of the groundwater samples obtained from the well. As shown in the following summary (Table 34), the groundwater samples collected during CY 2000 differ substantially from previous samples with respect to pH, carbonate and bicarbonate alkalinity, and TDS.

Table 34. Selected pH, alkalinity, and TDS results for aquifer well GW-170, 1992-2000

Parameter	Conventional Sampling					Low-Flow Sampling					
	Apr. 1992	Aug. 1993	Feb. 1994	June 1995	Mar. 1996	Feb. 1999	Aug. 1999	Jan. 2000	May 2000	Aug. 2000	Nov. 2000
Field pH	7.8	7.6	7.7	7.6	8.1	7.41	7.23	11.98	11.55	11.02	11.44
Bicarbonate	214	216	213	217	209	NA	NA	<2	<2	2	<2
Carbonate	<1	<1	<1	<1	<1	NA	NA	30	140	84	67
TDS	276	286	258	274	256	240	280	96	170	140	130

Note: Field pH in standard units; bicarbonate, carbonate, and TDS in mg/L; NA = Not analyzed

Similarly low bicarbonate alkalinity, high carbonate alkalinity, and high pH levels evident in groundwater samples from other monitoring wells at Y-12 typically reflect localized contamination from cement grout circulated into the surrounding bedrock during the installation/construction of the wells. However, grout contamination related to the installation of well GW-170, or the wells with which it is clustered (GW-169 and GW-232), seems unlikely considering that the wells were installed 15 years ago (Lockheed Martin Energy Systems, Inc. 1998) and the

lack of any previous evidence of grout contamination in any of the wells (as illustrated by the data summarized in Table 34). Moreover, grout contamination from well installation does not explain the sudden decrease in the levels of TDS reported for the groundwater samples collected from well GW-170 (e.g., 96 mg/L in January 2000). Low TDS implies short groundwater residence time and, considering the depth to the open-hole monitored interval in well GW-170 (104 - 157 ft bgs), potentially indicates a more direct hydraulic connection with the shallower flow system than previously evident. Perhaps construction activities near well GW-170, including the widening of Highway 61 east of the well, which has involved blasting and excavation of the bedrock (Copper Ridge Dolomite), and the construction of a large office building to the west of the well (Figure A.2) in some way altered the matrix of groundwater flowpaths (and contaminant transport pathways) intercepted by the well.

Deep aquifer well GW-230 (341 - 406.4 ft bgs), which is clustered with shallower wells GW-171 (26 - 31.2 ft bgs) and GW-172 (105 - 133.8 ft bgs), is located about 4,000 ft east of the ORR boundary along Scarboro Road (Figure A.2) and about 6,200 ft east of the nearest confirmed source of VOCs at Y-12 (Building 9720-6). Historical data show that this well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater containing dissolved chloroethenes, primarily c12DCE and VC. Both of these compounds were detected in the groundwater samples collected from the well during CY 2000, each of which had a concentration of VC (4 µg/L) that exceeds the MCL for drinking water (2 µg/L). Along with the historical data for the well, these VOC results reflect relatively stable or indeterminate long-term concentration trends. For example, the concentration of c12DCE in May 2000 (15 µg/L) reflects little if any change from the (total) 12DCE concentrations evident in November 1994 (17 µg/L), June 1995 (17 µg/L), June 1996 (13 µg/L), and February 1999 (12 µg/L).

3.2 EXIT PATHWAY/PERIMETER MONITORING EVALUATION

As shown in Table 35, the CY 2000 sampling results reported for 12 monitoring wells, including one well (GW-722) equipped with a multiport sampling apparatus (Westbay™), along with results for eight surface water sampling locations were evaluated for the purposes of DOE exit pathway/perimeter monitoring in the East Fork Regime.

Table 35. Network of sampling locations used for CY 2000 Exit Pathway/Perimeter Monitoring in the East Fork Regime

Groundwater		Surface Water	
GW-151	GW-744	OF 221	STATION 8
GW-207	GW-747	OF 225	SP-17
GW-208	GW-750	OF 200	LRSPW
GW-220	GW-816	OF 51	STATION 17
GW-722	GW-832		
GW-733	GW-845		
GW-735			

All of the monitoring wells are located in the eastern Y-12 area and are hydraulically downgradient (north/northeast or east/southeast) of New Hope Pond/Lake Reality, and all but two of the wells (GW-151 and GW-220) are located within 500 ft of the ORR boundary along Scarboro Road (Figure A.2). The surface water sampling stations include the outfalls for two storm drains located in the western Y-12 area near the Y-12 Salvage Yard (OF 221 and OF 225); two outfalls (OF 51 and OF 200) and a surface water sampling station (Station 8) in UEFPC located in the central Y-12 area; one perennial spring (SP-17) in the eastern Y-12 area;

and surface water sampling stations at the outfall of the UEFPC distribution channel underdrain (LRSPW) and in UEFPC downstream of Lake Reality (Station 17) near Bear Creek Road (Figure A.2). In addition to these surface water sampling locations within the East Fork Regime, analytical results reported for the surface water samples collected during CY 2000 from five sampling stations (GHK2.51ESW, GHK2.51WSW, NPR07.0SW, NPR10.0SW, and NPR12.0SW) located in unnamed drainage features north of Pine Ridge along the ORR Boundary also serve the exit-pathway/perimeter monitoring purposes of DOE Order 5400.1.

As illustrated in Table 36, known or suspected inorganic, organic, or radiological contaminants were detected only in the groundwater or surface water samples collected from six monitoring wells and seven surface water sampling stations used for DOE Order 5400.1 exit-pathway/perimeter monitoring during CY 2000.

Table 36. Types of contaminants detected at groundwater and surface water sampling locations used for DOE Exit-Pathway/Perimeter Monitoring during CY 2000

Sampling Location	Inorganics	Organics	Radiological
Groundwater			
GW-151	.	!	.
GW-220	.	!	.
GW-722	.	!	.
GW-733	.	!	.
GW-832	!	!	.
GW-845	.	!	.
Surface Water			
OF 225	!	.	!
OF 221	!	.	!
OF 200	!	!	.
STATION 8	!	!	!
OF 51	!	!	.
SP-17	!	.	.
LRSPW	!	!	.
STATION 17	!	!	.

The CY 2000 monitoring results along with respective historical data for each these sampling locations serve as the basis for the following evaluation of groundwater and surface water quality where contaminants from Y-12 are most likely to migrate beyond the ORR property line.

3.2.1 Groundwater

As shown in Table 35, contaminants potentially originating from one or more sources within Y-12 were detected in groundwater samples collected during CY 2000 from the following exit-pathway/perimeter monitoring wells: GW-151, GW-220, GW-722, GW-733, GW-832, and GW-845. The following discussion provides an evaluation of the CY 2000 monitoring results for these wells, presented in sequence from west to east.

Well GW-832 is located adjacent to the UEFPC distribution channel near the southeast corner of Lake Reality (Figure A.2). This shallow well (12 ft bgs), which intercepts the gravel underdrain beneath the UEFPC distribution channel, was completed with 6-inch well casing and served as the pumping well for a short-term pumping test performed in May 1995. Results of the pumping test demonstrated a direct hydraulic connection between the well and the Lake Reality Sump (AJA 1997). Historical monitoring data show that this well yields calcium-magnesium-bicarbonate groundwater with unusually high sulfate levels (>30 mg/L), which probably reflect contamination from one or more industrial sources upgradient of the well, along with sporadically elevated

concentrations of nitrate. For instance, the nitrate result reported for the sample collected from the well in August 2000 (4.4 mg/L), although below the MCL (10 mg/L), is at least an order-of-magnitude higher than ambient levels in the Maynardville Limestone and represents the highest nitrate concentration reported for this well. The specific source of the nitrate is not known, but may be the former urea stockpile located west of New Hope Pond. In any case, VOCs (CTET, chloroform, and PCE) are the primary contaminants in the groundwater at well GW-832. These compounds were detected in the groundwater samples collected from the well during CY 2000, with the maximum concentration of CTET (31 µg/L) exceeding the MCL for drinking water. These monitoring results are consistent with historical data for the well and reflect a relatively stable or indeterminate long-term concentration trend (Table B.3).

Aquifer wells GW-151 and GW-220 comprise a well cluster located about 200 ft directly east (hydraulically downgradient) of New Hope Pond and about 400 ft south-southeast of well GW-832 (Figure A.2). Historical data show that both wells, which are completed in the lower Maynardville Limestone at respective depths of about 97 ft and 45 ft bgs, yield calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved VOCs dominated by CTET. The CY 2000 sampling results for well GW-151 show that the maximum concentrations of PCE (140 µg/L), TCE (29 µg/L), and CTET (1,500 µg/L) remain above respective MCLs. Similarly, the maximum concentrations of PCE (95 µg/L), TCE (20 µg/L), CTET (1,000 µg/L) detected in the samples collected from well GW-220 during CY 2000 also remain substantially above the respective MCLs. The CY 2000 VOC results for these wells continue the clearly increasing long-term concentration trends evident from the respective historical monitoring results (see Section 3.3).

Aquifer well GW-845 is located near the base of Chestnut Ridge about 600 ft south-southeast (across geologic strike) of wells GW-151/GW-220 (Figure A.2). This well, which has a 281 ft open-hole monitoring interval (156.9–438.3 ft bgs) that spans much of the Maynardville Limestone, was sampled only once during CY 2000. Analytical results for this sample are generally consistent with the limited historical data for this well, which was sampled only once previously (May 1998), and show that the groundwater in the well contains a mixture of several dissolved chlorinated solvents dominated by CTET (2,100 µg/L), PCE (100 µg/L), and chloroform (83 µg/L) with lesser amounts of TCE (12 µg/L), c12DCE (9 µg/L), 111TCA (5 µg/L), and traces of 11DCE (3 µg/L) and 11DCA (2 µg/L). In October 2000, this well began serving as the pumping well to capture the CTET-dominated plume of VOCs in the Maynardville Limestone that extends beyond the ORR boundary into Union Valley. The intake of the pump is about 300 ft bgs and groundwater is pumped continuously at 25 gpm. The groundwater pumped from well GW-845 is treated at the well and initial influent/effluent testing shows about 95% efficiency in removing VOCs.

Aquifer well GW-722 is located about 600 ft east (along geologic strike) of well GW-845 and approximately 500 ft west of the ORR boundary (Figure A.2). This well is completed with a 500 ft open-hole interval in the Maynardville Limestone and, as noted previously, is equipped with a multiport sampling system that enables collection of discrete groundwater samples from multiple depths within the open-hole interval. In CY 2000, groundwater samples were collected from 10 sampling ports (numbered in ascending order from deepest to shallowest) ranging in depth from 563 to about 90 ft bgs (Table B.1). Historical data show that several of these sampling ports intercept the primary strike-parallel migration pathways for the dissolved plume of CTET that originates near aquifer wells GW-605/GW-606 and extends along strike beneath New Hope Pond into Union Valley east of the ORR boundary (SAIC 1998) (Figure A.6). One or more VOC was detected in at least one of the groundwater samples collected during CY 2000 from all but two of the sampling ports (30 and 32), with the highest summed VOC concentrations (>500 µg/L) evident in sampling ports 14, 17, 20, and 22 (Table B.2) at depths between 300 ft and 450 ft bgs. Compounds detected in at least one sample collected from these sampling ports include PCE, TCE, c12DCE, 11DCE, CTET, chloroform, 111TCA, 11DCA, benzene, dimethylbenzene, ethylbenzene, toluene, acetone, acrylonitrile, carbon disulfide, styrene, and trichlorofluoromethane. As shown in

the following data summary (Table 37), maximum concentrations of PCE, TCE, and CTET remain above respective MCLs.

Table 37. Maximum CY 2000 VOC concentrations in well GW-722 that exceed MCLs

Sampling Port	Depth (ft bgs)	Maximum Concentration (µg/L)		
		PCE	TCE	CTET
22	315.8	35	5	470
20	335.8	41	5	230
17	387.7	53	7	700
14	427.7	36	6	560
10	502.6	7	(2)	36
MCL (µg/L)		5	5	5
Note: “.” = Not Detected; () = Estimated concentration; Bold = Exceeds MCL.				

In addition to dissolved chlorinated solvents, acrylonitrile was detected (23 µg/L) in the groundwater sample collected from sampling port 26 in March 2000; this compound also was detected at similar concentrations in the samples collected from this port during CYs 1997, 1998, and 1999. According to the manufacturer, the Westbay™ sampling system contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999).

Monitoring results obtained during CY 2000 continue another conspicuous characteristic of the VOC data for well GW-722, which is the persistent detection of dissolved petroleum hydrocarbons in the groundwater from sampling port 26. Trace levels (1 - 4 µg/L) of benzene, dimethylbenzene, ethylbenzene, toluene, and styrene, which is a biodegradation product of ethylbenzene, were detected in the groundwater samples collected from the port during CY 2000. Several of these compounds also were detected in the samples collected from this port during CYs 1997, 1998, and 1999. It is difficult to explain the presence of dissolved petroleum hydrocarbons in the groundwater from sampling port 26 considering: (1) the depth of the port in well GW-722 (about 219 ft bgs); (2) the distance to well GW-722 from known sources of petroleum hydrocarbons (e.g., Tank 2331-U in the central Y-12 area) and the substantial attenuation that would be expected during transport from the source area(s); (3) the low permeability of the monitored interval potentially indicated by the consistent detection of acrylonitrile in the samples from the port; and (4) the overall lack of petroleum hydrocarbons in other shallow and intermediate depth Maynardville Limestone wells upgradient to the west (along geologic strike) of New Hope Pond.

Aside from having the highest concentration of VOCs, groundwater samples from sampling ports 14, 17, 20, and 22 in well GW-722 are also distinguished by elevated nitrate concentrations. Results for each of the samples collected from these ports during CY 2000 show nitrate concentrations above 1 mg/L, with the highest levels reported for samples collected from port 14 in September 2000 (2.4 mg/L) and from port 17 in July 2000 (2.51 mg/L). Although these nitrate concentrations do not exceed the MCL (10 mg/L), they are at least an order-of-magnitude higher than background levels in the Maynardville Limestone (e.g., <0.028 mg/L in sampling port 33). As noted in Sections 3.1.1.1 and 3.1.3.1, elevated nitrate concentrations in the East Fork Regime are believed to reflect migration from the contaminant plume emplaced in the western Y-12 area during operation of the former S-3 Ponds and/or the S-2 Site, with possible contribution from the former stockpile of urea located in the eastern Y-12 area.

Aquifer well GW-733 is located southeast (across geologic strike) of well GW-722, approximately 1,000 ft east-southeast of well GW-845 and about 500 ft west of the ORR property boundary along Scarboro Road (Figure

A.2). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater from the upper Maynardville Limestone that infrequently contains trace levels (<5 µg/L) of dissolved chloroethenes (primarily PCE) along with much higher (<100 µg/L) but generally decreasing concentrations of dissolved chloromethanes (primarily CTET). The CY 2000 monitoring results for well GW-733 are consistent with these historical findings and continue the decreasing VOC concentration trends evident since the mid 1990s (Figure A.15). Decreasing VOC concentrations in well GW-733 may be primarily attributable to hydrologic attenuation mechanisms (e.g., dilution and dispersion) because the consistently low proportions of chloroform relative to CTET (and infrequent detection of PCE degradation products) suggest minimal biotic and/or abiotic degradation in the groundwater near this well.

3.2.2 Surface Water

One or more inorganic, organic, and radiological contaminants originating from sources within Y-12 were detected in at least one of the samples collected from the following surface water sampling locations (listed in order from farthest upstream to farthest downstream): OF 225, OF 221, OF 200, Station 8, OF 51, SP-17, the LRSPW, and Station 17. Note that the monitoring results for these sampling locations essentially represent qualitative water-quality “snapshots” regarding the presence (or absence) of inorganic, organic, and radiological contaminants in the surface water at each sampling location.

Boron, cadmium, chloride, copper, manganese, mercury, nickel, nitrate, sulfate, uranium, and zinc are the inorganic contaminants that were detected in the samples collected from the surface water exit-pathway sampling locations during CY 2000. Of these, however, elevated concentrations of boron, nitrate, sulfate, mercury, and uranium were reported the most frequently and are the focus of the following discussion. Elevated concentrations of nitrate, mercury, and uranium were identified from comparison with the respective drinking water MCLs and elevated concentrations of boron and sulfate were identified from comparison with respective background values assumed to be representative of uncontaminated surface water in UEFPC. Respective upper tolerance limits (UTLs) determined from statistical analysis of historical (1986-1995) groundwater monitoring data (HSW Environmental Consultants, Inc. *et. al.* 1995) served as the background values for boron and sulfate.

The highest concentrations of boron, mercury, nitrate, sulfate, and uranium during CY 2000, summarized below in Table 38, were evident in samples collected from outfalls in the western Y-12 area (OF 225 and OF 221).

Table 38. Maximum boron, mercury, nitrate, sulfate, and uranium concentrations in surface water exit pathway sampling locations, 1999-2000

Sampling Location	Maximum concentration (mg/L)									
	Boron		Mercury		Nitrate (as N)		Sulfate		Uranium	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
OF 225	<i>0.171</i>	<i>12.7</i>	0.0002	0.0002	112	NA	39.3	54.9	0.145	0.06
OF 221	<i>0.14</i>	<i>6.9</i>	.	.	9.4	NA	27.3	53.6	0.406	0.112
OF 200	<i>0.461</i>	<i>0.83</i>	0.0007	0.001	5.7	8.7	41.5	32.3	0.261	0.17
STATION 8	<i>0.257</i>	<i>0.218</i>	0.0008	0.0005	3.9	3.4	34	29.2	0.169	0.05
OF 51	0.067	0.034	0.0018	0.0012	4.8	5	20.1	24.7	.	0.011
SP-17	.	0.013	.	.	9.6	8.2	4.5	20.3	.	.
LRSPW	.	.	.	.	1.5	1.56	25.9	26.6	0.005	0.009
STATION 17	0.029	0.026	0.001	0.00049	3	3	25.6	31	0.069	0.04

Note: NA = Not analyzed; “.” = Not detected; BOLD = Exceeds MCL; Italic = Exceeds UTL

The preceding data summary also shows that the CY 2000 monitoring results for each of these sampling locations are generally consistent with respective data obtained during CY 1999.

Samples collected from five of the surface water sampling locations (OF 200, Station 8, OF 51, SP-17, LRSPW, and Station 17) during CY 2000 contained one or more of the following VOCs (note that samples collected from OF 221 and OF 225 were not analyzed for VOCs): CTET, chloroform, PCE, TCE, c12DCE, 111TCA, and 11DCA. Most of the results for these compounds are estimated values below the respective analytical reporting limits, but as shown in the following data summary (Table 39), the maximum concentration of CTET reported for the LRSPW exceeds the MCL as do the maximum concentrations of PCE reported for OF 200, OF 51, and the LRSPW.

Table 39. Surface water exit-pathway: CY 2000 maximum VOC concentrations

Sampling Location	CY 2000 Maximum Concentration (µg/L)						
	PCE	TCE	c12DCE	CTET	Chloroform	11DCA	111TCA
OF 200	8	(2)	(2)	.	10	.	.
STATION 8	(1)	.	.	.	11	.	.
OF 51	18	(3)	8	(1)	(3)	(2)	(2)
SP-17	.	.	.	.	(3)	.	.
LRSPW	6	.	.	35	6	.	.
STATION 17	(2)	.	.	(1)	5	.	.
MCL (µg/L)	5	5	70	5	Not Applicable		200
Note: “.” = Not detected; () = Estimated concentration below the reporting limit; Bold = Exceeds MCL							

Dissolved VOCs in the groundwater intercepted by the buried headwaters of UEFPC and the buried tributaries may be the source of the compounds detected in the surface water samples from OF 200 and OF 51 (Figure A.4), and discharge of groundwater containing CTET from the dissolved plume in Maynardville Limestone near New Hope Pond/Lake Reality is the most likely source of the compounds detected in the surface water samples collected from the LRSPW.

As shown in Table 40, gross alpha and gross beta results that exceed the corresponding MCL or SDWA screening level were reported for at least one groundwater sample collected during CY 2000 from three of the surface water exit pathway sampling locations: OF 221, OF 225, and Station 8.

Table 40. Surface water exit-pathway: elevated CY 2000 gross alpha and gross beta results

Sampling Location	Date Sampled	Gross Alpha (pCi/L)			Gross Beta (pCi/L)		
		MDA	Activity ± CE		MDA	Activity ± CE	
OF 225	03/20/00	2.86	30.16	± 4.12	2.37	38.95	± 2.98
	09/19/00	3.19	22.89	± 4.13	2.85	186.9	± 5.27
OF 221	03/20/00	2.45	65.72	± 5.14	2.05	70.9	± 3.31
	09/19/00	2.45	15.29	± 3.08	2.48	125.5	± 4.2
STATION 8	03/20/00	1.31	15.91	± 1.99	1.3	10.96	± 1.38
Note: Bold = Gross alpha exceeds 15 pCi/L MCL; Gross beta exceeds 50 pCi/L SDWA screening level							

Analytical results obtained during CY 2000 show that uranium isotopes account for the elevated gross alpha and gross beta activity reported for most of the surface water sampling. However, it is possible that Tc-99 may contribute to the beta radioactivity, particularly in the outfalls located within the western Y-12 area (samples collected from each outfall during CY 2000 were not analyzed for Tc-99).

3.3 CONTAMINANT CONCENTRATION TRENDS

Monitoring data obtained since the late 1980s and early 1990s show indeterminate or generally decreasing long-term contaminant concentration trends for the majority of sampling locations in the East Fork Regime, including most of the CY 2000 sampling locations in the western, central, and eastern Y-12 areas (Table B.3). Indeterminate trends occur at monitoring locations where insufficient data are available, the trend is fairly stable, or concentrations fluctuate with no apparent linear trend over time. The decreasing concentration trends probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, remedial actions, natural attenuation mechanisms, and, in some cases, changes in sampling procedures and analytical methods. For the purposes of DOE Order 5400.1 requirements, the following discussion is focused on CY 2000 sampling locations that clearly exhibit increasing long-term contaminant concentration trends.

As shown in Table 41, increasing long-term contaminant concentration trends are indicated by the monitoring data for 11 of the CY 2000 sampling locations in the East Fork Regime, including four wells in the western Y-12 area and seven wells in the eastern Y-12 area.

