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Groundwater Impact Assessment Report for the 216-T-1 Ditch

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EXECUTIVE SUMMARY

As required by the Hanford Federal Facility Agreement and Consent Order[1] *(Tri-Party Agreement Milestone M-17-00A), this report assesses the impact of wastewater discharged to the 216-T-1 Ditch on groundwater quality. This assessment expands on the initial analysis conducted between 1989 and 1990 for the Liquid Effluent Study Final Project Plan.*[2]

Facility Description

The 216-T-1 Ditch, located in the northern 200 West Area, has received liquid effluents from the head-end of the 221-T Building since 1944. The 221-T Building head-end effluent stream, from 1990 to the present includes: cooling water and steam condensate from the heating and cooling systems. The average flow rate, as of July 1994, was estimated to be 3.46 x 10^5 L/month (9.13 x 10^4 gal/month) or 8 L/min (2 gal/min). Discharges to the ditch are scheduled to cease by June 1995.

Impact Assessment

Based on groundwater flow data, contaminant transport predictions, and groundwater hydrochemical data, the 216-T-1 Ditch has little influence on groundwater quality in the northern 200 West Area. Existing groundwater contaminants near the 216-T-1 Ditch (gross alpha, gross beta, carbon

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[1]Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

[2]WHC, 1990, *Liquid Effluent Study Final Project Plan*, WHC-EP-0367, Westinghouse Hanford Company, Richland, Washington.

tetrachloride, chloroform, nitrate, technetium-99, tritium, and uranium) are attributed to upgradient past-practice sources rather than the 216-T-1 Ditch.

Conclusions

Continued short-term operation of the 216-T-1 Ditch will have little effect on groundwater quality in the northern 200 West Area. The groundwater monitoring well currently installed at the 216-T-1 Ditch is adequate, under current operating conditions (December 1994) and until scheduled discharges cease (June 1995). If discharges to the 216-T-1 Ditch continue beyond June 1995, installation of additional groundwater monitoring wells for this site should be considered.

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GROUNDWATER IMPACT ASSESSMENT REPORT FOR THE 216-T-1 DITCH

1.0 INTRODUCTION

Groundwater impact assessments are conducted at liquid effluent receiving sites on the Hanford Site to determine hydrologic and contaminant impacts caused by discharging wastewater to the soil column. The assessments are conducted pursuant to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), Milestones M-17-00A and M-17-00B (Ecology et al. 1994). This report assesses impacts on the groundwater and vadose zone from wastewater discharged to the 216-T-1 Ditch. The effluent waste stream of interest is the 216-T-1 Ditch Laboratory Wastewater.

1.1 BACKGROUND

In response to public comments on the original Tri-Party Agreement, and at the request of the signatories on the Tri-Party Agreement, the U.S. Department of Energy, Richland Operations Office (RL) assessed the impact of liquid effluents discharged to the ground at the Hanford Site. The results are documented in the *Liquid Effluent Study Final Project Report* (WHC 1990b). Both the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) expressed concerns regarding uncertainties in the evaluation. Foremost among these concerns were the lack of site-specific data, the need to consider interactions with adjacent facilities, and the need for sophisticated modeling of contaminant flow and transport. In response to these concerns, Tri-Party Agreement Milestones M-17-00A, M-17-00B, M-17-13, and M-17-13A were established to direct groundwater impact assessments.

Tri-Party Agreement Milestones M-17-00A and M-17-00B require impact assessments for Phase I and II streams. Phase I and II streams are defined in Stordeur and Flyckt (1988). The 216-T-1 Ditch currently receives steam condensate and cooling water from the T Plant cooling and heating system, which is defined as a Phase II stream. Tri-Party Agreement Milestone M-17-13 required a methodology for assessing the impact of liquid effluent discharge on groundwater. This is documented in *A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluent to the Soil at the Hanford Site* (Tyler 1991). As required by Tri-Party Agreement Milestone M-17-13A, a schedule for performing the assessments at 13 receiving sites was completed 30 days after regulatory approval of the Milestone M-17-13 document.

The 216-T-1 Ditch is scheduled to cease receiving effluent discharges in June 1995. After that date, all effluent from the 216-T-1 Ditch waste stream will be routed to the 200 Areas effluent collection system as part of Hanford Environmental Compliance Subproject W-049H (WHC 1990b).

1.2 METHODOLOGY

Tyler (1991) categorizes 13 receiving sites based on the level of effort required to support the assessed impact. A Level 1 receiving site groundwater impact assessment relies on available information. A Level 2 receiving site may require nonintrusive field work to verify the extent of existing contamination. A Level 3 receiving site may involve intrusive field work. The actual level of effort, as defined in Tyler (1991), should be based on information presented in the *Groundwater Impact Assessment Plan* (Tyler et al. 1994).

The methodology document for a Level 1 receiving site must contain the following elements:

- Prepare, present, and describe how the groundwater assessment will be conducted
- Characterize the liquid effluent stream
- Evaluate the site-specific hydrogeology
- Develop a site conceptual model
- Assess the hydrologic impact of the liquid effluent stream
- Assess the contaminant impact of the liquid effluent stream
- Evaluate the adequacy of the existing monitoring well network
- Prepare a written report of the results.

The Level 2 and 3 site tasks are similar to those outlined above and may also include field activities. The 216-T-1 Ditch is a Level 3 receiving site.

Several key assumptions inherent to all groundwater impact assessments are explained in Tyler (1991). For this groundwater impact assessment, the following assumptions are relevant.

- The expected level of impact from the receiving site determines how well the chemistry, geology, and hydrology need to be understood.
- Modeling sophistication is tailored to available information and the expected level of impact of the receiving site.
- Historical data are fully useable.

2.0 FACILITY DESCRIPTION

Chapter 2.0 provides the location description and history of the 216-T-1 Ditch. A brief description is also provided of nearby waste management units, buildings, and structures. Information in Chapter 2.0 was primarily obtained from DOE-RL (1992).

2.1 216-T-1 DITCH LOCATION

The 216-T-1 Ditch is located on a 1,434-km^2 (560-mi^2) tract of land in the south-central portion of Washington State known as the Hanford Site. The ditch is located in the north-central portion of the Hanford Site in the 200 West Area, approximately 32 km (20 mi) northwest of Richland, Washington (Figure 2-1).

2.2 216-T-1 DITCH DESCRIPTION AND HISTORY

The 216-T-1 Ditch has been used to manage low-level radioactive wastewater, cooling water, and steam condensate by infiltration/absorption through the soil column and natural evaporation. The ditch was placed in service November 1944. The unlined and open ditch is 549 m (1,800 ft) long, 7.6 m (25 ft) wide at the top, and 0.9 m (3 ft) wide at the bottom. The ditch has a side slope of 2:5.1 and an average depth of 3 m (10 ft). The ditch is fed by a 15.2-cm- (6-in.-) diameter underground header pipe extending 90 m (295 ft) north of 221-T Building (T Plant). From 1944 to 1990, the ditch received wastewater from T Plant from the containment system test facility, vacuum fractionator, liquid metal reactor safety test, light water reactor test, fusion program activities, and bismuth phosphate process. These effluents originated in a portion of T Plant identified as the 221-T Building Head-End. Table 2-1 lists the dates and sources of discharge from the T Plant Head-End.

At present, liquid effluents associated with the decontamination mission are routed to wastewater streams other than the 216-T-1 wastewater stream. Effluent currently discharged to the 216-T-1 Ditch is identified in the *216-T-1 Laboratory Wastewater Stream Report* (WHC 1990a) and consists of steam condensate and cooling water from the T Plant cooling and heating system.

The 216-T-1 Ditch does not support a large population of aquatic plants, bushes, and trees as is typical of many receiving sites. Vegetation within the ditch consists of mainly grasses. The sparseness of aquatic plants, bushes, and trees is related directly to the quantity of effluent discharged and suggests limited influx into the ditch. The ditch is also covered with up to 1.2 m (4 ft) of tumble weed in places that has blown in from the surrounding area.

Figure 2-1. 216-T-1 Ditch Location.

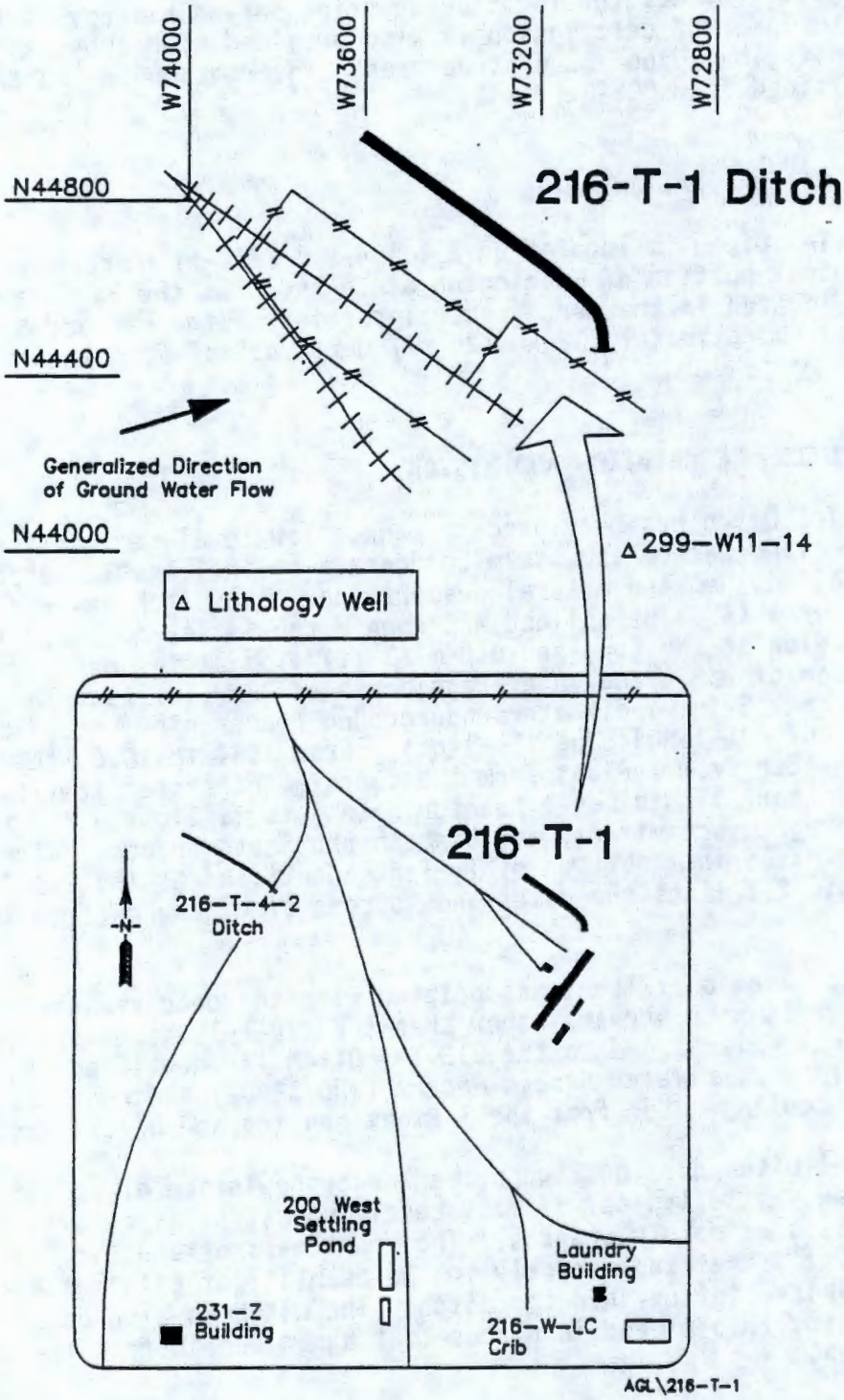

Table 2-1. Dates and Sources of Discharge to the 216-T-1 Ditch.

Date	Process	Effluent discharge to 216-T-1 Ditch
1944-1956	Bismuth phosphate	Cooling water and steam condensate
1956-1964	Inactive	N/A
1964-1969	Containment system test facility	Cooling water and miscellaneous waste
1972-1976	Vacuum fractionator	Condensate from heat radiators
1976-1985	Liquid metal reactor safety tests	Diluted nonradioactive sodium, lithium, and sodium iodine
1985-1990	Light water reactor tests and fusion program	Cooling water, steam condensate, and miscellaneous wastes
1990-present	No testing since 1990	Cooling water and steam condensate from heating and cooling systems

2.3 221-T (T PLANT) BUILDING

T Plant was built between 1943 and 1944 to extract plutonium from production reactor fuel. Processing of spent fuel at T Plant ended in 1956 when extraction technology transitioned from a process relying on bismuth phosphate to one based on reduction/oxidation (REDOX). A short hiatus ensued between this process conversion and the adaptation of T Plant for decontamination and equipment refurbishment in 1957. T Plant currently serves the Hanford Site as the primary decontamination facility. T Plant provides radioactive decontamination, reclamation, and decommissioning of process equipment contaminated with fission products and other highly contaminated pieces of equipment.

Wastewater generated from spent fuel processing between 1945 and 1956 consisted predominately of cooling water and steam condensate from the spent fuel dissolution process (Bolls 1992).

2.3.1 Head-End Process History

The T Plant Head-End has served as the site of experimental operations and testing and contains numerous storage and waste tanks and test vessels.

Most of the original bismuth phosphate process equipment has been removed from T Plant. When the dissolution equipment was removed from the T Plant Head-End in 1956, efforts were made to remove and/or stabilize radioactive contamination in the facility. A testing program was then established for the testing of iodine and radioactive cesium containment vessel in the old dissolver cells and canyon. This modified facility operated between 1964 and 1969 and was also referred to as the Containment System Test Facility (CSTF).

In 1972, a vacuum fractionator was built and tested. Testing ended in 1976 and the vacuum fractionator was removed. Between 1976 and 1985, liquid metal reactor safety tests were conducted in the CSTF with nonradioactive sodium, lithium, and sodium iodide. These tests consisted of sodium and lithium pool reaction spray reaction and aerosol behavior tests. The reacted sodium, lithium, and sodium iodide was dissolved in water and discharged to the 216-T-1 Ditch, provided the solution was not radioactive. Radioactive waste and unreacted metal were routed to either the 105-DR Reactor Facility or the 200 West Tank Farms.

Between 1985 and 1990 Light Water Reactor (LWR) tests were conducted using nonradioactive cesium, manganese, zinc, lithium sulfate, iodine, and hydrogen iodide. During the same period, several related tests were conducted using nonradioactive lithium and lithium-lead alloy in support of the fusion program. The process wastewater discharged to the 216-T-1 Ditch during these test programs consisted of cooling water, steam condensate, and T Plant Head-End waste solutions. Since March 1990, there have been no tests or operations performed in the T Plant Head-End. Steam condensate and cooling water associated with building heating and air conditioning and floor wash water are the only regular effluents expected to be generated and discharged to the 216-T-1 Ditch. Current activities within T Plant are associated with cleanup, including equipment removal.

2.3.2 224-T Building

The 224-T Building was originally used to purify plutonium nitrate using the lanthanum fluoride process. Like the 221-T Building, this building was deactivated in 1956 following phaseout of the bismuth phosphate plants. The 224-T Building remained inactive until the early 1970's, when it was modified to store plutonium scrap in liquid and solid form. The scrap was removed in 1985, when the building was officially designated the Transuranic Waste Storage and Assay Facility (TRUSAF). The TRUSAF operation consists of nondestructive assay and nondestructive examination of newly generated, contact-handled, transuranic (CH-TRU) solid waste. The NDAs and NDEs are used to overview sealed, certified CH-TRU solid waste packages to verify general compliance with the Waste Isolation Pilot Plant (WIPP) waste acceptance criteria requirements.

2.4 OTHER BUILDINGS AND STRUCTURES

The following buildings and structures are located in the study area have not released contaminants to the ditch:

- 211-T Building (bulk chemical storage area)
- 221-TA (contains two ventilation supply fans for the 221-T Building)
- 222-T Laboratory Building (originally built as a process analysis laboratory; currently houses Health Physics Technicians and operation groups
- 271-T Building (original office and support facility for T Plant)
- 291-T Building house the sand filters and stack for the 221-T Building
- 2706-T Building (equipment decontamination)
- 2715-T Building (paint shop).

2.5 NEARBY WASTE MANAGEMENT FACILITIES

Section 2.5 describes the waste management facilities associated with past practices of T Plant. The majority of these facilities are within 458 m (1,500 ft) of the 216-T-1 Ditch. Facilities outside this boundary include the 216-T-6 Crib, the 216-T-3 Reverse Well, and the 241-T-361 Settling Tank.

2.5.1 216-T-2 Reverse Well

The 216-T-2 Reverse Well is an inactive waste management unit located approximately 254 m (830 ft) southeast of the 216-T-1 Ditch. The well has a diameter of 15.2 m (6 in.) and extends to a depth of 22.9 m (75 ft). The pipeline is blanked at the well and sprayed over with concrete. The well operated between 1945 and 1950 and received 6×10^6 L (1.59×10^6 gal) of decontamination sink waste and sample slurper waste from the 222-T Building.

2.5.2 216-T-3 Reverse Well

The 216-T-3 Reverse Well is an inactive waste management unit located 508 m (1,667 ft) southwest of the 216-T-1 Ditch. The well consists of a 0.6-m- (2-ft-) high, stubbed steel pipe with a gauge at the tap. The well is 62.8 m (206 ft) deep with a diameter of 25.4 cm (10 in.). The well operated from 1945 to 1946 and received 1.1×10^7 L (2.99×10^7 gal) of cell drainage from the T Plant as well as overflow from the 241-T-361 Settling Tank. The aboveground piping was removed and the surface was decontaminated and leveled in August 1975.

2.5.3 216-T-9, 216-T-10, and 216-T-11 Trenches

The 216-T-9, 216-T-10, and 216-T-11 Trenches are an inactive waste management unit located about 318 m (1,042 ft) west of the 216-T-1 Ditch. Each trench is 15.2 m (50 ft) long, 3 m (10 ft) wide, and 1.8 m (6 ft) in depth. From 1951 to 1954, these trenches received heavy equipment and vehicle decontamination waste. No reference indicating the amount of the waste received has been documented. In 1954, the trenches were backfilled and decontamination activities were transferred to the 216-T-13 Trench. The trenches were exhumed in 1972 and released from radiation zone status. No radionuclides or chemical contamination has been documented for these trenches.

2.5.4 216-T-8 Crib

The 216-T-8 Crib is an inactive waste management unit located 267 m (875 ft) south of the 216-T-1 Ditch. The crib is surrounded by a light chain barricade and posted with cave-in potential, underground, and surface radiation warning signs. The crib consists of two structures, each with a 7.5-cm (3-in.) steel pipe placed vertically into a 3.6- by 3.6- by 2.1-m (12- by 12- by 7-ft) wooden frame, 5.2 m (17 ft) below grade. The bottom dimensions are 4.3 by 4.3 m (14 by 14 ft). The excavation is 6.1 m (20 ft) deep with a 1:1 slope. The crib has been backfilled.

The 216-T-8 Crib operated between May 1950 and September 1951. During that time it received 5×10^5 L (1.32×10^5 gal) of decontamination sink and sample slurper waste from the 222-T Building laboratory processes (Stenner et al. 1988). When laboratory operations were terminated, the pipeline from the crib to the building was blanked (WHC 1991).

2.5.5 216-T-29 Crib

The 216-T-29 Crib is an inactive waste management unit located approximately 76 m (250 ft) southeast of the 216-T-1 Ditch. The crib is constructed of 60 vitrified clay pipes, 15.2 cm (6 in.) in diameter, in a 30.5- by 14.6-m (100- by 48-ft) area. The crib operated between 1949 and 1964. During that time, the crib received a total of 7.4×10^4 L (1.96×10^4 gal) of condensate runoff from the 291-1-T Sand Filter. This waste is considered potentially acidic given the presence of nitric acid (Stenner et al. 1988; Cramer 1987). The crib was deactivated when the sand filter bypass water seal was removed, allowing the 221-T Building exhaust air to flow directly to the 291-T-1 Stack (WHC 1991).

2.5.6 216-T-33 Crib

The 216-T-33 Crib is an inactive waste management unit located approximately 254 m (830 ft) southwest of the 216-T-1 Ditch. The crib is posted with underground contamination warning signs. This crib operated for approximately 1 month, between January and February 1963, and received 1.9×10^5 L (5.02×10^5 gal) of decontamination waste from the 2706-T Building. However, the amount of liquid that actually reached the

crib has been questioned by plant personnel who suspected that the line to the unit retained all of the waste. This waste stream consisted primarily of sodium hydroxide (Cramer 1987). The bottom of the crib is 9.1 m (30 ft) long, 1.5 m (5 ft) wide, and 3.4 m (11 ft) deep. The slope of the excavation is 1:5:1. The bottom 1.4 m (4 ft) of the excavation is filled with washed gravel. A 20.3-cm (8-in.) perforated pipe located 2.1-m (7-ft) below grade runs the length of the unit. Use of 216-T-33 Crib was terminated when perforations at the discharge point became plugged.

2.5.7 216-T-34 Crib

The 216-T-34 Crib is an inactive waste management unit located about 89 m (292 ft) southeast of the 216-T-1 Ditch. The crib is located in an excavation 61 m (200 ft) long, 9.1 m (30 ft) wide, and 4.9 m (16 ft) deep. The crib has a side slope of 1:5:1. The dispersal system consists of 128 m (420 ft) of perforated 20.3-cm (8-in.) line in a 4.4- by 59-m (15- by 195-ft) rectangular structure with a 15.2-cm (6-in.) perforated line extending 15.2 m (50-ft) into the crib. The dispersal system is 3.7 m (12.2 ft) below grade. A 1.5-m (5-ft) layer of washed gravel is in the excavation and the site has been backfilled.

2.5.8 216-T-35 Crib

The 216-T-35 Crib is an inactive waste management unit located approximately 242 m (792 ft) east of the 216-T-1 Ditch. The crib is 137 m (450 ft) long, 3 m (10 ft) wide, and 4.6 m (15 ft) in depth. The slope of the excavation is 2:1. A 30.4-m (100-ft) long, perforated 15.2-cm (6-in.) distribution line and a 137-m (450-ft) long parallel line are placed 2.9 m (9.5 ft) below grade. These lines are covered by 1.5 m (5 ft) of gravel and 1.4 m (4.5 ft) of backfill.

This crib operated between March 1967 and January 1968 and received 5.72×10^7 L (1.51×10^6 gal) of 300 Area Laboratory waste from the 240 Building (Stenner et al. 1988). Low-level surface contamination of a small area near the unloading station has been reported but surface contamination has not been documented (Fecht et al. 1977).

2.5.9 218-W-8 Burial Ground

The 218-W-8 Burial Ground is an inactive waste management unit that consists of three underground vaults. These vaults are located 229 m (750 ft) southeast of the 216-T-1 Ditch. The burial ground operated from 1945 to 1952. During this time, the burial ground received 68 m^3 (89 yd^3) of 222-T Laboratory process sample waste containing cesium-137, ruthenium-106, and strontium-90 (Stenner et al. 1988; Anderson et al. 1991). The two original vaults are 3 m^2 (30 ft^2) and 3.6 m (12 ft) deep. The vaults are constructed of wooden planking and have tops located 1.5 m (5 ft) below grade. The third vault is a concrete culvert pipe encasement 2.4 m (8 ft) in diameter and 7.6 m (25 ft) long, placed approximately 0.9 m (3 ft) below grade. The top of the encasement is a 23-cm (9-in.) concrete cover and the bottom is a 30-cm (12-in.) concrete floor. The disposal chutes for the wooden vault were

removed and backfilled with soil. The disposal chute and three vaults are enclosed within a surface radiation contamination barrier that surrounds the original vault.

2.5.10 2607-W4 Septic Tank and Drain Field

The 2607-W4 Septic Tank is an active waste management unit operating since 1944. The tank is located 25 m (83 ft) southwest of the 216-T-1 Ditch. The tank accepts wastewater and sewage and includes a drain field 3 m (10 ft) long, 9.2 m (30 ft) wide, and 0.9 m (3 ft) in depth. The estimated rate of waste received is 10,600 L/day (2,799 gal/day) (Cramer 1987).

2.5.11 2607-W3 Septic Tank and Drain Field

The 2607-W3 Septic Tank is an active waste management unit operating since 1944. The tank is located approximately 458 m (1,500 ft) south of the 216-T-1 Ditch. This unit includes a 3.8-m- (12.5-ft-) deep reinforced concrete drain field. The tile field is constructed of 10.2-cm (4-in.) vitrified clay pipe. The laterals are open jointed and spaced 2.4 m (8 ft) apart. The drain field measures 6.4 by 2.7 m (21 by 9 ft). The tank accepts sanitary wastewater and sewage at the estimated rate of 14,200 L/day (3,749 gal/day) (Cramer 1987).

2.5.12 241-TX-154 Diversion Box

The 241-TX-154 Diversion Box is an active waste management unit operating since 1949. The diversion box is located approximately 153 m (500 ft) south of the 216-T-1 Ditch. The diversion box is associated with the 241-TX-302C Catch Tank and the 241-TX Tank Farm (WHC 1991). Diversion boxes house the switching facilities where waste can be routed from one process line to another. They are concrete boxes that were designed to drain by gravity to nearby catch tanks where waste is stored.

2.5.13 241-TX-302C Catch Tank

The 241-TX-302C Catch Tank is an active waste management unit operating since 1949. The catch tank is located 165 m (542 ft) south of the 216-T-1 Ditch. This catch tank is of steel construction, is 11 m (36 ft) long by 2.7 m (9 ft) in diameter, and is approximately 6 m (20 ft) below grade.

This tank was used to accept overflow radioactive waste solutions from the 241-TX-154 Diversion Box resulting from processing and decontamination operations (Cramer 1987). The tank currently holds 9,652 L (2,550 gal) of liquid waste and is associated with the 241-TX-154 Diversion Box and the 241-TX Tank Farm (WHC 1991).

2.5.14 241-T-361 Settling Tank

The 241-T-361 Settling Tank is and inactive tank and is located about 521 m (1,708 ft) south of the 216-T-1 Ditch. The tank is cylindrical, 6.1 m (20 ft) diameter by 5.8 m (19 ft) deep, and is constructed with a 15-cm (6-in.) reinforced, pre-stressed concrete shell. The top of the tank is located 2 m (6 ft) below grade.

The date that the 241-T-361 Settling Tank began operation has not been determined. The tank stopped receiving waste in 1976. The 241-T-361 Settling Tank received radioactive contaminated liquid from the 221-T Building process and is connected to the 216-T-6 Crib. As of February 1992, the tank was reported to contain 105,980 L (15,500 Ci beta/gamma). This unit was isolated in 1985 (Cramer 1987).

2.6 UNPLANNED RELEASES

Of the 46 unplanned releases that have occurred in the T Plant Aggregate Area (DOE-RL 1992), 17 are located near the 216-T-1 Ditch. The following sections discuss each of the 17 releases. For more information, refer to the Waste Information Data System (WIDS) (WHC 1991).

2.6.1 UPR-200-W-2

A waste line failure contributed to radionuclide contamination. This release occurred in 1947. Contamination levels were not recorded, but radiation readings were measured from ground surface to 3.1 to 3.4 m (10 to 11 ft) below ground surface. The waste line was replaced; no record was made of the disposition of the contaminated soils. The location of the release is approximately 127 m (417 ft) south of the 216-T-1 Ditch.

2.6.2 UPR-200-W-3

This release is associated with equipment that was in transit from T Plant to the 200 West Burial Ground. The release occurred in 1949 near the T Plant railroad cut, approximately 229 m (750 ft) southwest of the 216-T-1 Ditch. The contaminated area was covered with approximately 25.4 cm (10 in.) of clean gravel in the spring of 1950. No contamination levels were reported.

2.6.3 UPR-200-W-4

This release occurred near the T Plant railroad cut, approximately 229 m (750 ft) southwest of 216-T-1 Ditch. Contamination spread from a burial box in transit from T Plant to the heavy equipment burial ground sometime in 1949. Contamination levels are difficult to determine for this release. The only reported data is a 7-mR/h reading (average) without any associated distance measurements.

2.6.4 UPR-200-W-12

This release occurred in the spring of 1951. While jetting concrete from the waste evaporator, the waste was forced up and out of an open riser. Portions of the contamination were removed and the remaining waste was covered with 0.3 m (1 ft) of clean soil. Contamination levels were not recorded. The release occurred approximately 267 m (875 ft) from the 216-T-1 Ditch.

2.6.5 UPR-200-W-21

A cave-in over a process line caused contamination of an extended area approximately 229 m (750 ft) south of the 216-T-1 Ditch. A jumper leak in the 241-TX-154 Diversion Box, which caused an overflow to occur in the 241-TX-302C Catch Tank, is also related to this release. Dose rates as high as 25 R/h at 20.3 cm (8 in.) were recorded at the time of the release. The release occurred in July 1953. The area has subsequently been covered with asphalt.

2.6.6 UPR-200-W-27

This release occurred on December 20, 1954. The release involved the failure of an unencased process waste line from T Plant. The failure resulted in a cave-in and subsequent run-off of first-cycle process wastes. The exact location of the release is unknown but is estimated to be approximately 280 m (917 ft) south of the 216-T-1 Ditch. Exact contamination levels are not reported, but readings indicated "high ground-surface dose rates."

2.6.7 UPR-200-W-38

This release is associated with the rupture of an underground process line in 1956. The release created a 4.6 by 9.2 m (15 by 30 ft) pool of metal waste on the ground surface. The radiation field produced from this release measured 1.2 R/h at 24.4 m (80 ft). The release was stabilized by spraying concrete on the area surrounding the diversion box. The location of the release is 89 m (292 ft) southeast of the 216-T-1 Ditch, near the 241-TX-154 Diversion Box.

2.6.8 UPR-200-W-40

Leakage of an unknown liquid from the 241-TX-154 Diversion Box and the 241-TX-302C Catch Tank contributed to this release. Contamination levels are not reported, but the area affected is limited to approximately 139 m^2 (1,500 ft^2) on the southeast side of the 221-T Building. The spill is located approximately 127 m (417 ft) southwest of the 216-T-1 Ditch. The release occurred on January 3, 1956, and is associated with two other releases in the immediate vicinity (Sections 2.6.4 and 2.6.17).

2.6.9 UPR-200-W-58

This release is located approximately 89 m (292 ft) southwest of the 216-T-1 Ditch in an area between the 221-T railroad cut and the 200 West Burial Ground. The release occurred on April 26, 1965, and involved a cell block from the 221-T Canyon. The cell block was en route to the 200 West Burial Ground. The cell blocks spread contamination from the 221-T railroad cut to the 200 West Burial Ground. The contamination levels measured at the site are reported to be "unknown" beta/gamma with readings to a maximum of 100,000 ct/min. The contaminated soil was removed from the railroad bed.