Table 41. Monitoring wells sampled during CY 2000 that exhibit increasing long-term contaminant concentration trends

Monitoring Well		Increasing Long-Term Concentration Trends			Trend Graph
		Inorganics	VOCs	Radioactivity	
Western Y-12 Area					
	GW-108	.	!	!	Figure A.16
	GW-253	.	!	.	Figure A.17
	GW-274	.	!	!	Figure A.18
	GW-633	.	!	!	Figure A.19
Eastern Y-12 Area					
	GW-151	.	!	.	Figure A.20
	GW-220	.	!	.	Figure A.20
	GW-223	!	!	!	Figure A.21
	GW-382	.	!	.	Figure A.22
	GW-383	.	!	.	Figure A.23
	GW-605	.	!	.	Figure A.24
	GW-606	.	!	.	Figure A.25

A discussion of the increasing contaminant concentration trend(s) for each well is provided below (presented in the sequence shown in Table 41). Each trend is based on CY 2000 and historical monitoring results that meet the DQO criteria applicable to inorganic, organic, and radiological analytes, as defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (SAIC 2000).

The CY 2000 monitoring results for aquitard well GW-108 continue the increasing long-term concentration trends evident for chloroform, methylene chloride, and Tc-99 (Figure A.16). Increasing concentrations of these contaminants, which are all components of the contaminant plume emplaced during operation of the former S-3 Ponds, probably reflect increased flux along the groundwater flowpaths intercepted by the well. However, in contrast to the increasing trends for these contaminants, particularly Tc-99, the monitoring results for nitrate, which is the primary component of the S-3 Ponds contaminant plume, reflect a decreasing concentration trend (Figure A.7). Several factors may explain these divergent contaminant concentration trends. For example, differential flux of these contaminants may at least partially reflect the routine disposal of nitrate wastes at the former S-3 Ponds, which essentially emplaced a large contiguous mass of nitrate (from the Abandoned Nitric Acid Pipeline), as opposed to the intermittent disposal of Tc-99 wastes at the site, which emplaced more discontinuous “slugs” of Tc-99. Assuming that the decreasing nitrate concentrations in well GW-108 reflect reduced flux of nitrate resulting from the continued eastward (strike parallel) migration of the nitrate mass emplaced during routine operation of the S-3 Ponds, then the increasing Tc-99 concentrations may reflect a temporal “pulse” in flux of Tc-99 emplaced during intermittent disposal of Tc-99 wastes at the site. (AJA 2001b).

Monitoring data for aquifer well GW-253, which has a sporadic sampling history that begins in February 1987 and includes only one sampling event between April 1991 and February 1999, show generally increasing concentrations of 12DCE and VC (Figure A.17). For instance, 12DCE (total) concentrations increased from 60 µg/L in August 1989 to 250 µg/L in November 1999, but then dropped slightly to 190 µg/L in November 2000. However, the significance of these upward trends is not clear, particularly if degradation of parent compounds (i.e., PCE and TCE) in the groundwater is a primary source of the 12DCE and VC in the well. If so, a concurrent decrease in the concentration of PCE and TCE would be expected, but as noted in Section 3.1.1.2, relatively stable long-term trends are indicated by results for these and other VOCs detected in the groundwater samples from this well. This suggests a steady influx of parent compounds from suspected DNAPL at the S-2 Site (DOE 1998).

The CY 2000 monitoring results for well GW-274 show increasing concentrations of PCE, benzene, and beta radioactivity (Figure A.18). As noted in Section 3.1.1.3, beta radioactivity in the groundwater at this well is primarily from Tc-99, which is a signature component of the contaminant plume emplaced during operation of the former S-3 Ponds. Thus, the increasing level of beta radioactivity indicated by the CY 2000 monitoring results potentially reflect increased flux of Tc-99 along the groundwater flowpaths intercepted by the well, possibly a temporal “pulse” of Tc-99 described previously. Because PCE and benzene are not major components of the S-3 Ponds contaminant plume, however, the increasing concentration trends for these compounds potentially reflect increased flux from a different source. Assuming that both PCE and benzene follow the same strike-parallel transport pattern as that of Tc-99 (and nitrate), the source of these VOCs is probably located to the west-northwest of the well (possibly the Rust Garage and/or the Salvage Yard). This is supported by monitoring results for aquitard well GW-633, which is located west (hydraulically upgradient) of well GW-274 and, as discussed below, also exhibits sharply increased concentrations of PCE and benzene.

Analytical results reported for the 15 groundwater samples collected from well GW-633 between March 1991 and March 2001 show increasing concentration trends for PCE, petroleum hydrocarbons (represented by benzene), and gross beta (Figure A.19). Based on comparison with historical (conventional sampling) isotopic data, the increasing levels of beta radioactivity most likely correspond to increased concentrations of Tc-99 and, as noted previously, potentially reflect a temporal “pulse” in the flux of Tc-99 from the S-3 Ponds contaminant plume. However, because the historical results show relatively stable VOC concentrations through March 1994 (the last time the well was sampled before CY 2000), the higher levels of PCE and benzene may be an artifact of the change to low-flow sampling in CY 2000. Also, historical data for well GW-633 were interpreted to potentially indicate biodegradation of the dissolved petroleum hydrocarbons from the Rust Garage area, with microorganisms using the nitrate in the groundwater as an electron acceptor (DOE 1998). As noted in Section

3.1.1.1, the CY 2000 monitoring results show that nitrate levels in the well remain very high (>1,000 mg/L), so the sharp increase in the concentrations of PCE and petroleum hydrocarbons may indicate substantially decreased microbial activity in the shallow groundwater near the well. Alternatively, the concurrent increase in the concentrations of PCE and petroleum hydrocarbons may reflect greater flux of these VOCs from a common source area, possibly the Rust Garage Area.

Groundwater samples have been collected from aquifer wells GW-151 and GW-220 at least 45 times each between February 1986 and September 2000, and the analytical results for these samples show clearly increasing long-term concentration trends for several dissolved chlorinated solvents. As illustrated by respective results for CTET and PCE (Figure A.20), data for both wells reflect fairly steady concentration increases following the initial detection of these VOCs in February 1986 (GW-151) and August 1988 (GW-220). These concentrations trends probably result from a combination of reduced recharge and subsequent decrease in dilution of groundwater in the shallow flow system following installation of the low-permeability cap over New Hope Pond, and the locally strong hydrologic influence of the UEFPC distribution channel underdrain that was installed during construction of Lake Reality (DOE 1998).

Increasing long-term concentration trends are indicated by the total uranium, gross alpha, and 12DCE results reported for aquifer well GW-223 (Figure A.21). This well has a fairly extensive sampling history that begins in February 1986 and encompasses two extended periods (June 1991 through January 1995 and December 1996 through August 1999) during which the well was not sampled (note that the latter period spans the change from conventional sampling to low-flow sampling). The long-term trends for uranium and alpha radioactivity closely mirror each other, with respectively decreasing trends evident before closure of New Hope Pond and the associated Oil Skimmer Basin, but respectively increasing trends evident after closure of these sites. Analytical results for 12DCE, which was first detected in the groundwater sample collected from the well in August 1988, show a more moderately increasing trend through the mid-1990s followed by more widely fluctuating but sharply increased concentrations through October 2000 (96 µg/L), which had the highest 12DCE concentration detected in the well. Also, as noted in Section 3.1.3.2, the increasing concentration trend for 12DCE clearly contrasts with the decreasing concentrations trends evident for PCE and TCE (Figure A.21). This suggests that ongoing degradation of these parent compounds may at least partially account for the increasing levels of 12DCE in the well. In any case, note that the increasing long-term trends for uranium, alpha radioactivity, and 12DCE in well GW-223 generally coincide with a concurrent shift in the local vertical hydraulic gradients (as indicated by pre-sampling groundwater elevations in wells GW-154 and GW-223), with upward gradients evident before New Hope Pond was closed and capped, and downward gradients evident after closure of the site (Figure A.21). Thus, the increasing concentrations of groundwater contaminants in well GW-223 may be a direct result of this reversal in the vertical hydraulic gradient (DOE 1998).

The CY 2000 and historical monitoring data for chloroform in aquifer well GW-382, which has been sampled more than 30 times since December 1988 (but only once between May 1995 and May 2000), show a moderately increasing long-term concentration trend (Figure A.22). This long-term trend is skewed upward by the high chloroform concentrations detected in the samples obtained with the low-flow sampling method in September 1999 (920 µg/L), May 2000 (540 µg/L), and September 2000 (610 µg/L). Although coincident with low-flow sampling, the sharply upward trend for chloroform is probably not an artifact of the change from conventional sampling because the low-flow sampling results continue the clearly decreasing long-term concentration trend for CTET in well GW-382 (Figure A.22).

Groundwater in aquitard well GW-383 has been sampled on a continuous quarterly or semiannual frequency since August 1988. Concentrations of the dissolved chlorinated solvents detected in the groundwater samples from this well, as illustrated by results for PCE, show a fluctuating but clearly increasing long-term trend (Figure A.23).

Increasing VOC concentrations in the shallow groundwater at this well potentially reflect greater flux of dissolved chlorinated solvents northeastward toward the buried original channel of UEFPC (DOE 1998).

The extensive database of monitoring results for aquifer well GW-605, which has an uninterrupted quarterly or semiannual groundwater sampling history beginning in August 1991, show divergent long-term concentration trends for several dissolved chlorinated solvents, with the CY 2000 monitoring results indicating a slightly increasing trend for CTET (Figure A.24). The significance of this trend is questionable, however, because the conventional sampling data (1991-1997) reflect substantially higher CTET concentrations than indicated by subsequent low-flow sampling data (1998 - 2000). Nevertheless, separate quantitative analysis (least-squares linear regression) of the respective conventional sampling and low-flow sampling data both indicate an upward trend for CTET, whereas separate quantitative analysis of the respective sampling results for PCE indicate a decreasing trend (conventional sampling data) and an increasing trend (low-flow sampling data).

The CY 2000 monitoring results for chloroform in aquifer well GW-606, which has a groundwater sampling history equal to that of well GW-605, continue a clearly increasing concentration trend indicated by low-flow sampling data (Figure A.25), with the concentration of chloroform evident in July 2000 (420 $\mu\text{g/L}$) being the highest reported for the well since August 1992 (440 $\mu\text{g/L}$). This increasing trend for chloroform reverses a decreasing trend evident between August 1991 (2,800 $\mu\text{g/L}$) and July 1997 (66 $\mu\text{g/L}$) that generally mirrors a similarly decreasing trend for CTET (Figure A.25). Following the initial low-flow sampling in March 1998, however, the monitoring results continue the decreasing concentration trend for CTET, with the concentration evident in January 2000 (50 $\mu\text{g/L}$) being the lowest reported for the well. This suggests that the concurrently increasing trend for chloroform may not be an artifact of the change from conventional to low-flow sampling. Also, the divergent concentration trends for chloroform (increasing) and CTET (decreasing) suggest that the concentrations of the former may be at least partially attributable to ongoing biotic and/or abiotic degradation of the latter.

4.0 CONCLUSIONS

The bulk of the monitoring results for the network of CY 2000 groundwater and surface water sampling locations are consistent with respective historical data regarding the types of contaminants detected, the concentrations of the contaminants, and the long-term contaminant concentration trends. A summary of significant findings based on evaluation of these CY 2000 results for the purposes of DOE Order 5400.1 is provided below.

The CY 2000 surveillance monitoring results reported for 41 monitoring wells, one basement sump, and one process basin in the East Fork Regime, and six wells and three springs located in Union Valley to the east of the regime, were evaluated to meet the requirements of DOE Order 5400.1. In the western Y-12 area, the most significant finding is the sharply increased levels of PCE (>500 µg/L) and benzene (>50 µg/L) in the shallow groundwater at aquitard wells GW-274 and GW-633. These findings suggest an overall change in the overall flux of dissolved VOCs in the shallow groundwater near these wells with the Rust Garage Area as the most probable source. In the central Y-12 area, the most significant finding is the extremely high level of elemental uranium concentration (>15 mg/L) and alpha/beta radioactivity (>2,500 pCi/L) detected in a water sample collected from a process basin (designated basin 9215-STACK11) located beneath the exhaust stack for a ventilation system at Building 9215. Also, hydrologic monitoring of the water in the process basin indicates a possible connection to the surrounding groundwater system. This data indicates that basin 9215-STACK11 may be a substantial source of uranium (and radioactivity) in the central Y-12 area, which should undergo further investigation. In the eastern Y-12 area, the most significant finding is the sharp decrease (nearly an order-of-magnitude) in the CTET and chloroform concentrations which, if confirmed by future sampling results, potentially reflect a direct response to the efforts to capture the CTET-dominated plume of dissolved VOCs near New Hope Pond before it exits the regime. These findings indicate that pumping the plume-capture well (GW-845) is effectively removing the dissolved VOCs from the Maynardville Limestone. In Union Valley, the most significant finding is the abrupt change in the geochemical characteristics of the groundwater samples collected from well GW-170, and the coincident reduction in the concentration of CTET in this well. The cause of these changes in the monitoring data for this well is not readily apparent.

The CY 2000 exit pathway/perimeter monitoring results from nine surface water sampling locations and 12 monitoring wells in the East Fork Regime were evaluated to meet the requirements of DOE Order 5400.1. Known or suspected inorganic, organic, and radioactive contaminants from multiple sources within Y-12 were detected in the groundwater samples collected from four of the monitoring wells (GW-151, GW-220, GW-722, and GW-733) and all of the surface water locations (OF 195, OF 221, OF 225, OF 200, OF 51, Station 8, SP-17, LRSPW, and Station 17). Results from each sampling location are consistent with respective historical data (where available) and do not indicate any significant change in the quality of groundwater or surface water exiting the East Fork Regime.

Increasing long-term contaminant concentration trends are indicated by the monitoring data from 10 of the CY 2000 sampling locations in the East Fork Regime, including four monitoring wells in the western Y-12 area (GW-108, GW-253, GW-274, and GW-633) and six monitoring wells in the eastern Y-12 area (GW-151, GW-220, GW-382, GW-383, GW-605, and GW-606). For the most part, the increasing contaminant concentrations reflect the hydrochemical dynamics within the groundwater contaminant plumes. Monitoring results for the remaining CY 2000 sampling locations generally continue the decreasing or indeterminate contaminant concentration trends (Table B.3) evident since the late 1980s and early 1990s.

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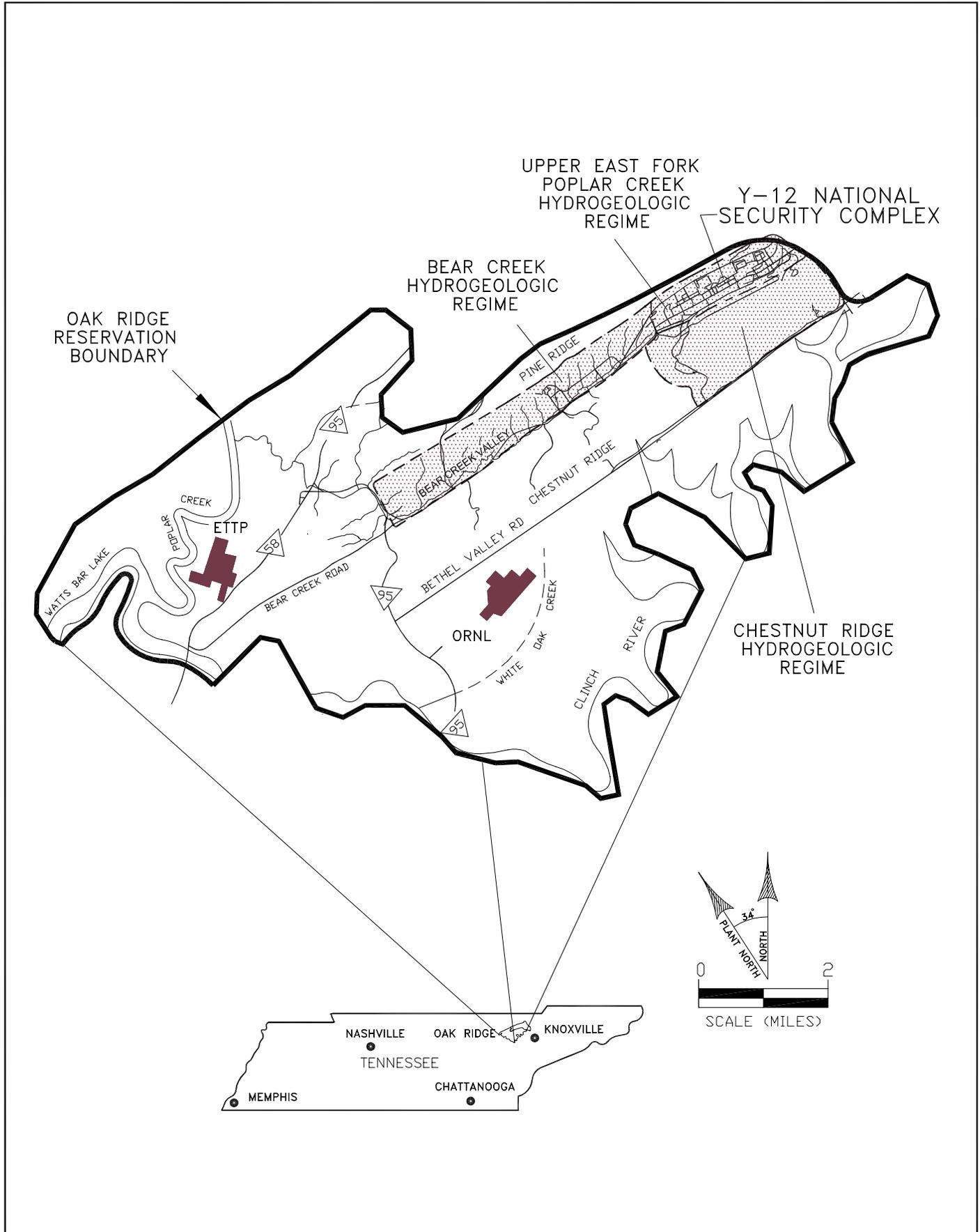
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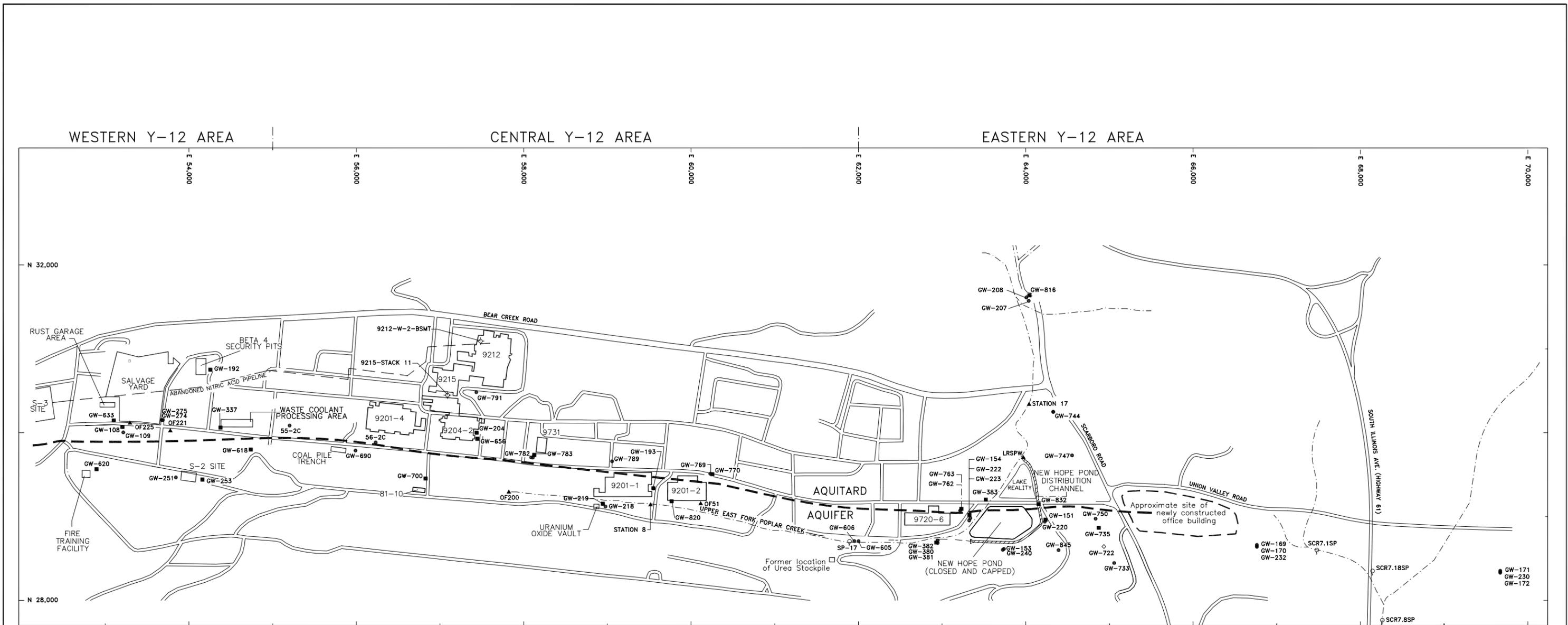
APPENDIX A

FIGURES



EFOODER_01.DWG

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



EXPLANATION

- — Water Table Monitoring Well
- — Bedrock Monitoring Well
- ◇ — Well With Westbay Multiport Sampling System
- ⊕ — Spring Sampling Location
- ▲ — Surface Water Sampling Location
- ⊕ — Sump or Process Basin Sampling Location
- LRSPW — Lake Reality Spillway

- AQUITARD — ROME FORMATION
PUMPKIN VALLEY SHALE
RUTLEDGE LIMESTONE
ROGERSVILLE SHALE
MARYVILLE LIMESTONE
NOLICHUCKY SHALE
- AQUIFER — MAYNARDVILLE LIMESTONE
COPPER RIDGE DOLOMITE

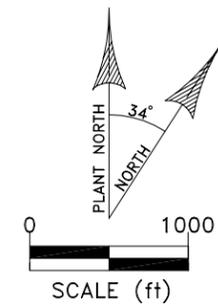
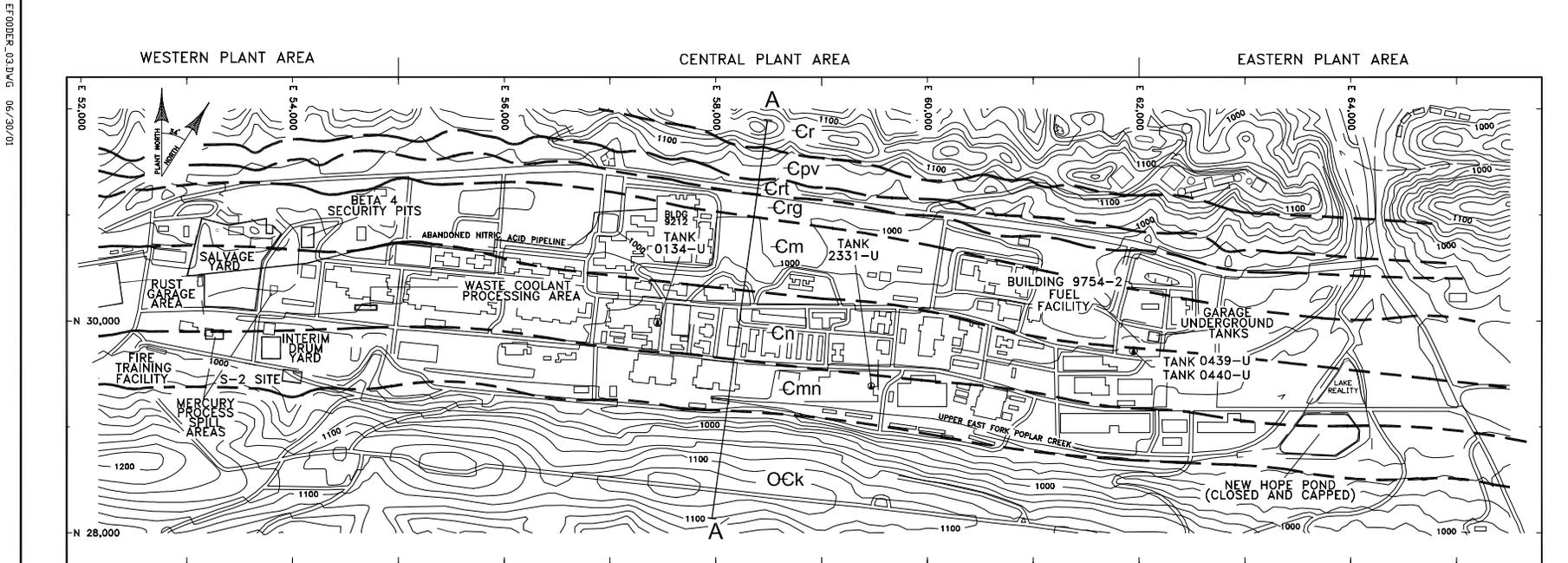
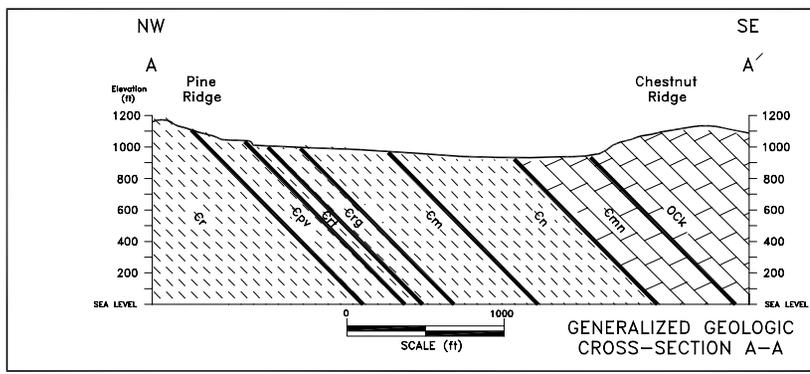


Fig. A.2. CY 2000 sampling locations in the Upper East Fork Poplar Creek Hydrogeologic Regime and in Union Valley.

Fig. A.3. Topography and bedrock geology in the Upper East Fork Poplar Creek Hydrogeologic Regime.

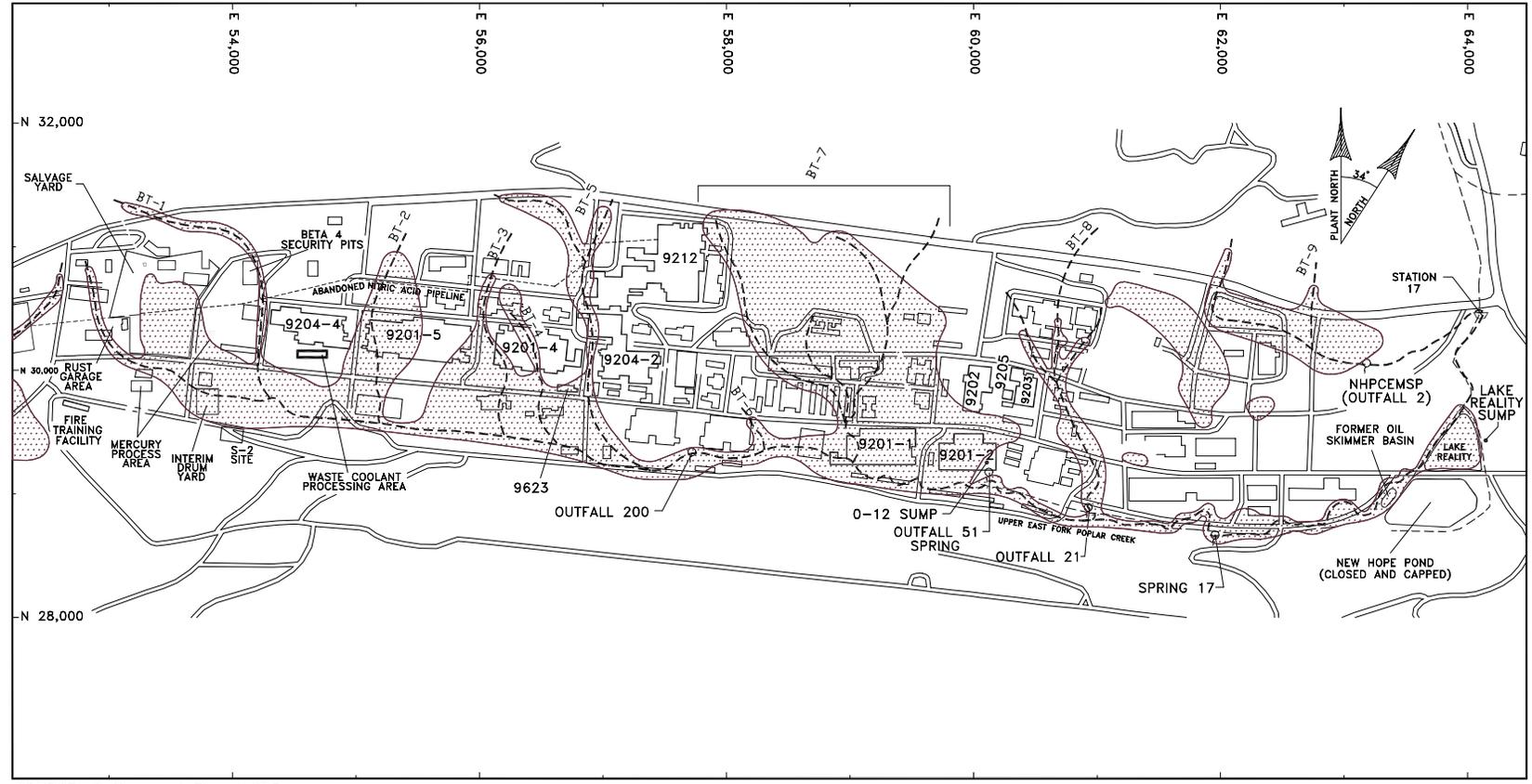


SOURCE: King and Haase, 1987

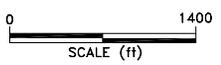


SYSTEM	GROUP	HYDRO UNIT	FORMATION	MAP SYMBOL	THICKNESS (ft)	
CAMBRIAN	UPPER	KNOX	COPPER RIDGE DOLOMITE	Ock	NOT DETERMINED	
			MAYNARDVILLE LIMESTONE	Cmn	418-450	
	MIDDLE	CONASAUGA	AQUITARD	NOLICHUCKY SHALE	Cn	422-550
				MARYVILLE LIMESTONE	Cm	346-445
				ROGERSVILLE SHALE	Crg	90-120
				RUTLEDGE LIMESTONE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

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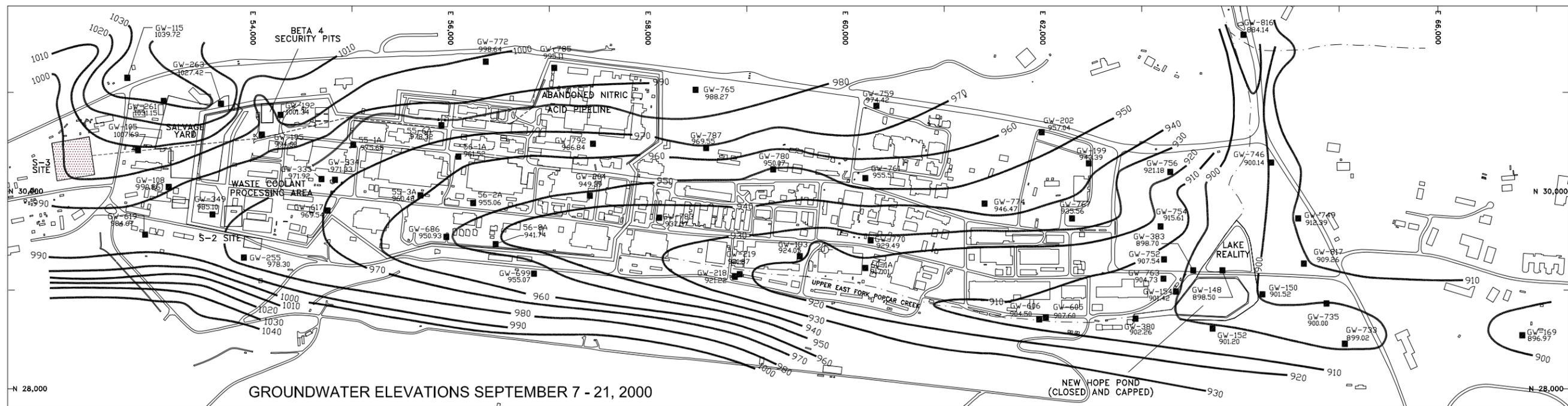
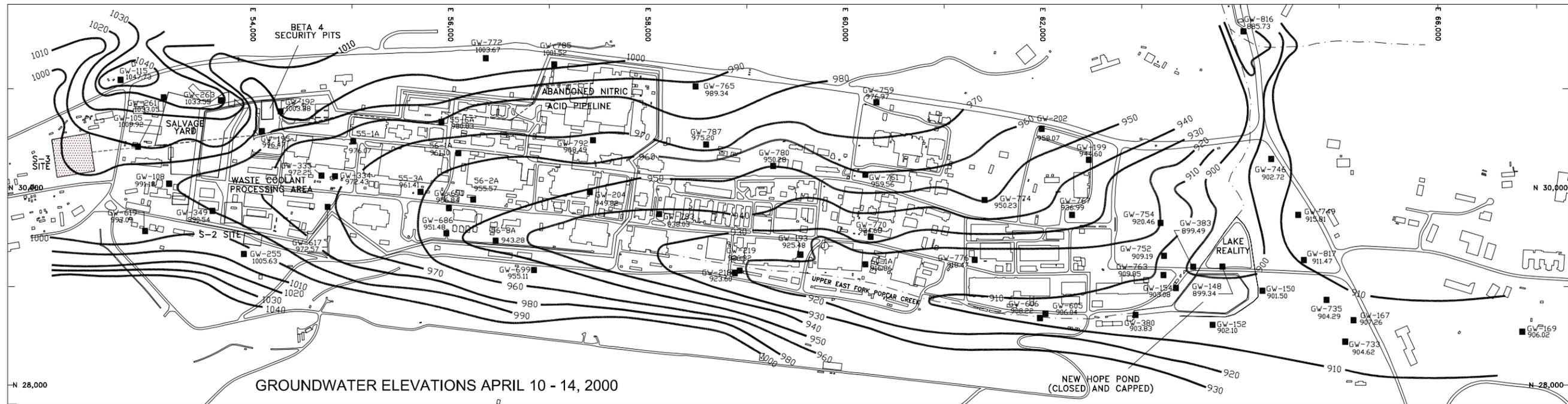
SOURCE: Sutton and Field 1995



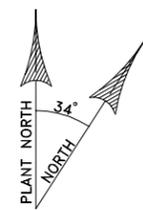
EXPLANATION

-  - FILL THICKNESS GREATER THAN OR EQUAL TO 5 FT
-  - BURIED TRIBUTARY (BT-)
-  - SPRING

Fig. A.4. Fill areas and preconstruction drainage features in the Upper East Fork Poplar Creek Hydrogeologic Regime.



EXPLANATION

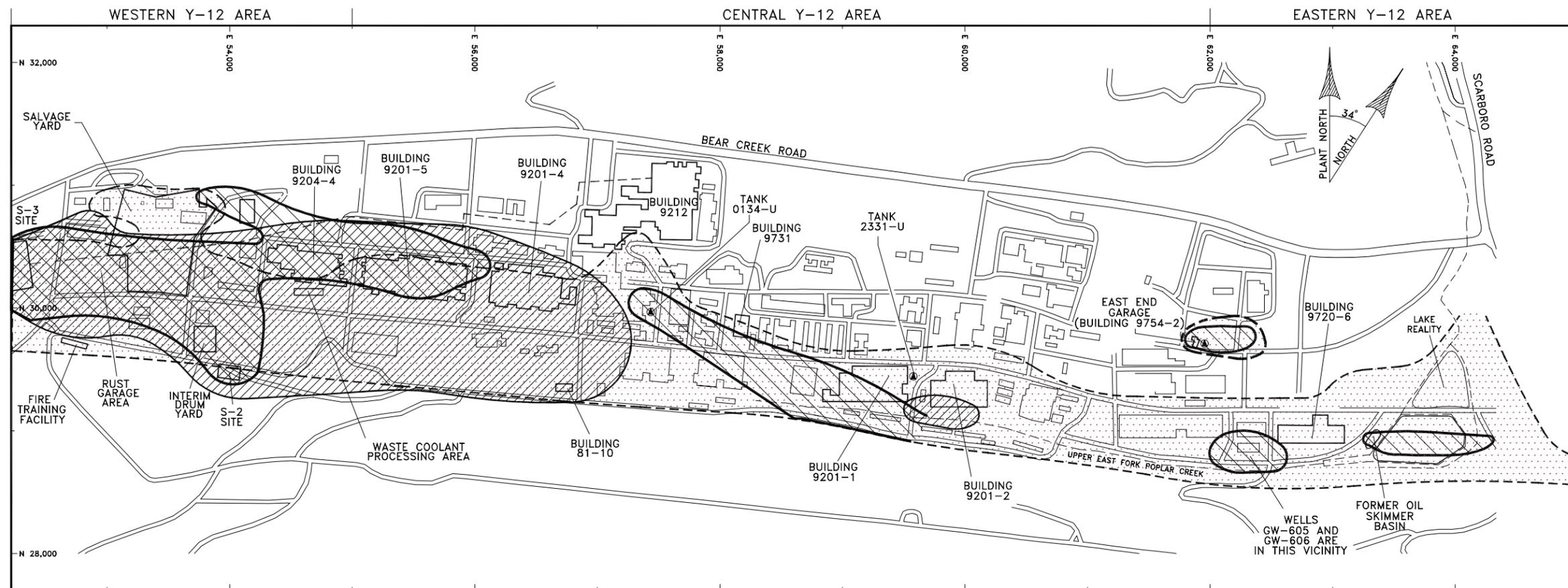


- — WATER TABLE INTERVAL MONITORING WELL
- — BUILDING 9201-2 SUMP

- 980 — APPROXIMATE WATER-LEVEL ISOPLETH (ft msl)
- - - SURFACE DRAINAGE FEATURE



Fig. A.5. Seasonal groundwater elevations in the Upper East Fork Poplar Creek Hydrogeologic Regime.



NOTE: MODIFIED FROM U.S. DEPARTMENT OF ENERGY 1998



EXPLANATION

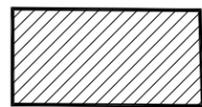
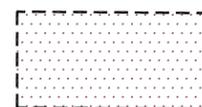
-  - NITRATE
-  - VOCs
-  - RADIOACTIVITY (GROSS ALPHA AND GROSS BETA)

Fig.A.6. Source areas and generalized extent of groundwater contamination in the Upper East Fork Poplar Creek Hydrogeologic Regime.

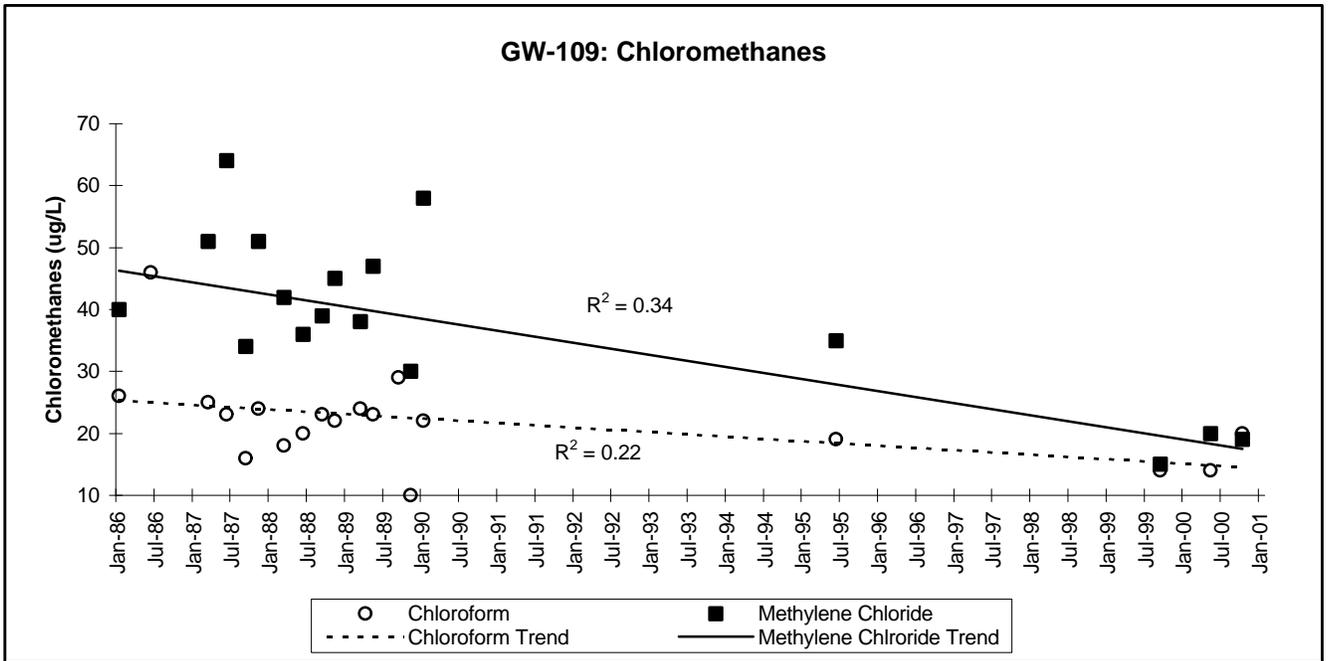
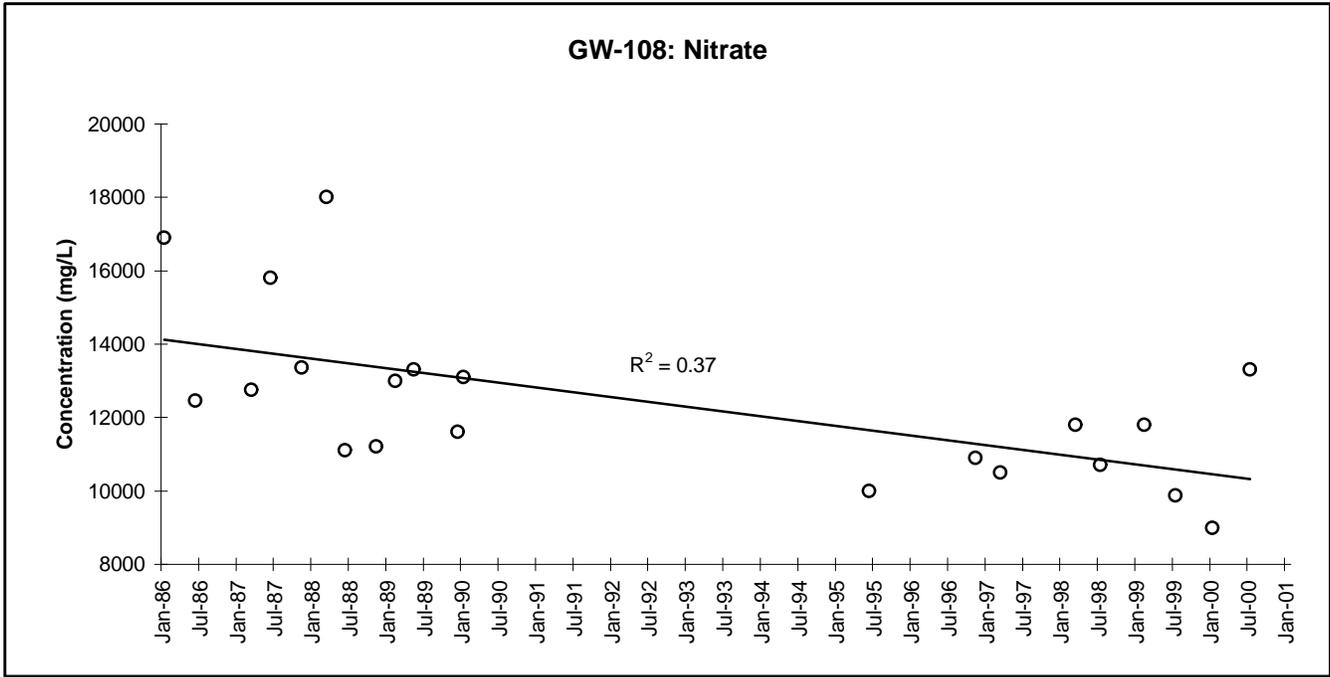


Fig. A.7. Decreasing contaminant concentrations in wells GW-108 and GW-109.