2.6.10 UPR-200-W-63

This release occurred on September 21, 1966, approximately 635 m (2,083 ft) southwest of the 216-T-1 Ditch. The source of the release was a used diversion box jumper in transit via truck from the 200 West Burial Ground to the 221-T Canyon. The waste material contained strontium-90 with readings of approximately 1 Ci. The contamination was found on the road and was subsequently removed. The area was covered with 15.2 cm (6 in.) of soil.

2.6.11 UPR-200-W-65

This release occurred at the T Plant railroad cut October 27, 1969, approximately 89 m (292 ft) southwest of the 216-T-1 Ditch. The release was the result of a rail car that was carrying radioactive material that was not effectively contained. The contamination associated with this release were reported to be "unknown" beta/gamma readings of 5,000 ct/min. The spur line where the release occurred is not labelled, stabilized, or barricaded.

2.6.12 UPR-200-W-67

This release is associated with the removal of an electric lift from the north side of the 2706-T Building. The release location is approximately 146 m (479 ft) southeast of the 216-T-1 Ditch. The residual contamination from the removal of the lift was approximately 20,000 ct/min. The contamination was reported on August 5, 1970.

2.6.13 UPR-200-W-73

This release is located approximately 146 m (479 ft) southeast of the 216-T-1 Ditch. The release is the result of a faulty transfer box that was in transit from the 221-T Building tunnel to the 2706-T Building. The release occurred on October 6, 1974. Contamination levels are difficult to determine for this release. The only reported data is an "unknown" beta/gamma reading of 40 mR/h without any associated distance measurements.

2.6.14 UPR-200-W-85

This release occurred approximately 146 m (479 ft) southeast of the 216-T-1 Ditch. On April 22, 1982, a spill occurred while contaminated liquids were being sluiced from a multi-purpose transfer box. The contaminated liquid had a "unknown" beta/gamma reading of 100,000 ct/min. The area was decontaminated to background levels.

2.6.15 UPR-200-W-98

This release is located approximately 305 m (1,000 ft) southeast of the 216-T-1 Ditch. A leak in an underground metal waste transfer line surfaced and spread an unknown amount of mixed fission contamination over a small ground area. The release occurred in the spring of 1945. Contamination levels from the high salt, neutral/basic fission products were reported to have readings of approximately 10 Ci. An "unknown" beta/gamma reading of 20 R/h, without any associated distance measurements, was also reported.

In 1968, Russian thistle containing strontium and cesium radioactivity were found growing over the spill site. The radioactivity of the Russian thistle was measured annually and each year the radioactivity in the new crop of Russian thistle decreased until no activity was detected after 1975. In the spring of 1977, an unspecified number of test holes were cut to a depth of 1.2 m (4 ft) across the site. No radioactivity was detected. However, the 1990 annual radiation surveillances of the affected area indicated a general contamination of 300 ct/min. There were also rabbit feces readings of 2,500 ct/min. Similar conditions were reported in the 1988 and 1989 surveys. The unit associated with this release does not comply with the *Environmental Compliance Manual* (WHC-CM-7-5).

The affected area has been covered Zwith approximately 1.2 m (4 ft) of clean soil. The area has subsequently been paved.

2.6.16 UPR-200-W-102

This release is located approximately 311 m (1,021 ft) south of the 216-T-1 Ditch. The release was reported in February 1972 but occurred over several years of operation. Contamination is believed to have resulted from alpha-laden moisture seeping through pipe joints from underground process tank vent lines. Excavation of the affected area revealed subsurface contamination 15.3 m (50 ft) long, 3.7 m (12 ft) wide, and 3.7 m (12 ft) in depth. The excavated soil was placed in 139 drums of unspecified size. The waste contained an estimated 72 g (2.5 oz) of plutonium. Contamination levels for this release were not documented, but a radiological survey conducted in October of 1975 showed no surface contamination.

2.6.17 UPR-200-W-160

This release area is located approximately 178 m (583 ft) southwest of the 216-T-1 Ditch. This area received two releases over a total area of 49 by 27.5 m (160 by 90 ft). The first leak occurred in July of 1953 (see

Section 2.6.5). The second was the result of the failure of an underground transfer line from the 214-TX-302C Catch Tank to the 241-U-101 Single-Shell Tank. The failure occurred on December 30, 1955, and involved the release of several thousand gallons of highly radioactive liquid primary metal waste and rainwater. The liquid forced through several feet of soil onto the surface surrounding the 214-TX-302C Catch Tank. The spill area has been backfilled and sprayed with tar and posted as a radiation zone.

During April and May 1968, the east side of the radiation zone was cut back a distance of 3 m (10 ft). Thin concrete cell cover blocks were leaned at a 60° angle against the side of the cut to shield the dose rates to acceptable levels. The cut was covered with cement blocks to provide adequate shielding. The radionuclide inventory for this release is given in Table 2-2. This release is associated with the UPR-200-W-40 release in the immediate vicinity (see Section 2.6.8).

Table 2-2. Radionuclide Inventory for 200-W-160.

Isotope data	
Cesium-137	17 Ci*
Ruthenium-106	3.46×10^{-10} Ci*
Strontium-90	16 Ci*
Gross data	
Plutonium	1 g
Alpha	6.14×10^{-2} Ci*
Beta	64.7 Ci*
Uranium (total)	1.51×10^{-3} Ci*

*Curies decayed through 12/31/89

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3.0 EFFLUENT CHARACTERISTICS

Chapter 3.0 focuses on the physical and chemical characteristics of the wastewater effluent from 1944 to the present. Past discharges are of interest for assessing the impacts on the soil column under the 216-T-1 Ditch and determining the level of contaminant migration to groundwater.

3.1 DISCHARGE VOLUMES AND FLOW RATES

Discharge volumes and flow rates to the 216-T-1 Ditch have varied with the changing chemical processes performed in the T Plant Head-End. Flow rates are assumed to be based on process knowledge since flow meters have not been used in discharge lines feeding into the 216-T-1 Ditch. Currently, only 45.8 m (150 ft) of the 216-T-1 Ditch is affected by discharges. Table 3-1 presents the estimated volumes and flow rates over the life of the 216-T-1 Ditch.

Table 3-1. Estimated Volume and Flow Rates for the 216-T-1 Ditch.

Time period	Volume (L)	Flow rate (L/min)	Reference
1944-1975	1.8×10^8	11	Anderson (1976)[a]
1976-1984	3.4×10^7	8	Dillon (1985)[b]
1985-1990	6.5×10^7	25	WHC (1990a)[c]
1990-present	2.0×10^7	8	Facility contact
Total volume	3.0×10^8		

[a]Anderson, J. D., 1976, *Input and Decayed Values of Radioactive Liquid Wastes Discharged to the Ground in the 200 Areas Through 1975*, ARH-CD-745, Atlantic Richfield Hanford Company, Richland, Washington.

[b]Dillon, K. L., 1985, *Separations Area Water-Use Balance through 1984*, RHO-RE-SR-50, Draft, Rockwell Hanford Operations, Richland, Washington.

[c]WHC, 1990a, *T Plant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 32, Westinghouse Hanford Company, Richland, Washington.

3.2 EFFLUENT HISTORY AND CONSTITUENTS

Before 1985, hazardous waste discharges were not monitored. Radiological hazards were measured on a periodic basis and were reported in operational monitoring reports (Anderson 1976). Table 3-2 presents the Waste Inventory

Table 3-2. Waste Identification Data System Radiological Inventory for the 216-T-1 Ditch.

Isotope	Activity (Ci)
Cesium-137	3.9×10^{-2}
Ruthenium-106	4.4×10^{-13}
Strontium-90	3.6×10^{-2}
Plutonium	1.0×10^{-1}
Gross alpha	6.1×10^{-3}
Gross beta	1.5×10^{-1}
Uranium (total)	1.5×10^{-3}

Data System (WIDS) (WHC 1991) radiological inventory reporting for the 216-T-1 Ditch. Figure 3-1 is a flow diagram of the wastewater discharge process from the T Plant Head-End to the 216-T-1 Ditch.

The chemical composition of the effluent currently discharged to the 216-T-1 Ditch is equivalent to Columbia River raw water. In the past the effluent has consisted primarily of steam condensate and cooling water. The source of these waste streams is the 221-T Building heating and cooling system. An additional wastewater source is storm water drainage. This source is considered routine but is weather dependent. These sources are expected to contain little or no radioactive and/or hazardous materials (Bolls 1993). Administrative controls have been implemented to remove hazardous constituents from the waste stream.

Historical releases of hazardous chemicals are known to have occurred from the 221-T Building. Records indicate that from 1976 to 1985, reacted sodium, lithium, and sodium iodide were dissolved in wastewater and were discharged to the 216-T-1 Ditch. Light water reactor safety testing also produced effluent streams that contained hazardous constituents. These constituents are listed in Table 3-3.

Appendix C contains annual average time-series plots for the chemical constituents detected in the wastewater effluent from 1985 through the present. The constituents that have exceeded Westinghouse Hanford Company (WHC) provisional backgrounds are aluminum, copper, iron, manganese, and zinc (Johnson 1993). These constituents mobilize and are not retained in the soil column when the chelating agent ethylenediametetraacetic acid (EDTA) is added. There were also measured concentrations of volatile and semivolatile organics in the effluent samples reported in 1993. Effluent sampling results for the period 1992 to 1993, however, confirm that wastewater released to the 216-T-1 Ditch is steam condensate and close to deionized water in composition.

Figure 3-1. Flow Diagram of the Wastewater Discharge Process from the T Plant Head-End to the 216-T-1 Ditch.

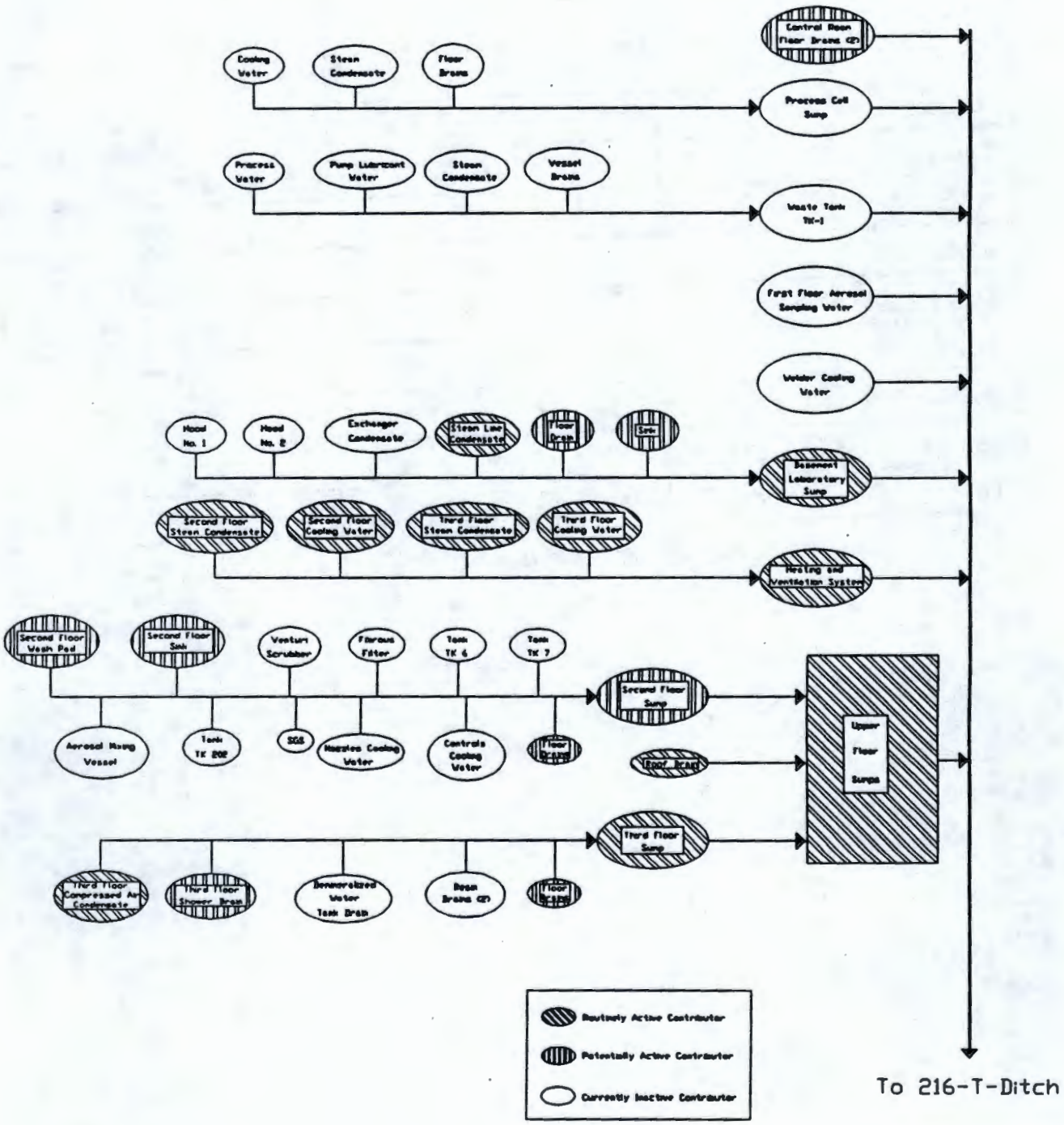


Table 3-3. Hazardous Chemicals Released to the 216-T-1 Ditch.

Constituent	Total mass (kg)	Average concentration* (ppb)	Concentration without dilution (ppb)
Cesium	33.5	620	4.0×10^5
Manganese	~24.0	33	33
Iodine	3.6	67	6.0×10^4
Potassium	7	130	1.4×10^6
Zinc	~18.5	19	710
Lithium	47	870	2.3×10^6
Sulfate	325	6,000	16.0×10^6
Phosphate	33.6	622	1,700
Sodium	120	2,200	7.76×10^5
Borate	124	2,300	4.8×10^6
EDTA	600	1.11×10^4	5.2×10^6

*Concentration average assumes dilution in 5.4×10^7 L of water.

4.0 CONCEPTUAL MODEL OF HYDROGEOLOGIC RESPONSE AND CONTAMINANT MIGRATION

Chapter 4.0 summarizes the Hanford Site hydrologic conditions. The information in Chapter 4.0 is taken largely from DOE (1988); Delaney et al. (1991); Connelly et al. (1992a, 1992b); and Lindsey et al. (1994).

4.1 HYDROGEOLOGIC FRAMEWORK

4.1.1 Regional and 200 West Area Geology

The Hanford Site is underlain by the following:

- Miocene-aged (17.5 to 6 Ma) basalts of the Columbia River Basalt Group (CRBG) (Myers et al. 1979; Reidel and Fecht 1981; DOE 1988; Tolan et al. 1989; Reidel et al. 1989, 1992)
- Sedimentary interbeds within the basalts assigned to the Miocene Ellensburg Formation (Reidel and Fecht 1981; DOE 1988; Smith 1988)
- Late Miocene to Holocene-aged (<8.5 Ma to present) suprabasalt sedimentary units (Myers et al. 1979; Tallman et al. 1981; DOE 1988; Smith et al. 1989; Lindsey 1991; Reidel et al. 1992). These are shown in Figure 4-1. Pre-Miocene sedimentary and crystalline rocks underlie the basalt (Campbell 1989) but will not be discussed in this report.

4.1.1.1 CRBG. The CRBG is an assemblage of tholeiitic, continental flood basalts that cover an area of more than 163,157 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho. The basalts have an estimated volume of approximately 174,356 km^3 (40,800 mi^3) (DOE 1988; Reidel and Hooper 1989; Tolan et al. 1989). Beneath the Hanford Site the CRBG is divided, from oldest to youngest, into four formations: Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (DOE 1988; Tolan et al. 1989) (see Figure 4-1). The Saddle Mountains Basalt is divided, from oldest to youngest, into the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, Elephant Mountain, and Ice Harbor Members at the Hanford Site (Reidel and Fecht 1981). Descriptions and interpretations of CRBG characteristics and evolution are compiled in Reidel and Hooper (1989).

The Elephant Mountain Member of the Saddle Mountains Basalt is the uppermost basalt unit beneath the 200 West Area and is continuous beneath the entire area. The top of the Elephant Mountain Member dips to the southwest and south into the Cold Creek syncline, reflecting the structure of the area (Figures 4-1 and 4-2). There is little evidence for significant erosion into the top of the Elephant Mountain Member and no indication of erosional "windows" through the basalt into the underlying Rattlesnake Ridge interbed of the Ellensburg Formation (Graham et al. 1981).

Figure 4-1. Neogene Stratigraphy of the Pasco Basin (Lindsey et al. 1994).

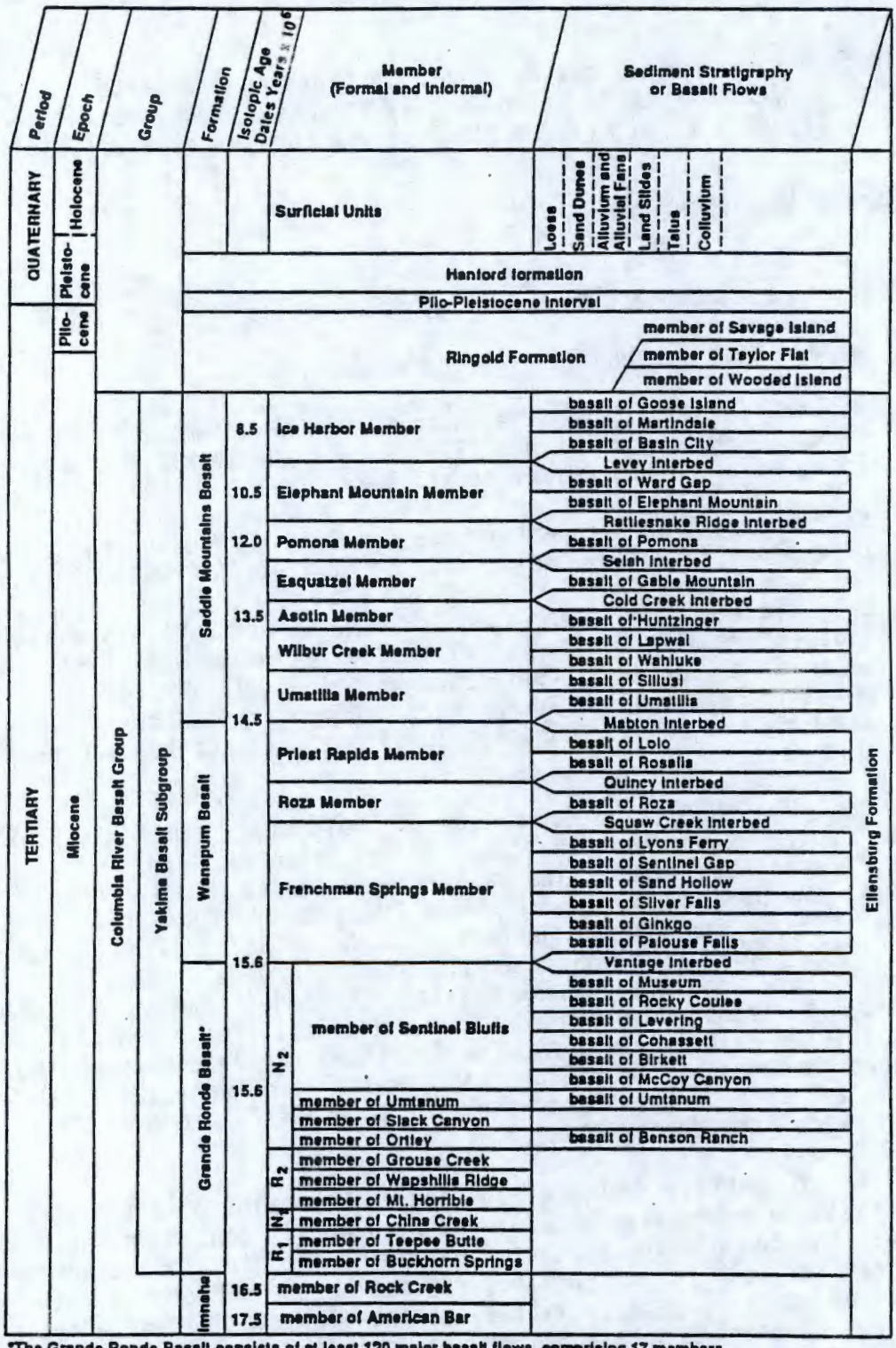
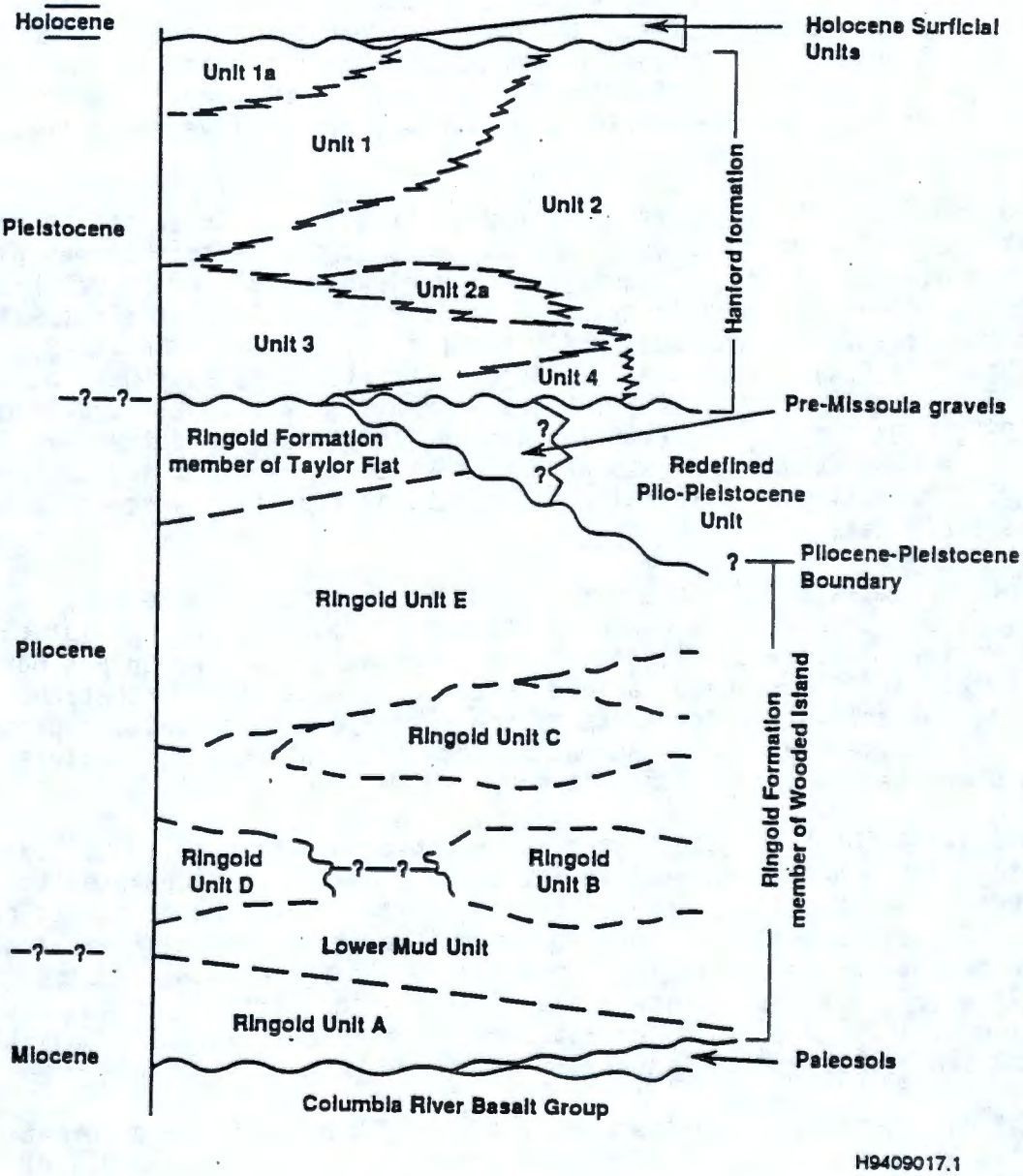


Figure 4-2. Generalized Suprabasalt Stratigraphy of the Pasco Basin and Hanford Site (Lindsey et al. 1994).



4.1.1.2 Ellensburg Formation. The Ellensburg Formation consists of volcaniclastic and silisiclastic deposits that occur between CRBG basalt flows (Swanson et al. 1979; DOE 1988; Smith 1988) (see Figure 4-1). At the Hanford Site, the three uppermost units of the Ellensburg Formation are, from oldest to youngest, the Selah interbed, the Rattlesnake Ridge interbed, and the Levy interbed. A detailed discussion of the Ellensburg Formation at the Hanford Site is given in Reidel and Fecht (1981). Smith (1988) and Smith et al. (1989) discuss the Ellensburg Formation and correlative units throughout the region.

4.1.1.3 Suprabasalt Sediments. The uppermost geologic units at the Hanford Site are generally referred to as the suprabasalt sediments. These units are the focus of this report. Discussions of various aspects of suprabasalt sediment geology are found in Myers et al. (1979); Tallman et al. (1979, 1981); PSPL (1982); Bjornstad (1984); Fecht et al. (1987); DOE (1988); Baker et al. (1991); Last et al. (1989); Smith et al. (1989); Delaney et al. (1991); Lindsey (1991, 1992); Lindsey et al. (1991, 1992); and Reidel et al. (1992). Delaney et al. (1991), Lindsey (1991), and Reidel et al. (1992) provide the most recent synopsis of Hanford Site suprabasalt sedimentary geology. The following discussion is summarized from these recent reports as well as field data.

The suprabasalt sedimentary sequence (see Figures 4-1 and 4-2) is up to 229 m (750 ft) thick at the Hanford Site and is dominated by the laterally extensive late-Miocene to Pliocene Ringold Formation and the Snipes Mountain Conglomerate and Pleistocene Hanford formation. Laterally discontinuous deposits, collectively referred to as the Plio-Pleistocene unit, separate the Hanford formation and Ringold Formation locally. Holocene-aged alluvial and eolian deposits cap the suprabasalt sequence.

4.1.1.3.1 Ringold Formation. The Ringold Formation is up to 183 m (600 ft) thick beneath the Hanford Site. It consists of uncemented to locally well-cemented clay, silt, fine- to coarse-grained sand, and pebble to cobble gravel. Ringold deposits are grouped into five facies associations that are defined on the basis of lithology, petrology, stratification, and pedogenic alteration (Lindsey 1991; Reidel et al. 1992). The facies associations, fluvial gravel, fluvial sand, overbank-paleosol, lacustrine, and basaltic alluvium are summarized in Lindsey et al. (1994, Table 1).

The distribution of facies associations within the Ringold Formation forms the basis for stratigraphic subdivision (Lindsey 1991; Reidel et al. 1992). The lower half of the Ringold Formation is informally referred to as the member of Wooded Island. It is subdivided into several subunits, designated as units A, B, C, D, and E (see Figure 4-2; Lindsey et al. 1994, Figures 4 and 5). These subunits are characterized by strata typical of the fluvial gravel and fluvial sand facies association. Grain-size analysis of core and surface exposures indicates the gravel facies association typically has a bimodal grain-size distribution with the dominant sizes being pebble-to-cobble gravel and medium- to fine-grained sand (Lindsey et al. 1994, Tables 2, 3, and 4). These distributions differ from those reported for the low-level burial grounds (LLBG) by Last et al. (1989). Data presented in that report, which indicated Ringold gravels were sand rich, were based on driven split-spoon and drive barrel samples. Consequently, those samples probably were not intact and the grain size data presented in the report should be used with

caution. Typical grain size distributions for intercalated sand and silt in units A and E of the member of Wooded Island are shown in Lindsey et al. (1994, Table 5).

Units A, B, C, D, and E of the member of Wooded Island are interbedded with fine-grained deposits typical of the overbank-paleosol and lacustrine facies association. The lowest of these fine-grained intervals is designated the lower mud unit of the member of Wooded Island (see Figure 4-2; Lindsey et al. 1994, Figures 4 and 5). Interstratified deposits of the fluvial sand and overbank-paleosol facies association, informally referred to as the member of Taylor Flat, and strata dominated by the lacustrine facies association, informally referred to as the member of Savage Island, form the upper half of the Ringold Formation (commonly referred to as the upper unit). Sand beds from the member of Taylor Flat have grain-size ranges similar to those found in the underlying member of Wooded Island (Lindsey et al. [1994, Table 6]). The 200 Areas are underlain by a combination of units A, D, and E and the lower mud unit of the member of Wooded Island and the lowermost part of the member of Taylor Flat (Lindsey et al. 1994, Figure 4).

Ringold stratigraphic units present beneath the 200 West Area are unit A, the lower mud unit, and unit E of the member of Wooded Island and erosional remnants of the member of Taylor Flat (Lindsey et al. 1994, Figures 5, 9, and 10). Unit B/D of the member of Wooded Island also is present, but the limited distribution of silty marker horizons at the site makes it difficult to determine its lateral continuity. Unit C of the member of Wooded Island also may be present, but the absence of any marker strata necessary to differentiate it from unit E of the member of Wooded Island makes identification of unit C impossible.

Unit A and the lower mud unit of the member of Wooded Island, the two lowest Ringold units in the 200 West Area, display similar trends. Unit A thickens to the south and southwest towards the axis of the Cold Creek syncline. The top of the unit is relatively flat, dipping to the west and southwest (Lindsey et al. 1994, Figure 11). Intercalated lenticular sand and silt is common in unit A in the western and southern parts of the area. The overlying overbank and lacustrine deposits of the lower mud unit also thicken and dip to the south and southwest. However, unlike unit A, the top of the lower mud sequence is irregular and the interval pinches out along the northeast edge of the 200 West Area (Lindsey et al. 1994, Figure 12).

At least locally throughout the 200 West Area, gravelly strata of unit B/D of the member of Wooded Island overlies the lower mud unit. These gravels are similar in composition to unit A below and unit E above. Unit B/D is differentiated from the other gravelly Ringold units by its stratigraphic position overlying the lower mud unit and below paleosols underlying unit E. Where the paleosols underlying unit E are absent, unit B/D is not identified.

Unit E of the member of Wooded Island generally thins from the north-northwest to the east-southeast. The top of the unit is irregular, displaying highs in the northern and southern parts of the area, lows in the central part of the area, and generally dipping to the southeast (Lindsey et al. 1994, Figure 13). Intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is difficult.

The member of Taylor Flat (Lindsey et al. 1994, Figures 14 and 16) is discontinuous across the 200 West Area because of post-Ringold erosion. It only is found in the northern, western, and southern parts of the 200 West Area. In these areas the top of the unit generally is dipping to the south-southwest. The member of Taylor Flat in the 200 West Area consists of interstratified deposits of the overbank-paleosol facies and the fluvial sand facies.

4.1.1.3.2 Plio-Pleistocene Unit. The Plio-Pleistocene unit includes all material overlying the Ringold Formation and underlying the Hanford formation. This interval formerly was divided into three units: (1) the Plio-Pleistocene unit, (2) early Palouse soil, and (3) pre-Missoula gravels (Myers et al. 1979; Tallman et al. 1979, 1981; DOE 1988; Last et al. 1989; Lindsey et al. 1991; Reidel et al. 1992). Recent core logging, borehole sampling, and outcrop studies indicate that a unified Plio-Pleistocene unit consisting of two subunits (locally derived and distally derived; pre-Missoula gravels are found southeast of the 200 East Area) better represents this interval because of uncertainties in stratigraphic relationships among the three formerly used units.

Major rivers (Columbia, Yakima, and Snake Rivers), local sidestreams, and wind deposited Plio-Pleistocene-aged alluvium in the Pasco Basin. The two subunits of the Plio-Pleistocene unit are differentiated based on recognition of deposits from these different sources. Major rivers transported clastic detritus from the northern Rocky Mountains, Okanagen highlands, Idaho Batholith, Cascade Range, and Wallowa Terrane that consist predominantly of quartzite, gneiss, basalt, andesite, rhyolite, and low-grade metamorphics.

The locally derived subunit consists of poorly sorted, locally derived, interbedded reworked loess, silt, sand, and basaltic gravel. Reworked Ringold-derived silt, sand, and gravel also may be present. These strata are bedded to massive; carbonate is irregularly distributed throughout. The gravels mark the course of alluvial channels, whereas the fine-grained material represents overbank, lacustrine, and eolian deposits.

Several forms of carbonate are developed in the subunit, including disseminated (which lightens the matrix and reacts strongly with hydrochloric acid but is otherwise indistinct), filamentous, nodular, massive (which impregnates the matrix imparting a white color and reacts strongly to violently with hydrochloric acid), and partial to complete carbonate coatings on clasts. Most of this carbonate developed subaerially during hiatuses in deposition. However, the absence of associated soil horizons, no apparent decrease in carbonate content with depth (as would be expected in pedogenic carbonates) in some carbonate layers, and some carbonates with textures that are not common to pedogenic carbonates all indicate that groundwater (or capillary fringe) processes may have influenced the morphology of these horizons.

Silt and sand in the upper part of the locally derived subunit has been previously described as a loess and referred to as the early Palouse soil (Myers et al. 1979; Tallman et al. 1981; Bjornstad 1984; DOE 1988; Last et al. 1989; Lindsey et al. 1991; Last and Rohay 1993). In fact, this interval consists of thin, planar-laminated fine sandy silts with little evidence of

the bedding disruption and massive character typical of loess deposits. Consequently, the term early Palouse soil is dropped and these laminated deposits are assigned to the Plio-Pleistocene unit.

The thickness (up to 20 m [66 ft]) of the locally derived subunit and facies distribution are related to depositional environment, the topography of the erosional surface on top of the Ringold Formation, and post-depositional erosion by the catastrophic Missoula floods (Hanford formation). Cold Creek, Dry Creek, and unnamed drainages off Umtanum Ridge, Yakima Ridge, and Rattlesnake Mountain deposited this subunit on a northwest-trending channel or fan complex.

The Plio-Pleistocene unit is irregularly distributed beneath the 200 West Area (Lindsey et al. 1994, Figures 17 and 18); it consists of a combination of facies ranging from pedogenic calcium carbonate to stratified silt-rich deposits.

4.1.1.3.3 Hanford formation. The Hanford formation (see Figure 4-2) consists of uncemented gravel, sand, and silt deposited by Pleistocene cataclysmic flood waters (Fecht et al. 1987; DOE 1988; Baker et al. 1991). The Hanford formation is thickest in the central Hanford Site where it can be up to 107 m (350 ft) thick. The Hanford formation is divided into three facies (gravel, sand, and silt dominated) that are gradational with each other (Lindsey et al. 1991, 1992). These correspond to the gravel, laminated sand, and graded rhythmites facies, respectively, of Baker et al. (1991).

The contact between the Hanford formation and underlying strata is everywhere a disconformity and commonly an angular unconformity. This contact is irregular (Lindsey et al. 1994, Figure 19) and reflects an erosion surface associated with Pleistocene cataclysmic flooding, pre-Hanford incision, or a combination of the two.

The silt-dominated facies consists of interbedded silt and fine- to coarse-grained sand forming well stratified normally graded rythmites. Some of the strata identified as loess dominated early Palouse soil in previous studies (Tallman et al. 1979; Bjornstad 1984; DOE 1988; Last et al. 1989; Last and Rohay 1993) are in fact deposits of the silt-dominated facies. The silt-dominated facies is differentiated from massive, unbedded loess and the lacustrine deposits of the Plio-Pleistocene unit by the presence of interbedded sand. The facies was deposited in backflooded areas during highstands of cataclysmic Pleistocene flood events (Baker et al. 1991).

Well-stratified, fine- to coarse-grained sand and granule gravel form the sand-dominated facies. Silt content is variable. Open framework texture is common where the silt content is low. Small pebbles and rip-up clasts may be present in addition to lenticular, pebble-gravel interbeds and silty interbeds. Deposits comprising this facies accumulated in areas transitional from low-energy backflooded areas to main high-energy channel tracts and as flood flows waned in areas adjacent to channelways and downstream of flow constrictions (Baker et al. 1991).

The gravel-dominated facies consists of cross-stratified, coarse-grained sand and granule to boulder gravel. Intercalated, lenticular silt-rich horizons that commonly display evidence of pedogenic activity are found

locally. Interbedded, gravelly, well-stratified coarse-grained to granular sands are present. This facies is generally uncemented and matrix poor, displaying an open framework texture. The facies was deposited in high-energy main channelways (Baker et al. 1991).

In addition to these three facies, clastic dikes are found in the Hanford formation as well as locally in other sedimentary units in the Pasco Basin (Black 1979). Clastic dikes throughout the Pasco Basin usually consist of alternating vertical to subvertical layers of silt, sand, and granule gravel less than 1 cm (0.4 in.) up to 2 m (6.6 ft) thick. They generally cross-cut bedding, although they do locally parallel bedding. A feature known as patterned ground is observed where the dikes intersect the ground surface.

Studying the distribution of Hanford formation facies types and identifying similarities in lithologic succession across the 200 West Area indicates that the Hanford formation can be divided into two widely distributed stratigraphic units: a gravelly unit referred to as unit 1 and a sand-rich unit that is referred to as unit 2. Also, three localized units are found in the 200 West Area. These units consist of a sandy unit overlying unit 1, referred to as unit 1a; a second gravel interval near the bottom of the section, referred to as unit 3; and a silt-rich unit at the base of the section, referred to as unit 4. Mineralogic and geochemical data are not used in differentiating units because there is no comprehensive mineralogic and geochemical data set.

Unit 4. Unit 4 is dominated by strata typical of the silt-dominated facies and lesser sand-dominated facies. It is largely restricted to the west-central part of the 200 West Area where it underlies and interfingers with gravels of unit 3. Where unit 3 is absent it may not be possible to differentiate unit 4 from other silt- and sand-dominated parts of the Hanford formation. However, some borehole data reported in Last and Rohay (1993) and Rohay et al. (1993) indicate that unit 4 may be separable from other silt and sand units on the basis of decreased grain size.

Unit 3. Deposits of the gravel- and sand-dominated facies form the bulk of unit 3. Unit 3 is most common in the west-central part of the area (Rohay et al. 1993). Because there are no distinctive marker lithologies and beds, it is impossible to determine whether unit 3 in the 200 West Area is correlative to unit 3 in the 200 East Area. It is also not possible to differentiate the gravels of unit 3 from other gravelly Hanford units, such as unit 1, where intervening sandy strata are absent.

Unit 2. Unit 2 consists dominantly of silt, silty sand, and sand typical of the silt-dominated facies interbedded with coarser sands like those comprising the sand-dominated facies. Thin (<3 m [<9.8 ft]) intervals dominated by the gravel facies are found locally. The distribution of facies within the unit is variable, although the unit generally fines to the south where silt-dominated facies become more common. Unit 2 pinches out in the northern part of 200 West Area and it generally thickens to the south (Lindsey et al. 1994, Figures 20 and 21).

Unit 1. Unit 1 consists of interstratified gravel facies, sand facies, and lesser silt facies. At some localities deposits typical of the sand-dominated facies dominate. This is especially common in the west-central

200 West Area where a sandy interval, referred to as unit 1a, gradationally overlies unit 1 gravels (Rohay et al. 1993). Minor, laterally discontinuous silty deposits like those that form the silt facies are found locally. The thickness and distribution of individual facies within unit 1 vary. Fining upwards sequences of coarse to fine gravel and gravel to gravelly sand are present at some locations. The base of unit 1 is incised into underlying strata. However, where the unit thins to the south the contact is less well defined as unit 1 interfingers with the sand and silt of unit 2 (Lindsey et al. 1994, Figure 22).

4.1.1.3.4 Holocene Deposits. Holocene surficial deposits consist of a mix of silt, sand, and gravel deposited by a combination of eolian and alluvial processes. These Holocene deposits form a thin (4.9 m [<16 ft]) veneer across much of the Hanford Site.

Holocene deposits in the 200 West Area consist of thin (<3 m [<9.8 ft]) eolian sheet sands. These sands are very fine to medium grained and occasionally silty. These deposits have been removed from much of the area by construction activities.

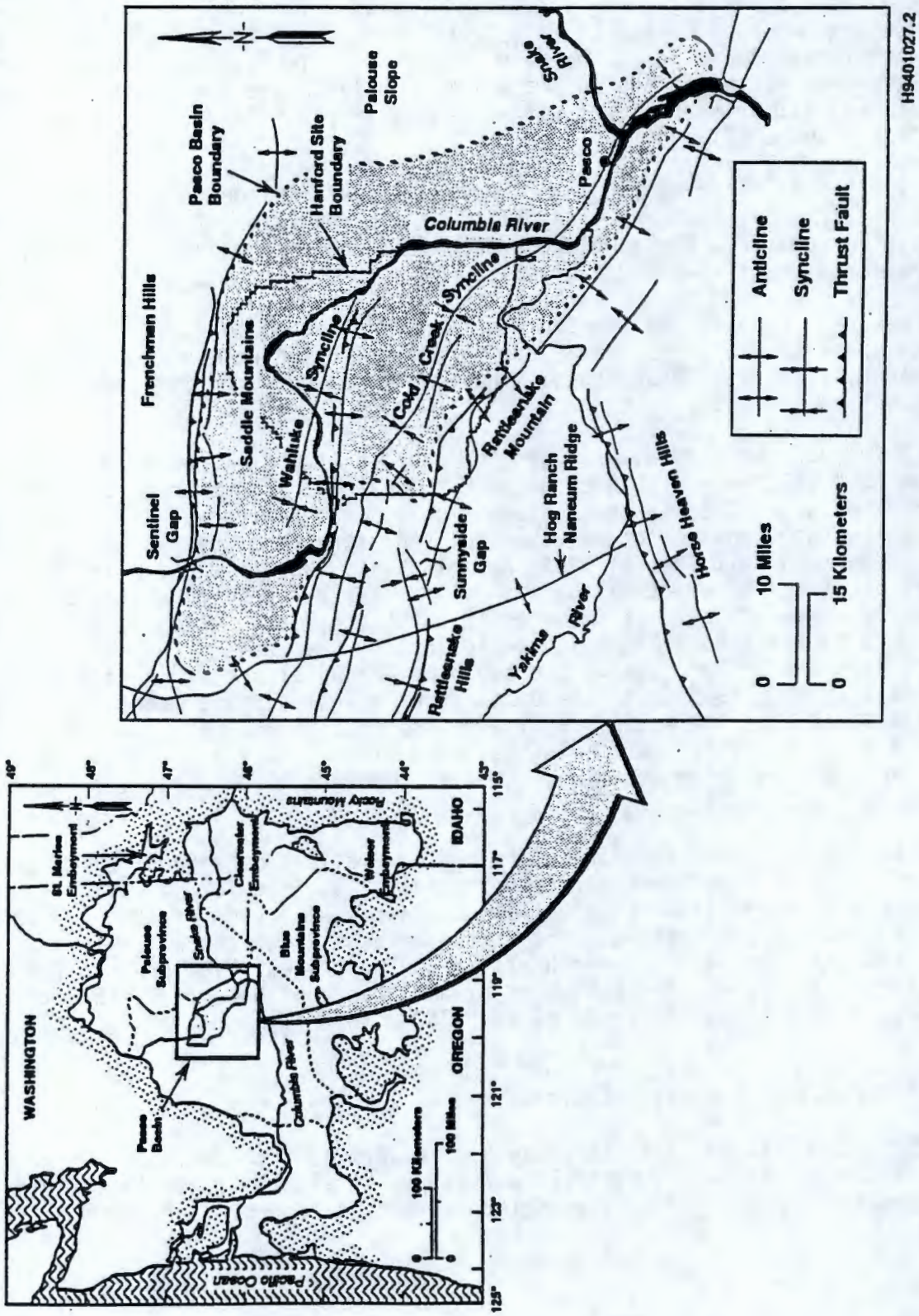
4.1.1.3.5 Structural Geology The Hanford Site is located in the eastern Yakima Fold Belt near its junction with the Palouse subprovince (DOE 1988). A series of segmented, narrow, asymmetric, and generally east-west trending anticlines that separate broad, low-amplitude structural basins characterizes the Yakima Fold Belt (Reidel 1984; Reidel et al. 1989; Tolan and Reidel 1989). One of the largest structural basins within the Yakima Fold Belt is the Pasco Basin. The Hanford Site is situated in the Pasco Basin, which is bounded on the north by the Saddle Mountains anticline, on the west by the Hog Ranch-Naneum Ridge anticline, and on the south by the Rattlesnake Mountain anticline (Figure 4-3) (DOE 1988). The Palouse slope, a west-dipping monocline, bounds the Pasco Basin on the east (see Figure 4-3) (DOE 1988). The Pasco Basin is divided into the Wahluke and Cold Creek synclines by the Gable Mountain anticline, the easternmost extension of the Umtanum Ridge anticline (see Figure 4-3) (DOE 1988).

The 200 West Area is situated on the generally southward dipping north limb of the Cold Creek syncline approximately 1 to 5 km (0.6 to 3.1 mi) north of the syncline axis (see Figure 4-3; Lindsey et al. 1994, Figure 5). The Gable Mountain-Gable Butte segment of the Umtanum Ridge anticline lies approximately 4 km (2.5 mi) north of the 200 West Area. The axes of the anticline and syncline are separated by a distance of 9 to 10 km (5.6 to 6.2 mi), with structural relief of over 250 m (820 ft).

4.1.2 Geology of the 216-T-1 Ditch

Site-specific geologic parameters were derived from earlier investigations in the 200 West LLBGs (Lindsey et al. 1994) and from field investigations performed in conjunction with this report.

Figure 4-3. Structural Geologic Setting of the Pasco Basin and Surrounding Area.



4.1.2.1 218-W-6 Burial Ground

The 218-W-6 Burial Ground (Lindsey et al. 1994, Figure 23) is underlain, from the surface to the top of basalt, by (1) Hanford formation gravel and lesser sand facies; (2) the Plio-Pleistocene unit; (3) the lower part of the Ringold Formation member of Taylor Flat; and (4) unit E, the lower mud unit, and unit A of the Ringold Formation member of Wooded Island (Lindsey et al. 1994, Figures 24, 25, and 26).

The Hanford formation ranges from 7 to 24 m (23 to 80 ft) thick and is dominated by the gravel facies. Sands also occur in several wells at the base of the Hanford formation. Stratigraphic trends throughout the 200 West Area indicate the gravels are part of Hanford formation unit 1. The sands are assigned to Hanford formation unit 2. Unit 2 pinches out in the northern part of the 200 West Area and is not continuous beneath the burial ground.

The Plio-Pleistocene unit is continuous beneath the entire burial ground (Lindsey et al. 1994, Figure 27). It ranges from approximately 3 m (10 ft) thick in the eastern part of the site to as much as 18 m (60 ft) thick in the north-central part of the site. The top of the unit ranges from 7 to 24 m (23 to 80 ft) below the surface, generally becoming deeper to the south. Beneath the burial ground the unit consists of a combination of all its sediment types except laminated silts. Consequently, a complex vadose zone transport system should be expected. The Plio-Pleistocene unit commonly grades downward into underlying Ringold strata, and the top of the Plio-Pleistocene unit generally is placed at the base of the lowest calcium carbonate-rich layer, which is greater than 8 cm (0.25 ft) thick.

Except for the southernmost borehole examined for this site (W11-18), erosional remnants of the Ringold Formation member of Taylor Flat are present everywhere beneath the burial ground. These strata vary from 1.5 to 17 m (5 to 55 ft) thick because of the gradational nature of the contact between it and the overlying Plio-Pleistocene unit. Consequently, the contact between the two units is not everywhere at the same horizon. Beneath the burial ground the member is dominated by the fluvial sand facies and contains lesser occurrences of the overbank-paleosol and fluvial gravel facies.

Unit E of the member of Wooded Island is present everywhere beneath the burial ground. Three wells (W6-6, W6-3, and W6-1) penetrate the full thickness of unit E at the site, i.e., 96 to 100 m (315 to 329 ft). Unit E is dominated by the fluvial gravel facies while minor laterally discontinuous occurrences of the fluvial sand and overbank-paleosol facies are also present. Well-cemented zones throughout the unit can generate locally confined conditions beneath the water table and have the potential to generate local perched water conditions in the vadose zone.

Wells W6-6, W6-3, and W6-1 also fully penetrate fine-grained strata of the lower mud unit. The lower mud unit is 3 to 4.5 m (10 to 15 ft) thick beneath the site. Trends throughout the 200 West Area (Lindsey et al. 1994, Figures 24, 25, and 26) indicate that the unit pinches out near the state-approved land disposal site located north of the burial ground. It is not known if the lower mud unit of the member of Wooded Island generates confined or partially confined conditions in underlying strata.

Approximately 11 m (35 ft) of fluvial gravel of unit A of the member of Wooded Island separate the lower mud unit of the member of Wooded Island from the top of the Saddle Mountains Basalt. Both unit A and the overlying lower mud unit dip and thicken southward.

4.1.2.2 Well 299-W11-37. Well 299-W11-37 (Figures 4-4, 4-5, and 4-6) was drilled to supplement stratigraphic data near the 216-T-1 Ditch and to estimate proximal vadose and groundwater contamination. The stratigraphic horizons encountered in the course of drilling the well coincide with those found beneath the 216-W-6 Burial Ground. Grain size nomenclature related to fine-grained sediments can be found in WHC-CM-7-7, EII 9.1. All depths reported are measured from ground surface at the time of drilling.

The Hanford formation resides from near ground surface to a depth of 26 m (85 ft). Approximately 1.5 m (5 ft) of sandy backfill overlies the upper coarse gravel of the Hanford formation. The gravel extends to a depth of approximately 13 m (44 ft) and are not matrix supported. Clast sizes ranged from 4 mm (0.2 in.) to 15.2 cm (6 in.). Occasional fining sequences are found within the gravels, but their vertical distribution is sporadic. One particular zone of sandy silt resides at 12.2 m (40 ft). This sequence is the thickest fining horizon (0.03 m [0.1 ft]) within the gravel unit. The fines normally associated with this unit are interpreted to be clast coatings due to the limited relative percentage of their occurrence in the samples.

A sharp contact found between the upper coarse gravel and a sandy gravel horizon occurs at 13.4 m (44 ft). This horizon contains approximately 30 percent sandy matrix. The clast sizes are similar to those found in the upper coarse found above, but with a higher proportion of 4 to 8 mm (0.2 to 0.3 in.) pebbles (approximately 50 percent). The fines are predominantly coarse fractions with only trace amounts of silt.

Another sharp contact separates the sandy gravel and a uniform sand horizon at 16.5 m (54 ft). This unit comprises approximately 80 percent coarse and medium sands and 20 percent fine to very fine sand. Occasional clasts are found in this horizon, with a maximum clast size of 15.2 cm (6 in). Two distinct fine-grained intervals are found at depths of 19.1 m (62.5 ft) and at 19.5 m (64 ft). The fine-grained sediments at these depths are approximately 15.2 cm (6 in.) and 20.3 cm (8 in.) thick, respectively.

At a depth of 22.9 m (75 ft), the Hanford formation reverts back to a coarse gravel. The clast sizes are dominated by fine gravels (4 to 8 mm [0.2 to 0.3 in.]). The proportion of clasts declines at a depth of 24.4 m (80 ft). The matrix, which constitutes approximately 40 percent of the horizon, is dominated by coarse sand. Fine-grained horizons comprising very fine sand are found at depths of 23.5 m and 25.3 m (77 and 83 ft). Caliche stringers are found at 25.9 m (85 ft).

Sand, silt, and caliche occur in alternating horizons beginning at a depth of 26.8 m (88 ft). The sands are relatively uniform without significant amounts of clasts. The clasts that are present are 4 to 8 mm (0.2 to 0.3 in.) in size and represent only 10 percent of an interval 0.3 m (1 ft) in thickness. This gravelly-sand interval occurs at 38.1 m (125 ft). The sands vary in grain size from very fine sand to medium to coarse sand. Silt horizons occur at two intervals. A 12.7-cm- (5-in.-) thick silt horizon with

Figure 4-4. Location Map for 216-T-1 Ditch Cross Sections and Test Pits.

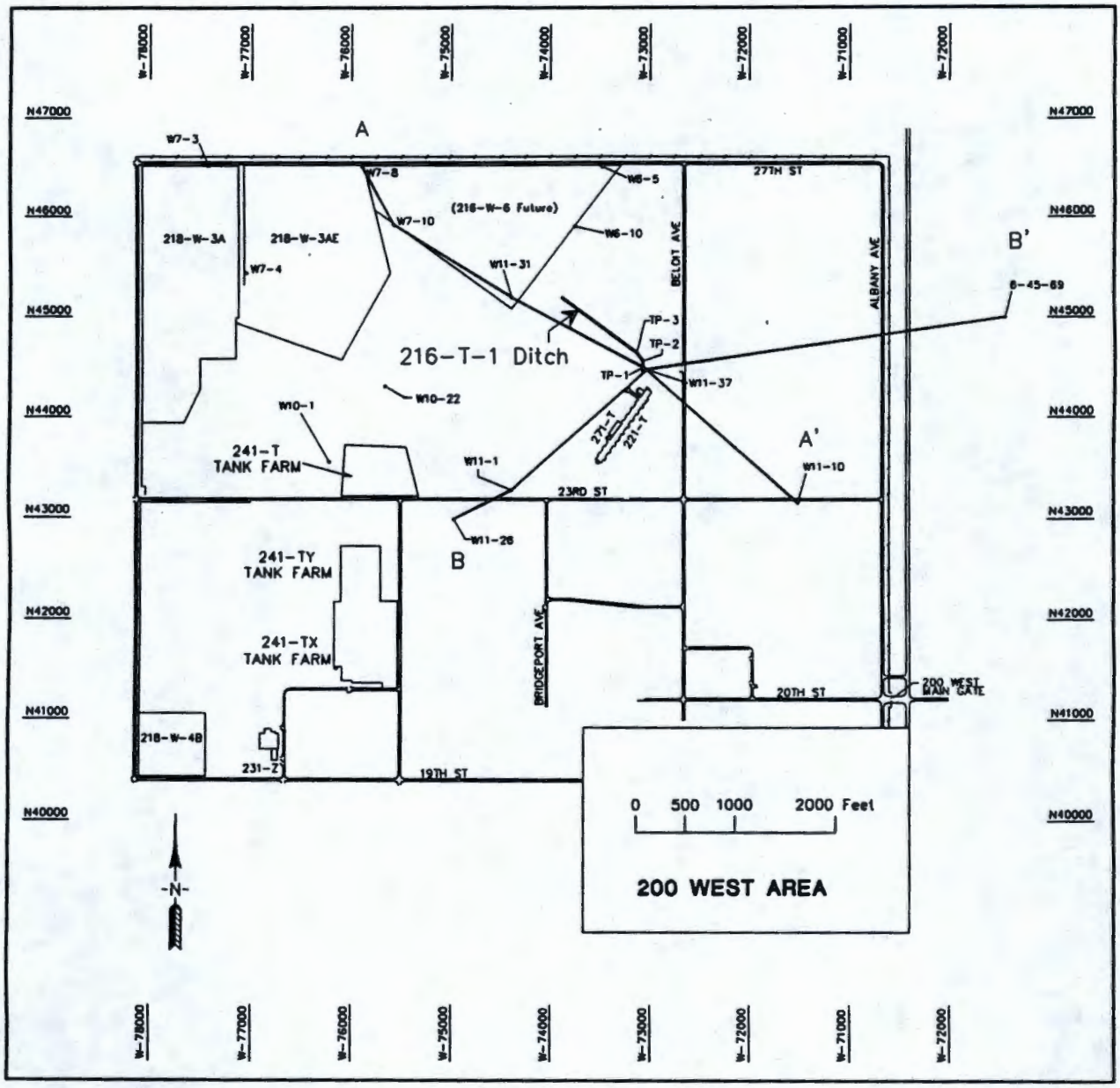


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Figure 4-5. Cross Section A-A' Through Well 299-W11-37.

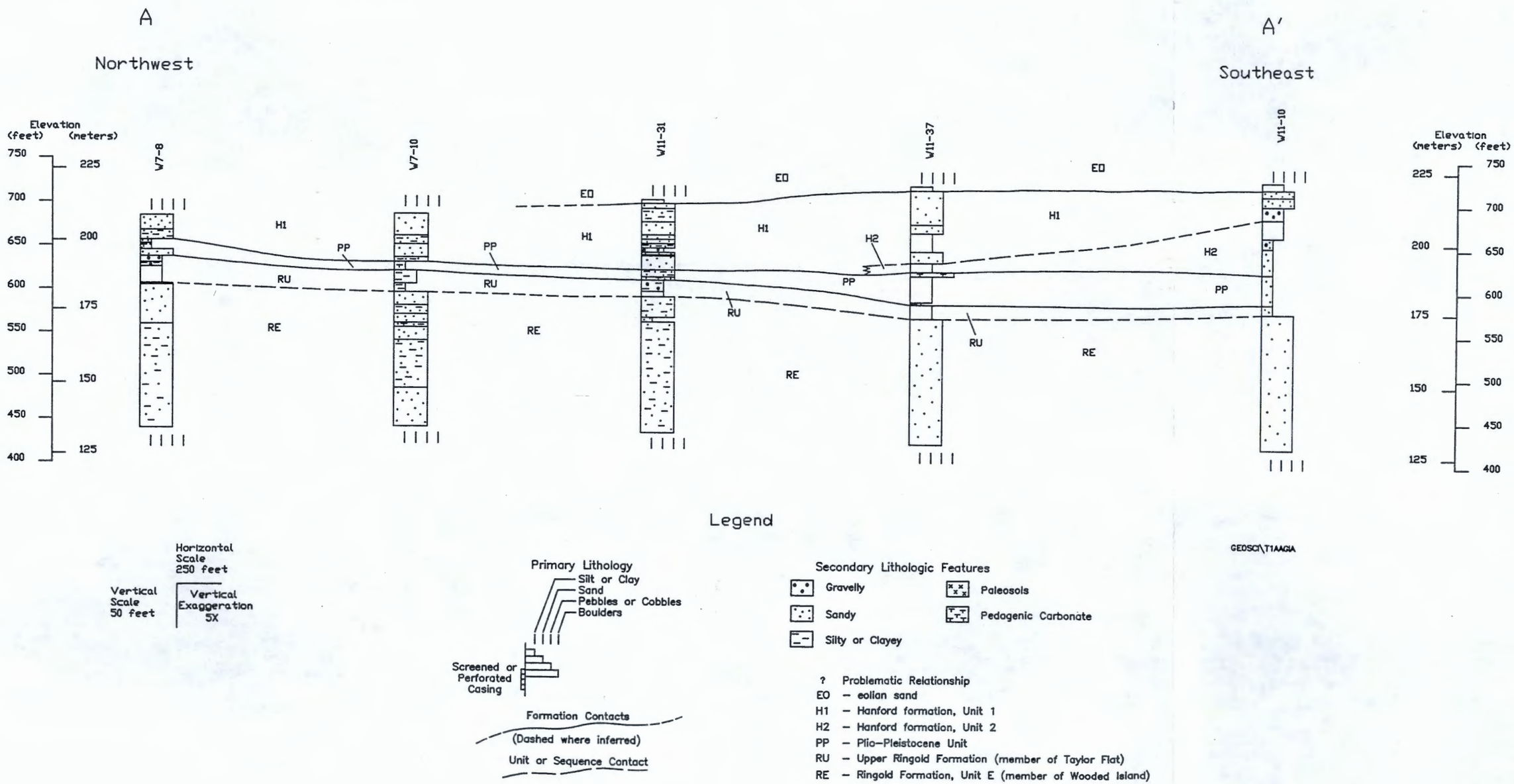
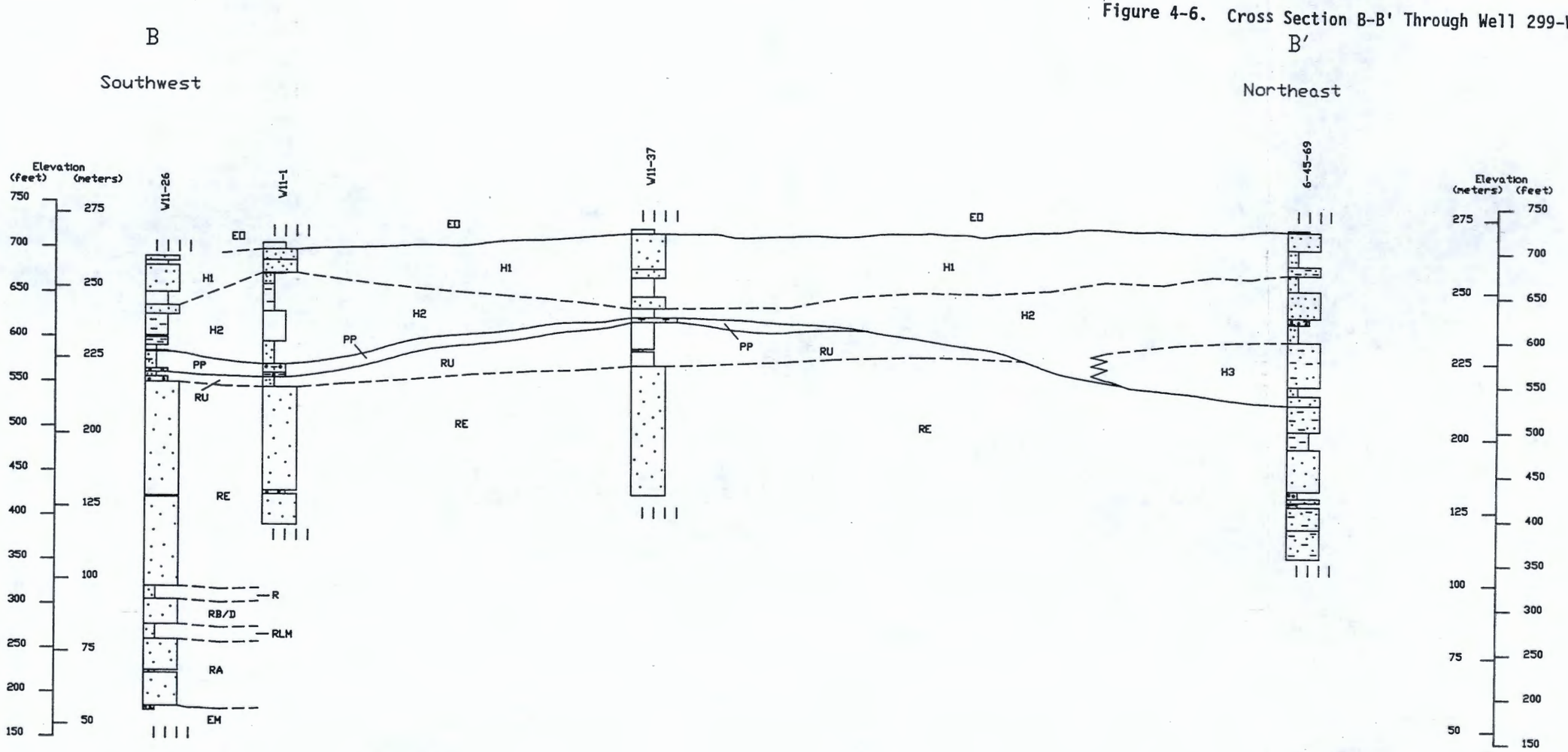


Figure 4-6. Cross Section B-B' Through Well 299-W11-37.