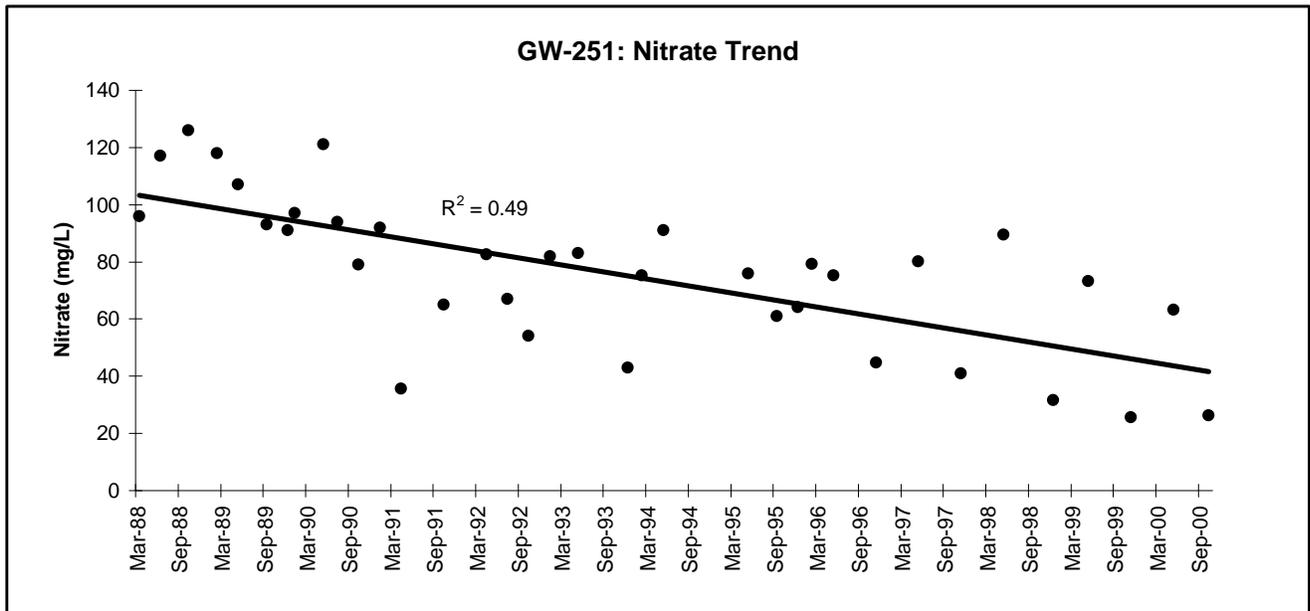
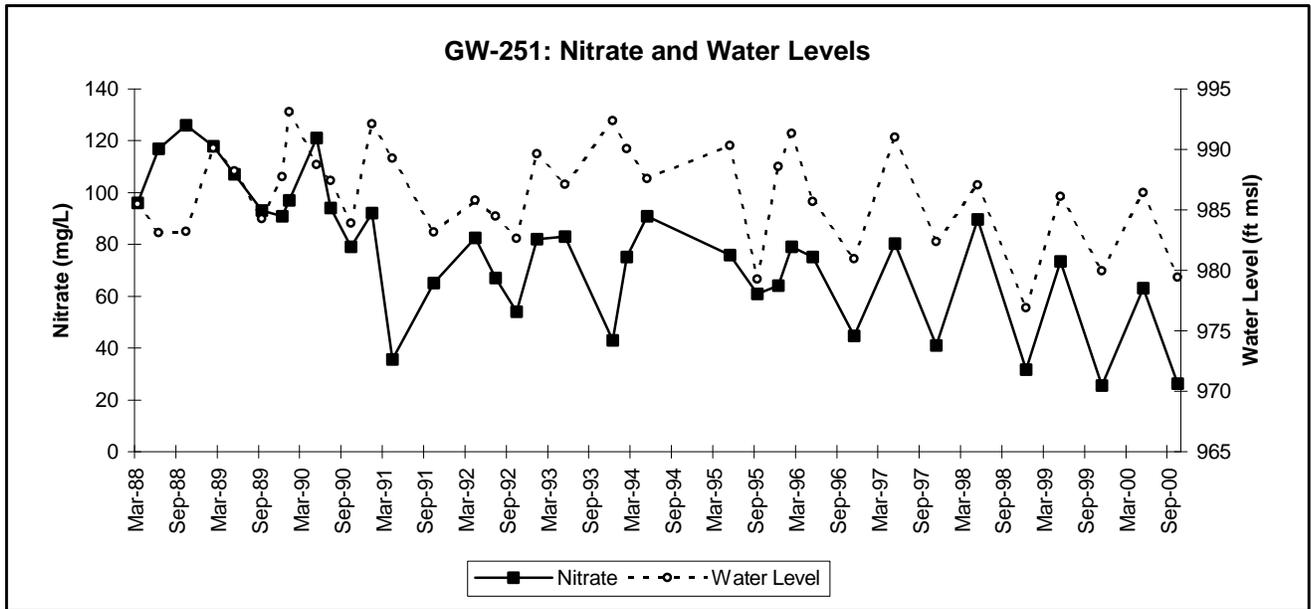


Fig. A.8. Presampling water levels and decreasing nitrate concentrations in well GW-251.

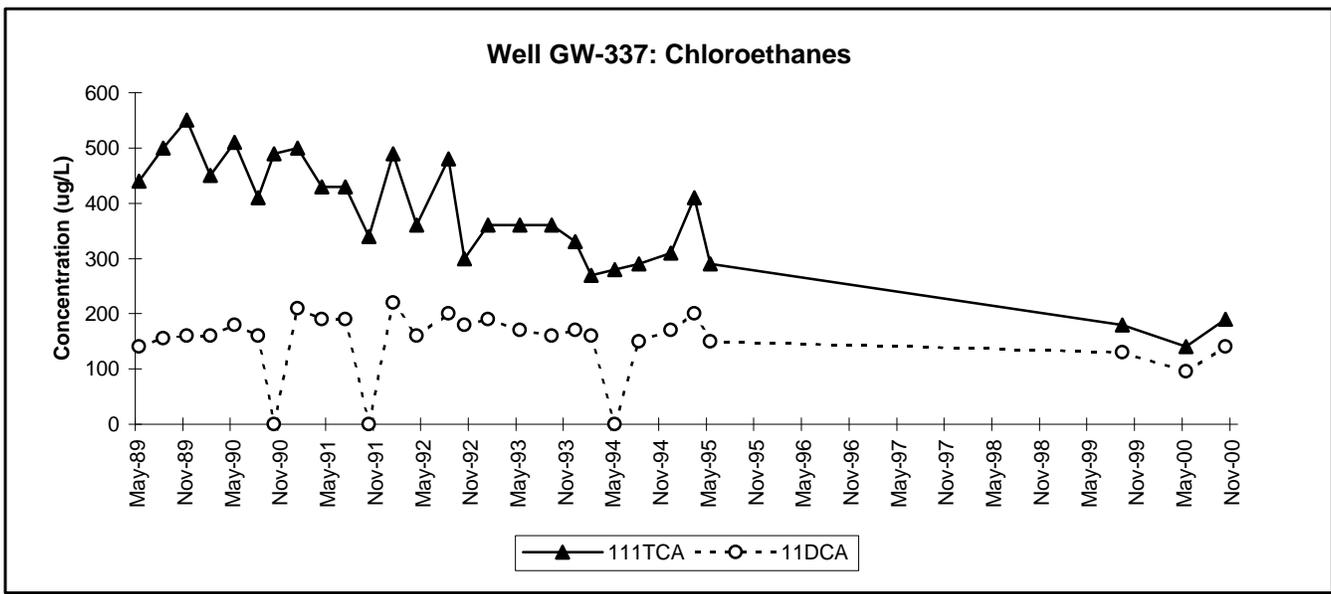
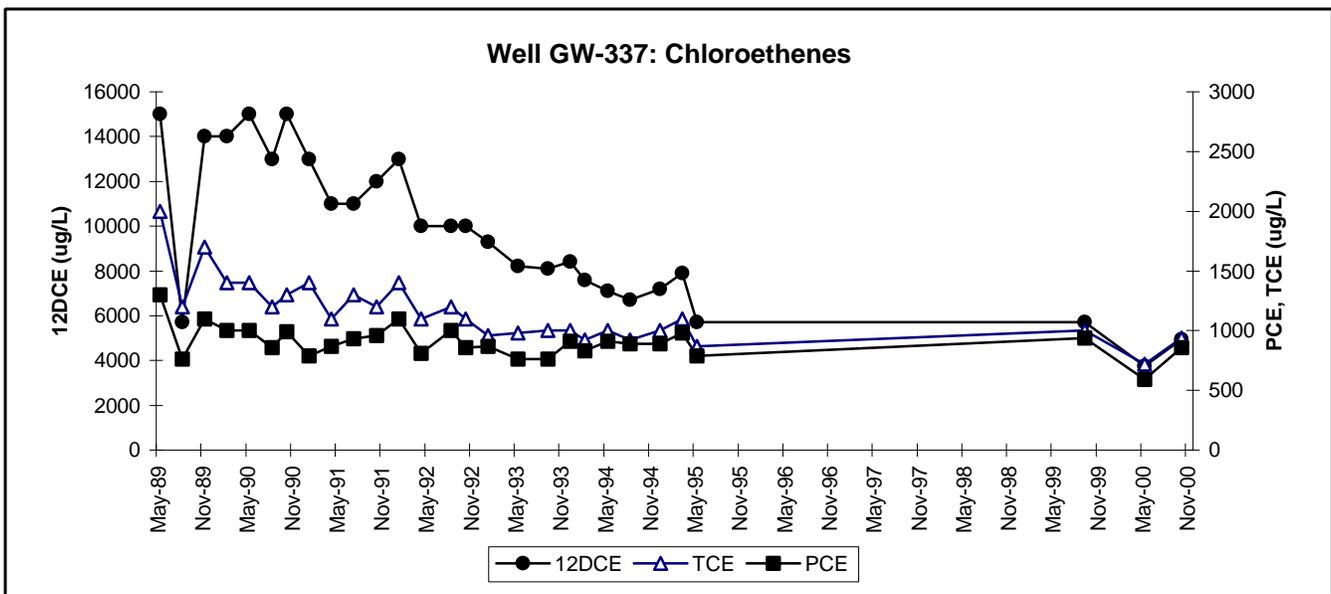
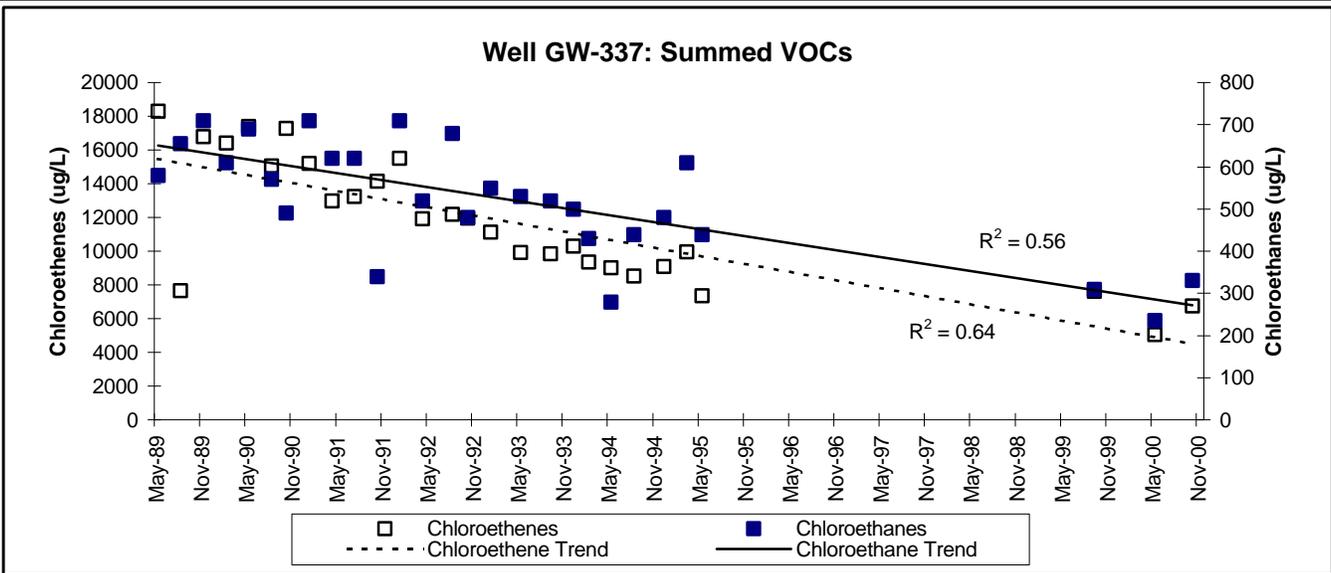


Fig. A.9. Decreasing VOC concentrations in well GW-337.

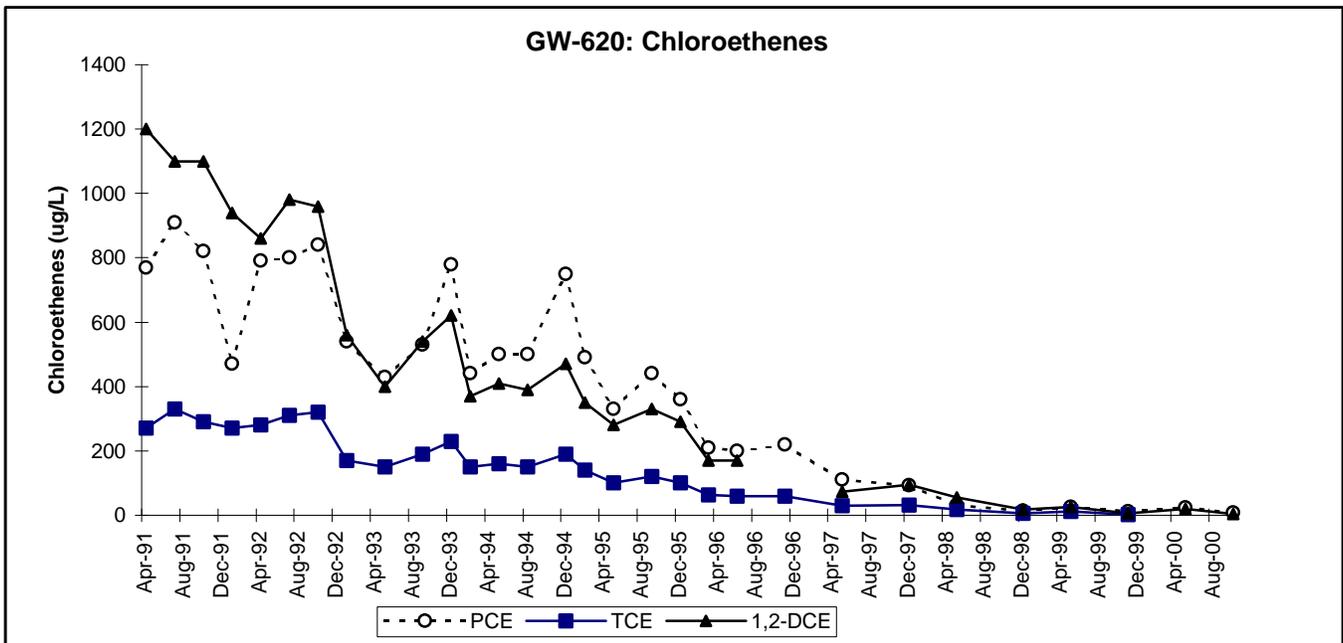
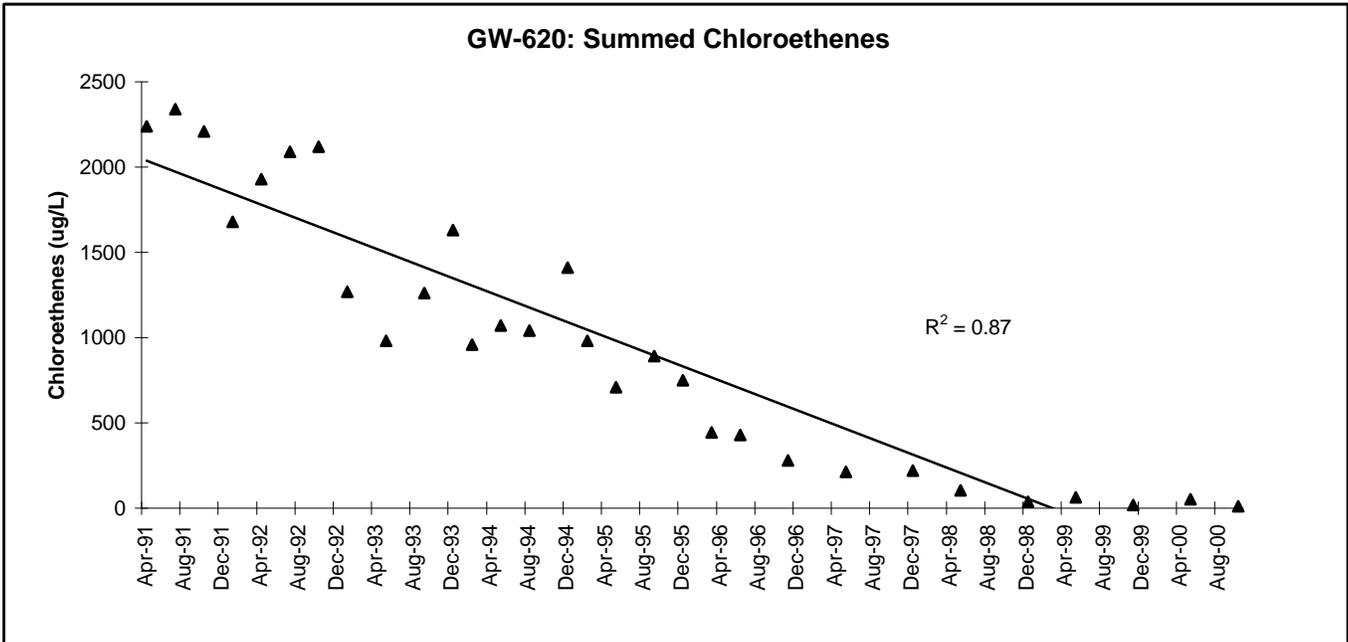


Fig. A.10. Decreasing VOC concentrations in well GW-620.

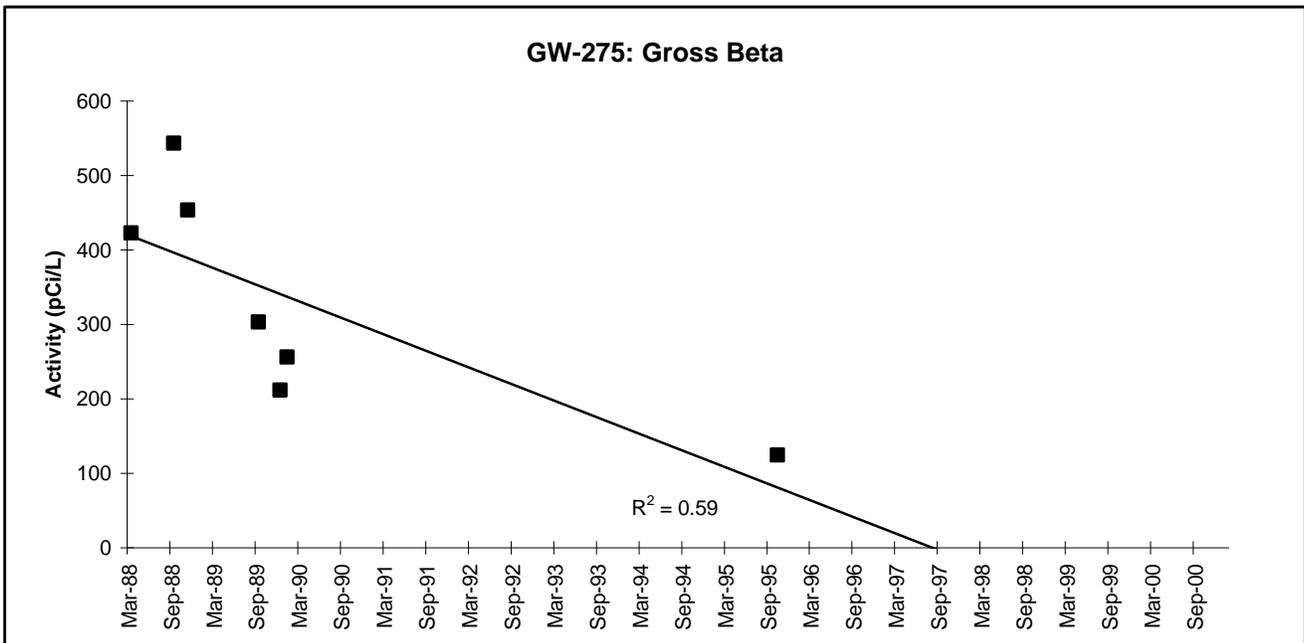
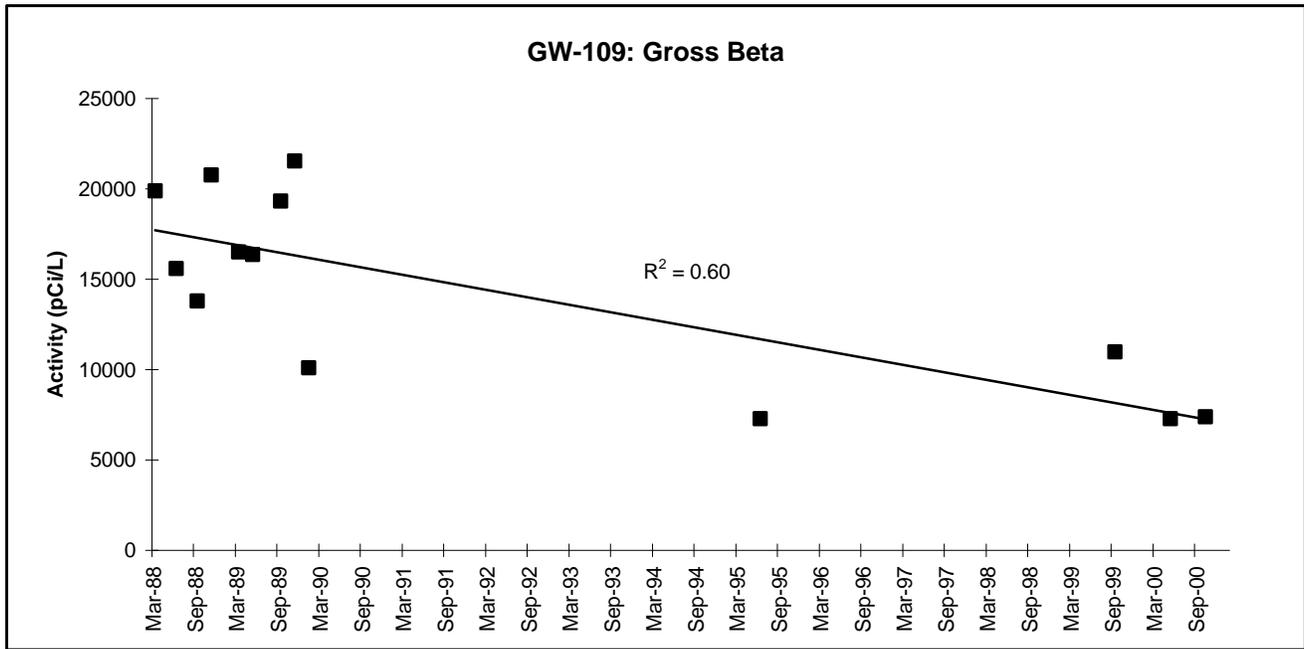


Fig. A.11. Decreasing gross beta radioactivity in wells GW-109 and GW-275.