Legend

Horizontal Scale 250 feet

Vertical Scale 50 feet

Vertical Exaggeration 5X

Primary Lithology
- Silt or Clay
- Sand
- Pebbles or Cobbles
- Boulders

Screened or Perforated Casing

Formation Contacts

(Dashed where inferred)

Unit or Sequence Contact

Secondary Lithologic Features
- Gravelly
- Sandy
- Silty or Clayey
- Paleosols
- Pedogenic Carbonate
- Basalt

? Problematic Relationship
EO – Eolian Sand
H1 – Hanford formation, Unit 1
H2 – Hanford formation, Unit 2
H3 – Hanford formation, Unit 3
PP – Plio-Pleistocene Unit
R – Undifferentiated Ringold Formation

RU – Upper Ringold Formation (member of Taylor Flat)
RLM – Ringold Formation, Lower Mud Unit
RB/D – Ringold Formation, Unit B or D
RA – Ringold Formation, Unit A
RE – Ringold Formation, Unit E
EM – Elephant Mountain Member, Saddle Mountain Basalt
} member of Wooded Island

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a hackly texture, possibly a paleosol, is located at a depth of 31.4 m (103 ft). The second horizon, at a depth of 39.2 m (128.6 ft), is approximately 0.3 m (1 ft) thick and was sampled with a split-spoon sampling device during drilling. Caliche occurs in two locations. The first interval, at a depth of 30 to 31 m (98.3 to 100.3 ft), developed on a fine-grained sand. The second horizon, located at a depth of 38.6 m (126.6 ft), is found in a sand and silt sequence. This interval is approximately 15.2 cm (6 in.) thick.

The Plio-Pleistocene unit is represented by a caliche within a slightly silty fine sand found at a depth of 40.6 to 41.5 m (133 to 136 ft). This horizon is interpreted to be a paleosol.

Ringold Formation sediments at the 216-T-1 Ditch include a fluvial sand sequence and fluvial gravels. The sand is found at a depth of 41.5 m (136 ft). Trace amounts of silt are incorporated into this medium- to fine-grained sand. The sand is relatively uniform to a depth of 45.8 m (150 ft), where a small fraction of 7.6-cm (3-in.) cobbles is found.

Ringold gravels comprise the remaining sediments between a depth of 47.3 m (155 ft) and total depth at 90.4 m (296.5 ft). The relative percentages of sand and gravel vary in this interval, but the interpretation given from field observations is that the sequence represents the unit E of the member of Wooded Island. From a depth of 47.3 m (155 ft) to 79 m (259 ft), and again between depths of 87 and 90.4 m (285 and 296.5 ft), gravel dominates the unit. Clast sizes range from 4 mm to 12.8 cm (0.2 to 5 in.). The smaller fractions (4 to 16 mm [0.2 to 0.6 in.]) represent the greatest proportion of the gravel size. The matrix is predominantly coarse to very coarse sand. Sand dominates the unit between the depths of 79 and 87 m (259 and 296.5 ft). The clast sizes are similar to those found in the sandy-gravel horizons, but the sand is represented by very coarse sand.

4.1.2.4 Test Pits. Three test pits were excavated within the confines of the 216-T-1 Ditch. The test pits were required to evaluate near-surface contamination resulting from past practices associated with 216-T-1 Ditch operations. The location of the test pits is shown in Figure 4-4.

In all three test pits, a thin (<0.3 m [1 ft]) sandy horizon was found to overlie a sandy gravel. The sandy gravel is continuous beneath the ditch to at least 3 m (10 ft). The sediments in the ditch were slightly damp at the time of sampling.

4.1.3 Regional and 200 West Area Hydrology

Delaney et al. (1991) presents a synopsis of regional and Hanford Site hydrogeology. Section 4.1.3 is summarized from Delaney et al. (1991). Connelly et al. (1992a, 1992b) summarizes the hydrology of the 200 West Area.

4.1.3.1 Surface Hydrology. The primary surface water features near the Hanford Site are the Columbia and Yakima Rivers. The freeflowing stretch of the Columbia River adjacent to the Hanford Site is known as the Hanford Reach. It extends from Priest Rapids Dam to the headwaters of Lake Wallula (the reservoir behind McNary Dam) at about the 300 Area. Flow along the Hanford Reach is controlled by the Priest Rapids Dam. Approximately one-third of the

Hanford Site is drained by the Yakima River system. West Lake, about 4 ha (10 acres) in size and less than 1 m (3 ft) deep, is the only natural lake on the Hanford Site (DOE 1988). Wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and waste disposal activities are also present on the site.

4.1.3.2 Subsurface Hydrology.

4.1.3.2.1 Saturated Zone. The Hanford Site is underlain by a multiaquifer system consisting of four hydrogeologic units that correspond to the upper three formations of the CRBG (Grande Ronde, Wanapum, and Saddle Mountains Basalt) and the suprabasalt sediments (DOE 1988; Delaney et al. 1991). The basalt aquifers generally are confined and found within sedimentary interbeds of the Ellensburg Formation and permeable zones that occur between flows.

Recharge to the shallow basalt aquifers in the Saddle Mountains and upper Wanapum Basalts is from infiltration of precipitation and runoff along the margins of the Pasco Basin. Recharge of the deep basalt aquifers in the lower Wanapum and Grande Ronde Basalts is inferred to occur northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1988). Groundwater discharge from shallow basalt aquifers is probably to overlying aquifers and to the Columbia River. Discharge areas for the deeper aquifers are uncertain but are inferred to be south of the Hanford Site (DOE 1988). Erosional "windows" through dense basalt flow interiors at the top of the basalt aquifer system allow direct interconnection between the suprabasalt aquifer system and the uppermost basalt aquifers (Graham et al. 1984).

The suprabasalt sediment aquifer is contained within the Hanford formation and the Ringold Formation. The top of this aquifer lies at depths ranging from less than 30 cm (1 ft) near West Lake and the Columbia and Yakima Rivers, to greater than 107 m (350 ft) near the center of the Hanford Site. The base of the uppermost aquifer system is the top surface of the underlying basalt. Beneath the western part of the Hanford Site the water table generally is within gravels of unit E of the member of Wooded Island. In the northern and eastern portions of the Hanford Site the water table is generally at or near the Hanford-Ringold contact. In the east-central part of the Hanford Site the water table lies up to 24 m (80 ft) above the top of the Ringold Formation. Widespread intervals dominated by the paleosol-overbank and lacustrine facies associations form at least partially confining layers between the main Ringold gravel-bearing units (A, B/D, C, and E of the member of Wooded Island) (Lindsey et al. 1994, Figure 5). The uppermost aquifer system is bounded laterally by anticlinal basalt ridges and is approximately 152 m (500 ft) thick near the center of the basin. Hydraulic conductivities for the Hanford formation are much greater than those of the gravel facies of the Ringold Formation (Connelly et al. 1992a, 1992b).

Natural recharge to the uppermost aquifer system consists of rainfall and runoff from the hills bordering the Hanford Site, water infiltration from small ephemeral streams, river water along influent reaches of the Yakima and Columbia Rivers, and water rising from underlying confined basalt aquifers along faults and fractures. The movement of moisture from precipitation through the unsaturated (vadose) zone varies. Gee (1987) and Routson and

Johnson (1990) indicate that the downward movement of moisture from surface recharge is nonexistent across much of the Hanford Site, while Rockhold et al. (1990) suggest that downward water movement below the root zone is common in the 300 Area. Artificial recharge occurs from the disposal of wastewater on the Hanford Site (principally in the 200 Areas) and from large irrigation projects surrounding the Hanford Site.

4.1.3.2.2 Unsaturated Zone. Strata in the vadose zone across the Hanford Site and the 200 Areas show variations similar to those displayed in the uppermost aquifer system. The Hanford formation, Plio-Pleistocene unit, and Ringold Formation are all present in the vadose zone in the 200 West Area. In the 200 East Area the vadose zone is situated almost entirely within the Hanford formation. The distribution of fine-grained layers, cemented zones, and clastic dikes within these units probably have the greatest influence on vadose zone flow and transport properties.

Van Genuchten curve fitting parameters for the major stratigraphic units beneath the 200 East Area and 200 West Area are summarized in Connelly et al. (1992a, Table 3-1; 1992b, Table 3-1), respectively. Close examination of these parameters reveals significant variability. Because of this high degree of variation, known heterogeneities in the geology of the area, borehole sampling techniques inappropriate for intact sediment sampling, and the limited number of data points, these data are not representative of vadose conditions.

4.1.3.2.3 200 West Area Hydrology. The surface of the unconfined aquifer in the 200 West Area is situated entirely within partially cemented fluvial gravels of unit E of the member of Wooded Island (Connelly et al. 1992b). Transmissivity and hydraulic conductivity values summarized in Connelly et al. (1992b, Table 3-2) indicate ranges of 1.7 to 4,738 m^2/day and 0.3 to 1,554 m/day (18 to 51,000 ft^2/day and 1 to 5,100 ft/day), respectively. The vadose zone beneath the 200 West Area is situated in the Hanford formation, the Plio-Pleistocene unit, the Ringold member of Taylor Flat, and the upper part of unit E. Van Genuchten curve fitting parameters for lithologies that typically comprise these units are listed in Connelly et al. (1992a, Table 3-1; 1992b, Table 3-1).

Clastic dikes also are common in the vadose zone in the 200 West Area. Data describing the physical characteristics and hydrologic properties of clastic dikes are not available. However, some empirical observations have been made that allow the following generalized conclusions to be made:

- Clastic dikes are most common within strata typical of the sand- and silt-dominated facies. However, the dikes are very difficult to detect in the subsurface.

- Clastic dikes can potentially act as barriers or pathways to fluid transport. Their behavior depends on the content of the dike and the type of sediment the dike transects.

- The lateral extent of the spreading of individual perched water zones is limited where dikes appear to form pathways for vertical fluid transport.

4.1.4 Hydrology of the 216-T-1 Ditch

The hydrostratigraphic units of concern in the vicinity of the 216-T-1 Ditch are the (1) Elephant Mountain Basalt, (2) Ringold Formation, (3) Plio-Pleistocene interval, and (4) Hanford formation. The Elephant Mountain Basalt forms the lower confining bed of the uppermost aquifer. The dense interior of this basalt has low-hydraulic conductivities (0.0009 m/day [0.03 ft/day]). The surface of the Elephant Mountain Basalt dips south-southeast toward the axis of the Cold Creek syncline from a high just north of the 200 East Area.

The suprabasalt aquifer beneath the 216-T-1 Ditch is contained within Ringold formation unit E of the member of Wooded Island. These strata exhibit locally confined to unconfined conditions caused by fine intervals and cemented zones. The saturated thickness of the unconfined aquifer is approximately 68.6 m (225 ft) in the vicinity of the ditch. Hydraulic conductivities for the gravels and sands of unit E range from 0.02 to 61 m/day (0.06 to 200 ft/day).

The Plio-Pleistocene unit is approximately 12 m (40 ft) thick with the top of the unit dipping to the south-southwest. The Plio-Pleistocene unit is within the unsaturated zone within the 216-T-1 Ditch study area. Pedogenic $CaCO_3$-cemented horizons within the interval may create locally perched conditions. However, there were no occurrences of perched water during the drilling of well 299-W11-37. No perched water was reported by Last et al. (1989) above this unit although it is encountered elsewhere in the southern 200 West Area.

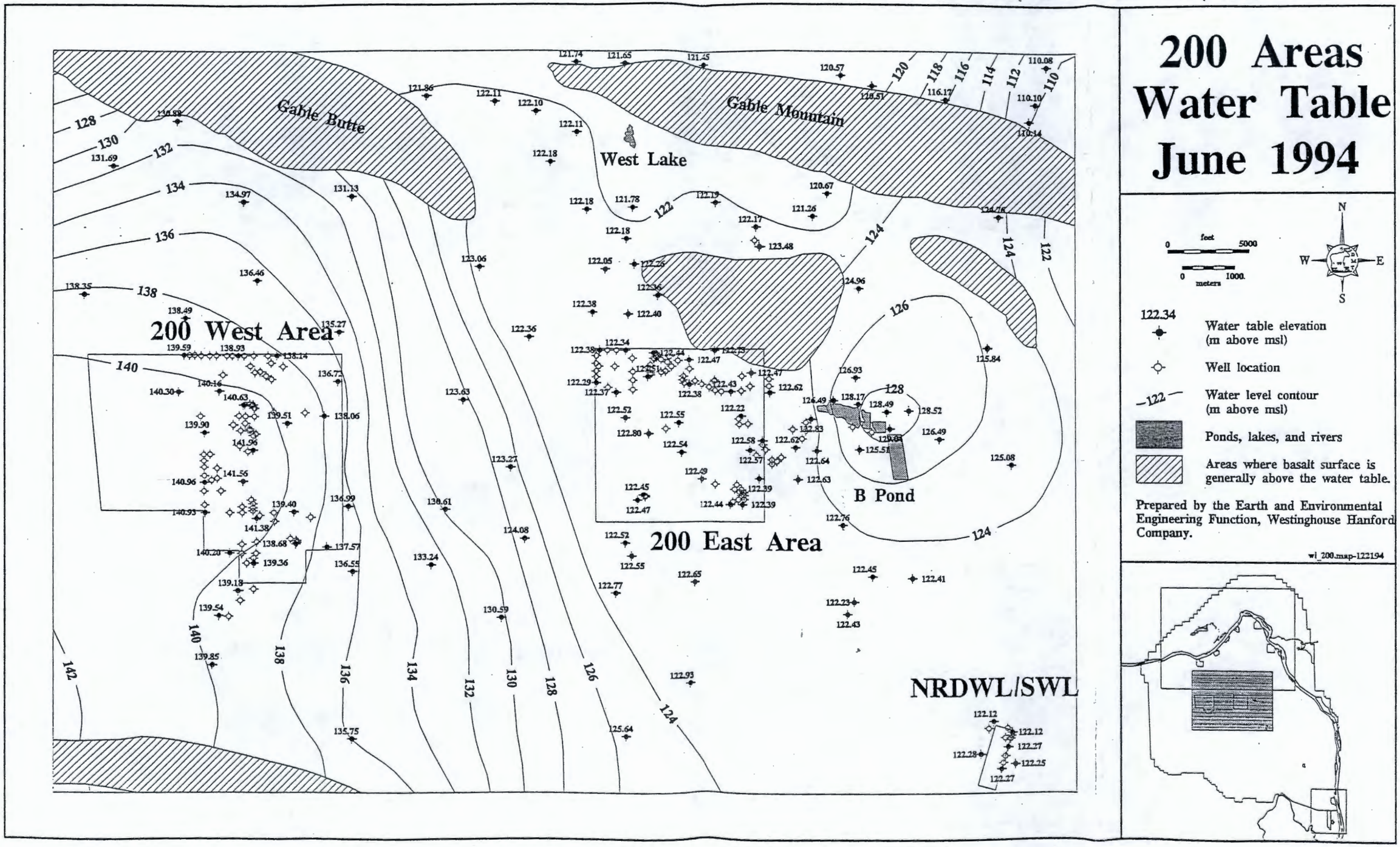
The thickness of the unsaturated zone beneath the 216-T-1 Ditch is approximately 67 m (220 ft) and consists of the upper portion of the Plio-Pleistocene unit and the units of the Hanford formation. Hydrologic properties for the Hanford formation are summarized in Connelly et al. (1992).

Groundwater flow in the uppermost aquifer system (near the water table) is east-northeast in the vicinity of the 216-T-1 Ditch (Figure 4-7) (Serkowski et al. 1994). The groundwater flows from a large mound or lobe on the west side of the 200 West Area. The lobe, although its apex had declined and shifted eastward in recent years, is mainly due to surface discharges to the 216-U-10 Pond system (mainly 284-WB Powerplant Ponds, 216-U-14 Ditch, and 216-Z-20 Pond).

4.2 HYDROLOGIC RESPONSES TO EFFLUENT DISPOSAL

The water table northeast (downgradient) of the large mound on the east side of 200 West Area is a relatively uniform surface that is dipping to the northeast (see Figure 4-7). No irregularities exist near the 216-T-1 Ditch. Furthermore, the water level in well 299-W11-37 is consistent with the regional water table. This indicates that the amount of wastewater discharged at the 216-T-1 Ditch (see Figure 2-1) is insufficient to form a discernible mound.

Figure 4-7. 200 Areas Water Table (Serkowski et al. 1994).



Discharged wastewater to the 216-T-1 Ditch is decreasing with time and will cease in June 1995. Therefore, the formation of a future groundwater mound at the 216-T-1 Ditch site is unlikely assuming the continued decrease in the quantities of wastewater being discharged into the ditch.

Because only one well exists near the 216-T-1 Ditch and water level measurements are consistent with the regional water table, it is difficult to determine if the wastewater discharged at the ditch influences the groundwater other than to say that the water is of insufficient quantity to form a mound. Consequently, it is only possible to speculate on the nature of the groundwater conditions beneath the ditch. Based on experience elsewhere at the Hanford Site, the following is a very general conceptualization of water movement through the ground beneath the ditch.

When wastewater from the 216-T-1 Ditch is sufficient enough to saturate the soil beneath the ditch, it percolates down into the uppermost sediment unit at the crib site, a silty and sandy unit that represents the interbedded sand- and silt-dominated facies of the Hanford formation. Significant lateral spreading may occur in this fine-grained unit. Because lateral discontinuities, such as pinchouts and clastic dikes, are common in the silt-rich horizons, lateral spreading is probably limited on individual beds. However, because multiple silt-rich horizons and the cumulative thickness of this interbedded interval are present, lateral spreading may be quite pronounced through the entire interval. Lateral spreading of moisture may also occur on the underlying Plio-Pleistocene interval, which is known to have many discontinuous $CaCO_3$-cemented horizons.

If any perching of the downward-migrating wastewater had occurred, the amount would have probably been minimal because of the discontinuous nature of the silt-rich layers in the Hanford formation and the intermittent $CaCO_3$-cemented layers in the Plio-Pleistocene interval. Furthermore, if any perching had occurred in the silt-rich layers of the Hanford formation, the preferential flow direction is unknown because the bedding is fairly horizontal. However, any perching that takes place on top, or within, the Plio-Pleistocene interval may cause groundwater at those perched layers to flow to the southeast because the interval generally dips that direction.

4.3 GROUNDWATER QUALITY

4.3.1 216-T-1 Ditch Groundwater Quality

Groundwater analyses data from well 299-W11-37 (at the head-end of the 216-T-1 Ditch) give an indication of the local groundwater quality, as well as potential local influences from the 216-T-1 Ditch. Appendix A1 lists the 1994 results of groundwater analyses data for all samples collected from well 299-W11-37 during drilling and well installation.

Table 4-1 summarizes the groundwater data from Appendix A1 by listing the constituents detected in the analyses. The table lists the concentration measured for the parameters listed. This table lists both field and laboratory analytical results. Where a conflict exists between values, the

Table 4-1. Constituents Analyzed - Groundwater Monitoring Data for Well 299-W11-37. (4 sheets)

Constituent	Result[a]	Result[b]	Units	Background[c]	EB	Limit[d]	EL
Alkalinity	NM	NM	ppb	137,000 ±33,656	--	--	--
Aluminum (f)	19.0/19.0	36.9/<57	ppb	<200			
Americium-241	-0.0371/0.221	NM	pCi/L	--		1.2 (1/25 DCG)	
Antimony (f)	19.5/19.5	30.5/<46	ppb	--			
Arsenic (f)	5.3/3.0	2.3/4.2	ppb	<5			
Barium (f)	36.4/36.2	53.4/50	ppb	41 ±20		1,000 (WWQS)	
Beryllium (f)	0.67/0.33	0.2/<1	ppb	<5			
Cadmium (f)	1.8/1.8	2.2/<4	ppb	<10		10 (WWQS)	
Calcium (f)	52,100/51,500	44,100/41,000	ppb	38,352 ±11,023		--	--
Carbon tetrachloride	79/80	50/38	ppb	--		5 (MCL)[f]	
Cesium-137	-3.72/-8.08	NM	pCi/L	--	--	120 (1/25 DCG)	--
Chloride	10,000[f] (880)/9,800	13,600[f] 9,400/9,800	ppb	5,302 ±1,774 (low) to 23,296 ±2,463 (high)		250,000 (WWQS)	
Chloroform	<5/<5	7/5.5	ppb	--	Y	7 (WWQS)	
Chromium, total (f)	<10[f] 2.9/2.8	16.7[f] 3.0/<5	ppb	<30		50 (WWQS)	
Chromium, hexavalent (f)	<10[f] --	16.7[f] --	ppb	--	--	--	--
Cobalt (f)	2.9/2.9	3.2/<10	ppb	--	--	--	--
Cobalt-60	-0.988/0.767	NM	pCi/L	--	--	200 (1/25 DCG)	

Table 4-1. Constituents Analyzed - Groundwater Monitoring Data for Well 299-W11-37. (4 sheets)

Constituent	Result[a]	Result[b]	Units	Background[c]	EB	Limit[d]	EL
Copper (f)	4.5/4.5	14.0/<5	ppb	<30		1,000 (WWQS)	
DO	6.36[f]	6.64[f]	mg/L	--	--	--	--
Fluoride	100/470	490/560	ppb	437 ±131		4,000 (WWQS)	
Gross alpha	1.68/1.79	NM	pCi/L	2.5 ±1.5		15 (WWQS)	
Gross beta	23.0/29.9	NM	pCi/L	7.1 ±2.6		50 (WWQS)	
Iron, total (f)	30[f] 145/99.9	11.7[f] 20.5/<10	ppb	<50 (low) to 494 ±118 (high)		300 (WWQS)	
Iron, ferrous (f)	<10[f] --	<10[f] --	ppb	--	--	--	--
Lead (f)	0.8/0.8	0.9/<2	ppb	<5		50 (WWQS)	
Magnesium (f)	15,900/15,800	14,700/13,000	ppb	11,190 ±2,578		--	--
Manganese (f)	159/156	134/130	ppb	<20 (low) to 118 ±17 (high)		50 (WWQS)	
Mercury (f)	0.11/0.10	0.1/0.2	ppb	<0.1		2 (WWQS)	
Nickel (f)	4.9/4.9	13.3/<12	ppb	<30	?		
Nitrate	4,600[f] (170)/4700	4,220[f] 4,100/3,700	ppb	5,170 ±3,576		10,000 (WWQS)	
Nitrite	13.5[f] --	54.3[f] --	ppb	--	--	--	--
ORP	+181.9[f]	+200.1[f]	mV	--	--	--	--
pH	7.78[f]	7.88[f]	---	7.57 ±0.29		6.5 to 8.5 (WWQS)	
Phosphate	117.5[f] <1000/<1000	153.3[f] <1000,(<43)	ppb	<1,000			

Table 4-1. Constituents Analyzed - Groundwater Monitoring Data for Well 299-W11-37. (4 sheets)

Constituent	Result[a]	Result[b]	Units	Background[c]	EB	Limit[d]	EL
Plutonium-238	-0.253/-0.334	NM	pCi/L	--	-- -	1.6 (1/25 DCG)	
Plutonium-239/240	0.01/0.23	NM	pCi/L	--	--	1.2 (1/25 DCG)	
Potassium (f)	4,940/4,870	4,090/4,100	ppb	4,993 ±1,453		--	--
Ruthenium-106	--	--	pCi/L	--	--	240 (1/25 DCG)	--
Selenium (f)	0.73/0.7	0.7/<3	ppb	<5		10 (WWQS)	
Silver (f)	4.2/4.2	3.0/<7	ppb	<10		50 (WWQS)	
Sodium (f)	14,100/14,100	14,700/13,000	ppb	15,774 ±6,784		--	--
Specific conductance	591[f]	356[f]	μmhos /cm	344 ±83		--	--
Strontium (f,nr)	--	--	ppb	164 ±37		--	--
Strontium-90	0.065/0.207	NM	pCi/L	--	--	8 (WWQS)	
Sulfate	29,000[f] (9,260)/24,700	26,670[f] 23,900/23,000	ppb	30,605 ±22,611		250,000 (WWQS)	
Sulfide	ND[f] --	ND[f] --	ppb	--	--	--	--
Technetium-99	103/114	NM	pCi/L	--	--	4,000 (1/25 DCG)	
Temperature	23.5[f]	18.7[f]	°C	--	--	--	--
Thallium (f)	1.0/1.0	1.4/<4	ppb	--	--	--	--
Tritium	488/484	337/380	pCi/L	400[f]		20,000 (WWQS)	
Uranium (nr)	--	--	ppb	1.7 ±1.2		--	--

Table 4-1. Constituents Analyzed - Groundwater Monitoring Data for Well 299-W11-37. (4 sheets)

Constituent	Result[a]	Result[b]	Units	Background[c]	EB	Limit[d]	EL
Uranium-234	1.36/1.65	NM	pCi/L	--	--	20 (1/25 DCG)	
Uranium-235	0.037/0.037	NM	pCi/L	--	--	24 (1/25 DCG)	
Uranium-238	2.08/1.67	NM	pCi/L	--	--	24 (1/25 DCG)	
Vanadium (f)	44.7/38.4	21.9/<14	ppb	9 ±4		--	--
Zinc (f)	13.9/43.5	6.8/<10	ppb	<50 (low) to 247 ±165 (high)		5,000 (WWQS)	

[a]Results from samples taken on 8-27-94 at a depth of 82.1 m (269.34 ft). Samples are listed as original sample set (HEIS Sample No. B09TJ0)/duplicate sample set (HEIS Sample No. B0C8D9).

[b]Results from samples taken on 9-16-94 at a depth of 81.9 m (268.54 ft). Samples are listed as original sample set (HEIS Sample No. B09W15)/split sample set (HEIS Sample No. B09W16).

[c]Johnson, V. G., 1993, *Westinghouse Hanford Company Operational Groundwater Status Report*, WHC-EP-0595, Westinghouse Hanford Company, Richland, Washington.

[d]WWQS = Washington Water Quality Standards, Washington Administrative Code 173-200; 1/25 DCG = 1/25 Derived Concentration Guidelines, *Environmental Compliance*, WHC-CM-7-5, Westinghouse Hanford Company, Richland, Washington (Section 8.0).

[e]Calculated value for tritium, based on results from sample blanks and samples taken as part of the RCRA groundwater monitoring program.

[f]Field analytical measurement.

DO = Dissolved oxygen.
EB = Exceed background.
EL = Exceed limit.
f = Filtered.
ND = Not detectable.
NM = Not measured.
nr = Nonradiological.
ORP = Oxidation-Reduction Potential.
? = Background value below detection limit, unable to determine.

value considered least accurate is shown in parentheses. If no parentheses are used, then both values are considered valid. Complete lists of values measured for the sample sets are given in Appendix A1.

The constituents that were detected at levels above analytical detection limits were compared to background values for the unconfined aquifer on the Hanford Site (DOE-RL 1992). Of the constituents detected in the groundwater, 14 had concentrations greater than those found in background wells (Johnson 1993): arsenic, barium, calcium, carbon tetrachloride, chloride, chloroform, fluoride, gross beta, manganese, mercury, pH, specific conductance (conductivity), tritium, and vanadium. Of these 14 constituents, only 2 exceeded a limit (either state or Hanford Site):

- Carbon tetrachloride concentrations were 79 and 80 ppb for the first set of samples, and 50 and 38 ppb for the second set of samples. The Washington State water quality standard (WWQS) (WAC 1990) for carbon tetrachloride is 0.3 ppb.

- Manganese concentrations were 159 and 156 ppb for the first set of samples, and 134 and 130 ppb for the second set of samples. The WWQS (WAC 1990) for manganese is 50 ppb.