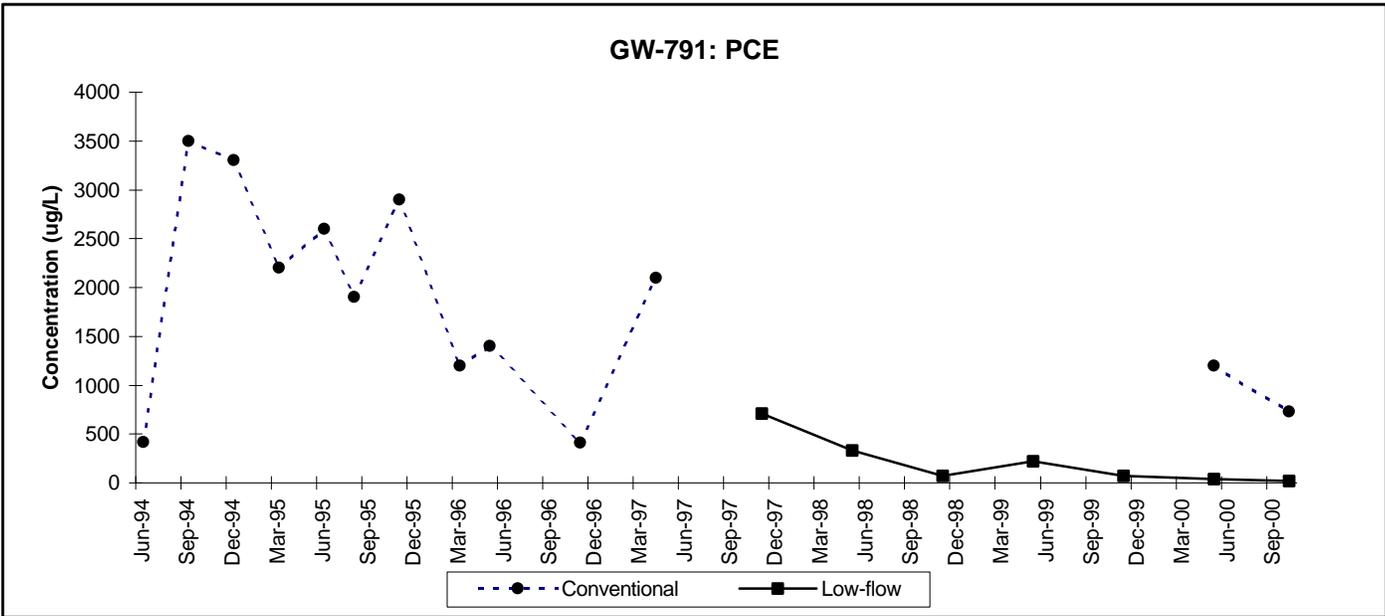
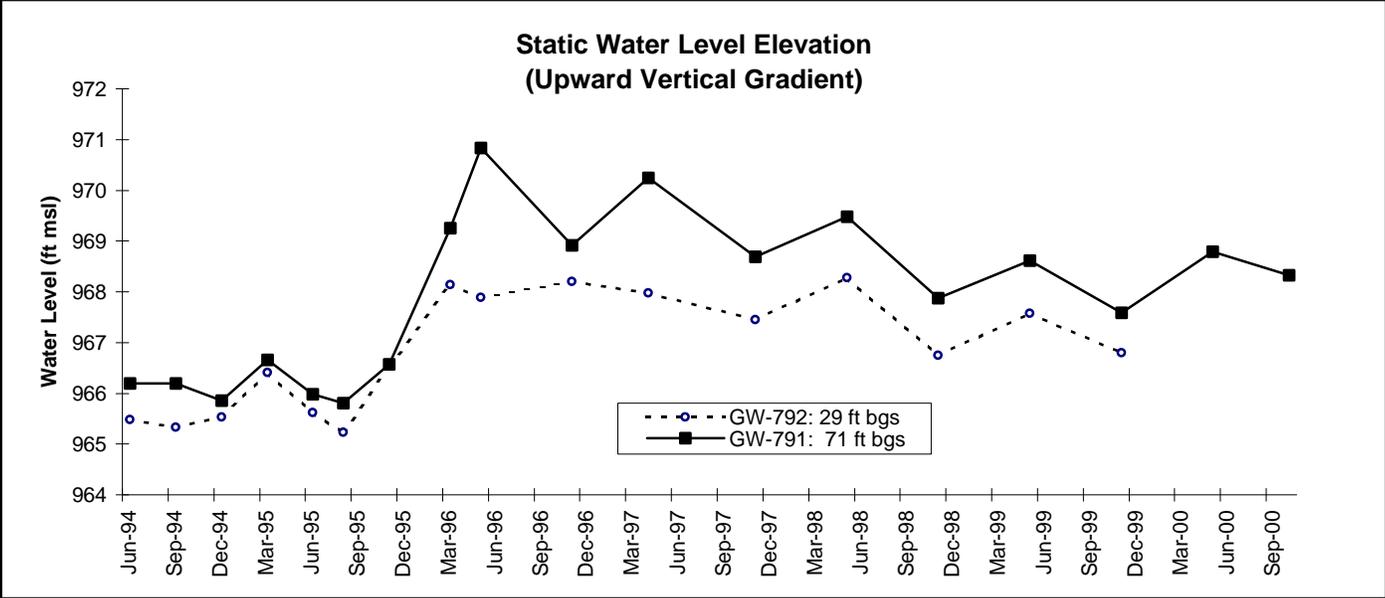
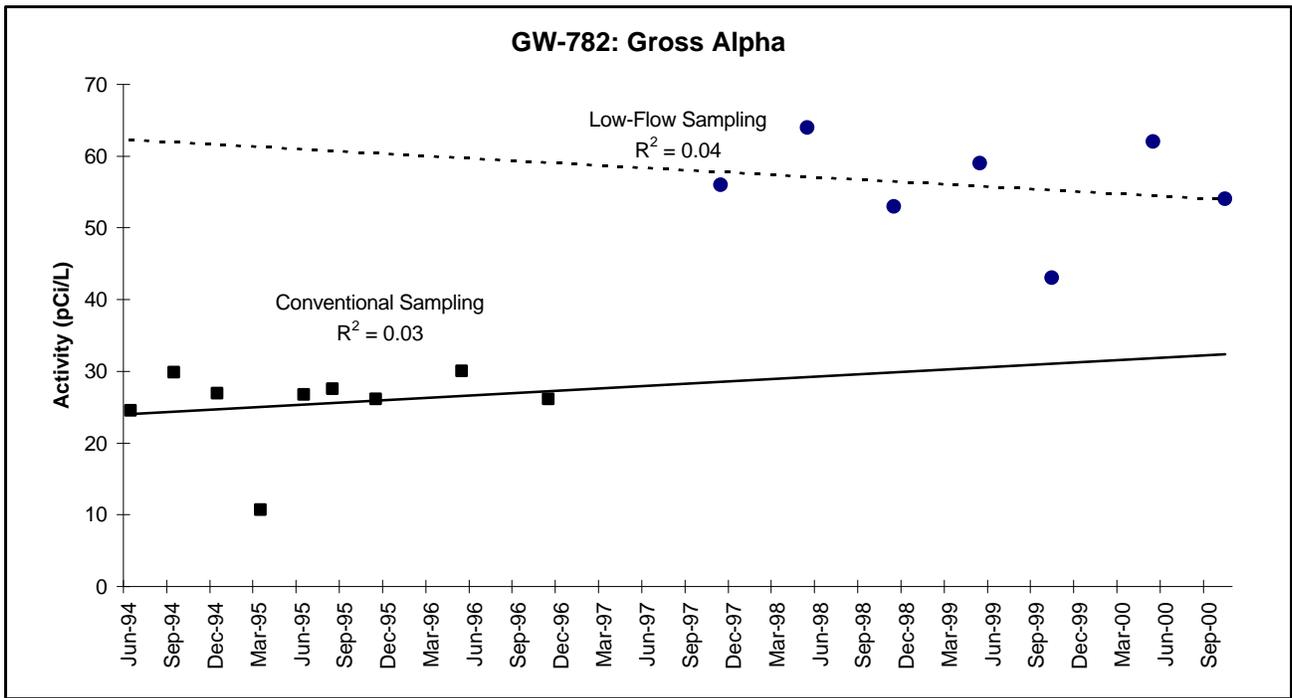


Fig. A.12. Presampling water levels and decreasing PCE concentrations in well GW-791.
A-12



Note: Results for conventional samples collected in February 1996 (52 pCi/L) and May 1997 (44 pCi/L) are not shown.

Fig. A.13. Gross alpha radioactivity in well GW-782.

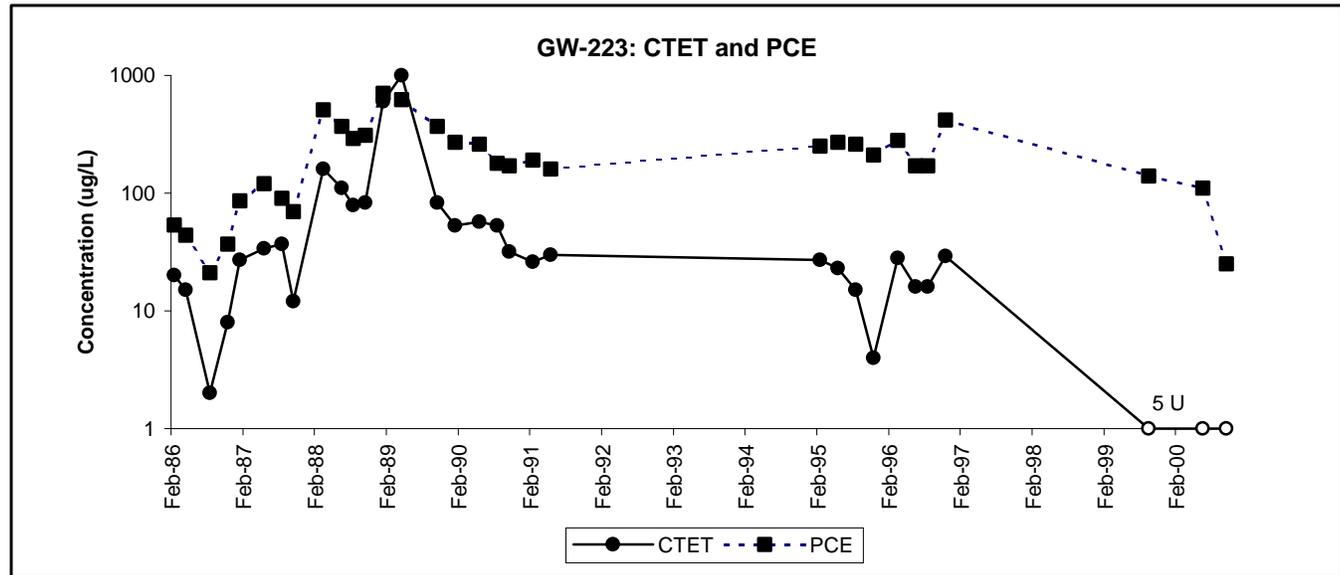
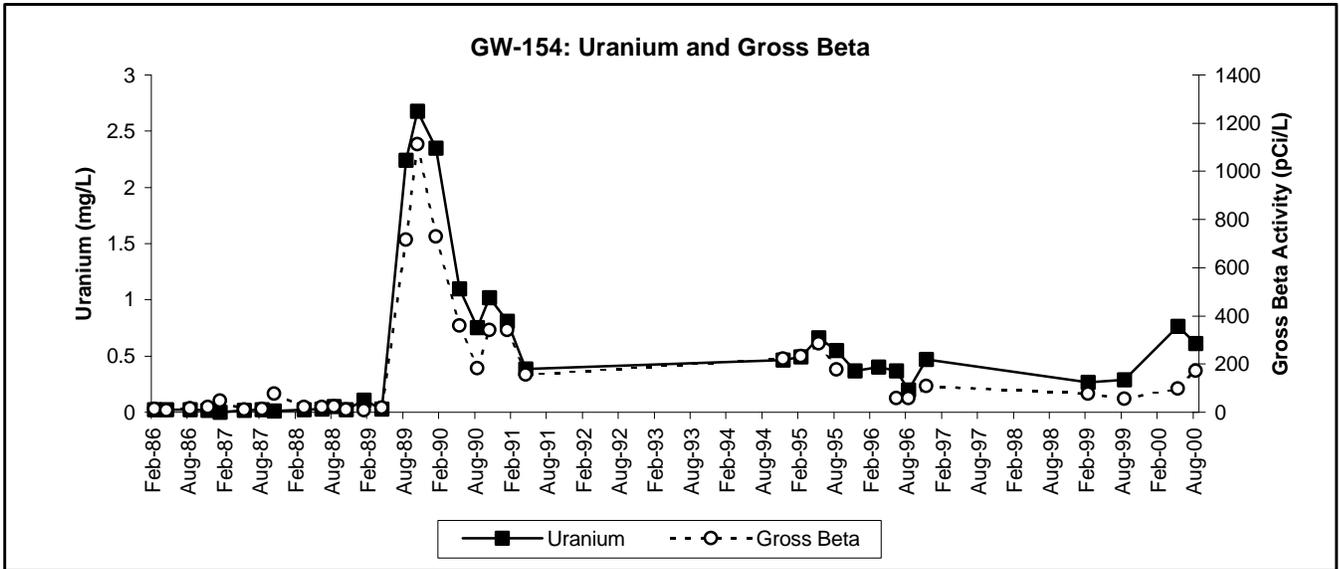
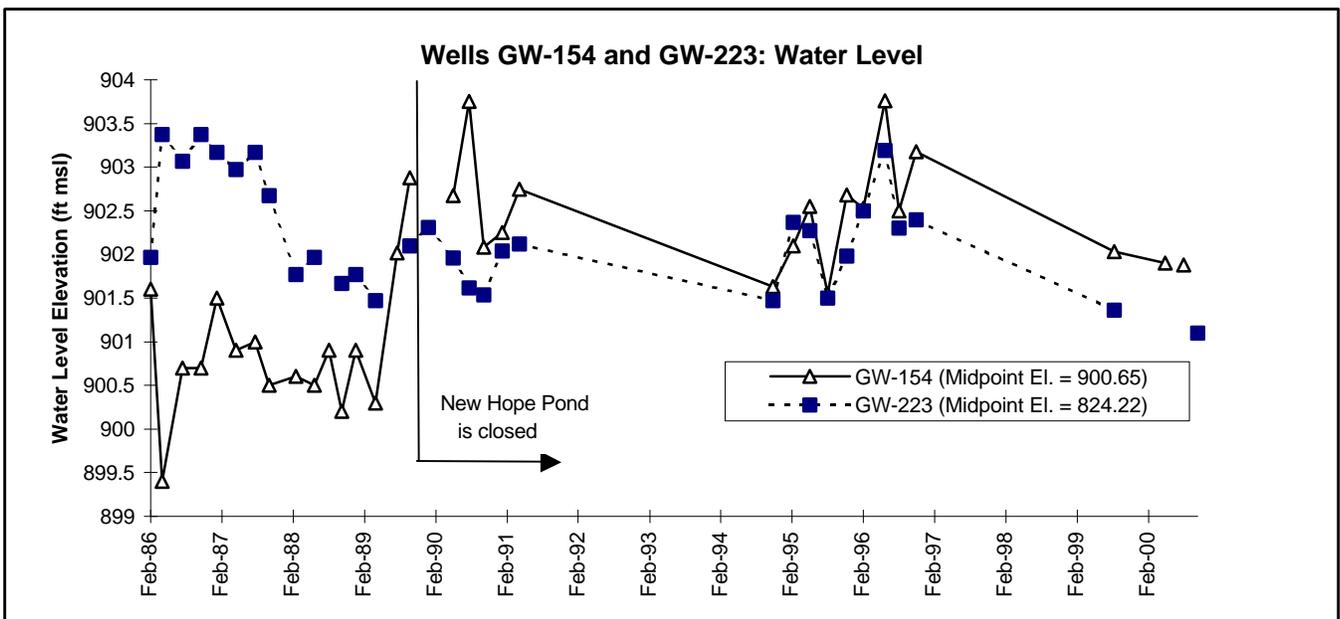


Fig. A.14. Presampling water levels and decreasing contaminant concentrations in wells GW-154 and GW-223.

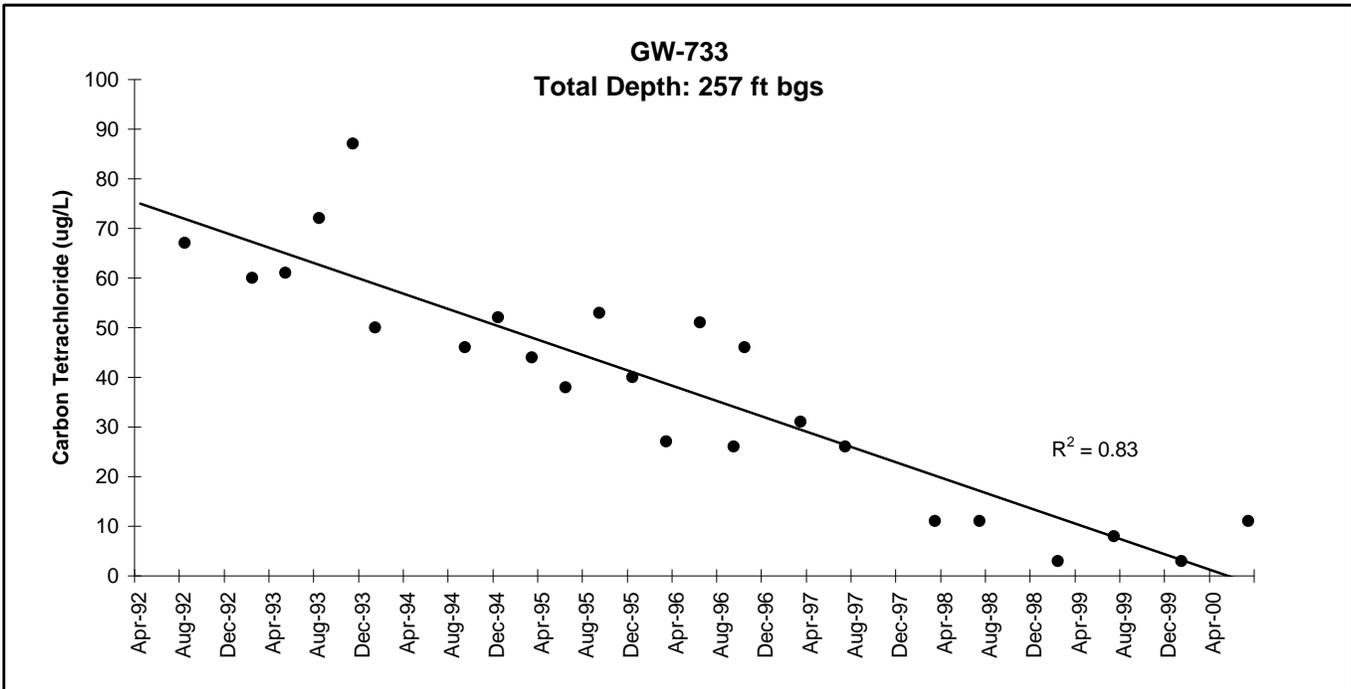
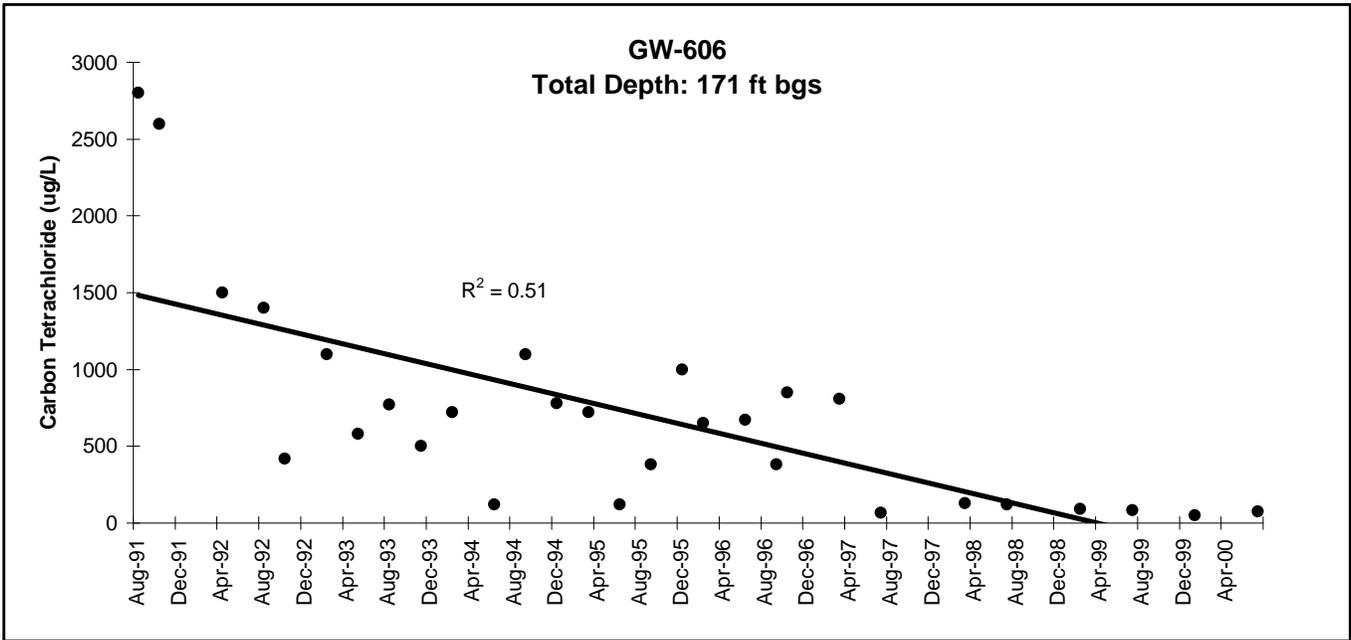


Fig. A.15. Decreasing carbon tetrachloride concentrations in wells GW-606 and GW-733.

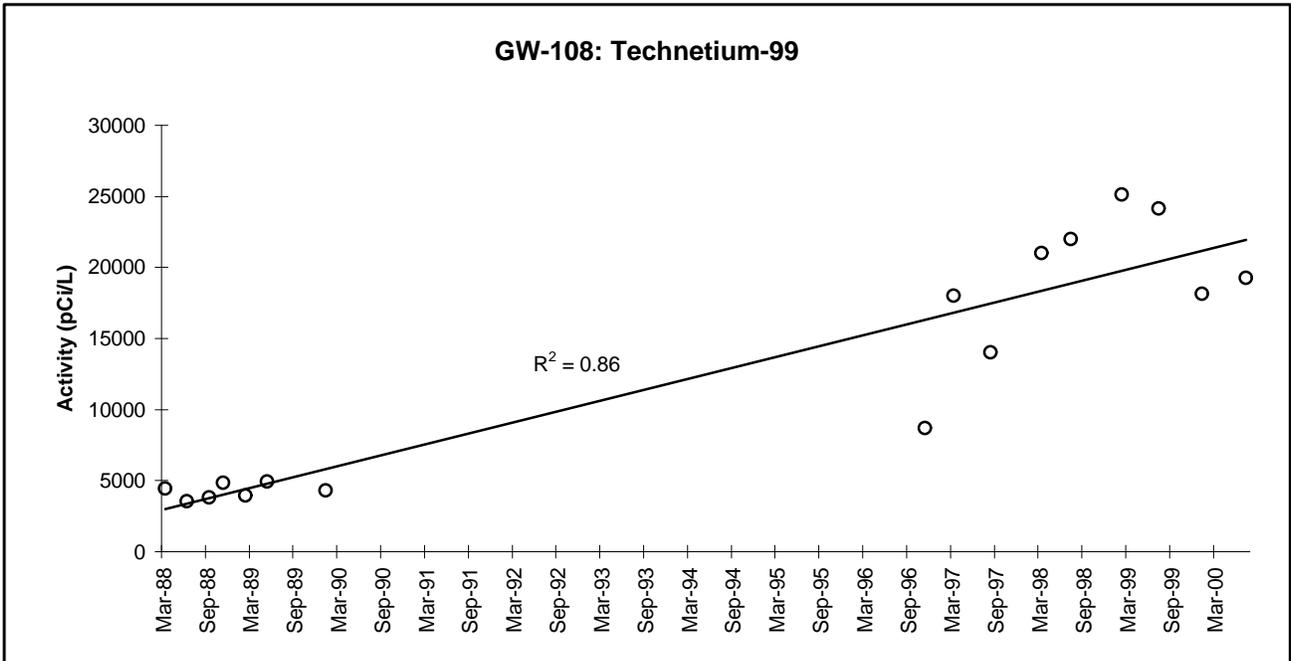
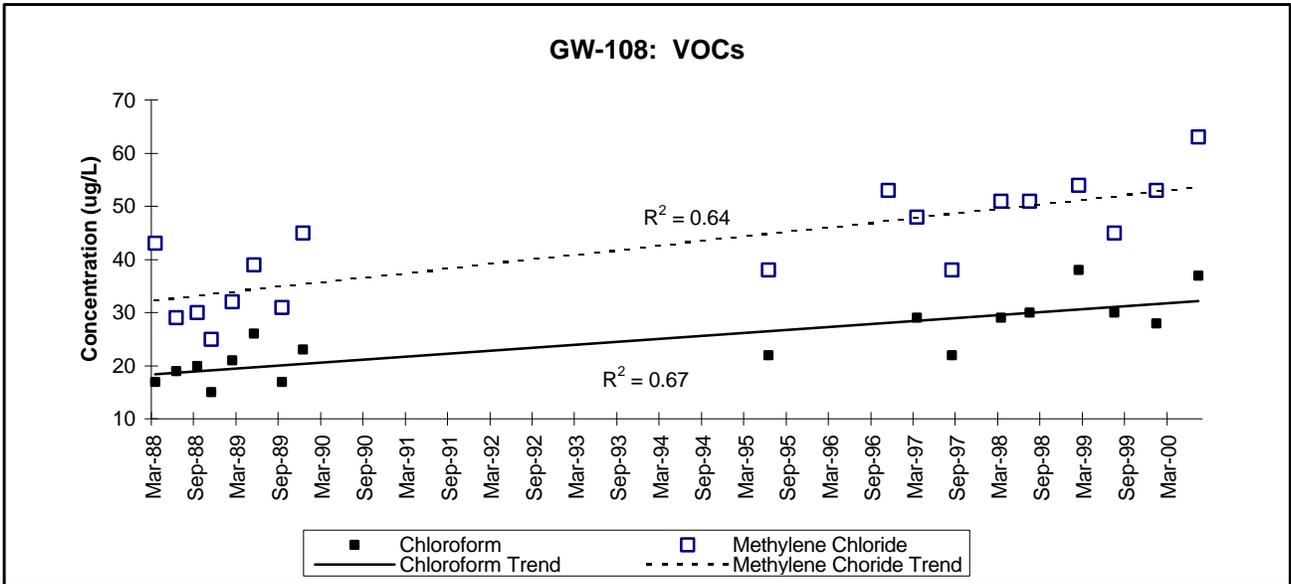


Fig. A.16. Increasing contaminant concentrations in well GW-108.

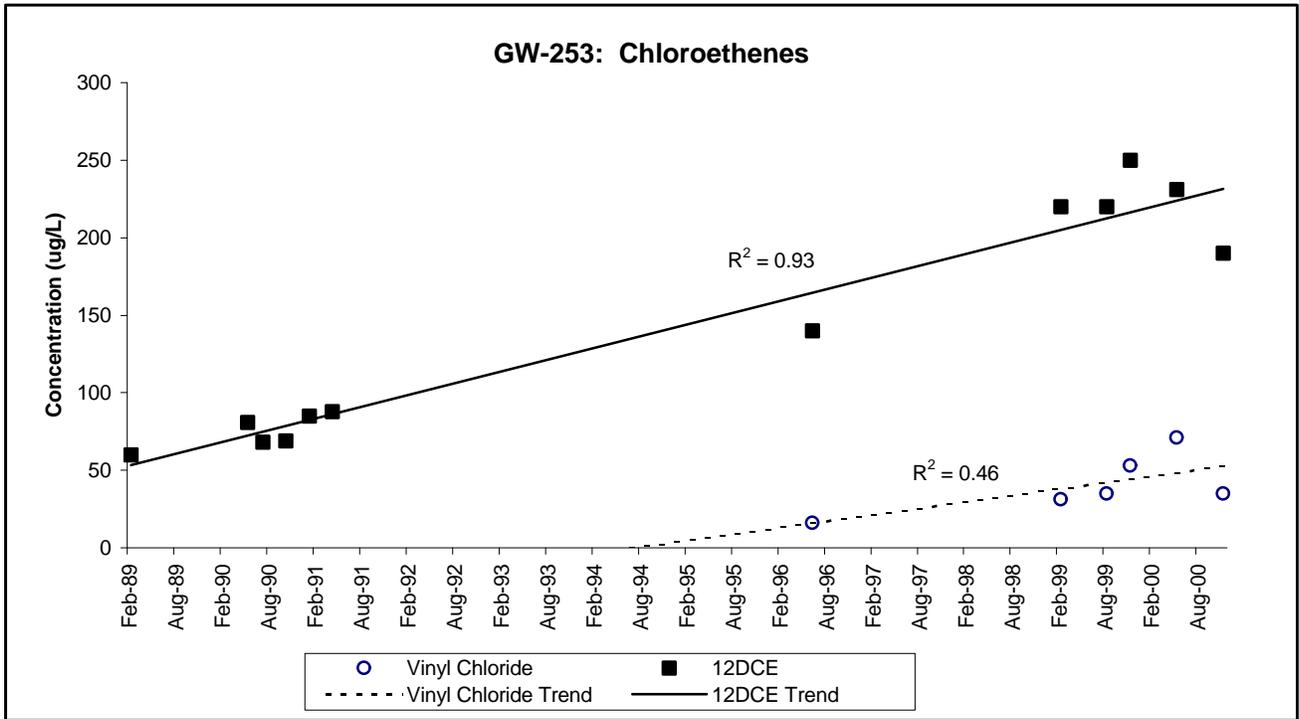


Fig. A.17. Increasing VOC concentrations in well GW-253.
A-17

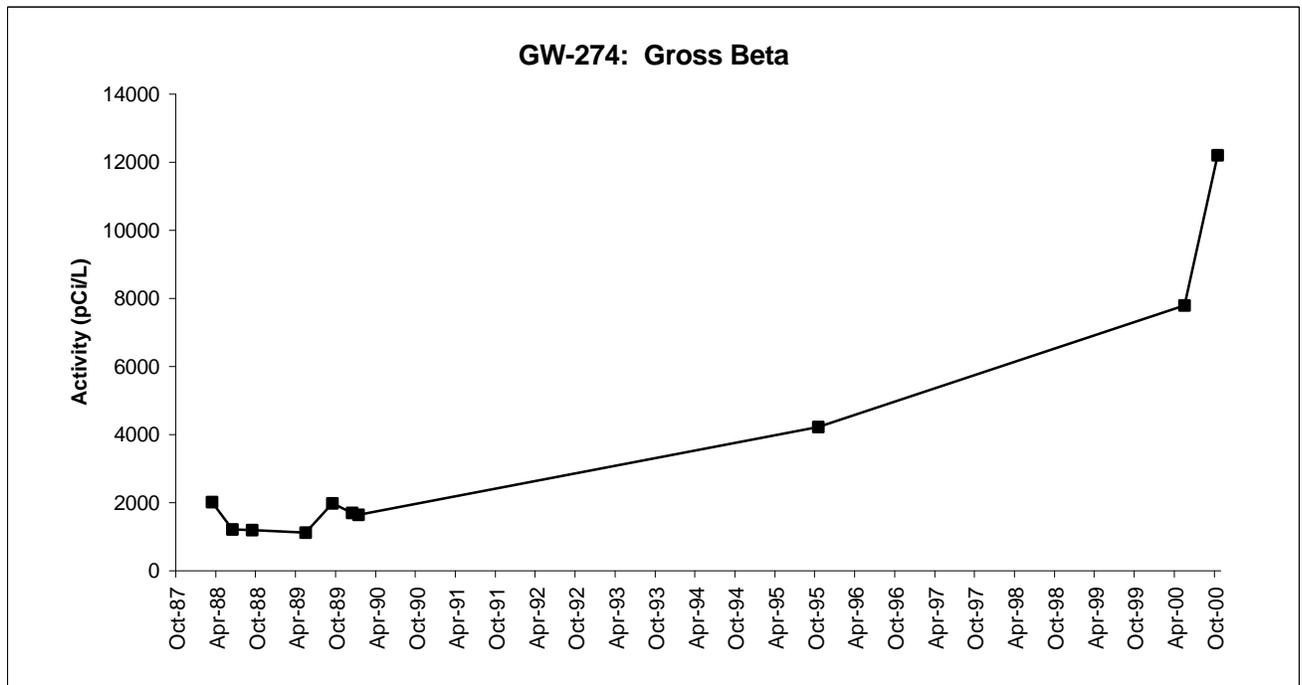
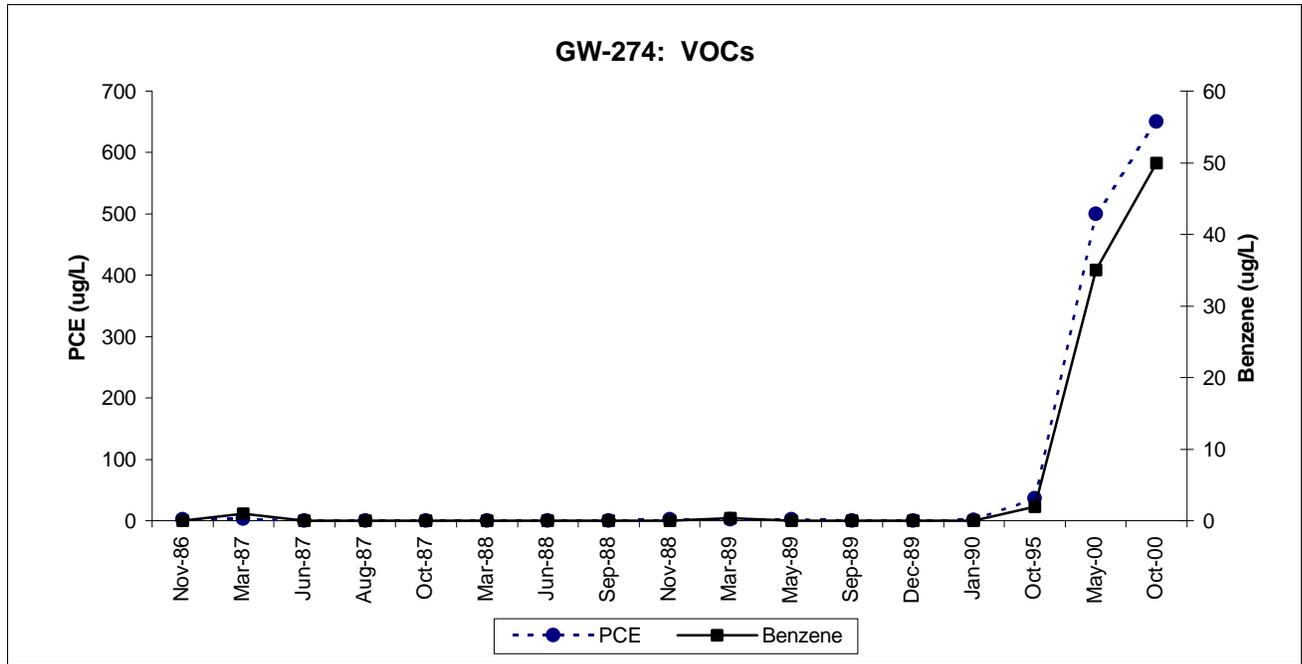


Fig. A.18. Increasing contaminant concentrations in well GW-274.

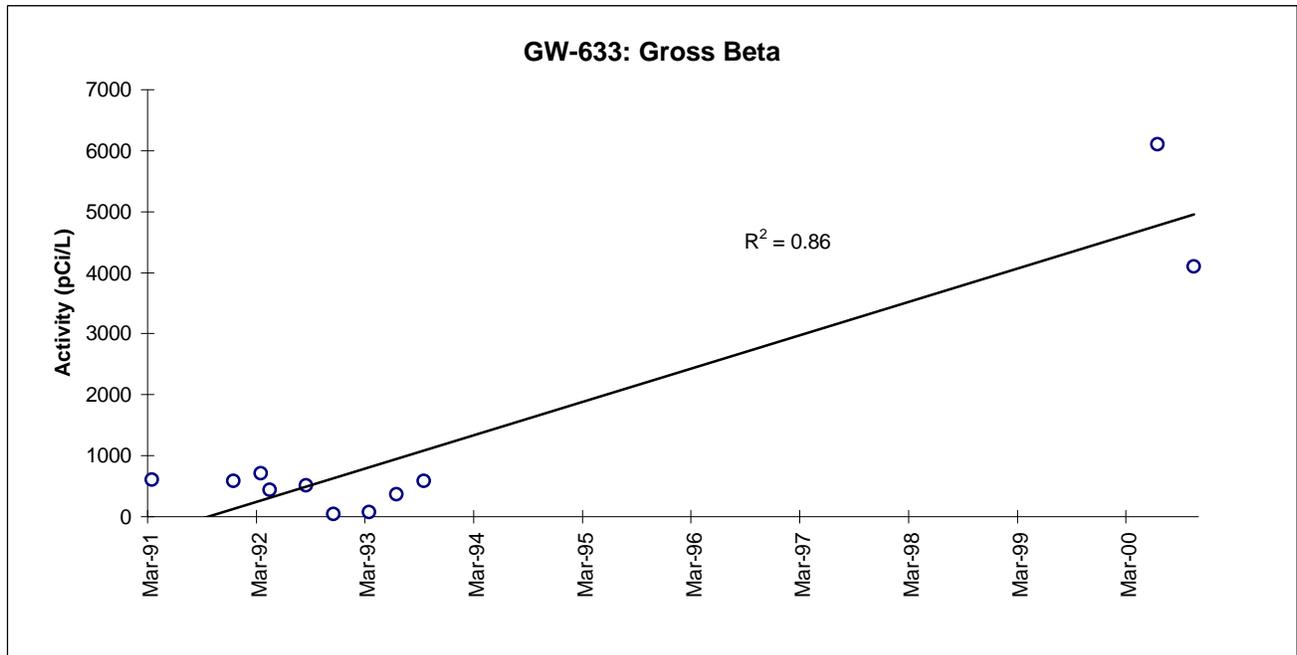
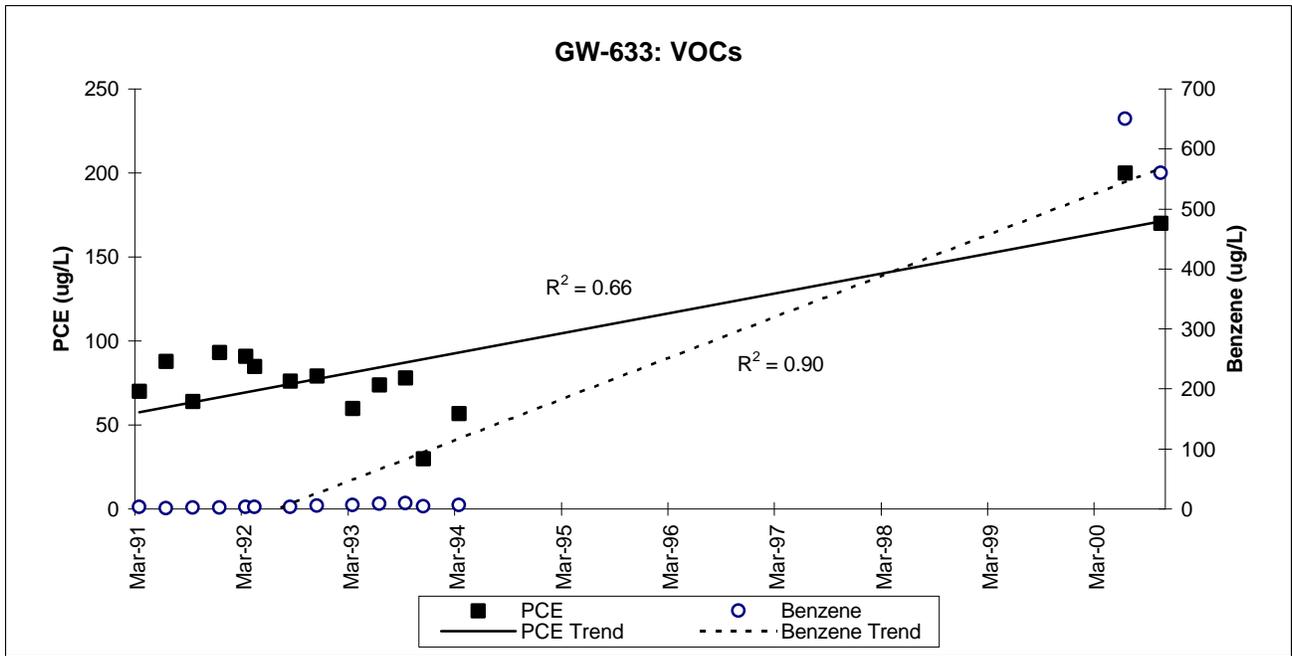


Fig. A.19. Increasing contaminant concentrations in well GW-633.

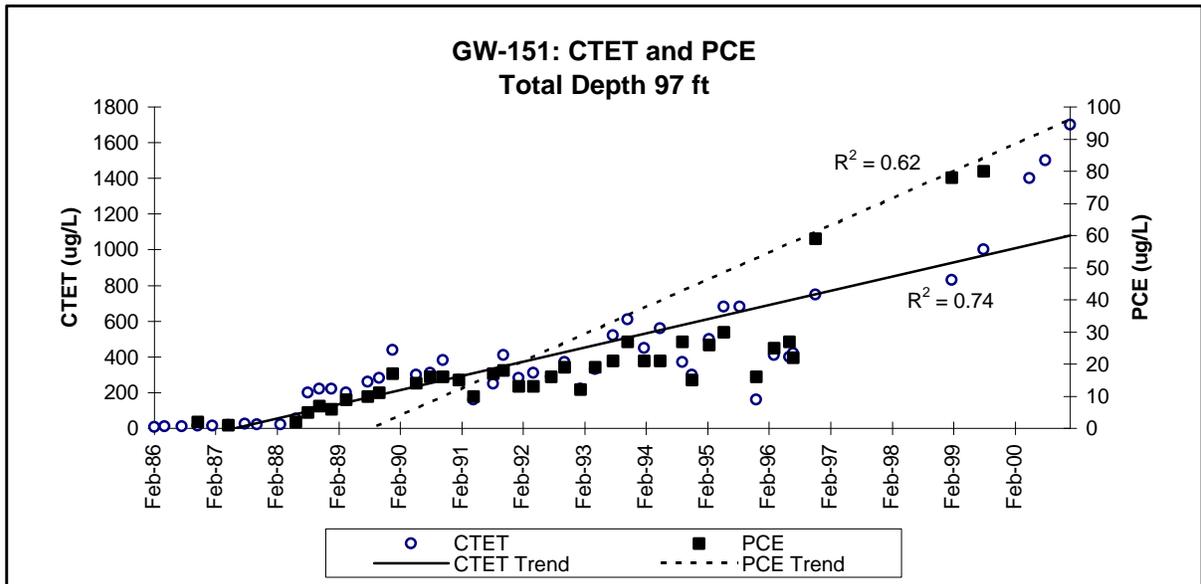
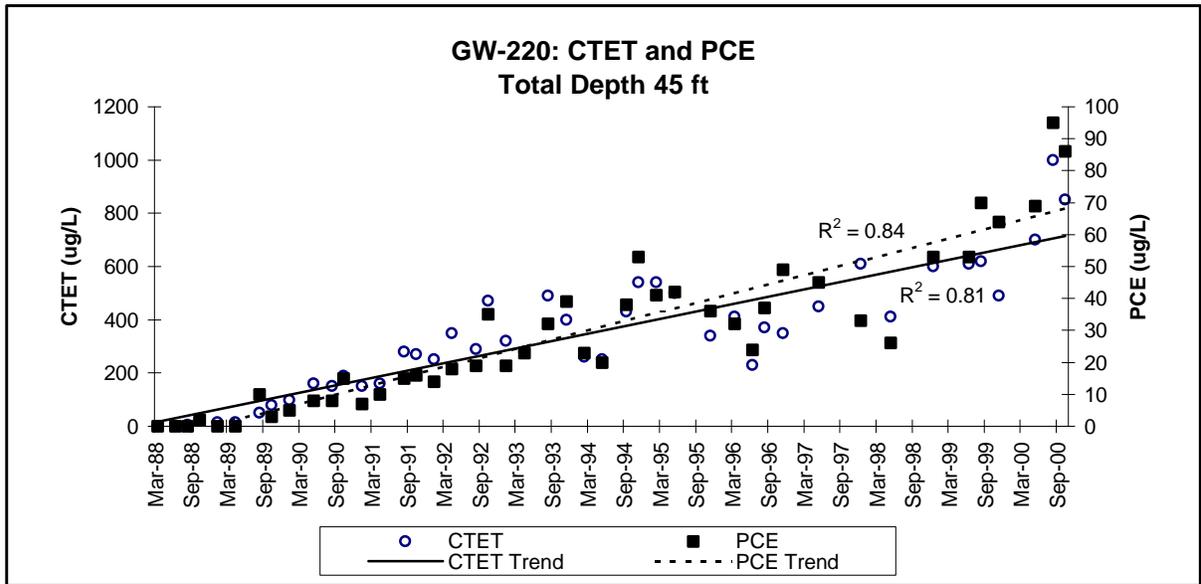


Fig. A.20. Increasing VOC concentrations in wells GW-151 and GW-220.