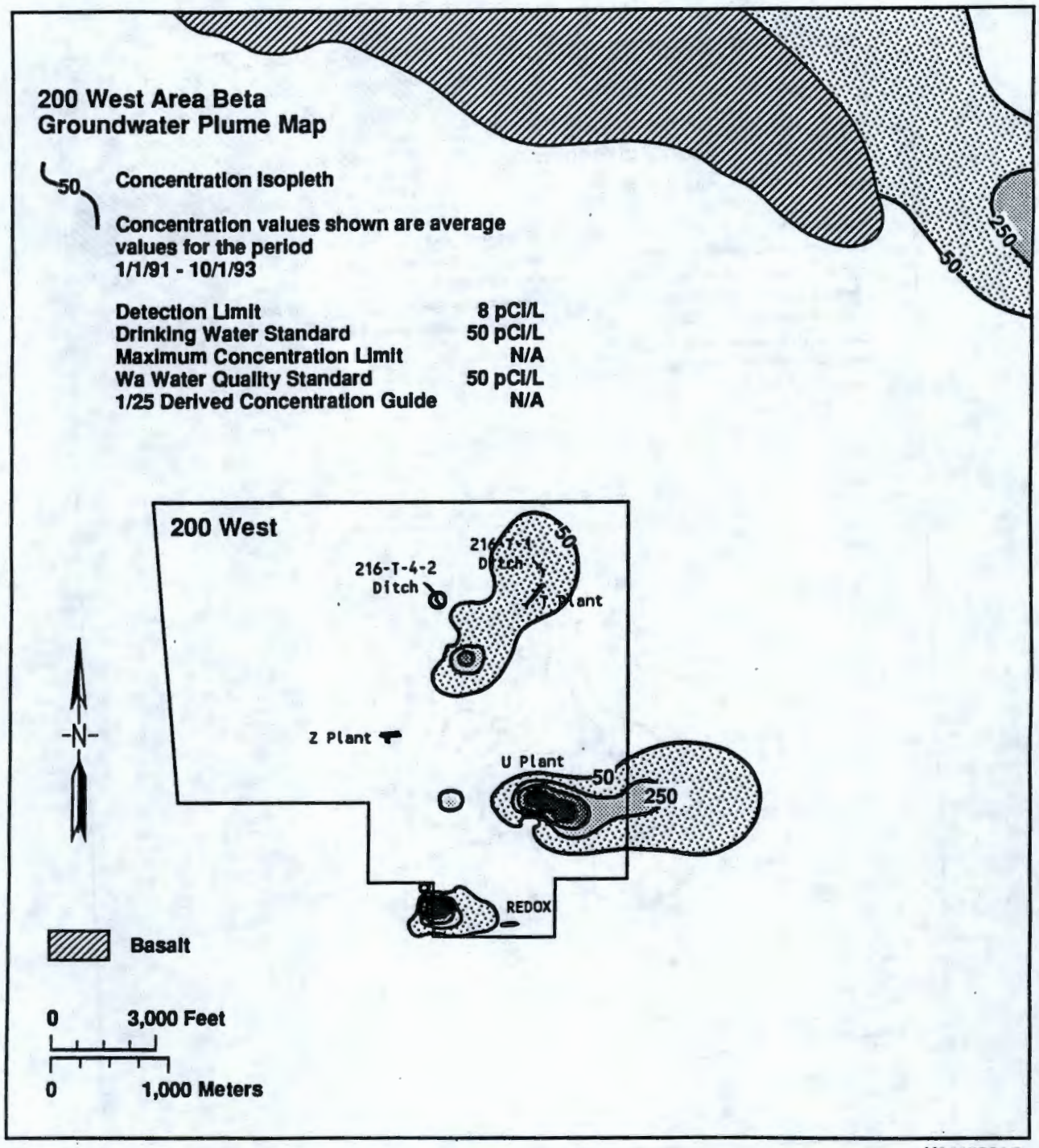
The following constituents were present in elevated concentrations when compared to what could normally be expected to be present in the unconfined aquifer, but did not exceed any regulatory limits: nitrate, sulfate, technetium-99, and uranium.

Section 4.3.2 will discuss groundwater quality in the 216-T-1 Ditch area, including the conditions immediately beneath the ditch and how the ditch effluent may be influencing concentrations, and upgradient and downgradient conditions and influences.

4.3.2 Upgradient Groundwater Quality

4.3.2.1 200 West Area Groundwater Contaminant Plumes. Examination of contaminant plume maps (Figures 4-8 through 4-13) and comparison to regulatory limits indicate that six major contaminant plumes may be present beneath the 216-T-1 Ditch (Connelly et al. 1992; Ford 1993): gross beta, carbon tetrachloride, chloroform, nitrate, technetium-99, and tritium. The apparent groundwater flow direction beneath the ditch is from the southwest to the northeast. The closest well immediately upgradient (299-W11-14) is approximately 300 m (984.3 ft) to the southwest. In addition, there are other wells just southwest, south, and southeast of the ditch (299-W11-7, 299-W11-3, and 299-W11-10) about 600 m (1,968.5 ft), 400 m (1,312.3 ft), and 550 m (1,804.5 ft) away, respectively. The nearest well downgradient of the ditch (299-W12-1), other than well 299-W11-37 located at the ditch, is approximately

Figure 4-8. Gross Beta Plume Map for the 200 West Area.



H9412004.2

Figure 4-9. Carbon Tetrachloride Plume Map for the 200 West Area.

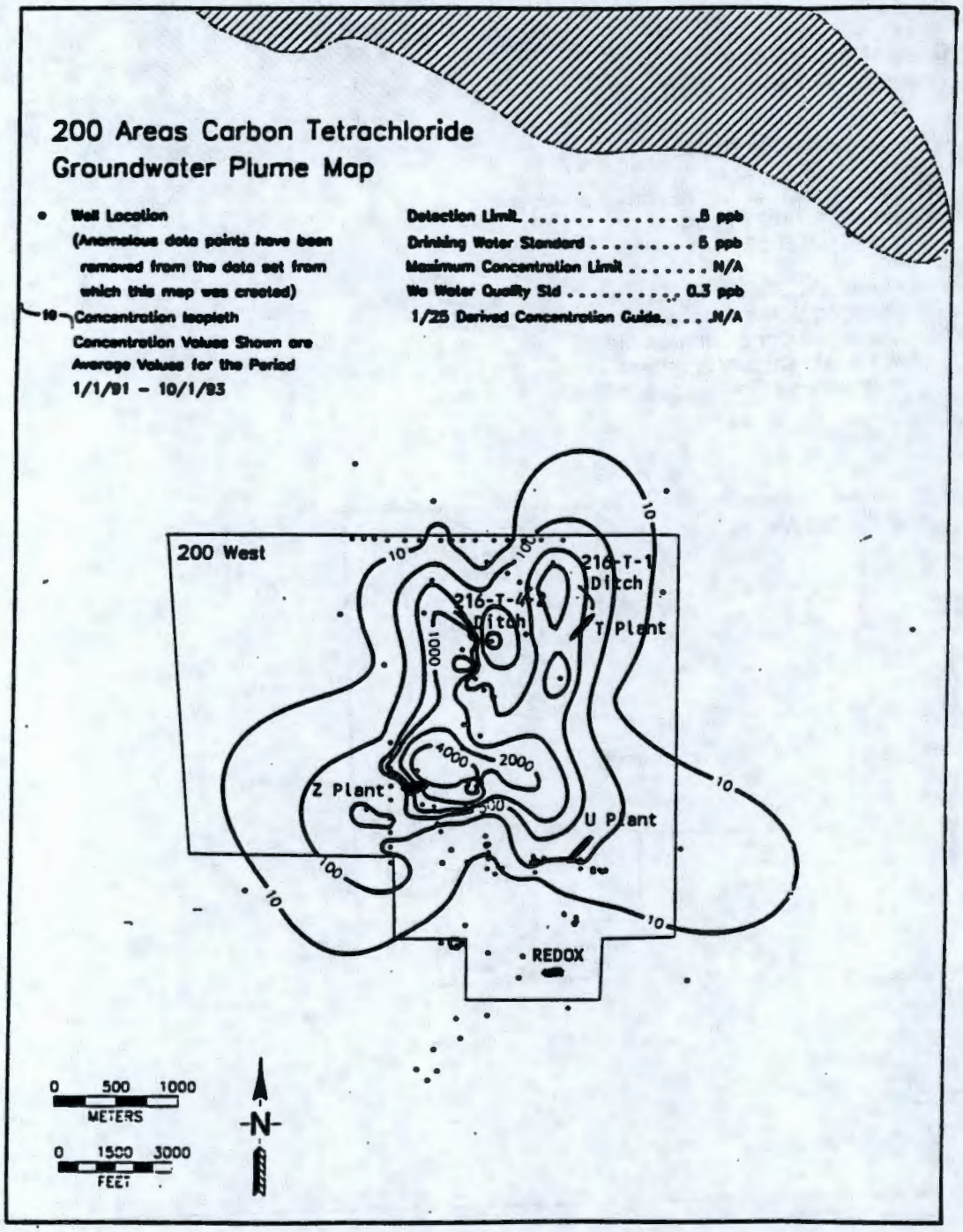


Figure 4-10. Chloroform Plume Map for the 200 West Area.

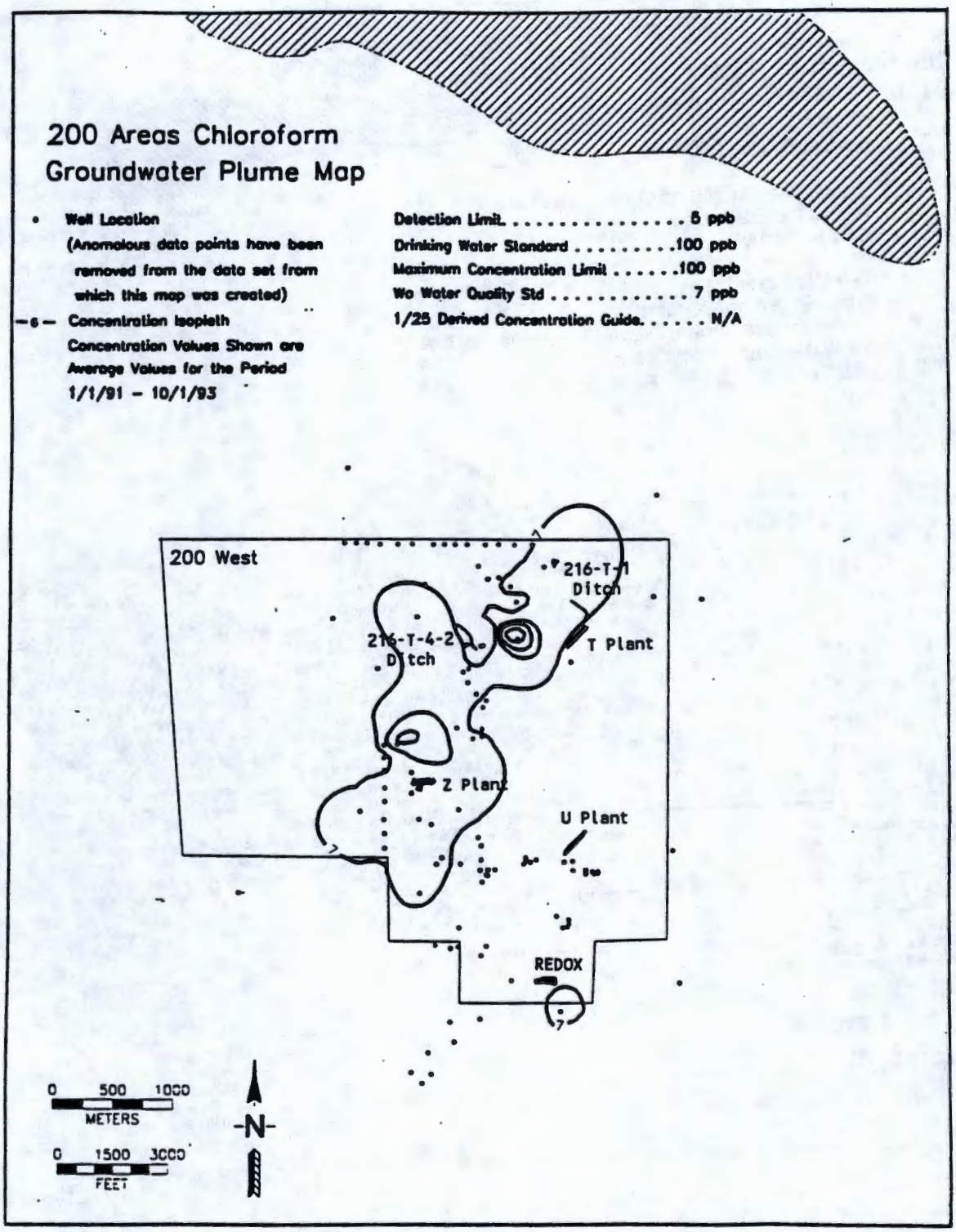
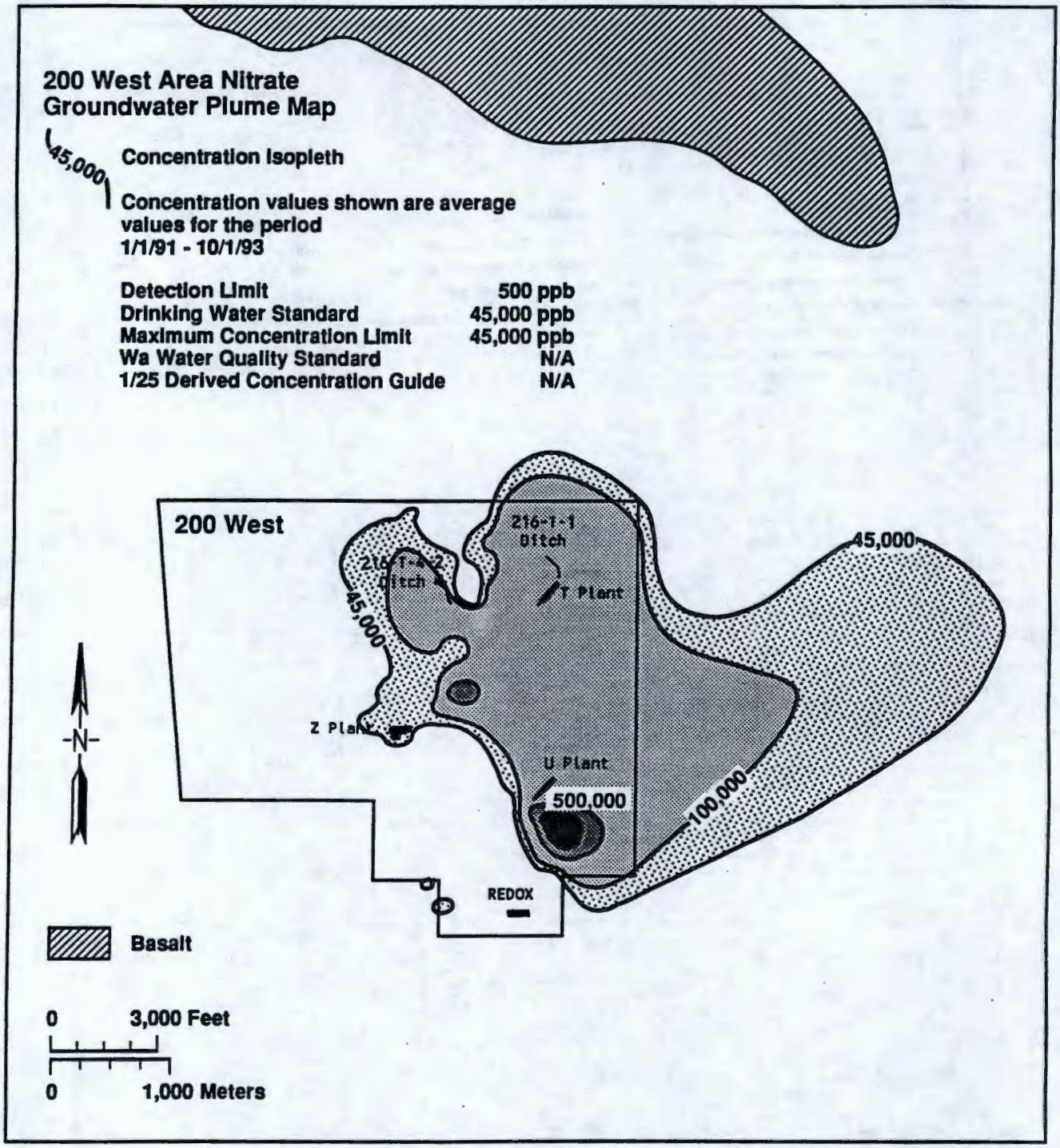
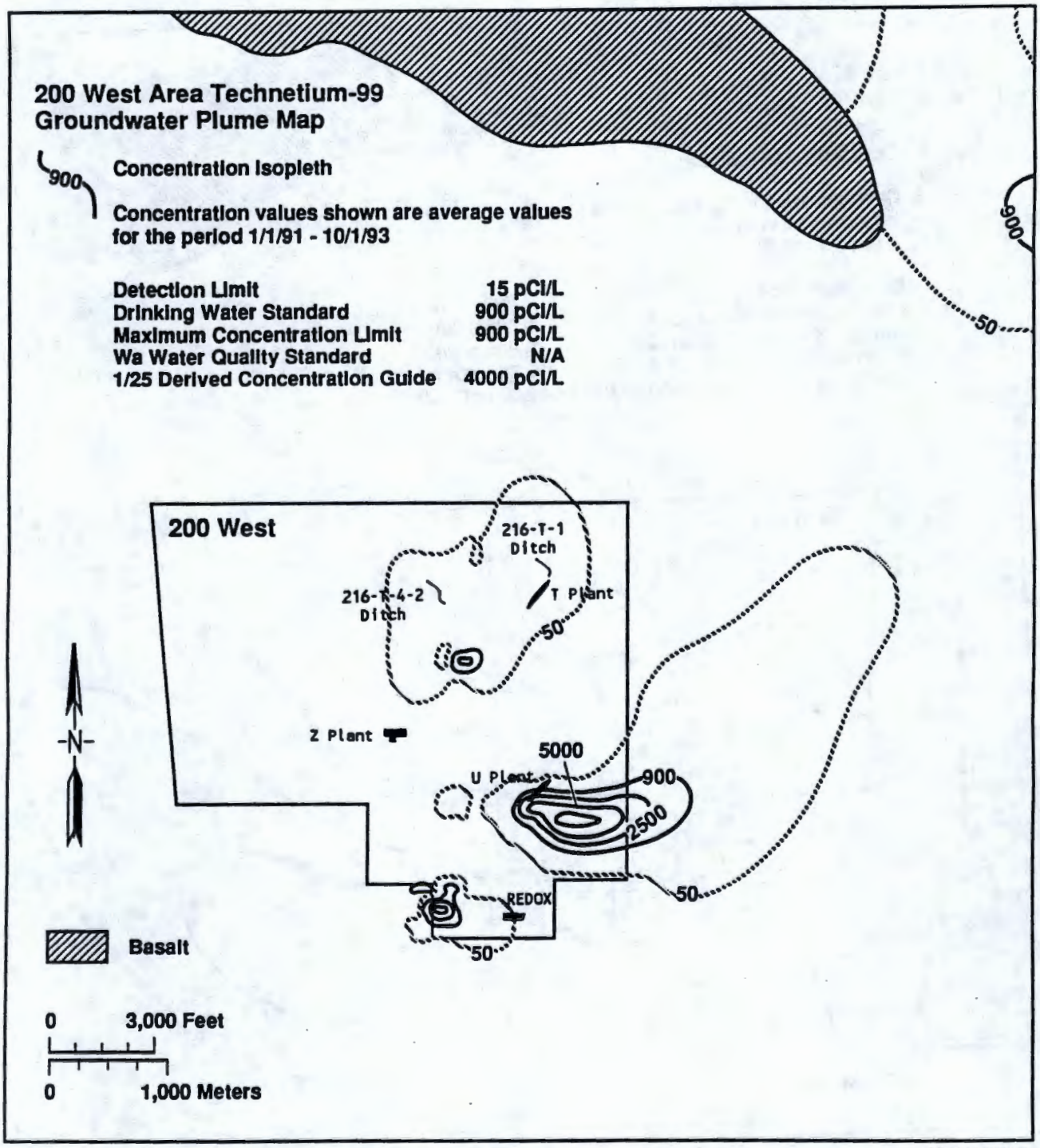


Figure 4-11. Nitrate Plume Map for the 200 West Area.



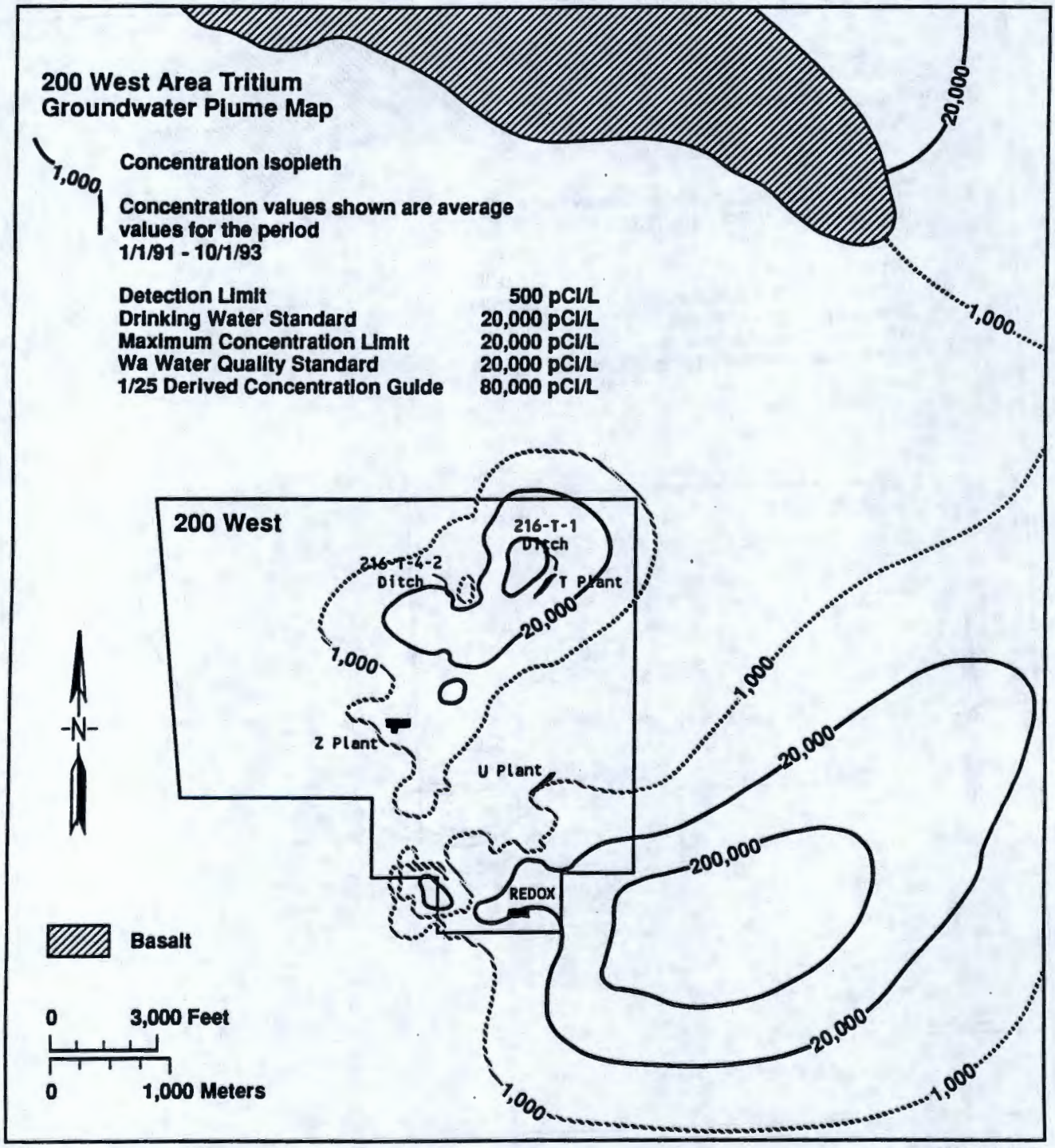
H9412004.4

Figure 4-12. Technetium-99 Plume Map for the 200 West Area.



H9412004.6

Figure 4-13. Tritium Plume Map for the 200 West Area.



2,000 m (6,561.7 ft) to the east/northeast. The concentrations of the seven constituents forming plumes beneath the ditch site are given below. Section 4.3.2.2 provides more detail on the probable sources.

- Gross beta plumes are detected at several places in the 200 West Area (see Figure 4-8). The largest and most concentrated plume is in the southeastern portion of the 200 West Area. Another major plume is located in the northeastern portion of the 200 West Area, and a tongue extends to the northwest through the area of the ditch. Concentrations downgradient are as high as 250 pCi/L, but near the ditch the concentration is greater than 50 but less than 250 pCi/L.

- A carbon tetrachloride plume covers the majority of the 200 West Area (see Figure 4-9). The predominant source of this plume is several disposal sites near Z Plant (located in the west-central 200 West Area). Concentrations near the 216-T-1 Ditch could be as high as 100 ppb. However, groundwater monitoring results from well 299-W11-37 (head-end of the 216-T-12 Ditch) are in the 40 to 80 ppb range.

- The chloroform plume map (see Figure 4-10) indicates major sources of chloroform in the west-central part of the 200 West Area. This plume is related to the carbon tetrachloride plume, in that chloroform is a potential degradation product of this constituent. The plume extends north and northeast, and underlies the 216-T-1 Ditch site. Concentrations above the detection limit (5 ppb) and sometimes exceeding the WWQS (7 ppb) have been detected in the well at the ditch (299-W11-37) and in other wells in the vicinity.

- Nitrate is found in highly variable concentrations in a major plume throughout most of the 200 West Area (see Figure 4-11), indicating many possible sources. The plume covers most of the eastern half of the 200 West Area and underlies the 216-T-1 Ditch. Concentrations in the vicinity of the ditch could be as high 45,000 to 100,000 ppb. However, current sample results from well 299-W11-37 (head-end of the 216-T-1 Ditch) are in the 2,100 to 2,200 ppb range.

- Several technetium-99 plumes exist in the 200 West Area (see Figure 4-12), indicating several sources of the constituent. One plume covers most of the north-central to northeast part of the 200 West Area. Concentrations of Technetium-99 at the 216-T-1 Ditch site could be over 50 pCi/L. Actual sample results have ranged from 103 to 114 pCi/L.

- Two large tritium plumes extend out to the northeast and east of the 200 West Area (see Figure 4-13). The smaller of the two plumes underlies the 216-T-1 Ditch area. The highest concentration in the this plume is to the northwest of the ditch. In the vicinity of the ditch, the concentrations could be as high as 20,000 pCi/L. In well 299-W11-37 the concentration of tritium is 337 to 438 pCi/L.

4.3.2.2 Upgradient Groundwater Quality and Sources of Contaminants. Groundwater chemistry data from one nearby upgradient well (299-W11-14) and several other wells located to the west, southwest, and south of the 216-T-1 Ditch site were examined to determine the overall quality of groundwater upgradient of the ditch area. The Hanford Environmental Information System (HEIS) database was queried for analytical results from the 1980s to February 1995 to give an indication of historical as well ascurrent groundwater conditions. Appendix A2 lists the groundwater monitoring results for well 299-W11-14. Appendix A3 lists results of the groundwater analyses data for the other selected upgradient and downgradient groundwater monitoring wells from the 1980s through February 1995. Table 4-2 gives the potential contamination sources and accompanying wells that were examined. Figure 4-14 shows the well and disposal site locations.

The list of parameters used to determine groundwater conditions in upgradient wells was arrived at using data from the 216-T-1 Ditch groundwater monitoring well 299-W11-37. Constituents of interest, known contaminants present in plumes in the area, groundwater quality indicators, and other related chemical parameters were examined and the following parameters were chosen for plotting:

- Radiological parameters - uranium/gross alpha and technetium-99/gross beta
- Organics - carbon tetrachloride and chloroform
- Anions - nitrate and sulfate
- Metals - aluminum and iron.

Plots of effluent chemistry (for the 216-T-1 Ditch waste stream), groundwater chemistry (for upgradient and down gradient wells and associated Hanford Site background average values for the unconfined aquifer [Johnson 1993]), maximum contamination levels (MCL) (40 CFR 141), or 1/25 derived concentration guide (DCG) (WHC-CM-7-5) were prepared for several key parameters. These plots are shown and discussed in Appendix B. The following is a short summary of the results:

- Uranium/gross alpha and technetium-99/gross beta concentrations are elevated in upgradient groundwater, specifically in well 299-W11-14. Well 299-11-37 (216-T-1 Ditch head-end) also has slightly elevated concentrations of these parameters. However, 216-T-1 Ditch effluent is low in concentration for these parameters, indicating that sources upgradient of the 216-T-1 Ditch are responsible for these elevated concentrations (see Figure 4-14).

Table 4-2. Potential Contamination Sources and Nearby Groundwater Monitoring Wells.

Potential contamination source	Nearby well
216-T-3	299-W11-7
216-T-9,-10,-11	299-W11-14
216-T-12	299-W11-7 and 299-W11-14
Other upgradient wells	299-W11-3 and 299-W11-10

- Carbon tetrachloride and chloroform concentrations are elevated in upgradient groundwater. Well 299-11-37 (216-T-1 Ditch head-end) also has slightly elevated concentrations of these parameters. The 216-T-1 Ditch effluent does not have any detectable concentration of these parameters. It is highly likely that the Z Plant Complex (located in the west-central 200 West Area) is the source of these contaminants. Large plumes of both constituents are present in the 200 West Area and in the vicinity of the 216-T-1 Ditch (see Figure 4-14).

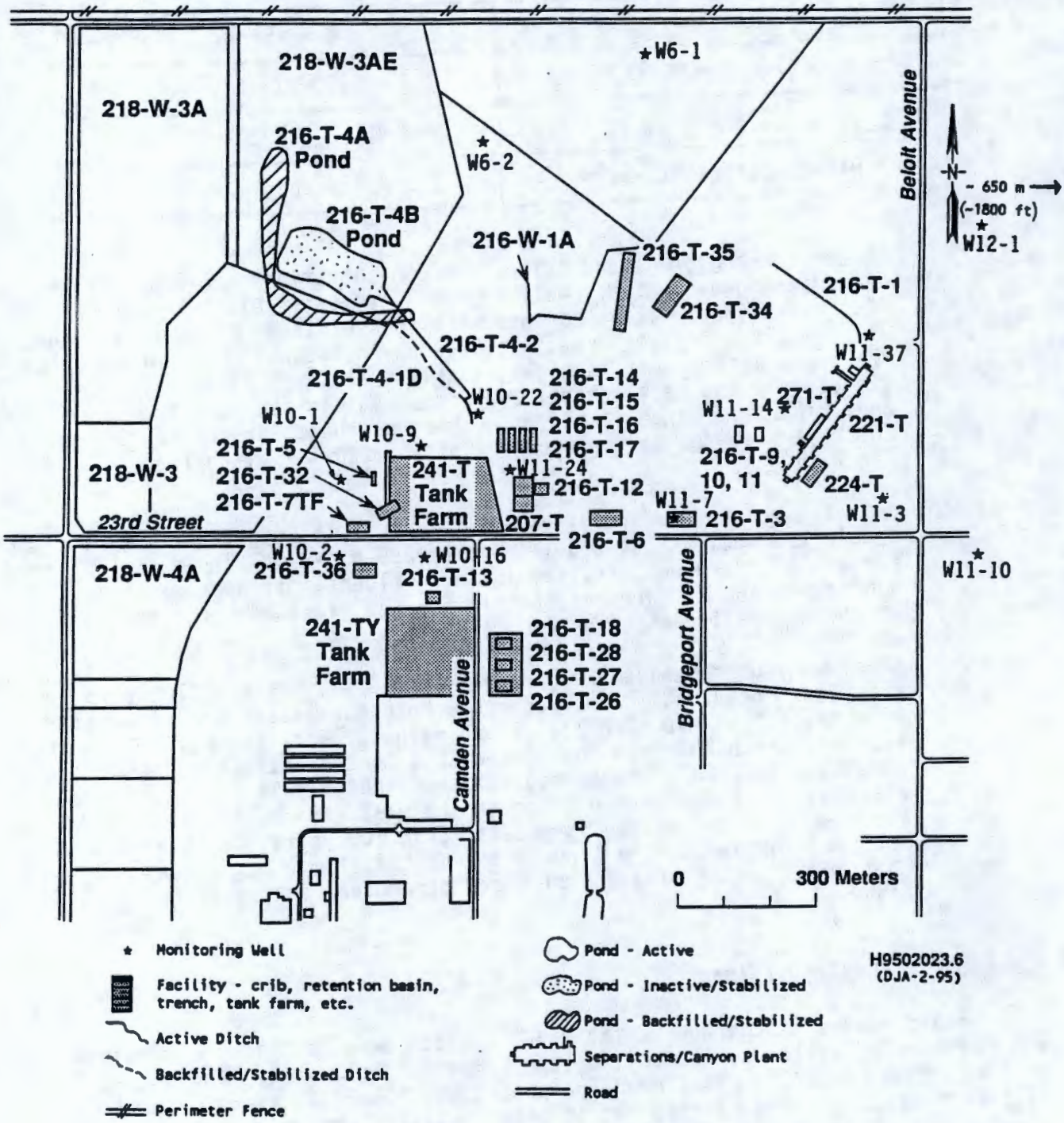
- Nitrate and sulfate are elevated in most of the upgradient wells, and in the well at the 216-T-1 Ditch (299-W11-37). These constituents are not elevated in the effluent. It appears that upgradient sources are responsible for the elevated concentrations of these constituents (see Figure 4-14).