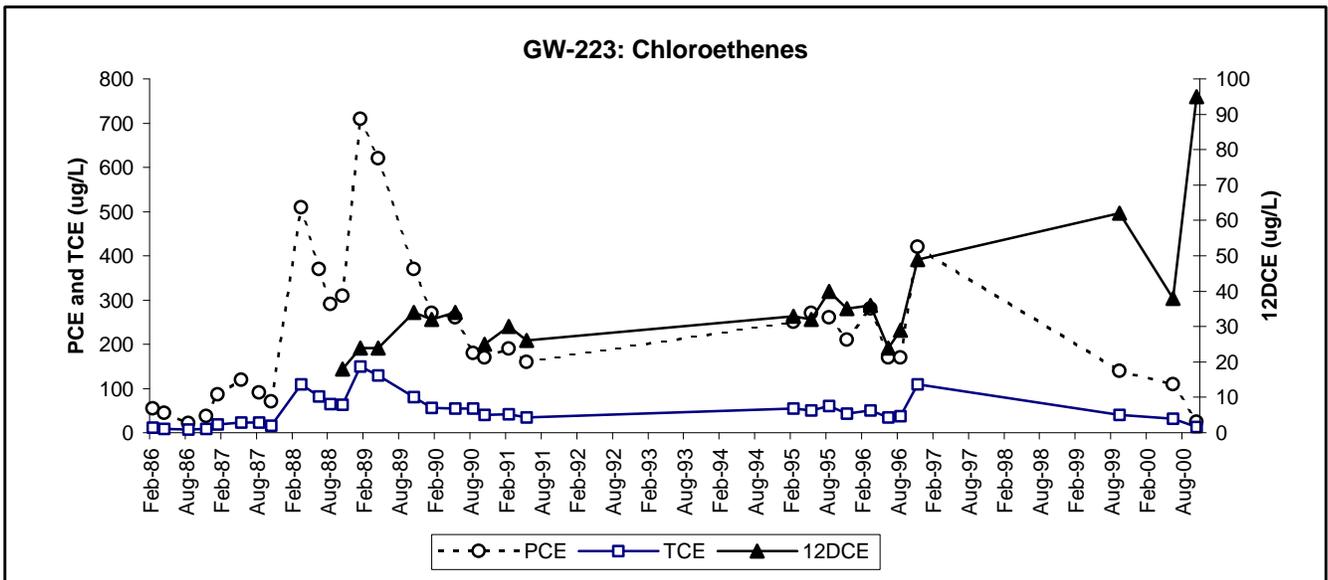
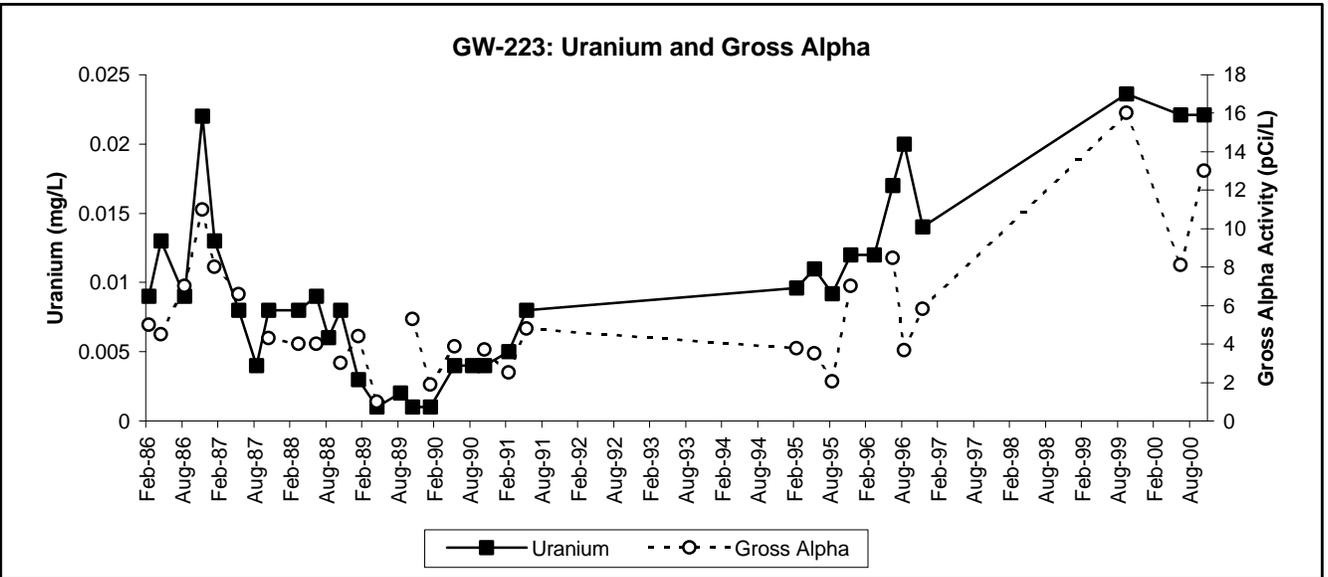
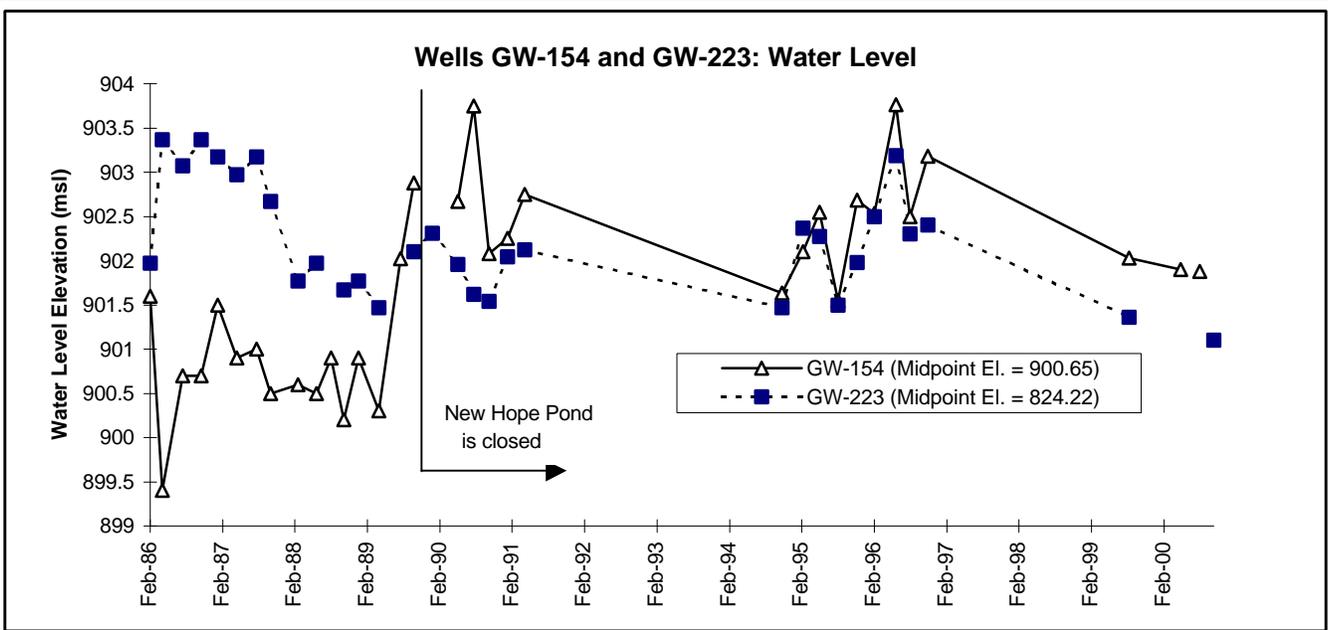


Fig. A.21. Presampling water levels and increasing contaminant concentrations in well GW-223.

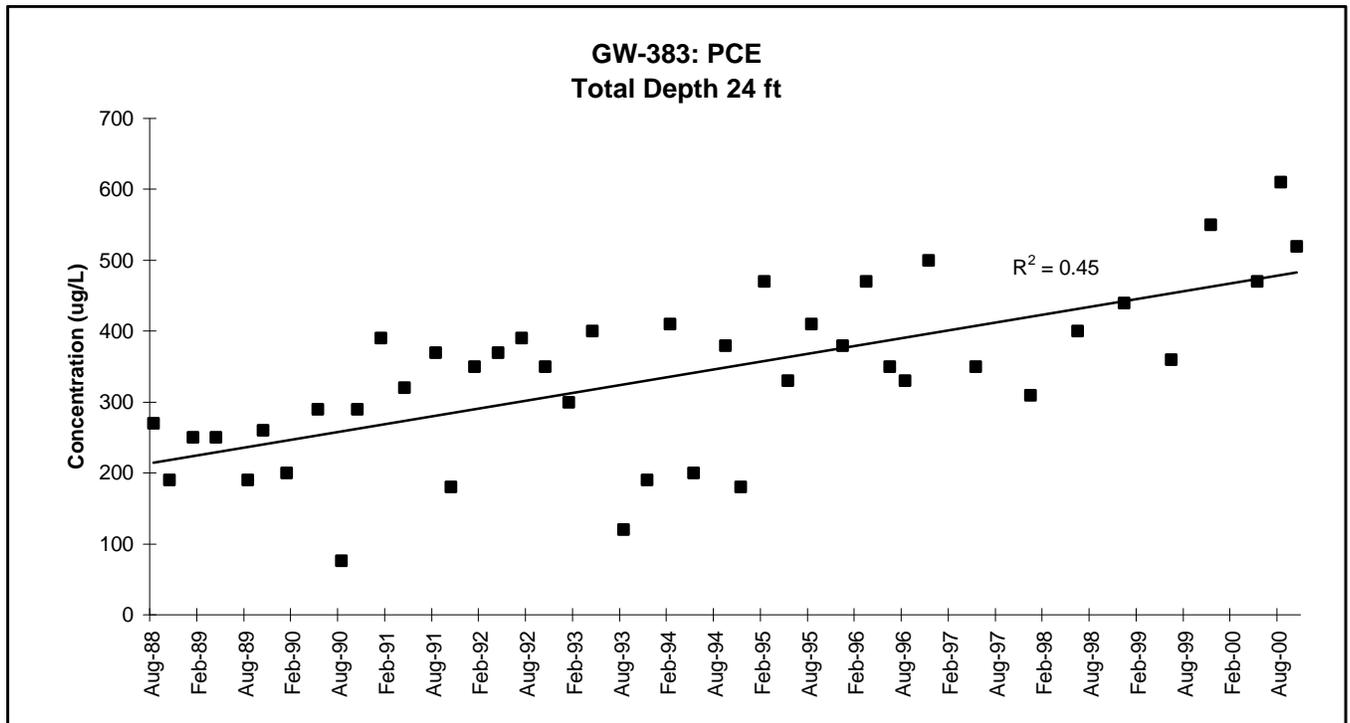


Fig. A.23. Increasing PCE concentrations in well GW-383.
A-23

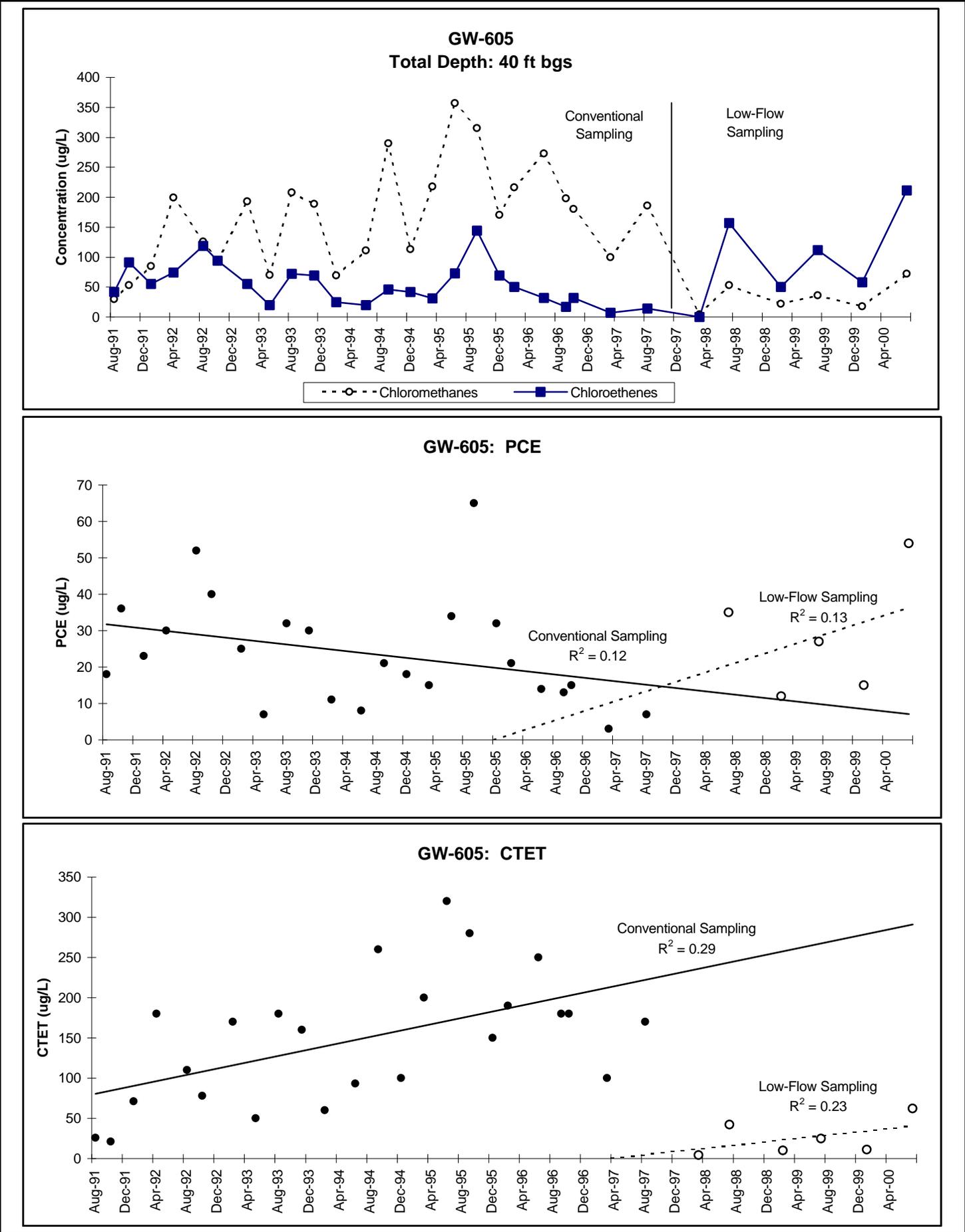


Fig. A.24. Increasing VOC concentrations in well GW-605.

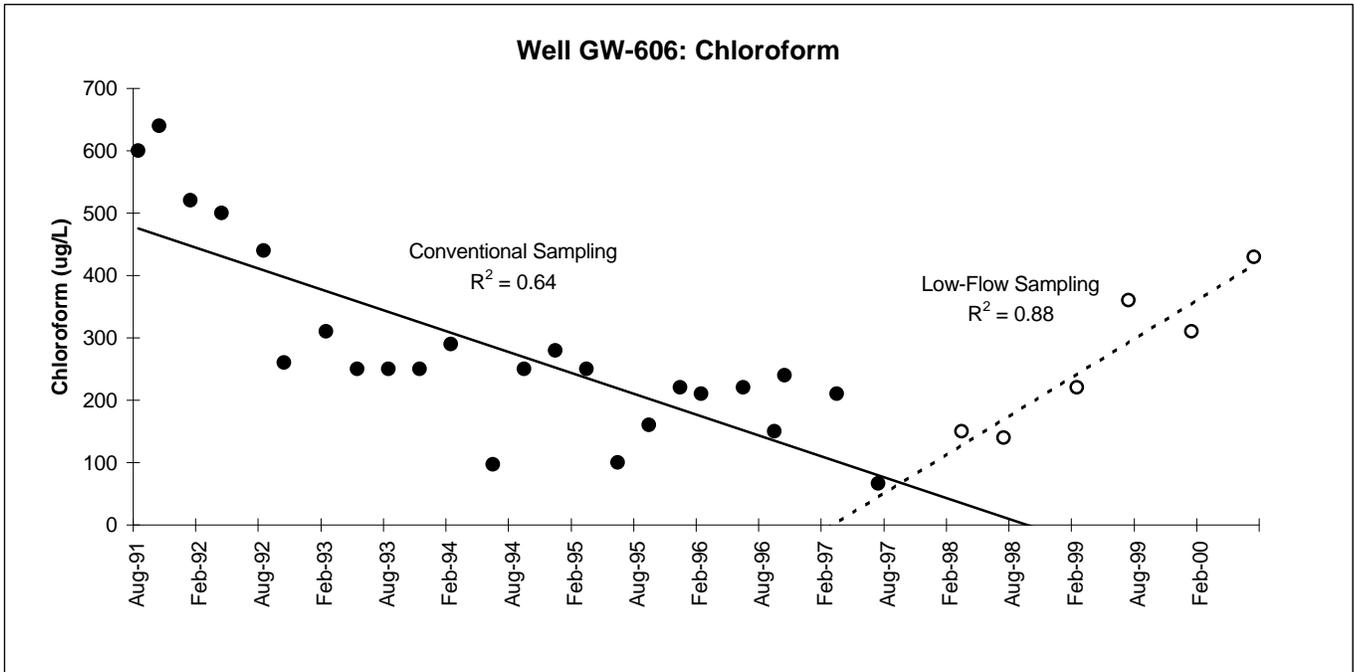
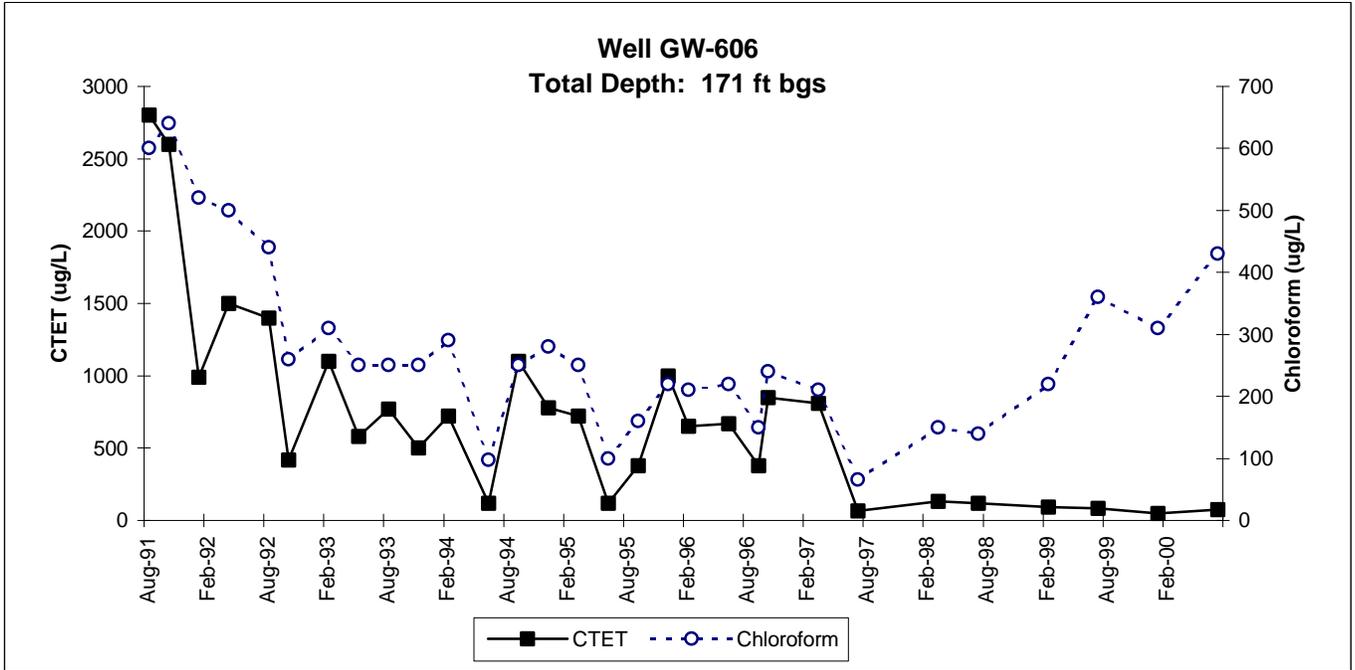


Fig. A.25. Increasing chloroform concentrations in well GW-606.

APPENDIX B

TABLES

Table B.1. CY 2000 groundwater and surface water sampling locations and dates

Evaluation Purpose ¹		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring							
		DOE Order 5400.1 Surveillance Monitoring							
		Y-12 Area ⁴			CY 2000 Sampling Date ⁵				
Sampling Point ²	Sampling Location ³	W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
55-2C	Y12		!		.	05/22/00	.	10/17/00	!
56-2C	Y12		!		.	05/22/00	.	10/17/00	!
9212-W-2-BSTM	B9212		!		03/08/00	.	.	.	!
9215-STACK11	B9215		!		.	.	.	11/30/00	!
GHK2.51ESW	EXP-NPR			*	.	04/19/00	.	11/09/00	!
GHK2.51WSW	EXP-NPR			*	.	04/19/00 D	.	11/09/00	!
GW-108	S3	!			01/11/00	.	07/18/00		!
GW-109	S3	!			.	5/25/00	.	10/19/00	!
GW-151	NHP			!	.	05/16/00	08/17/00	.	!
GW-153	NHP			!	.	05/11/00	.	10/12/00	!
GW-154	NHP			!	.	05/17/00	08/22/00	.	!
GW-169	EXP-UV			*	01/25/00	05/18/00	08/09/00		!
GW-170	EXP-UV			*	01/24/00 D	05/18/00 D	08/08/00 D	11/01/00 D	!
GW-171	EXP-UV			*	01/19/00	05/17/00	08/07/00	.	!
GW-172	EXP-UV			*	01/19/00	05/17/00	08/08/00	.	!
GW-192	B4	!			.	05/09/00 D	.	10/09/00	!
GW-193	T2331		!		01/12/00	.	07/18/00	.	!
GW-204	T0134		!		.	06/07/00	.	10/24/00	!
GW-207	EXP-SR			!	.	04/05/00	.	11/07/00	!
GW-208	EXP-SR			!	.	04/05/00	.	11/07/00	!
GW-218	UOV		!		.	05/31/00	.	10/30/00	!
GW-219	UOV		!		.	06/06/00 D	.	10/30/00	!
GW-220	NHP			!	.	5/15/00	08/22/00	10/12/00 D	!
GW-222	NHP			!	.	06/13/00	.	10/26/00	!
GW-223	NHP			!	.	06/12/00	.	10/31/00	!
GW-230	EXP-UV			*	01/20/00	05/17/00	08/08/00	11/01/00	!
GW-232	EXP-UV			*	01/25/00	05/18/00	08/09/00	.	!
GW-240	NHP			!	.	05/17/00	.	10/11/00	!
GW-251	S2	!			.	05/09/00	.	10/09/00	!
GW-253	S2	!			.	05/23/00	.	11/02/00	!
GW-274	SY	!			.	05/30/00	.	10/18/00	!
GW-275	SY	!			.	05/30/00	.	10/18/00	!

Table B.1 (continued)

Evaluation Purpose ¹		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring							
		DOE Order 5400.1 Surveillance Monitoring							
Sampling Point ²	Sampling Location ³	Y-12 Area ⁴			CY 2000 Sampling Date ⁵				
		W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
GW-337	WC	!			.	05/23/00	.	10/19/00	!
GW-380	NHP			!	.	05/16/00	.	.	!
GW-381	NHP			!	.	05/17/00	.	10/16/00	!
GW-381	NHP			!	.	05/17/00	.	.	!
GW-382	NHP			!	.	05/18/00	09/11/00	.	!
GW-383	NHP			!	.	05/15/00	08/17/00	10/16/00	!
GW-605	EXP-I			!	01/12/00 D	.	07/17/00 D	.	!
GW-606	EXP-I			!	01/12/00	.	07/17/00	.	!
GW-618	EXP-E	!			.	05/23/00	.	11/08/00	!
GW-620	FTF	!			.	05/10/00	.	10/10/00	!
GW-633	RG	!			.	06/08/00	.	10/24/00	!
GW-656	T0134		!		.	06/12/00	.	10/25/00	!
GW-690	CPT		!		.	06/19/00	.	10/25/00	!
GW-700	B8110		!		.	06/19/00	.	10/25/00	!
GW-722-06	EXP-J			!	03/14/00	.	07/17/00 09/12/00	11/30/00	!
GW-722-10	EXP-J			!	03/20/00	.	07/20/00 09/12/00	11/30/00	!
GW-722-14	EXP-J			!	03/21/00	.	07/26/00 09/13/00	11/30/00	!
GW-722-17	EXP-J			!	03/21/00	.	07/26/00 09/13/00	11/30/00	!
GW-722-20	EXP-J			!	03/21/00	.	07/25/00 09/13/00	12/04/00	!
GW-722-22	EXP-J			!	03/21/00	.	07/25/00 D 09/13/00	12/04/00	!
GW-722-26	EXP-J			!	03/15/00 D	.	07/18/00 09/14/00 D	12/04/00 D	!
GW-722-30	EXP-J			!	03/15/00	.	07/18/00 09/14/00	12/06/00	!
GW-722-32	EXP-J			!	03/20/00	.	07/18/00 09/14/00	12/05/00	!
GW-722-33	EXP-J			!	03/20/00	.	07/18/00 09/18/00	12/05/00	!
GW-733	EXP-J			!	01/13/00	.	07/17/00	.	!

Table B.1 (continued)

Evaluation Purpose ¹		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring							
		DOE Order 5400.1 Surveillance Monitoring							
Sampling Point ²	Sampling Location ³	Y-12 Area ⁴			CY 2000 Sampling Date ⁵				
		W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
GW-735	EXP-J			!	.	04/25/00 05/15/00	08/21/00	11/2/00	!
GW-744	GRIDK1			!	.	04/17/00	.	11/01/00 D	!
GW-747	GRIDK2			!	.	04/24/00	.	11/01/00	!
GW-750	EXP-J			!	.	04/25/00	.	11/02/00	!
GW-762	GRIDJ3			!	.	05/16/00 D	08/21/00 D	.	!
GW-763	GRIDJ3			!	.	05/10/00	.	10/10/00	!
GW-763	GRIDJ3			!	.	05/11/00 C	.	10/11/00 C	!
GW-769	GRIDG3		!		.	04/27/00	.	10/03/00	!
GW-770	GRIDG3		!		.	04/26/00	.	10/02/00 D	!
GW-782	GRIDE3		!		.	05/01/00	.	10/03/00	!
GW-783	GRIDE3		!		.	05/01/00	.	.	!
GW-789	GRIDF3		!		.	04/26/00 D	.	10/02/00	!
GW-791	GRIDD2		!		.	05/02/00	.	10/03/00	!
GW-791	GRIDD2		!		.	05/03/00 C	.	10/04/00 C	!
GW-816	EXP-SR			!	.	04/10/00	.	11/08/00	!
GW-820	B9201-2		!		.	06/13/00	.	10/26/00 D	!
GW-832	NHP			!	.	05/17/00	08/23/00	.	!
GW-845	NHP			!	03/15/00	.	.	.	!
LRSPW	EXP-SW			!	.	04/18/00 D	.	12/19/00	!
NPR07.0SW	EXP-NPR			*	.	04/19/00	.	11/09/00	!
NPR10.0SW	EXP-NPR			*	.	05/24/00	.	DRY	!
NPR12.0SW	EXP-NPR			*	.	04/19/00	.	11/09/00 D	!
OF 51	EXP-SW		!		.	04/10/00	09/19/00	.	!
OF 200	EXP-SW		!		03/20/00 D	04/10/00 D	09/19/00 D	.	!
OF 221	EXP-SW	!			03/20/00	.	09/19/00	.	!
OF 225	EXP-SW	!			03/20/00	.	09/19/00	.	!
SCR7.1	EXP-UV				01/19/00	05/30/00	09/06/00	.	!
SCR7.18SP	EXP-UV				01/19/00	05/30/00	.	.	!
SCR7.8SP	EXP-UV				01/19/00	05/30/00	09/06/00	.	!
SP-17	EXP-SW			!	.	04/10/00	09/19/00	.	!
STATION 17	EXP-SW			!	03/20/00	04/10/00	09/19/00	.	!
STATION 8	EXP-SW		!		03/20/00	04/10/00	09/19/00	.	!

Table B.1 (continued)

Notes:

- 1 Although samples were collected from the sampling locations for a variety of monitoring purposes (e.g., RCRA), this report uses all of the monitoring results for DOE Order 5400.1 data evaluation purposes. The monitoring program for each location is provided in the CY 2000 GWMR (AJA Technical Services, Inc. 2001a).

- 2
 - GHK - Gum Hollow Branch Kilometer (surface water sampling location)
 - GW - Groundwater Monitoring Well; Westbay well GW-722
 - LRSPW - Lake Reality Spillway (surface water sampling location)
 - NPR - North of Pine Ridge near the Scarboro Community (surface water sampling location)
 - OF - Storm drain outfall (surface water sampling location)
 - SCR - Spring sampling location in Union Valley
 - SP - Spring sampling location
 - STATION - Surface water sampling location in Upper East Fork Poplar Creek

- 3
 - B4 - Beta-4 Security Pits
 - B9201-2 - Building 9201-2
 - B9212 - Building 9212 (sump sampling location)
 - B9215 - Building 9215 (process basin sampling location)
 - EXP - Exit Pathway monitoring location:
 - ! -E, -I, or -J: Maynardville Limestone Picket monitoring well.
 - ! -NPR: Surface water station located north of Pine Ridge where drainage exits the Oak Ridge Reservation.
 - ! -SW: Onsite spring or surface water station
 - ! -SR: Along Scarboro Road in the gap through Pine Ridge
 - ! -UV: East of the Oak Ridge Reservation boundary in Union Valley
 - FTF - Fire Training Facility
 - GRID - Comprehensive Groundwater Monitoring Plan Grid Location
 - NHP - New Hope Pond
 - RG - Rust Garage Area
 - S2 - S-2 Site
 - S3 - S-3 Ponds Site
 - SY - Y-12 Salvage Yard
 - T0134 - Tank 0134-U
 - T2331 - Tank 2331-U
 - UOV - Uranium Oxide Vault
 - WC - Waste Coolant Processing Area

- 4
 - W - Western, west of Y-12 Grid east coordinate 55,000
 - C - Central, between east coordinates 55,000 and 62,000
 - E - Eastern, east of 62,000
 - * - Not in the East Fork Regime; either in Union Valley or North of Pine Ridge

- 5
 - . - Not sampled.
 - C - Sample obtained using the conventional sampling method.
 - D - Duplicate sample was collected (shown in bold typeface).

Table B.2. CY 2000 maximum summed VOC concentrations

Sampling Point		Maximum Concentration ²		Chlorinated Solvents ⁴			Petroleum Hydrocarb. ⁵	Misc. Compounds ⁶
Identity ¹	Location ²	Date	Summed VOCs	Ethenes	Ethanes	Methanes		
WESTERN Y-12 AREA								
GW-108	S3	07/18/00	358	6	0	179	0	173
GW-109	S3	06/08/00	305	175	0	34	0	96
GW-192	B4	05/09/00	40	40	0	0	0	0
GW-251	S2	05/09/00	476	460	0	16	0	0
GW-253	S2	05/23/00	1,739	1,545	0	138	4	52
GW-274	SY	10/18/00	810	669	0	85	50	6
GW-275	SY	05/30/00	9	9	0	0	0	0
GW-337	WC	10/19/00	7,364	6,982	330	33	0	19
GW-618	EXP-E	11/08/00	41	41	0	0	0	0
GW-620	FTF	05/10/00	52	52	0	0	0	0
GW-633	RG	06/08/00	1,365	216	0	61	1,084	4
CENTRAL Y-12 AREA								
55-2C	Y12	05/22/00	2,630	2,574	35	0	0	21
56-2C	Y12	05/22/00	4,559	4,505	0	0	0	54
9212-W-2-BSTM	B9212	03/08/00	10	0	0	7	0	3
9215-STACK11	B9215	11/30/00	6	6	0	0	0	0
GW-193	T2331	01/12/00	20	0	0	0	20	0
GW-656	T0134	10/25/00	5,206	5,171	35	0	0	0
GW-690	CPT	10/25/00	285	285	0	0	0	0
GW-700	B8110	10/25/00	273	273	0	0	0	0
GW-769	GRIDG3	10/03/00	96	18	0	78	0	0
GW-770	GRIDG3	10/02/00	11	0	0	11	0	0
GW-782	GRIDE3	10/03/00	416	258	158	0	0	0
GW-791	GRIDD2	05/03/00	1,203	1,203	0	0	0	0
GW-820	B9201-2	06/13/00	5,167	5,158	0	0	0	9
EASTERN Y-12 AREA								
GW-153	NHP	10/12/00	299	7	0	292	0	0
GW-222	NHP	06/13/00	217	184	0	33	0	0
GW-223	NHP	06/12/00	179	179	0	0	0	0
GW-240	NHP	10/11/00	9	0	0	9	0	0
GW-381	NHP	05/17/00	1,289	9	0	1,280	0	0
GW-382	NHP	05/18/00	1,957	17	0	1,940	0	0
GW-383	NHP	08/17/00	959	954	5	0	0	0
GW-605	EXP-I	07/17/00	283	211	0	72	0	0
GW-606	EXP-I	07/17/00	512	7	0	505	0	0
GW-762	GRIDJ3	08/21/00	2,670	2,655	15	0	0	0
GW-763	GRIDJ3	05/11/00	246	244	2	0	0	0

Table B.2 (continued)

Sampling Point		Maximum Concentration ²		Chlorinated Solvents ⁴			Petroleum Hydrocarb. ⁵	Misc. Compounds ⁶
Identity ¹	Location ²	Date	Summed VOCs	Ethenes	Ethanes	Methanes		
UNION VALLEY								
GW-169	EXP-UV	05/18/00	2	2	0	0	0	0
GW-170	EXP-UV	05/22/00	27	7	0	15	5	0
GW-230	EXP-UV	05/17/00	19	19	0	0	0	0
SCR7.1SP	EXP-UV	09/06/00	2	1	0	1	0	0
SCR7.18SP	EXP-UV	05/30/00	4	1	3	0	0	0
EXIT PATHWAY/PERIMETER MONITORING								
GW-151	NHP	08/17/00	1,736	179	5	1,552	0	0
GW-220	NHP	08/22/00	1,165	121	0	1,044	0	0
GW-722-06	EXP-J	09/12/00	2	2	0	0	0	0
GW-722-10	EXP-J	03/20/00	70	6	0	64	0	0
GW-722-14	EXP-J	07/26/00	873	57	0	811	0	5
GW-722-17	EXP-J	07/26/00	1,048	76	2	963	0	7
GW-722-20	EXP-J	12/04/00	837	77	3	757	0	0
GW-722-22	EXP-J	12/04/00	658	61	2	595	0	0
GW-722-26	EXP-J	12/04/00	41	0	0	2	16	23
GW-722-33	EXP-J	12/05/00	3	0	0	3	0	0
GW-733	EXP-J	07/17/00	13	0	0	13	0	0
GW-832	NHP	05/17/00	36	5	0	31	0	0
GW-845	NHP	03/15/00	2,314	124	7	2,183	0	0
LRSPW	EXP-SW	04/18/00	47	6	0	41	0	0
OF 51	EXP-SW	09/19/00	34	33	0	1	0	0
OF 200	EXP-SW	03/20/00	16	11	0	5	0	0
SP-17	EXP-SW	09/19/00	3	0	0	3	0	0
STATION 8	EXP-SW	04/10/00	13	1	0	11	0	1
STATION 17	EXP-SW	03/20/00	6	2	0	4	0	0

Notes:

- 1 GW - Groundwater Monitoring Well; GW-722 is a Westbay well
- LRSPW - Lake Reality Spillway (surface water station)
- OF - Outfall (surface water station)
- SCR - Spring sampling location in Union Valley
- SP - Spring sampling location
- STATION - Surface water sampling location in Upper East Fork Poplar Creek

Table B.2 (continued)

Notes: (continued)

- 2
- B4 - Beta-4 Security Pits
 - B9201-2 - Building 9201-2
 - B9212 - Building 9212 (sump sampling location)
 - B9215 - Building 9215 (sump sampling location)
 - EXP - Exit Pathway monitoring location:
 - ! -E, -I, or -J: Maynardville Limestone Picket monitoring well.
 - ! -SW: Onsite spring or surface water station
 - ! -SR: Along Scarboro Road in the gap through Pine Ridge
 - ! -UV: East of the Oak Ridge Reservation boundary in Union Valley
 - FTF - Fire Training Facility
 - GRID - Comprehensive Groundwater Monitoring Plan Grid Location
 - NHP - New Hope Pond
 - RG - Rust Garage Area
 - S2 - S-2 Site
 - S3 - S-3 Ponds Site
 - SY - Y-12 Salvage Yard
 - T0134 - Tank 0134-U
 - T2331 - Tank 2331-U
 - UOV - Uranium Oxide Vault
 - WC - Waste Coolant Processing Area
- 3 The maximum sum of all VOC concentrations, in micrograms per milliliter, reported for the sample collected on the date shown. Only results for the sample with the highest summed value and with a maximum summed value greater than zero are shown on the table. Anomalous results (e.g., carbon disulfide) and/or artifacts (e.g., acrylonitrile) are excluded.
- 4 Ethenes: Summed chloroethenes (PCE, TCE, 12DCE, 11DCE, 11DCE, VC)
Ethanes: Summed chloroethanes (111TCA, 11DCA, chloroethane)
Methanes: Summed chloromethanes (CTET, chloroform, methylene chloride)
- 5 Petroleum hydrocarbons: summed benzene, ethylbenzene, toluene, xylenes (dimethylbenzene), and styrene (degradation product of ethylbenzene).
- 6 Miscellaneous compounds:
Western Y-12 Area = acetone, 2-butanone, bromomethane, bromoform, dichlorodifluoromethane, and trichlorofluoromethane;
Central Y-12 Area = 2-butanone, 1,4-dichlorobenzene, bromodichloromethane, dichlorodifluoromethane, and trichlorofluoromethane;
Exit pathway = acetone, bromodichloromethane, and trichlorofluoromethane.

**Table B.3. Long-term contaminant trends observed
at monitoring locations sampled in CY 2000**

CY 2000 Sampling Location ¹	Contaminant Type and Long-Term Trend ²						
	Inorganics ³		VOCs ⁴			Radioactivity ⁵	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
Western Y-12 Area							
GW-108	—	"	"	.	[.	[
GW-109	"	.	"	.	—	.	—
GW-192	.	.	"
GW-251	—	.	"	.	"	.	.
GW-253	"	.	[.	"	"	.
GW-274	—	—	[.	"	.	[
GW-275	"	.	"
GW-337	.	.	—	—	.	.	.
GW-618	.	.	"
GW-620	.	.	—
GW-633	"	.	[.	.	"	[
OF 221	.	"	.	.	.	"	"
OF 225	.	"	.	.	.	"	"
Central Y-12 Area							
55-2C	"	.	"	"	.	.	.
56-2C	.	.	"
9212-W-2-BSMT	"	.	.
9215-STACK 11	.	"	"	.	.	"	"
GW-193
GW-204	.	"	.	.	.	"	.
GW-218
GW-219	.	"	.	.	.	"	"
GW-656	.	.	"	"	.	.	.
GW-690	.	.	"
GW-700	.	.	"
GW-769	.	.	"	.	"	.	.
GW-770	"	.	.
GW-782	.	.	"	"	.	"	.
GW-783
GW-788
GW-789
GW-791	.	.	—
GW-820	.	.	"
OF 51	"	.	"
OF 200	"	"	"	.	"	.	.
STATION 8	.	"	.	.	"	"	.

Table B.3 (continued)

CY 2000 Sampling Location ¹	Contaminant Type and Long-Term Trend ²						
	Inorganics ³		VOCs ⁴			Radioactivity ⁵	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
Eastern Y-12 Area							
GW-151	"	.	["	[.	.
GW-153	.	.	"	.	"	.	.
GW-154	.	—	.	.	.	"	—
GW-207
GW-208
GW-220	.	"	[.	["	"
GW-222	.	"	"	.	"	"	"
GW-223	.	[",[.	.	.	.
GW-240	"	.	.
GW-380	"	.	.
GW-381	.	.	"	.	"	.	.
GW-382	.	.	"	.	—,[.	.
GW-383	.	.	["	.	.	.
GW-605	.	"	[.	["	.
GW-606	"	.	"	.	—,[.	.
GW-722-06	.	.	"
GW-722-10	"	.	.
GW-722-14	.	.	"	.	"	.	.
GW-722-17	.	.	"	.	"	.	.
GW-722-20	.	.	"	.	"	.	.
GW-722-22	.	.	"	.	"	.	.
GW-722-26	.	.	"
GW-722-30
GW-722-32
GW-722-33
GW-733	—	.	.
GW-735
GW-744
GW-747
GW-750
GW-762	.	.	.	"	.	.	.
GW-763	.	.	"
GW-816	.	.	"
GW-832	"	.	.
GW-845	.	.	"	"	"	.	.
LRSPW	.	.	"	.	"	.	.
SP-17	"	.	"
STATION 17	.	"	.	.	"	.	.

Table B.3 (continued)

CY 2000 Sampling Location ¹	Contaminant Type and Long-Term Trend ²						
	Inorganics ³		VOCs ⁴			Radioactivity ⁵	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
Union Valley							
GW-169
GW-170	.	.	"	.	"	.	.
GW-171
GW-172
GW-230	.	.	"
GW-232
SCR7.1SP
SCR7.18SP
SCR7.8SP
North of Pine Ridge							
GHK2.51ESW
GHK2.51WSW
NPR07.0SW
NPR10.0SW
NPR12.0SW

Notes:

- All CY 2000 sampling locations are included on the table. The exit pathway/perimeter monitoring locations are in bold typeface.
- Trend types were interpreted from data tables or plots of concentration changes over time. Some locations in the eastern Y-12 area have divergent VOC trends (e.g, decreasing carbon tetrachloride and increasing chloroform).
 - .
 - " - Indeterminate trend: insufficient data, fairly stable trend, affected by sampling methods or highly fluctuating with no clear upward or downward trend.
 - - Generally decreasing trend.
 - [- Generally increasing tend.
- CY 2000 nitrate concentration greater than or equal to 5 mg/L.
Total uranium concentration greater than or equal to 0.02 mg/L.
- Summed CY 2000 concentration of a solvent group greater than or equal to 5 : g/L.
 - Ethenes = Summed chloroethenes (PCE, TCE, 12DCE, 11DCE, 11DCE, vinyl chloride)
 - Ethanes = Summed chloroethanes (111TCA, 11DCA, chloroethane)
 - Methanes = Summed chloromethanes (carbon tetrachloride, chloroform, methylene chloride)
- Maximum CY 2000 gross alpha activity greater than or equal to 15 pCi/L.
Maximum CY 2000 gross beta activity greater than or equal to 50 pCi/L.

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