- Aluminum and iron have been present in 216-T-1 Ditch effluent in elevated concentrations. Presently, both parameters are elevated with respect to expected background values. Well 299-W11-37 (216-T-1 ditch head-end) has detectable concentrations of both constituents. Only one upgradient well (299-W11-7) has shown elevated concentrations of iron in the past. Since travel time to the water table for iron is greater than 100 years, it is probably not contributing to the groundwater at this time, but it may contribute to the presence of these parameters in the future (see Figure 4-14).

4.4 SOIL COLUMN CONTAMINANTS

Liquid wastes discharged to the 216-T-1 Ditch have contributed chemical and radioactive wastes to the soil column. These liquid wastes included effluent from the 221-T Plant Head-End processes. Over the years several different missions were carried out in this facility, including the original separations plant for the bismuth phosphate process, containment system testing, the vacuum fractionator process, liquid metal reactor safety tests, and the light-water reactor safety tests and fusion program.

Figure 4-14. Location of Nearby Facilities, Past-Practice Disposal Sites, and Selected Monitoring Wells in the Vicinity of the 216-T-1 Ditch.



Some of the chemicals that are known to have been released to the 216-T-1 Ditch are reacted sodium and lithium,[1] sodium iodide, other alkali metals, cesium, manganese, lithium sulfate, iodine, and hydrogen. The following radionuclides have been released to the ditch: cesium-137, strontium-90, plutonium, gross alpha, and gross beta (WHC 1991).

4.4.1 Test Pit Excavations

Several sediment samples were taken from near-surface (0 to 3 m [0 to 10 ft]) test pits within the 216-T-1 Ditch during June 1994. Three test pits were excavated in the ditch: (1) the first pit was located at the head-end of the ditch, within 4.6 to 7.6 m (15 to 25 ft) of the effluent outfall pipe and as close to the bottom of the ditch as the equipment could reach; (2) the second pit was located approximately 30 m (98 ft) down the ditch from the first pit, and (3) the third pit was located 49.4 m (162 ft) down the ditch from the second pit.

Samples were collected at four depth intervals and analyses performed on those samples as follows (Table 4-3):

- 0 to 0.6 m (0 to 2 ft) Appendix IX constituents
- 0.6 to 1.2 m (2 to 4 ft) Radionuclides
- 1.2 to 1.8 m (4 to 6 ft) Appendix IX constituents
- 3 m (10 ft) Appendix IX constituents.

Appendix IX constituents include: inductively coupled plasma (ICP) and atomic absorption (AA) metals, volatile organics (VOA), semi-volatile organics (SVOA), herbicides, organophosphate pesticides, and polychlorinated biphenyls (PCB) and pesticides. The results for all the VOA, SVOA, herbicides, pesticides, and PCBs were below the detection limit for each analyte. Metal results varied within the test pits, so all the depth interval results were averaged for inclusion in Table 4-3. Since only one depth interval was sampled for radionuclides, those results were reported as is.

4.4.1.1 Nonradioactive Constituents. Only two constituents exceeded the given background values: lead and zinc. Lead values ranged from 12.5 to 38.6 mg/kg. Background for lead on the Hanford Site is 11.88 mg/kg. Lead concentrations are highest in the middle test pit, which suggests that at one time there was enough effluent discharged to the 216-T-1 Ditch to transport materials farther down the ditch than under current conditions. Concentrations are lowest at the head-end of the ditch, and this may be because inflow of relatively "clean" recent effluent has flushed the soil column of residual contaminants. Zinc results ranged from 34.7 to 165 mg/kg. Background values are 71.8 mg/kg for the Hanford site. Zinc concentrations within the ditch are similar to lead, with the highest concentrations in the middle test pit and the lowest concentrations present at the head-end. This is most likely caused by the same process described above.

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[1]Liquid sodium and lithium were "reacted" and dissolved in water before disposal (Nickels et al. 1991).

Table 4-3. Constituents Analyzed - Test Pit Sampling Data for 216-T-1 Ditch Test Pits. (2 sheets)

Constituent	Pit No. 1[a]	Pit No. 2[b]	Pit No. 3[c]	Units	90PUCL[d]	EX	Background[e]	EX
Aluminum	5,293	3,935	3,833	mg/Kg	13,400	N	82,000 ppm	
Americium-241	0.00	0.01	0.00	pCi/g	---	--	---	--
Antimony	2.7 U	3.4 B	3.4	mg/Kg	---	--	0.2 ppm	
Arsenic	2.0	1.8	1.3	mg/Kg	7.27	N	1.8 ppm	
Barium	51.8	75.0	57.6	mg/Kg	148	N	425 ppm	
Beryllium	0.44 B	0.41 B	0.32 B	mg/Kg	1.58	N	2.8 ppm	
Cadmium	0.20 B	0.82 B	0.55 B	mg/Kg	---	--	0.2 ppm	
Calcium	9,953	7,165	4,427	mg/Kg	19,500	N	41,500 ppm	
Cesium-137	4.81	102	36.2	pCi/g	---	--	---	--
Chromium	5.7	4.0	5.8	mg/Kg	22.2	N	100 ppm	
Cobalt	6.5	8.1	5.6	mg/Kg	17.5	N	25 ppm	
Cobalt-60	0.00	0.01	-0.00	pCi/g	---	--	---	--
Copper	14.3	22.9	19.3	mg/Kg	24.5	N	55 ppm	
Iron	14,533	16,475	11,957	mg/Kg	35,150	N	56,300 ppm	
Lead	12.5	38.6	12.7	mg/Kg	11.88	Y	12.5 ppm	
Magnesium	3,803	3,705	2,797	mg/Kg	7760	N	23,300 ppm	
Manganese	245	249	172	mg/Kg	549	N	950 ppm	
Nickel	9.4	8.4	8.4	mg/Kg	21.6	N	75 ppm	
Plutonium-238	0.00	0.00	0.00	pCi/g	---	--	---	--
Plutonium-239/240	0.05	0.08	0.00	pCi/g	---	--	---	--
Potassium	1.002	660	620	mg/Kg	22,550	N	20,900 ppm	
Radium-224	0.62	0.58	0.72	pCi/g	---	--	---	--
Radium-226	0.48	0.41	0.52	pCi/g	---	--	---	--

Table 4-3. Constituents Analyzed - Test Pit Sampling Data for 216-T-1 Ditch Test Pits. (2 sheets)

Constituent	Pit No. 1[a]	Pit No. 2[b]	Pit No. 3[c]	Units	90PUCL[d]	EX	Background[e]	EX
Radium-228	0.69	---	0.65	pCi/g	---	--	---	--
Selenium	0.19 U	0.19 U	0.19 U	mg/Kg	---	--	0.05 ppm	
Silver	0.40 U	0.40 U	0.40 U	mg/Kg	1.1	N	0.07 ppm	
Sodium	336	197	135	mg/Kg	721-887	N	23,600 ppm	
Strontium-90	0.19	0.28	0.10	pCi/g	---	--	---	--
Technetium-99	-0.12	0.02	0.27	pCi/g	---	--	---	--
Thallium	0.16 U	0.16 U	0.16 U	mg/Kg	---	--	0.45 ppm	
Uranium-234	0.87	0.86	0.57	pCi/g	---	--	---	--
Uranium-235	0.07	0.04	0.03	pCi/g	---	--	---	--
Uranium-238	0.81	0.80	0.76	pCi/g	---	--	---	--
Vanadium	18.6	25.0	16.4	mg/Kg	94.9	N	135 ppm	
Zinc	34.7	165	52.8	mg/Kg	71.8	Y(1)	70 ppm	
Gross alpha	6.57	6.51	10.7	pCi/g	---	--	---	--
Gross beta	3.33	133	50.9	pCi/g	---	--	---	--

[a]Results from test pit No. 1, HEIS Sample Numbers: B09GJ8, B09GK4, B09GL0, and B09GK1.

[b]Results from test pit No. 2, HEIS Sample Numbers: B09GJ9/B09GY5(Duplicate), B09GK5, B09GK3, and B09GK2.

[c]Results from test pit No. 3, HEIS Sample Numbers: B09GY6, B09GK0, B09GZ1, and B09GK6.

[d]90th Percentile Upper Confidence Limit; DOE-RL 1994, *Hanford Environmental Information System (HEIS): Volume 2 Operator's Guide*, DOE/RL-93-24-2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[e]Bowen, H. J. M., "Trace Elements in Biochemistry", Academic Press, Inc., New York, NY, 241 pp.

EX = Exceed 90th Percentile UCL or Background.

4.4.1.2 Radioactive Constituents. Most of the reported radionuclide results were near detection limits except for cesium-137, gross beta, and the naturally occurring isotopes of uranium and radium. Concentrations of the latter were consistent with natural background levels for uranium-238, radium-226, and thorium-232 (e.g., 0.7 to 1.1 pCi/g) as reported for Columbia River sediment collected from behind Priest Rapids Dam (located just upstream from the northern boundary of the Hanford Site) and within the Hanford Reach (Peterson and Johnson 1992). Cesium-137, a beta-gamma emitter, was reported at levels of 102 and 36 pCi/g in Test Pits Number 2 and 3, respectively, as compared to a Priest Rapids Dam mean value (global fallout) of 0.3 $\pm$0.02 (n = 4) (Peterson and Johnson 1992). The much higher concentrations of cesium-137 than strontium-90 (<0.3 pCi/g) in the pit samples may reflect the greater mobility of strontium-90; i.e., downward migration due to continued discharge of relatively uncontaminated wastewater.

The gross alpha results (Table 8) can be accounted for with the naturally occurring alpha emitters; uranium/thorium decay series radionuclides that include the alpha emitting isotopes of radium, as well as other "daughters" or decay products.

4.4.2 Split-Spoon Samples

Several split-spoon samples were taken during drilling of monitoring well 299-W11-37 at the 216-T-1 Ditch. These samples were collected from specific intervals to aid in determining sediment properties, soil column characteristics, and geologic parameters. In addition, samples were submitted for chemical analysis. Table 4-4 lists the sample intervals, numbers, and corresponding analytical parameters.

Samples were collected at 11 depth intervals and analyzed for Appendix IX, ICP/AA metals, and radionuclides or just ICP/AA metals and radionuclides. Results of these analyses are summarized in Table 4-5.

4.4.2.1 Nonradioactive Constituents. Only two constituents exceeded the given background values and only in one depth interval each; those constituents are calcium and chromium. Calcium exceeds the background value of 19,500 mg/kg in the 29.3 to 29.9 m (96 to 98 ft) interval, where it had a concentration of 23,400 mg/kg. The predicted depth of penetration of calcium for this site (Section 5.2.3) was approximately 26 m (85.3 ft) deep in the soil column. Chromium exceeds the background value of 22.2 mg/kg in the 74.4 to 74.7 m (244 to 245 ft) interval, where it had a concentration of 42.5 mg/kg. The predicted travel time for chromium (hexavalent) at this site suggests chromium should have broken through to groundwater within a year (Section 5.2.3). It is uncertain what mechanisms are controlling the movement of chromium through the soil column, as there are a couple of depths where concentrations appear to be somewhat higher than expected, although they do not exceed the background value of 22.2 mg/kg.

4.4.2.2 Radioactive Constituents. Most of the reported results for the radionuclides of interest in the split spoon samples (Table 10) were either equivalent to natural background levels (e.g., uranium and thorium decay series radionuclides, gross alpha and gross beta; see Section 4.4.1.2 discussion), or were at or below detection limits. The few reported

Table 4-4. Split-Spoon Sediment Samples from Well 299-W11-37 at the 216-T-1 Ditch.

Sample number(s)	Depth sampled (ft)	Types of analyses
B0C890 (N1018)*	20 - 22	ICP & AA Metals/Radionuclides
B0C891 (N1019)*	30.5 - 32.5	ICP & AA Metals/Radionuclides
B0C892 (N1052)*	49.5 - 51.5	ICP & AA Metals/Radionuclides
B0C893 (N1053)*	71.5 - 73.5	ICP & AA Metals/Radionuclides
B0C894 (N1054)*	96 - 98	ICP & AA Metals/Radionuclides/ Appendix IX
B0C895 (N____)*	126.5 - 128.5	ICP & AA Metals/Radionuclides/ Appendix IX
B0C896 (N____)*	149.5 - 151.5	ICP & AA Metals/Radionuclides
B0C897 (N____)*	153 - 155	ICP & AA Metals/Radionuclides
B0C898 (N____)*	244 - 245	ICP & AA Metals/Radionuclides
B0C899 (N____)*	263 - 265	ICP & AA Metals/Radionuclides/ Appendix IX
B0C8B0 (N____)**	290.5 - 292.5	ICP & AA Metals/Radionuclides

Note: For "N" numbers left blank in table, numbers are missing from hard copy data sheets, and were not available for inclusion in table before document issuance.

*Vadose zone samples.

**Groundwater zone samples.

Table 4-5. Constituents Analyzed - Sediment Sampling Data for Well 299-W11-37 Split-Spoon Samples. (3 sheets)

Constituent	Result[a]	Result[b]	Result[c]	Result[d]	Result[e]	Result[f]	Result[g]	Result[h]	Result[i]	Result[j]	Result[k]	Units
Aluminum	5,490	4,930	2,590	3,830	5,280	4,180	5,140	5,900	4,090	5,320	1,840	mg/Kg
Americium-241	0.005	0.003	0.004	0.003	0.009	0.016	0.004	0.017	0.01	0.118	0.01	pCi/g
Antimony	3.0 U	3.0 U	3.2 B	3.3 U	3.2 U	3.1 U	3.2 U	<9.5	3.3 U	3.3 U	4.0 B	mg/Kg
Arsenic	1.9	1.7	1.5	0.93	2.5	1.8	1.3	2.0	0.34	0.69	0.40	mg/Kg
Barium	57.1	70.3	34.6	56.9	69.1	48.6	80.7	78	46.6	57.4	32.2	mg/Kg
Beryllium	0.42 B	0.39 B	0.24 B	0.27 B	0.41 B	0.26 B	0.40 B	0.24 B	0.32 B	0.48 B	0.21 B	mg/Kg
Cadmium	0.22 B	0.24 U	0.23 U	0.24 U	0.23 U	0.27 B	0.27 B	<0.83	0.24 U	0.24 U	0.27 U	mg/Kg
Calcium	7,630	9,240	4,230	6,850	23,400	11,700	5,370	5,100	2,390	3,110	7,970	pCi/g
Cesium-137	0.295	0.015	0.004	0.028	0.004	-0.00	0.005	-0.002	-0.003	-0.002	---	mg/Kg
Chromium	9.4	21.3	4.7	5.9	10.4	9.4	14.4	9.8	42.5	18.4	23.7	mg/Kg
Cobalt	7.5	7.4	5.3	4.9	7.0	4.9	8.4	6.1 B	5.7	8.2	3.6	pCi/g
Cobalt-60	0.0003	-0.014	0.008	-0.015	0.02	0.009	-0.009	0.001	0.012	-0.01	-0.002	mg/Kg
Copper	15.1	15.0	10.2	10.9	14.1	10.5	16.8	14	11.2	14.4	6.7	mg/Kg
Iron	16,200	14,600	10,200	11,300	14,000	9,910	16,300	15,000	11,400	16,500	15,000	mg/Kg
Lead	3.0	3.0	2.2	1.8	4.3	2.3	2.2	2.3	3.5	3.0	1.4	mg/Kg
Magnesium	3,850	3,650	1,970	3,130	5,790	3,570	3,820	4,000	2,570	3,150	1,250	mg/Kg
Manganese	245	316	143	187	230	194	255	240	166	207	188	mg/Kg
Mercury	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	<0.10	0.05 U	0.05 U	0.06 U	mg/Kg
Nickel	9.6	15.7	4.8	7.6	12.3	9.5	13.8	10	26.2	12.8	12.7	mg/Kg
Plutonium-238	0.00	0.009	0.00	-0.002	0.00	0.00	0.00	0.026	0.00	0.00	-0.002	pCi/g
Plutonium-239/240	-0.002	0.009	0.011	-0.002	0.008	0.00	0.003	0.066	0.00	0.00	0.02	pCi/g

Table 4-5. Constituents Analyzed - Sediment Sampling Data for Well 299-W11-37 Split-Spoon Samples. (3 sheets)

Constituent	Result[a]	Result[b]	Result[c]	Result[d]	Result[e]	Result[f]	Result[g]	Result[h]	Result[i]	Result[j]	Result[k]	Units
Potassium	1,230	1,010	713	970	1,090	1,150	1,030	840 B	750	823	329 U	mg/Kg
Radium-224	0.661	0.657	0.549	0.597	1.19	0.661	0.576		0.717	0.842	0.590U	pCi/g
Radium-226	0.488	0.482	0.399	0.451	0.801	0.432	0.347	1.01	0.421	0.531	0.367	pCi/g
Radium-228	0.753	0.667	0.615	0.588	1.29	0.634	0.577		0.725	0.796	0.589	pCi/g
Selenium	0.06 U	0.06 U	0.06 U	0.06 U	0.06 U	0.06 U	0.06 U	0.89 B	0.15 U	0.15 U	0.17 U	mg/Kg
Silver	0.30 U	0.30 U	0.32 U	0.32 U	0.32 U	0.31 U	0.31 U	<1.5	0.53 B	0.49 B	0.36 U	mg/Kg
Sodium	209	183	144	221	134	120	317	640 B	286	193	117 B	mg/Kg
Strontium-90	0.249	0.108	0.119	0.311	0.559	0.219	0.367	0.02	0.142	0.06	-0.00	pCi/g
Technetium-99	0.342	0.072	-0.318	0.667	0.034	-0.009	0.146	0.04	0.381	0.750	0.201	pCi/g
Thallium	0.13 B	0.10 B	0.11 U	0.11 U	0.13 U	0.10 U	0.10 U	<0.83	0.11 U	0.11 U	0.12 U	mg/Kg
Uranium-234	0.834	0.734	0.619	0.794	1.08	0.849	0.782	0.83	0.399	0.795	0.371	pCi/g
Uranium-235	0.008	0.046	0.077	0.022	0.09	0.054	0.023	0.165	0.051	0.087	0.023	pCi/g
Uranium-238	0.858	0.606	0.798	0.777	1.12	0.704	0.501	0.54	0.613	0.813	0.342	pCi/g

Table 4-5. Constituents Analyzed - Sediment Sampling Data for Well 299-W11-37 Split-Spoon Samples. (3 sheets)

Constituent	Result[a]	Result[b]	Result[c]	Result[d]	Result[e]	Result[f]	Result[g]	Result[h]	Result[i]	Result[j]	Result[k]	Units
Vanadium	36.0	33.4	25.8	22.6	41.8	21.9	45.0	34	24.8	40.4	13.6	mg/Kg
Zinc	33.3	30.3	20.0	24.8	29.9	25.9	35.6	34	23.4	36.5	21.6	mg/Kg
Gross alpha	8.59	9.21	10.1	9.51	16.2	13.3	4.23	11.6	7.33	8.13	4.26	pCi/g
Gross beta	23.9	21.9	20.7	2.47	27.3	24.7	2.06	19.4	18.3	16.5	15.9	pCi/g

[a]Sample interval 20-22 ft; HEIS Sample No. B0C890.
[b]Sample interval 30.5-32.5 ft; HEIS Sample No. B0C891.
[c]Sample interval 49.5-51.5 ft; HEIS Sample No. B0C892.
[d]Sample interval 71.5-73.5 ft; HEIS Sample No. B0C893.
[e]Sample interval 96-98 ft; HEIS Sample No. B0C894.
[f]Sample interval 126.5-128.5 ft; HEIS Sample No. B0C895.
[g]Sample interval 149.5-151.5 ft; HEIS Sample No. B0C896.
[h]Sample interval 153-155 ft; HEIS Sample No. B0C897.
[i] Sample interval 244-245 ft; HEIS Sample No. B0C898.
[j] Sample interval 263-265 ft; HEIS Sample No. B0C899.
[k] Sample interval 290.5-292.5 ft; HEIS Sample No. B0C8B0.
B = Result is from blank contamination.
U = Result at or below detection limit.

detections were for trace amounts of cesium-137 (0.3 pCi/g) for the uppermost split-spoon sample depth interval (6.1 to 6.7 m [20 to 22 ft]) and trace amounts (0.1 to 0.56 pCi/g) of strontium-90 from a depth of 6.1 m (20 ft) and down to 74.7 m (245 ft). The greater apparent depth of occurrence of trace amounts of strontium-90 than cesium-137 may reflect the greater affinity of layer silicate or clay mineral phases (smectite clays) for the cesium ion (Cs^+) than for the strontium ion (Sr^{+2}). The mechanism for this effect apparently involves isomorphous substitution of Cs^+ (1.67 Å) for potassium (K^+ - 1.33 Å) in the crystalline silicate lattice; i.e. the substitution of cesium for potassium apparently results in *fixation* of the cesium within the crystal structure, rather than retention on mineral grain surfaces by simple or nonspecific ion exchange bonding.

4.5 SUMMARY AND CONCEPTUAL MODEL

Based on the data available, a conceptual model of potential impacts of effluent discharges to the 216-T-1 Ditch is summarized in the following paragraphs and illustrated in Figure 4-15.

- Wastewater discharged to the 216-T-1 Ditch slowly infiltrates the fine sediments in the bottom of the ditch. Once past these fine sediments, it moves quickly through the open-framework gravels of unit 1 of the Hanford formation. Once it enters the sands and silty sands of unit 2 of the Hanford formation it slows down. If there were higher rates of flow into the 216-T-1 Ditch, near-saturated conditions could exist in the lower portion of this unit. Perched water and lateral spreading can occur within unit 2 of the Hanford formation along the Plio-Pleistocene interval in this part of the 200 West Area. The intervals contain $CaCO_3$-cemented portions and fine-grained sediments, which allow downward percolating waters to accumulate.

- Discharges of 221-T Complex (T Plant Head-End) effluent containing low-level radioactive liquids and various chemicals contributed to the soil column inventory.

- The mobile constituents of concern (chloride, chromium, fluoride, nitrate, potassium, sodium, sulfate, technetium-99, and uranium) have moved through the soil column and broken through to groundwater. Residual amounts of some constituents can still be found in sediments from this area, but they are all at or near background concentration levels.

- Once the wastewater moves past the Plio-Pleistocene interval and enters the member of Taylor Flat (Ringold Formation) silts and sands, the constituents have the potential to be adsorbed by finer grained sediments of this stratigraphic unit.

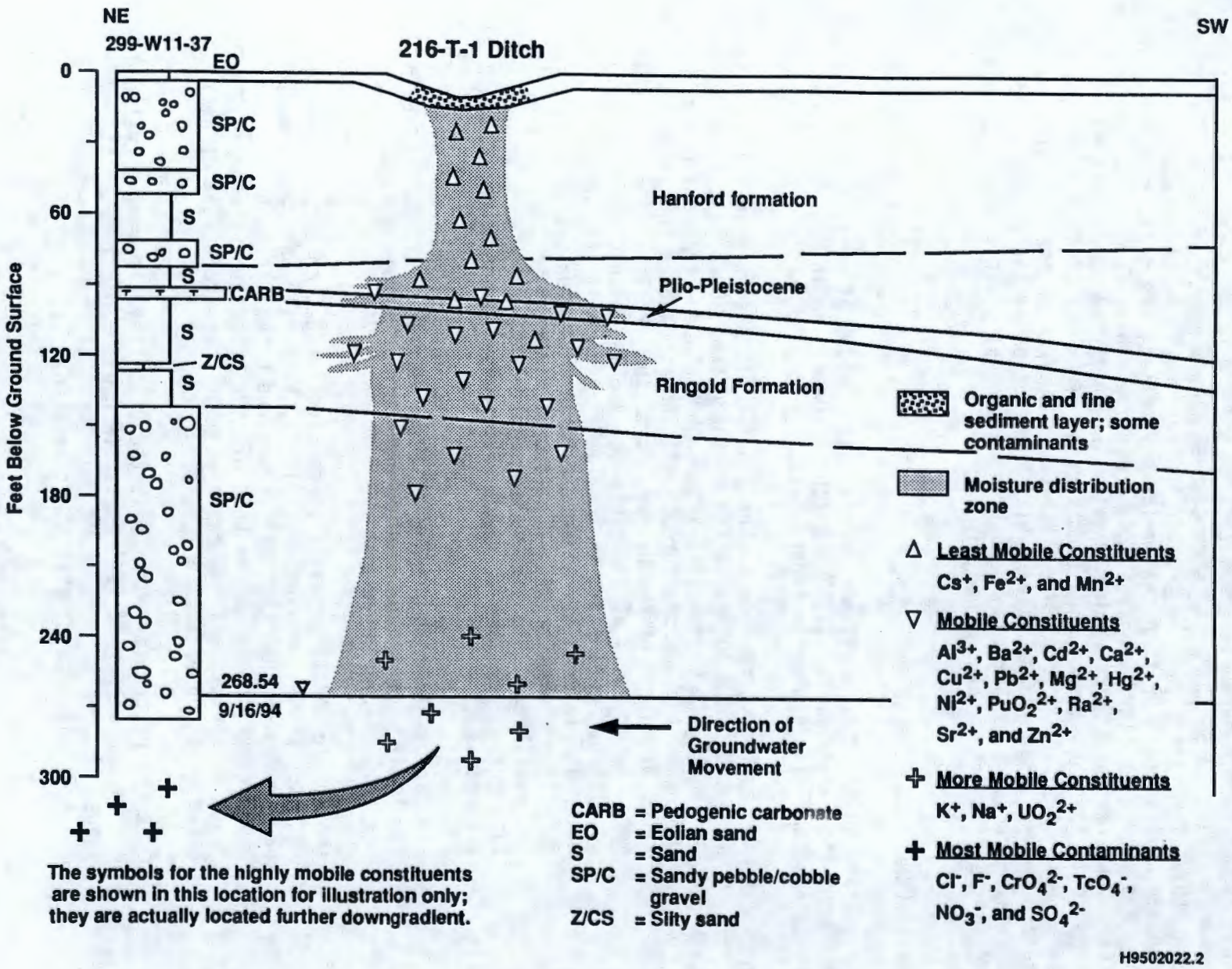

Figure 4-15. Illustrated Conceptual Model for the 216-T-1 Ditch.

- Beneath the member of Taylor Flat (Ringold Formation) are the gravels and interbedded sands and silts of unit E of the member of Wooded Island. The water will move through this unit to the water table easily. The unconfined aquifer occurs within this unit and is found at approximately 82 m (269 ft) below ground surface. The direction of groundwater movement is to the northeast at this site.

- Aluminum, barium, cadmium, calcium, cesium-137, copper, iron, lead, magnesium, manganese, mercury, nickel, plutonium-239, radium, strontium, strontium-90, and zinc discharged to the 216-T-1 Ditch would most likely still be present on the soil column but would not have broken through to groundwater. Groundwater chemistry results that are above background values are due to upgradient sources. Only aluminum and iron appear to be related to effluent disposal to the ditch in recent years.

- Uranium, gross alpha, technetium-99, gross beta, nitrate, carbon tetrachloride, chloroform, and tritium occur in concentrations above background in the groundwater upgradient and beneath the 216-T-1 Ditch. These constituents are present because of past-practice disposal activities in the immediate area and further upgradient.

The impact assessment presented in Chapter 5.0 addresses these issues using a combination of contaminant migration modeling, groundwater sampling and analysis results, and existing groundwater hydraulic data from other ongoing programs.

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5.0 IMPACT ASSESSMENT

As required by Tyler (1991), both hydrologic and contaminant impacts are considered for each groundwater impact assessment. Accordingly, hydrologic factors relevant to the current status of the disposal facility are discussed first followed by contaminant transport analysis.

5.1 HYDROLOGIC IMPACTS

Based on current discharges to the 216-T-1 Ditch, impact to the local groundwater flow regime is minimal. Groundwater flow is to the northeast in the vicinity of the 216-T-1 Ditch. There are no irregularities in the water table near the 216-T-1 Ditch. Wastewater discharge to the 216-T-1 Ditch will cease by June 1995.

Effluent discharged to the ditch percolates downward through a multi-layered sequence of sediments. Perched water conditions could occur within the Hanford formation, just on top of the Plio-Pleistocene interval significant, which has $CaCO_3$ cementation at this location. However, no perched water conditions were encountered during drilling of monitoring well 299-W11-37 at this site. There is not enough effluent going into the ditch to cause more than near-surface wetting of the ditch soil column (within 3 to 4.6 m [10 to 15 ft] of the ditch bottom).

5.2 CONTAMINANT IMPACTS

5.2.1 Analytical Technique

The one-dimensional analytical method described in the *Liquid Effluent Study Final Project Report* (WHC 1990b) estimates the rate of moisture and contaminant movement through the soil column beneath the 216-T-1 Ditch. The method considered only flow in the vertical direction and did not allow for lateral spreading, and thus is expected to provide calculated contaminant migration rates that are more conservative (faster) than those that occur under natural conditions.

The method used is based on steady-state flow conditions in the unsaturated zone and assumes a unit hydraulic gradient. The basic equation for any layer of sediments is

$$t = L \times \theta / q \qquad (1)$$

where:

t = time of travel through layer (s)
L = thickness of layer (cm)
θ = moisture content of sediment, related to hydraulic conductivity
q = Darcy velocity or moisture flux in layer (cm/s).

The total travel time, T, is determined as the summation of the travel times for each of the "i" layers:

$$T = \sum_{i=1}^{n} L_i \times \theta_i / q_i \qquad (2)$$

where n is the number of sediment layers to model a particular disposal site. For transport calculation purposes, the soil column beneath the ditch was treated as a four-layer system of 61 m (200 ft) depth in the original analytical solution (Section 5.2.2) and as a six-layer system of 90.3 m (296 ft) depth in the revised analytical solution (Section 5.2.3). Figure 5-1 illustrates the soil column used in the original analytical solution. Figure 5-2 illustrates the soil column used in the revised analytical solution.

The relationship between hydraulic conductivity, K, and moisture content, θ, is described graphically in Figure 5-3. These curves were derived empirically from laboratory tests on more than 20 different Hanford Site sediment types and established five major sediment types, as noted in Figure 5-3.

The one-dimensional flow analysis embodied in equation 2 was carried out on a Symphony[1] spreadsheet. The total travel time, T, obtained with equation 2 is divided into the vadose zone thickness to provide an estimate of the rate of moisture migration from the disposal facility to the groundwater.

To obtain an estimate of the rate of contaminant migration, the computed moisture migration rate, V_w, was divided by the retardation factor, R_f, for Each of the contaminants of concern. The R_f values were estimated using K_d values (or R_d values) selected from Ames and Serne (1991) for neutral pH, low-salt, and low-organic content effluent conditions and the following generalization for Hanford Site soils:

$$R_f = 1 + 5K_d \qquad (3)$$

The constant, 5, in equation 3 accounts for the average porosity and bulk density of Hanford Site soils. Where appreciable amounts of gravel are present, the second term in the above equation should be multiplied by:

$$(1\text{-\%gravel present})/100 \qquad (4)$$

to account for the reduced surface area (i.e., sorption tests on Hanford Site soils have been typically conducted on the sand-size fraction, <2 mm [<0.08 in.]).

The effluent discharge rate, as described previously, was entered as liters per month in the spreadsheet computational method. Effluent volumes

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[1]Symphony is a registered trademark of the Lotus Development Corporation.

Figure 5-1. Lithology of Well 299-W11-14 Southwest of the 216-T-1 Ditch (WHC 1990b).

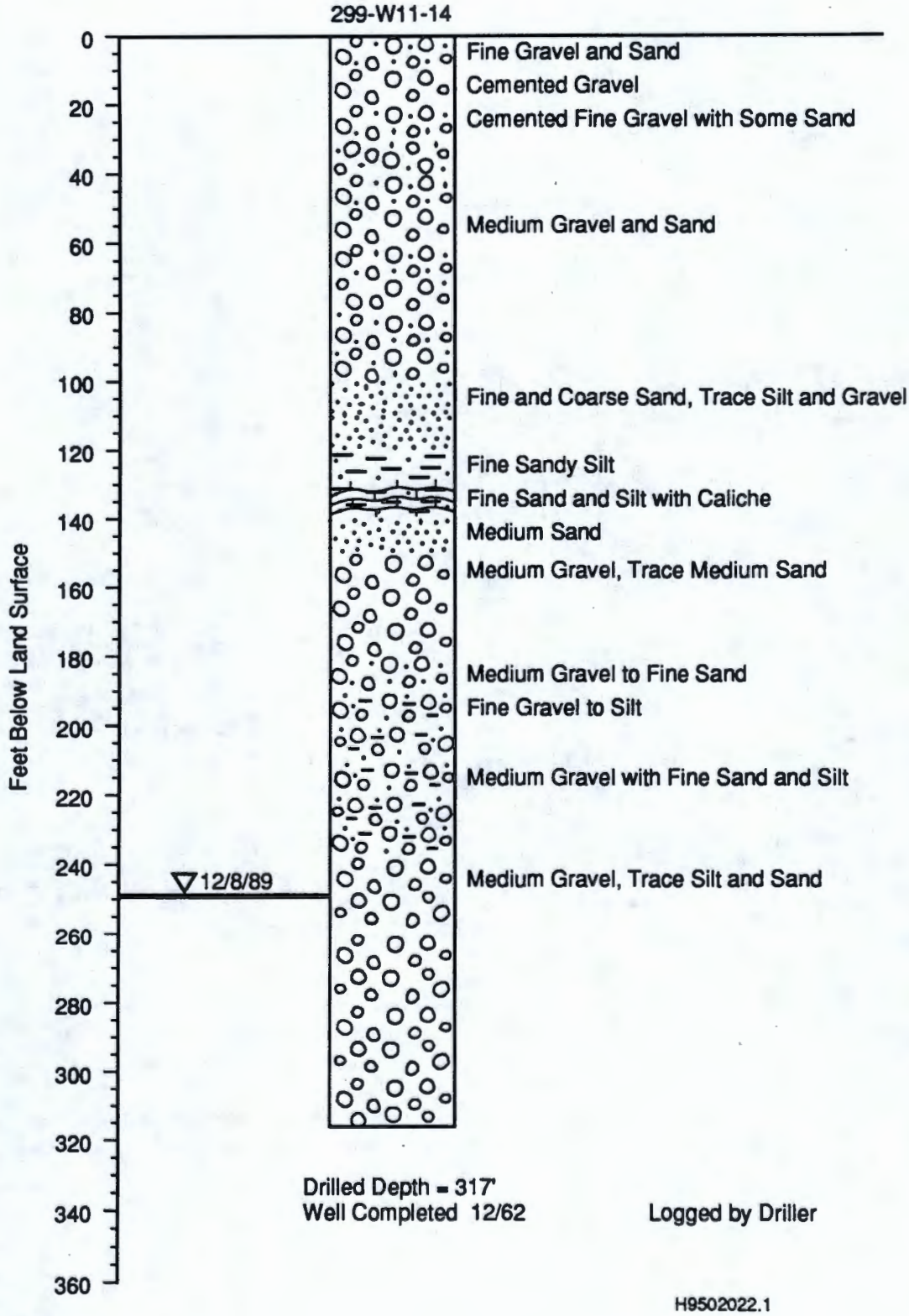


Figure 5-2. Lithology of Well 299-W11-37 at the 216-T-1 Ditch.

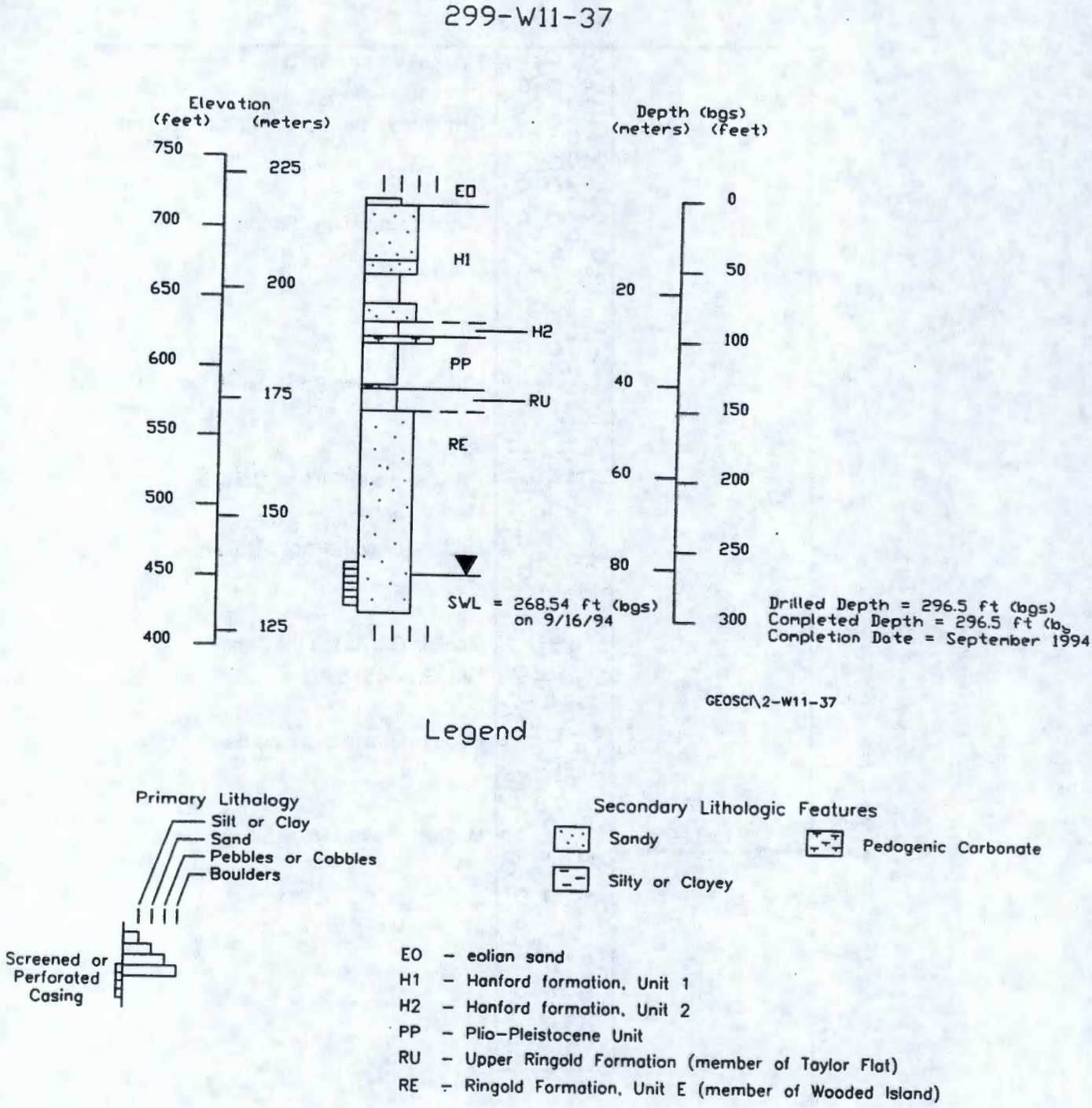
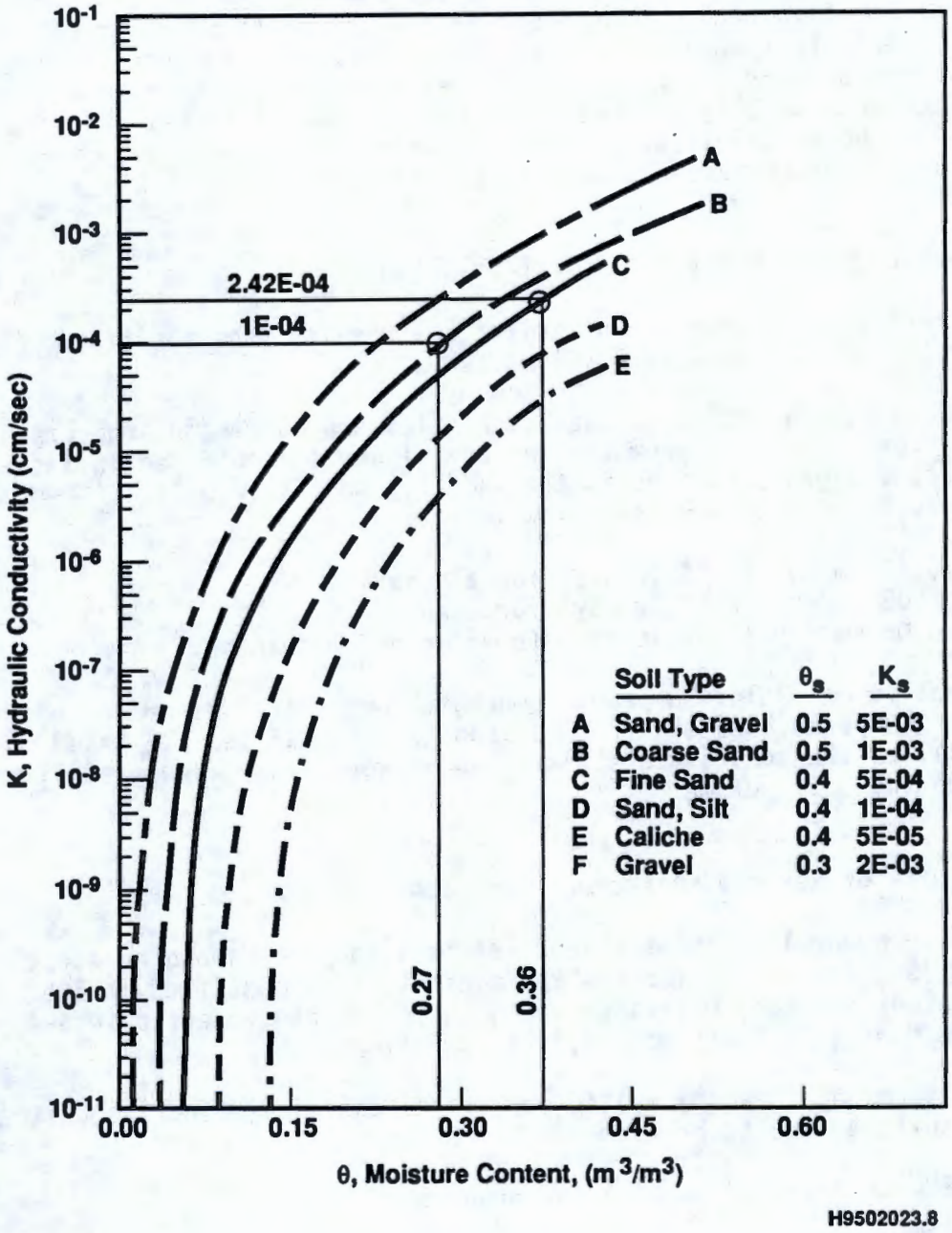


Figure 5-3. Hydraulic Conductivity Versus Moisture Content (WHC 1990b).



through 1987 listed in the *Waste Stream Characterization Report* (WHC 1989), were updated to include 1988 and 1989 data for the *Liquid Effluent Study Final Project Report* (WHC 1990b); the same average infiltration rate was also assumed for the time period subsequent to 1989. The total volume (liters) was divided by the corresponding operating period (months) to establish an average rate of inflow (liters per month). This effluent discharge rate was divided by the ditch area to obtain an estimate of the average infiltration rate. More details and an illustrative example for application of the overall computational approach are provided in WHC (1990b).

5.2.2 Results of Original Analytical Solution

The following discussion summarizes the results from the *Liquid Effluent Study Final Project Report* (WHC 1990b).

Based on general effluent characteristics and corresponding sorption parameters (Section 5.2.1) for the key constituents identified in Table 5-1, the calculated migration rates in the vadose zone (Table 5-2), listed most mobile to least mobile, are as follows:

- 0.12 cm/day (0.05 in/day) for aluminum
- 0.08 cm/day (0.03 in/day) for lead
- 0.05 cm/day (0.02 in/day) for iron and manganese.

The analytical solution predicts breakthrough of aluminum in 166 years, of lead in 249 years, and of iron and manganese in 416 years. Based on these results, all of the constituents listed above would most likely still be retained on the soil column.

5.2.3 Results of Revised Analytical Solution

Based on general effluent characteristics and corresponding sorption parameters (Section 5.2.1) for the key constituents identified in Table 5-3, the calculated (average) migration rates in the vadose zone (Table 5-4), listed most mobile to least mobile, are as follows:

- 24 cm/day (9.4 in/day) for chloride, chromium, fluoride, nitrate, sulfate, and technetium-99

- 2.4 cm/day (1.0 in/day) for uranium

- 1.2 cm/day (0.5 in/day) for potassium and sodium

- 0.2 cm/day (0.1 in/day) for aluminum, barium, cadmium, calcium, copper, lead, magnesium, mercury, nickel, plutonium-239, radium, strontium, strontium-90, and zinc

- 0.10 cm/day (0.04 in/day) for cesium-137, iron, and manganese.

Table 5-1. Effluent Stream Sampling Data for T Plant Laboratory Wastewater (WHC 1990a).

Key constituents	Detection limit[a]	Detection/ analyses	Sample concentration (90% CI)[a]
12/85 to 08/86, During Wastewater 1 -- Plasma Torch Operation			
Aluminum	NA	3/3	270
Iron	30	3/3	1,100
Lead	5	1/3	160
Manganese	5	3/3	620
12/86 to 03/88, During Wastewater 2 -- Plasma Torch Standby			
Aluminum	NA	3/4	1,200
Manganese	5	4/4	180
Lead	5	4/4	56
Iron	30	4/4	2,800
10/89 to 03/90, During Wastewater 1			
Aluminum	NA	ND	ND
Iron	30	1/1	125[b]
Lead	5	ND	ND
Manganese	5	1/1	45[b]
10/89 to 03/90, During Wastewater 2			
Aluminum	NA	1/4	182
Manganese	5	4/4	181
Lead	5	1/4	10[b]
Iron	30	4/4	397

[a]Units: Chemical = parts per billion (ppb).
[b]Concentrations below Group A study guidelines (WHC 1990a, Appendix A); values given for comparison purposes.
CI = Confidence interval.
NA = Not available.
ND = Not detected.

Table 5-2. Analytical Solution for the 216-T-1 Ditch from the *Liquid Effluent Study Final Project Report* (WHC 1990b).

Disposal facility	Rate (L/month)	Area (m^2)	f, infiltration rate (cm/s)	Layer number
216-T-1 Ditch	3.35 E+05	502	2.54 E-05	1 2 3 4
Thickness (m)	Soil type	θ_s	K_s	θ
27 6 11 29 73	A B D A	0.5 0.5 0.4 0.5	5.0 E-03 1.0 E-03 1.0 E-04 5.0 E-03	0.16 0.20 0.29 0.16
Moisture state	q (cm/s)	t (s)	T (d)	Estimated moisture migration (cm/d)
Unsaturated Unsaturated Unsaturated Unsaturated	2.54 E-05 2.54 E-05 2.54 E-05 2.54 E-05	1.70 E+07 4.72 E+06 1.25 E+07 1.82 E+07 5.25 E+07	607	12.0
Constituent	R_f (retardation factor)	Estimated contaminant migration (cm/day)*	Contaminant transport to water table (year)	
Aluminum Iron Lead Manganese	100 250 150 250	0.12 0.05 0.08 0.05	166 416 249 416	

*Considering the uncertainties in the input parameters for this solution, no more than one significant figure is justified in interpretation of these results; additional figures are computer generated and are left here to illustrate the small differences between numbers for given constituents.

Table 5-3. Revised List of Key Constituents.

Key constituent	Key constituent
Aluminum	Mercury
Barium	Nickel
Cadmium	Nitrate
Calcium	Plutonium-239
Cesium-137	Potassium
Chloride	Radium
Chromium	Sodium
Copper	Strontium
Fluoride	Strontium-90
Iron	Sulfate
Lead	Technetium-99
Magnesium	Uranium
Manganese	Zinc

Table 5-4. Revised Analytical Solution for the 216-T-1 Ditch.[1]
(2 sheets)

Disposal facility	Rate (L/month)	Area (m^2)	f, infiltration rate (cm/s)	Layer number
216-T-1 Ditch	3.31 E+05	46.45	2.72 E-04	1 2 3 4 5 6
Thickness (m)	**Soil type**	**θ_s**	**K_s**	**θ**
1.5	D	0.4	1.0 E-04	0.4
14.9	F[2]	0.3	2.0 E-03	0.3
13.5	A	0.5	5.0 E-04	0.5
11.5	E	0.4	5.0 E-05	0.4
4.9	B	0.5	1.0 E-03	0.5
44.0	F[2]	0.3	2.0 E-03	0.3
90.3				
Moisture state	**q (cm/s)**	**t (s)**	**T (d)**	**Estimated moisture migration (cm/d)**
Saturated	1.0 E-04	6.00 E+05		
Saturated	1.0 E-04	4.47 E+06		
Saturated	1.0 E-04	6.75 E+06	371	24.3
Saturated	1.0 E-04	4.60 E+06		
Saturated	1.0 E-04	2.45 E+06		
Saturated	1.0 E-04	1.32 E+07		

Table 5-4. Revised Analytical Solution for the 216-T-1 Ditch.[1]
(2 sheets)

Constituent	R_f (retardation factor)	Estimated contaminant migration (cm/day)[3]	Contaminant transport to water table (year)
Aluminum	100	0.24	101
Barium	125	0.19	127
Cadmium	150	0.16	152
Calcium	100	0.24	101
Chloride	1	24.33	1
Chromium	1	24.33	1
Fluoride	1	24.33	1
Iron	250	0.10	254
Lead	150	0.16	152
Magnesium	100	0.24	101
Manganese	250	0.10	254
Mercury	150	0.16	152
Nickel	150	0.16	152
Nitrate	1	0.16	1
Potassium	20	1.22	20
Sodium	20	1.22	20
Strontium	125	0.19	127
Sulfate	1	24.33	1
Uranium	10	2.43	10
Zinc	150	0.16	152
Cesium-137	250	0.10	254
Plutonium-239	125	0.19	127
Radium	125	0.19	127
Strontium-90	125	0.19	127
Technetium-99	1	24.33	1

[1]This solution differs from the Table 4-8 solution in that it looks at the ditch as a "pond" covering the first 15 m (50 ft) of ditch length, and it uses six layers of sediment (based on the monitoring well 299-W11-37 geology) instead of the four originally used.

[2]Soil Type F is a new type designation and is in addition to the original five types discussed in WHC (1990b, Figure B-1). See Figure 5-3 for detail information.

[3]Considering the uncertainties in the input parameters of this solution, no more than one significant figure is justified in interpretation of these results; additional figures are computer generated and are left here to illustrate the small differences between numbers for given constituents.

Computed travel times, or the time for breakthrough of the constituents to occur, are listed as follows:

- 1.0 year for chloride, chromium, fluoride, nitrate, sulfate, and technetium-99
- 10 years for uranium
- 20 years for potassium and sodium
- 101 years for aluminum, calcium, and magnesium
- 127 years for barium, plutonium-239, radium, strontium, and strontium-90
- 152 years for cadmium, copper, lead, mercury, nickel, and zinc
- 254 years for cesium-137, iron, and manganese.

Based on these results, the following constituents would most likely still be retained on the soil column: aluminum, barium, cadmium, calcium, cesium-137, copper, iron. lead, magnesium, manganese, mercury, nickel, plutonium-239, radium, strontium, strontium-90, and zinc.

5.2.4 Actual Field Conditions and Indications

5.2.4.1 Expected Depth Distribution of Contaminants. As noted, many of the constituents of interest should still be present on the soil column (see Sections 4.4.1 and 4.4.2). They would most likely be found 10 to 26 m (32.8 to 85.3 ft) in depth. Limited amounts of relatively "clean" effluent could potentially drive them further down in the soil column, but since discharge to the 216-T-1 Ditch is scheduled to cease in June 1995, this would be an unlikely occurrence.

5.2.4.2 Breakthrough to Groundwater. As discussed in Section 4.5, the most significant expected or potential contamination of groundwater at the 216-T-1 Ditch would be from constituents that have reached the water table. Of the constituents of concern previously identified, only chloride, chromium, fluoride, nitrate, potassium, sodium, sulfate, technetium-99, and uranium should have broken through to groundwater. Constituents that are seen at elevated concentrations in the groundwater are: aluminum, carbon tetrachloride, chloroform, gross alpha, gross beta, iron, nitrate, sulfate, technetium-99, tritium, and uranium. Aluminum and iron are present in elevated concentrations in the effluent, which may account for their presence in groundwater. However, it is likely that most of the other constituents are present due to the influence of sources other than the 216-T-1 Ditch. These constituents are highly mobile species, and they would be present some distance downgradient from the 216-T-1 Ditch if the ditch had been their sole source. Using a groundwater transport rate of 0.15 to 0.3 m/day (0.5 to 1 ft/day) to estimate this distance, shows these constituents should be a few kilometers (miles) downgradient. Some of the downgradient wells in the area (e.g., 299-W12-1) may have intercepted the hypothetical plume from such a

release. Chromium, gross beta, and nitrate have shown elevated concentrations in this well. This may be a result of disposal activities at the T-1 Ditch and/or other upgradient sources of a similar nature.

The groundwater at the 216-T-1 Ditch continues to show somewhat elevated concentrations for the above constituents, so it is more likely to assume they originated from upgradient sources. The following is an explanation of probable sources for these constituents:

- The carbon tetrachloride is probably from past-practice activities at the Z Plant Complex (located in the west-central portion of the 200 West Area). There is a major carbon tetrachloride plume in the 200 West Area from these activities. Chloroform is most likely a degradation product of carbon tetrachloride.

- The uranium/gross alpha and technetium-99/gross beta originate from other upgradient sources; there is a small plume of uranium/gross alpha and technetium-99/gross beta in the vicinity of well 299-W11-14 and this may be due to nearby T Plant facilities.

- The tritium is also from upgradient sources. The tritium plume present in the 200 West Area extends up into the 216-T-1 Ditch area.

- A source for the nitrate and sulfate is more difficult to determine, since there are many potential upgradient sources for these constituents, including, but not limited to cribs, ditches, and tank farms.

5.3 EVALUATION OF MONITORING NETWORK ADEQUACY

5.3.1 Groundwater Monitoring Well Placement

There were no monitoring wells in the immediate vicinity of the 216-T-1 Ditch, which necessitated drilling a monitoring well for the ditch as part of this groundwater impact assessment project. Monitoring well 299-W11-37 was located at the head-end of the ditch, approximately 4.6 m (15 ft) in the down stream direction from the ditch outfall pipe, and 1.5 m (5 ft) from the surface contamination area control rope which surrounds the ditch. This well was placed on the northeast side of the ditch, which is the downgradient groundwater flow direction. This location should be ideal for detecting any contaminants that might come from the ditch. The only other well near the ditch is well 299-W11-14, which is located southwest and upgradient from the ditch (see Figure 4-14).

5.3.2 Reporting of Monitoring Data

All hydrochemical monitoring data are reported in the HEIS database, which is publicly accessible. Monitoring results for the wells in 216-T-1 Ditch area, for historical data from the 1980's through February 1995 for well 299-W11-14 and data from the 1980s through February 1995 for other wells, were summarized and used to evaluate the groundwater quality and chemistry in Section 4.3 (see also Appendices A-1, A-2, and A-3).

6.0 SUMMARY AND CONCLUSIONS

6.1 GROUNDWATER QUALITY IMPACTS

Effluent data, vadose zone transport predictions, and groundwater chemistry data suggest the 216-T-1 Ditch has minimal influence on groundwater quality in the northeastern 200 West Area. Locally the primary groundwater contaminants are uranium, gross alpha, technetium-99, gross beta, nitrate, tritium, carbon tetrachloride, and chloroform, which are attributed to other past practice disposal sites in the vicinity of the 216-T-1 Ditch. The most likely sources are the other T Plant disposal facilities located upgradient (south and southwest) from the 216-T-1 Ditch. Other sources of upgradient contamination are the facilities near Z Plant, which originated the carbon tetrachloride and chloroform plumes.

Calculated transport times for constituents of interest in the soil column were varied, suggesting some the constituents should have broken through to groundwater and some are still retained in the soil column. Calculated transport times for chloride, chromium, fluoride, nitrate, sulfate, technetium-99, uranium, potassium, and sodium were less than 20 years. However, there is no conclusive evidence that the constituents listed above and present in the groundwater at the 216-T-1 Ditch are due to discharges to the ditch alone. Based on comparison between the 216-T-1 Ditch effluent and upgradient groundwater contaminant levels, it is likely that the source of these constituents is upgradient of the 216-T-1 Ditch.

6.2 HYDROLOGIC IMPACTS

Discharge of water to the 216-T-1 Ditch, under current conditions (December 1994), has an insignificant impact on artificial recharge to the northern 200 West Area unconfined aquifer, as evidenced by the smooth surface of the water table in the northeastern 200 West Area (i.e., no groundwater mound) (see Figure 4-7).

6.3 CONCLUSIONS

The 216-T-1 Ditch has a low impact on groundwater quality in the northeastern 200 West Area because of:

- The low effluent flow rate of 8 L/min (4 gal/min)
- The lack of significant amounts of mobile contaminants in the effluent and present on the soil column
- The limited time remaining before discharges to the ditch cease (June 1995).

The groundwater monitoring well that was installed at the 216-T-1 Ditch in the summer of 1994 is adequate under current operating conditions (December 1994), until discharges cease in June 1995. If discharges to the 216-T-1 Ditch continue beyond June 1995, it would be advisable to install additional groundwater monitoring wells for this site to provide improved monitoring capabilities.

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APPENDIX A1

GROUNDWATER DATA - FIELD AND LABORATORY RESULTS FOR WELL 299-W11-37 (MONITORING WELL FOR 216-T-1 DITCH)

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GROUNDWATER DATA - FIELD AND LABORATORY RESULTS FOR WELL 299-W11-37 (MONITORING WELL FOR 216-T-1 DITCH)

The results given on the following pages are from samples collected during the summer and fall of 1994, during installation of the monitoring well for the 216-T-1 Ditch (299-W11-37). The results are given in table form as whole sample sets, in the following order of analysis type:

1. Field Analyses (Table A1-2).

   a. Field parameters measured at the well head:

      - depth to water
      - pH
      - temperature
      - specific conductance (conductivity)
      - dissolved oxygen
      - oxidation-reduction potential.

   b. Field parameters measured in portable field laboratory:

      - sulfate
      - nitrate
      - total iron
      - total chromium
      - copper
      - chloride
      - sulfide
      - nitrite
      - ferrous iron
      - hexavalent chromium
      - phosphate
      - alkalinity.

2. Laboratory Analyses (Table A1-3).

   a. Inductively Coupled Plasma (ICP) Metals - Unfiltered and Filtered: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc

   b. Atomic Absorption (AA) Metals - Unfiltered and Filtered: arsenic, lead, mercury, selenium, and thallium

   c. Anions - Unfiltered: chloride, fluoride, nitrate, nitrite, orthophosphate, sulfate, and sulfide

   d. Volatile Organics - Unfiltered

   e. Semi-Volatile Organics - Unfiltered

   f. Herbicides - Unfiltered

   g. Organophosphate Pesticides - Unfiltered

   h. Pesticides and Polychlorinated Biphenyls (PCBs) - Unfiltered

i. Radionuclides - Unfiltered: total alpha, total beta, gamma spectroscopy, Americium-241, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, tritium, and Technetium-99

j. Total Activity Screening - 222-S Laboratory.

Table A1-1 lists all the samples taken at this well and gives all of the identification numbers used for each sample set. The following is an explanation of three of the most common types of sample numbers these samples were given.

- HC Number - A number assigned to all samples collected by Hydrochemistry and Geochemistry personnel performing special projects. The numbers are assigned in consecutive order and have the following format:

  HC-94-xx

  where:
  HC = Hydrochemistry
  94 = Year sample was taken in
  xx = Next consecutive number, starting with 1 and ending with last number used in a given year.

- HEIS Number - A number generated by Hanford Analytical Services Management (HASM) and assigned by the Project Scientist/Sampler for samples being submitted to an offsite laboratory. Numbers are generated using a special program (DOE-RL 1994a, 1994b). The number usually has a six-digit format, using a combination of letters and numbers.

- 222-S Laboratory Number - For total activity analysis. This number has the following format:

  N-xxxx

  where:
  N = 222-S Laboratory designation
  xxxx = next consecutive number in 222-S logbook.

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Table A1-1. List of Samples Taken at Well 299-W11-37.

HC Number	Other Identifying Number(s) (HEIS/222-S)	Description of Sample
HC-94-9	B09TJ0 N2229	Groundwater at 299-W11-37; Depth = 269.34 ft; Date = 8-27-94
HC-94-10	B0C8D9 N2315	Duplicate Sample - B09TJ0 Groundwater at 299-W11-37; Depth = 269.34 ft; Date = 8-27-94
HC-94-15	B09W15 N2403	Groundwater at 299-W11-37; Depth = 268.54 ft; Date = 9-16-94
HC-94-16	B09W16 N2404	Split Sample - B09W15 Groundwater at 299-W10-22; Depth = 268.54 ft; Date = 9-16-94

HC = Hydrochemistry.

Table A1-2a. Field Results from Well Head and Portable Field Laboratory for Groundwater Samples HT-94-9 and HT-94-10-Duplicate.

Sample Numbers	HT-94-9 HT-94-10 (dupl.)	Depth	269.34 ft	Date	8-27-94
Location	299-W11-37	Sampling Method		Submersible Pump	
Constituent (units)	Results	Constituent (units)		Results	
Well Head Measurements					
pH	7.78	DO (mg/L)		6.36	
Temperature (°C)	23.5	ORP (mV)		+181.9	
SC (μmhos/cm)	591	Turbidity (NTU)		3.55	
Portable Field Laboratory Measurements					
Nitrate (ppb)	4,600	Nitrite (ppb)		13.5	
Sulfate (ppp)	29,000	Sulfide (ppb)		ND	
Total Chromium (ppb)	<10	Hexavalent Chromium (ppb)		<10	
Total Fe (ppb)	30	Ferrous Fe (ppb)		<10	
Chloride (ppb)	10,000	Alkalinity (ppb)		NM	
Phosphate (ppb)	117.5	---		---	

DO = Dissolved Oxygen.
NM = not measured.
ORP = Oxidation-Reduction Potential.
SC = Specific Conductance or Conductivity.
NTU = Nephelometric Turbidity Unit.
ND = not detected.

Table A1-2b. Inductively Coupled Plasma and Atomic Absorption Metals Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (2 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Aluminum[1] - Unfiltered (U)	7429-90-5	34.5	34.5	200
Aluminum[2] - Filtered (F)	7429-90-5	19.0	19.0	200
Antimony[1] - U	7440-36-0	53.3	30.5	100
Antimony[2] - F	7440-36-0	19.5	19.5	100
Arsenic[3] - U	7440-38-2	5.3	3.0	3.0
Arsenic[3] - F	7440-38-2	3.7	3.1	3.0
Barium[1] - U	7440-39-3	36.4	36.2	200
Barium[2] - F	7440-39-3	40.6	40.4	200
Beryllium[1] - U	7440-41-7	0.20	0.20	7.0
Beryllium[2] - F	7440-41-7	0.67	0.33	7.0
Cadmium[1] - U	7440-43-9	2.2	2.2	20.0
Cadmium[2] - F	7440-43-9	1.8	1.8	20.0
Calcium[1] - U	7440-70-2	39,900	40,100	5000
Calcium[2] - F	7440-70-2	52,100	51,500	5000
Chromium[1] - U	7440-47-3	3.0	3.5	20.0
Chromium[2] - F	7440-47-3	2.9	2.8	2.0
Cobalt[1] - U	7440-48-4	3.2	3.2	20.0
Cobalt[2] - F	7440-48-4	2.9	2.9	2.0
Copper[1] - U	7440-50-8	4.0	3.1	20.0
Copper[2] - F	7440-50-8	4.5	4.5	2.0
Iron[1] - U	7439-89-6	145	99.9	100
Iron[2] - F	7439-89-6	4.9	4.4	100
Lead[4] - U	7439-92-1	0.9	0.9	3.0
Lead[4] - F	7439-92-1	0.8	0.8	3.0
Magnesium[1] - U	7439-95-4	13,600	13,600	5000

Table A1-2b. Inductively Coupled Plasma and Atomic Absorption Metals Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (2 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Magnesium[2] - F	7439-95-4	15,900	15,800	5000
Manganese[1] - U	7439-96-5	128	127	10.0
Manganese[2] - F	7439-96-5	159	156	10.0
Mercury[5] - U	7439-97-6	0.11	0.10	0.2
Mercury[5] - F	7439-97-6	0.11	0.10	0.2
Nickel[1] - U	7440-02-0	11.4	11.4	40.0
Nickel[2] - F	7440-02-0	4.9	4.9	40.0
Potassium[1] - U	7440-09-7	4,380	2,710	5000
Potassium[2] - F	7440-09-7	4,940	4,870	1000
Selenium[6] - U	7782-49-2	1.4	1.4	3.0
Selenium[6] - F	7782-49-2	0.73	0.7	3.0
Silver[1] - U	7440-22-4	3.0	3.0	200
Silver[2] - F	7440-22-4	4.2	4.2	200
Sodium[1] - U	7440-23-5	13,400	12,400	1000
Sodium[2] - F	7440-23-5	14,100	14,100	1000
Thallium[7] - U	7440-28-0	1.2	1.2	3.0
Thallium[7] - F	7440-28-0	1.0	1.0	3.0
Vanadium[1] - U	7440-62-2	33.9	34.1	20.0
Vanadium[2] - F	7440-62-2	44.7	38.4	20.0
Zinc[1] - U	7440-66-6	107	107	20.0
Zinc[2] - F	7440-66-6	13.9	43.5	20.0

ICP Metals (EPA Method 6010[1] and EPA CLP ICAP Metals[2])
AA METALS (EPA Methods 7060[3], 7421[4], 7470[5], 7740[6], 7841[7])
CAS = Chemical Abstract Services.

Table A1-2c. Anion Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate.

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Chloride[1]	16887-00-6	880	9,800	250
Fluoride[1]	16984-48-8	100	470	100
Nitrate[1]	14797-55-8	170	4,700	200
Nitrite[1]	7632-00-0	20	20	20
o-Phosphate[1]	7778-77-0	1,000	1,000	1,000
Sulfate[1]	14808-79-8	9,260	24,700	1,000
Sulfide[2]	18496-25-8	1,770	190	200

Anions (EPA Method 300.0[1] and Method 9030[2]).
CAS = Chemical Abstract Services.

Table A1-2d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (3 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Dichlorodifluoromethane	75-71-8	<5	<5	5
Chloromethane	74-87-3	<10	<10	10
Bromomethane	74-83-9	<10	<10	10
Vinyl Chloride	75-01-4	<10	<10	10
Chloroethane	75-00-3	<10	<10	10
Acrolein	107-02-8	<100	<100	100
Methylene Chloride	75-09-2	[a]2	<5	5
Acetone	67-64-1	[a]7	[a]3	100
Trichlorofluoromethane	75-69-4	<5	<5	5
Allyl Chloride	107-95-1	<5	<5	5
Carbon Disulfide	75-15-0	<5	<5	5
trans-1,2-Dichloroethene	156-60-5	<5	<5	5
1,1-Dichloroethene	75-35-4	<5	<5	5
Acetonitrile	75-05-8	<100	<100	100
Acrylonitrile	107-13-1	<100	<100	100
Propionitrile	107-12-0	<100	<100	100
1,1-Dichloroethane	75-34-3	<5	<5	5
Iodomethane	74-88-4	<5	<5	5
Chloroform	67-66-3	<5	<5	5
1,2-Dichloroethane	107-06-2	<5	<5	5
2-Chloro-1,3-butadiene	126-99-8	<5	<5	5
Methacrylonitrile	126-98-7	<100	<100	100
2-Butanone	78-93-3	<100	<100	100
Isobutyl Alcohol	78-83-1	<500	<500	500
1,1,1-Trichloroethane	71-55-6	<5	<5	5

Table A1-2d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (3 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Carbon Tetrachloride	56-23-5	79	80	5
Vinyl Acetate	108-05-4	<50	<50	50
Bromodichloromethane	75-27-4	<5	<5	5
1,2-Dichloropropane	78-87-5	<5	<5	5
cis-1,3-Dichloropropene	10061-01-5	<5	<5	5
Methyl methacrylate	80-62-6	<5	<5	5
Trichloroethene	79-01-6	<5	<5	5
Ethyl methacrylate	97-63-2	<5	<5	5
1,1,2-Trichloroethane	79-00-5	<5	<5	5
Benzene	71-43-2	<5	<5	5
Dibromomethane	74-95-3	<5	<5	5
trans-1,3-Dichloropropene	10061-02-6	<5	<5	5
Bromoform	75-25-2	<5	<5	5
1,2-Dibromomethane	106-93-4	<5	<5	5
1,4-Dioxane	23-91-1	<500	<500	500
4-Methyl-2-Pentanone	108-10-1	<50	<50	50
2-Hexanone	591-78-6	<50	<50	50
Tetrachloroethene	127-18-4	<5	<5	5
1,1,2,2-Tetrachloroethane	79-34-5	<5	<5	5
Dibromochloromethane	124-48-1	<5	<5	5
Toluene	108-88-3	<5	<5	5
Chlorobenzene	108-90-7	<5	<5	5
Ethyl benzene	100-41-4	<5	<5	5
Styrene	100-42-5	<5	<5	5

Table A1-2d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (3 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
trans-1,4-Dichloro-2-butene	764-41-0	<100	<100	100
Xylenes (total)	1330-20-7	<5	<5	5
Pentachloroethane	76-01-7	<10	<10	10
1,2,3-Trichloropropane	96-18-4	<5	<5	5
1,2-Dibromo-3-chloropropane	96-12-8A	<100	<100	100

Volatiles (Method EPA 8240)
CAS = Chemical Abstract Services.
[a]Value is estimated, because it is below a detection limit.

Table A1-2e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (5 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
n-Nitrosodimethylamine	62-75-9	<10	<10	10
Pyridine	110-86-1	<10	<10	10
Phenol	108-95-2	<10	<10	10
Aniline	62-53-3	<10	<10	10
bis(2-Chloroethyl) Ether	111-44-4	<10	<10	10
2-Chlorophenol	95-57-8	<10	<10	10
1,3-Dichlorobenzene	541-73-1	<10	<10	10
1,4-Dichlorobenzene	106-46-7	<10	<10	10
Benzyl Alcohol	100-51-6	<20	<20	20
1,2-Dichlorobenzene	95-50-1	<10	<10	10
2-Methylphenol	95-48-7	<10	<10	10
bis(2-Chloroisopropyl) Ether	108-60-1	<10	<10	10
4-Methylphenol	65794-96-9	<10	<10	10
n-Nitroso-di-n-propylamine	621-64-7	<10	<10	10
Hexachloroethane	67-72-1	<10	<10	10
Nitrobenzene	98-95-3	<10	<10	10
Isophorone	78-59-1	<10	<10	10
2-Nitrophenol	88-75-5	<10	<10	10
2,4-Dimethylphenol	105-67-9	<10	<10	10
bis(2-Chloroethoxy)Methane	111-91-1	<10	<10	10
2,4-Dichlorophenol	120-83-2	<10	<10	10
1,2,4-Trichlorobenzene	120-82-1	<10	<10	10
Naphthalene	91-20-3	<10	<10	10
4-Chloroaniline	106-47-8	<20	<20	20
Hexachlorobutadiene	87-68-3	<10	<10	10

Table A1-2e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (5 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
4-Chloro-3-Methylphenol	59-50-7	<20	<20	20
2-Methylnaphthalene	91-57-6	<10	<10	10
Hexachlorocyclopentadiene	77-47-4	<10	<10	10
2,4,6-Trichlorophenol	88-06-2	<10	<10	10
2,4,5-Trichlorophenol	95-95-4	<10	<10	10
2-Chloronaphthalene	91-58-7	<10	<10	10
2-Nitroaniline	88-74-4	<50	<50	50
Dimethyl Phthlate	131-11-3	<10	<10	10
Acenaphthylene	208-96-8	<10	<10	10
2,6-Dinitrotoluene	606-20-2	<10	<10	10
3-Nitroaniline	99-09-2	<50	<50	50
Acenaphthene	83-32-9	<10	<10	10
2,4-Dinitrophenol	51-28-5	<50	<50	50
4-Nitrophenol	100-02-7	<50	<50	50
Dibenzofuran	132-64-9	<10	<10	10
2,4-Dinitrotoluene	121-14-2	<10	<10	10
Diethylphthlate	84-66-2	<10	<10	10
4-Chlorophenyl Phenyl Ether	7005-72-3	<10	<10	10
Fluorene	86-73-7	<10	<10	10
4-Nitroaniline	100-01-6	<20	<20	20
4,6-Dinitro-2-Methylphenol	534-52-1	<50	<50	50
n-Nitrosodiphenylamine	86-30-6	<10	<10	10
4-Bromophenyl Phenyl Ether	101-55-3	<10	<10	10
Hexachlorobenzene	118-74-1	<10	<10	10
Pentachlorophenol	87-86-5	<50	<50	50

Table A1-2e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (5 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Phenanthrene	85-01-8	<10	<10	10
Anthracene	120-12-7	<10	<10	10
di-N-Butylphthlate	84-74-2	<10	<10	10
Fluoranthene	206-44-0	<10	<10	10
Pyrene	129-00-0	<10	<10	10
Butyl Benzyl Phthlate	85-68-7	<10	<10	10
3,3-Dichlorobenzidine	91-94-1	<20	<20	20
Benzo(a)Anthracene	56-55-3	<10	<10	10
Chrysene	218-01-9	<10	<10	10
bis(2-Ethylhexyl)Phthlate	117-81-7	<10	<10	10
di-N-Octyl Phthlate	117-84-0	<10	<10	10
Benzo(b)Fluoranthene	205-99-2	<10	<10	10
Benzo(k)Fluoranthene	207-08-9	<10	<10	10
Benzo(a)Pyrene	50-32-8	<10	<10	10
Indeno(1,2,3-CD)Pyrene	193-39-5	<10	<10	10
Dibenzo(a,h)Anthracene	53-70-3	<10	<10	10
Benzo(g,h,i)Perylene	191-24-2	<10	<10	10
Acetophenone	10383-88-7	<10	<10	10
2-Acetylaminofluorene	53-96-3	<20	<20	20
4-Aminobiphenyl	92-67-1	<20	<20	20
Aramite I	140-57-8A	<20	<20	20
Aramite II	140-57-8B	<20	<20	20
Chlorobenzilate	510-15-6	<10	<10	10
Diallate I	2303-16-4A	<20	<20	20
Diallate II	2303-16-4B	<20	<20	20

Table A1-2e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (5 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
2,6-Dichlorophenol	87-65-0	<10	<10	10
Dimethoate	60-51-5	<20	<20	20
p-Dimethylaminoazobenzene	60-11-7	<10	<10	10
7,12-Dimethylenz(a)Anthracene	57-97-6	<10	<10	10
3,3-Dimethylbenzidine	119-93-7	<10	<10	10
a,a-Dimethylphenethylalamine	122-09-8	<10	<10	10
1,3-Dinitrobenzene	99-65-0	<20	<20	20
Dinoseb	88-85-7	<20	<20	20
Disulfoton	298-04-4	<10	<10	10
Ethyl Methanesulfonate	62-50-0	<20	<20	20
Famphur	52-85-7	<50	<50	50
Hexachloropropene	1888-71-7	<10	<10	10
Isodrin	465-73-6	<20	<20	20
Isosafrole	120-58-1	<10	<10	10
D-Kepone	143-50-0	<50	<50	50
Methapyrilene	91-80-5	<100	<100	100
3-Methylcholanthrene	56-49-5	<10	<10	10
Methyl Methanesulfonate	66-27-3	<10	<10	10
Methyl Parathion	298-00-0	<10	<10	10
1,4-Naphthoquinone	130-15-4	<10	<10	10
1-Naphthylamine	134-32-7	<10	<10	10
2-Naphthylamine	91-59-8	<10	<10	10
5-Nitro-o-toluidine	99-55-8	<10	<10	10
4-Nitroquinoline-1-oxide	56-57-5	<40	<40	40
n-Nitroso-di-n-butylamine	924-16-3	<10	<10	10

Table A1-2e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate. (5 sheets)

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
n-Nitrosodiethylamine	55-18-5	<20	<20	20
n-Nitrosopiperdine	100-75-4	<20	<20	20
n-Nitrosopyrrolidine	930-55-2	<40	<40	40
Parathion	56-38-2	<10	<10	10
Pentachlorobenzene	608-93-5	<10	<10	10
Pentachloroethane	76-01-7	<10	<10	10
Pentachloronitrobenzene	82-68-8	<20	<20	20
Phenacetin	62-44-2	<20	<20	20
1,4-Phenylenediamine	106-50-3	<100	<100	100
n-Nitrosomethylethylamine	10595-95-6	<10	<10	10
n-Nitrosomorpholine	59-89-2	<10	<10	10
Pronamide	23950-58-5	<20	<20	20
Safrole	94-59-7	<10	<10	10
1,2,4,5-Tetrachlorobenzene	95-94-3	<10	<10	10
2,3,4,6-Tetrachlorophenol	58-90-2	<10	<10	10
Sulfotepp	3689-24-5	<40	<40	40
Thioazin	297-97-2	<20	<20	20
o-Toluidine	95-53-4	<10	<10	10
1,3,5-Trinitrobenzene	99-35-4	<50	<50	50
o,o,o-triethyl Phosphorothioat	126-68-1	<20	<20	20
Phorate	298-02-2	<10	<10	10
2-Picoline	109-06-8	<10	<10	10
Hexachlorophene	70-30-4	<100	<100	100

Semi-volatiles (Method EPA 8270).
CAS = Chemical Abstract Services.

Table A1-2f. Herbicide Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate.

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Dalapon	75-99-0	<58	<58	58
Dicamba	1918-00-9	<2.7	<2.7	2.7
MCPA	94-74-6	<2,500	<2,500	2500
MCPP	93-65-2	<1,900	<1,900	1900
2,2-Dichloropropionic acid	120-36-5	<6.5	<6.5	6.5
2,4-D	94-75-7	<12	<12	12
2,4,5-TP (Silvex)	93-72-1	<1.7	<1.7	1.7
2,4,5-T	93-76-5	<2.0	<2.0	2.0
Dinoseb	88-85-7	<0.7	<0.7	0.7
2,4-DB	94-82-6	<9.1	<9.1	9.1

Herbicides (Method SW 8150).
CAS = Chemical Abstract Services.

Table A1-2g. Organophosphate Pesticide Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate.

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
Demeton #1	298-03-3A	<1.2	<1.2	1.2
Demeton #2	298-03-3B	<1.2	<1.2	1.2
Diazinon	333-41-5	<2.0	<2.0	2.0
Disulfoton	298-04-4	<0.7	<0.7	0.7
Methyl Parathion	298-00-0	<1.2	<1.2	1.2
Malathion	121-75-5	<1.1	<1.1	1.1
Parathion	56-38-2	<0.6	<0.6	0.6
Ethion	563-12-2	<0.6	<0.6	0.6
Azinphos-methyl	86-50-0	<1.0	<1.0	1.0

Organophosphate pesticides (Method EPA 8140).
CAS = Chemical Abstract Services.

Table A1-2h. Pesticides and Polychlorinated Biphenyls Laboratory Results for Groundwater Samples HT-94-9 and HT-94-10-Duplicate.

Constituent	CAS Number	HT-94-9 Result (μg/L)	HT-94-10 Result (μg/L)	DL (μg/L)
alpha-BHC	319-84-6	<0.03	<0.03	0.03
beta-BHC	319-85-7	<0.06	<0.06	0.06
delta-BHC	319-86-8	<0.09	<0.09	0.09
gamma-BHC (Lindane)	58-89-9	<0.04	<0.04	0.04
Heptachlor	76-44-8	<0.03	<0.03	0.03
Aldrin	309-00-2	<0.04	<0.04	0.04
Heptachlor Epoxide	1024-57-3	<0.83	<0.83	0.83
Endosulfan I	959-98-8	<0.14	<0.14	0.14
Dieldrin	60-57-1	<0.02	<0.02	0.02
4,4-DDE	72-55-9	<0.04	<0.04	0.04
Endrin	72-43-5	<0.0	<0.06	0.06
Endosulfan II	33213-65-9	<0.04	<0.04	0.04
4,4-DDD	72-54-8	<0.11	<0.11	0.11
Endosulfan Sulfate	1031-07-8	<0.66	<0.66	0.66
4,4-DDT	50-29-3	<0.12	<0.12	0.12
Methoxychlor	72-43-5	<1.8	<1.8	1.8
Endrin Aldehyde	7421-93-4	<0.23	<0.23	0.23
Chlordane	57-74-9	<0.14	<0.14	0.14
Toxaphene	8001-35-2	<2.4	<2.4	2.4
Arochlor-1016	12674-11-2	<0.65	<0.65	0.65
Arochlor-1221	11104-28-2	<1.0	<1.0	1.0
Arochlor-1232	11141-16-5	<1.0	<1.0	1.0
Arochlor-1242	53469-21-9	<0.65	<0.65	0.65
Arochlor-1248	12672-29-6	<1.0	<1.0	1.0
Arochlor-1254	11097-69-1	<1.0	<1.0	1.0
Arochlor-1260	11096-82-5	<1.0	<1.0	1.0

Pesticides and polychlorinated biphenyls (EPA Method 8080).
CAS = Chemical Abstract Services.

Table A1-2i. Radionuclide Laboratory Results for Groundwater Sample HT-94-9. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Am-241	-0.0371	0.0428	0.0433	0.390	pCi/L	58.7	RD3302
Pu-238	-0.253	0.589	0.645	0.135	pCi/L	83.8	RD3209
Pu-239/40	-0.0995	0.141	0.141	0.135	pCi/L	83.8	RD3209
U-234	1.36	0.518	0.546	0.223	pCi/L	85.2	RD3234
U-235	0.0372	0.0988	0.0989	0.244	pCi/L	85.2	RD3234
U-238DA	2.08	0.642	0.694	0.276	pCi/L	85.2	RD3234
Co-58	-0.835	4.97	4.97	8.99	pCi/L	N/A	RD3219
Co-60	-0.988	4.38	4.38	8.36	pCi/L	N/A	RD3219
Cs-137DA	-3.72	4.14	4.15	6.41	pCi/L	N/A	RD3219
Eu-152	4.21	10.0	10.0	19.2	pCi/L	N/A	RD3219
Eu-154	0.534	12.7	12.7	25.4	pCi/L	N/A	RD3219
Eu-155	4.36	9.00	9.01	17.0	pCi/L	N/A	RD3219
Fe-59	-12.0	11.4	11.4	16.7	pCi/L	N/A	RD3219
Alpha	1.68	1.22	1.24	1.64	pCi/L	100.0	RD3214
Beta	23.0	2.71	3.16	3.10	pCi/L	100.0	RD3214
Strontium	0.0648	0.266	0.267	0.757	pCi/L	96.5	ITAS-IT-RS-001

Table A1-2i. Radionuclide Laboratory Results for Groundwater Sample HT-94-9. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Tc-99	103.0	2.04	14.3	2.12	pCi/L	95.1	RD3205
Tritium	488.0	118.0	227.0	243.0	pCi/L	97.7	RD4003

Radioisotopes (Method-Lab Specific).
MDA = Minimum detectable activity.

Table A1-2j. Radionuclide Laboratory Results for Groundwater Sample HT-94-10-Duplicate. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Am-241	0.221	0.234	0.237	0.279	pCi/L	62.4	RD3302
Pu-238	-0.334	0.620	0.673	0.275	pCi/L	72.5	RD3209
Pu-239/40	0.230	0.230	0.232	0.156	pCi/L	72.5	RD3209
U-234	1.65	0.643	0.681	0.330	pCi/L	67.4	RD3234
U-235	0.0371	0.126	0.126	0.349	pCi/L	67.4	RD3234
U-238DA	1.67	0.643	0.681	0.249	pCi/L	67.4	RD3234
Co-58	-0.393	4.09	4.09	7.70	pCi/L	N/A	RD3219
Co-60	0.767	5.26	5.26	10.3	pCi/L	N/A	RD3219
Cs-137DA	-8.08	5.07	5.14	7.27	pCi/L	N/A	RD3219
Eu-152	-2.99	11.8	11.8	19.1	pCi/L	N/A	RD3219
Eu-154	8.08	10.4	10.5	24.1	pCi/L	N/A	RD3219
Eu-155	4.17	8.80	8.81	14.9	pCi/L	N/A	RD3219
Fe-59	3.32	8.60	8.60	17.9	pCi/L	N/A	RD3219
Alpha	1.79	1.22	1.24	1.53	pCi/L	100.0	RD3214
Beta	29.9	2.95	3.63	2.89	pCi/L	100.0	RD3214

Table A1-2j. Radionuclide Laboratory Results for Groundwater Sample HT-94-10-Duplicate. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Am-241	0.221	0.234	0.237	0.279	pCi/L	62.4	RD3302
Strontium	0.207	0.282	0.287	0.750	pCi/L	98.9	ITAS-IT-RS-001
Tc-99	114.0	2.12	15.4	2.12	pCi/L	95.1	RD3205
Tritium	484.0	118.0	227.0	243.0	pCi/L	97.7	RD4003

Radioisotopes (Method - Laboratory Specific).
MDA = Minimum detectable activity.

Table A1-3a. Field Results from Well Head and Portable Field Laboratory for Groundwater Samples HT-94-15 and HT-94-16-Split.

Sample Numbers	HT-94-15 HT-94-16 (split)	Depth	268.54 feet	Date	9-16-94
Location	299-W11-37	Sampling Method		Hydrostar* pump	
Constituent (units)	Results	Constituent (units)		Results	
Well Head Measurements					
pH	7.88	DO (mg/L)		6.64	
Temperature (°C)	18.7	ORP (mV)		+200.1	
SC (μmhos/cm)	356	---		---	
Portable Field Laboratory Measurements					
Nitrate (ppb)	4,220	Nitrite (ppb)		54.3	
Sulfate (ppb)	26,670	Sulfide (ppb)		ND	
Total chromium (ppb)	16.7	Hexavalent Chromium (ppb)		16.7	
Total Fe (ppb)	11.7	Ferrous Fe (ppb)		<10	
Chloride (ppb)	13,600	Alkalinity (ppb)		NM	
Copper (ppb)	63.3	Phosphate (ppb)		153.3	

*Hydrostar is a trademark of Instrumentation Northwest Incorporated.
DO = Dissolved Oxygen.
ORP = Oxidation-Reduction Potential.
SC = Specific Conductance or Conductivity.
ND = not detected.
NM = not measured.

Table A1-3b. ICP and AA Metals Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16. (2 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT=94-16 Result (μg/L)	DL1/DL2 (μg/L)
Aluminum[1] - Unfiltered	7429-90-5	345	270	200/200
Aluminum[2] - Filtered	7429-90-5	36.9	<57	200/200
Antimony[1] - U	7440-36-0	30.5	<46	100/60
Antimony[2] - F	7440-36-0	30.5	<46	100/60
Arsenic[3] - U	7440-38-2	2.5	<3	3.0/10
Arsenic[3] - F	7440-38-2	2.3	4.2	3.0/10
Barium[1] - U	7440-39-3	56.8	57	200/200
Barium[2] - F	7440-39-3	53.4	50	200/200
Beryllium[1] - U	7440-41-7	0.51	<1	7.0/5.0
Beryllium[2] - F	7440-41-7	0.20	<1	7.0/5.0
Cadmium[1] - U	7440-43-9	2.2	<4	20.0/5.0
Cadmium[2] - F	7440-43-9	2.2	<4	20.0/5.0
Calcium[1] - U	7440-70-2	40,700	41,000	5000/5000
Calcium[2] - F	7440-70-2	44,100	41,000	5000/5000
Chromium[1] - U	7440-47-3	22.6	21	20.0/10.0
Chromium[2] - F	7440-47-3	3.0	<5	2.0/10.0
Cobalt[1] - U	7440-48-4	3.2	<10	20.0/50.0
Cobalt[2] - F	7440-48-4	3.2	<10	2.0/50.0
Copper[1] - U	7440-50-8	22.4	9.1	20.0/25.0
Copper[2] - F	7440-50-8	14.0	<5	2.0/25.0
Iron[1] - U	7439-89-6	924	810	100/100
Iron[2] - F	7439-89-6	20.5	<10	100/100
Lead[4] - U	7439-92-1	0.90	2.5	3.0/3.0
Lead[4] - F	7439-92-1	0.90	<2	3.0/3.0
Magnesium[1] - U	7439-95-4	13,200	13,000	5000/5000

Table A1-3b. ICP and AA Metals Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16. (2 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT-94-16 Result (μg/L)	DL1/DL2 (μg/L)
Magnesium[2] - F	7439-95-4	14,700	13,000	5000/5000
Manganese[1] - U	7439-96-5	144	140	10.0/15.0
Manganese[2] - F	7439-96-5	134	130	10.0/15.0
Mercury[5] - U	7439-97-6	0.10	0.2	0.2/0.2
Mercury[5] - F	7439-97-6	0.10	<0.2	0.2/0.2
Nickel[1] - U	7440-02-0	13.0	19	40.0/40.0
Nickel[2] - F	7440-02-0	13.3	<12	40.0/40.0
Potassium[1] - U	7440-09-7	4380	4,200	5000/5000
Potassium[2] - F	7440-09-7	4090	4,100	1000/5000
Selenium[6] - U	7782-49-2	0.70	<3	3.0/5.0
Selenium[6] - F	7782-49-2	0.70	<3	3.0/5.0
Silver[1] - U	7440-22-4	3.0	<7	200/10.0
Silver[2] - F	7440-22-4	3.0	<7	200/10.0
Sodium[1] - U	7440-23-5	12,900	15,000	1000/5000
Sodium[2] - F	7440-23-5	14,700	13,000	1000/5000
Thallium[7] - U	7440-28-0	1.4	<4	3.0/10.0
Thallium[7] - F	7440-28-0	1.4	<4	3.0/10.0
Vanadium[1] - U	7440-62-2	26.1	<14	20.0/50.0
Vanadium[2] - F	7440-62-2	21.9	<14	20.0/50.0
Zinc[1] - U	7440-66-6	24.2	35	20.0/20.0
Zinc[2] - F	7440-66-6	6.8	<10	20.0/20.0

Inductively Coupled Plasma metals (EPA Method 6010[1] and EPA CLP ICAP Metals[2]).
Atomic Absorption metals (EPA Methods 7060[3], 7421[4], 7470[5], 7740[6], 7841[7]).
CAS = Chemical Abstract Services.
DL1 = detection limit, first sample.
DL2 = detection limit, second sample-split.

Table A1-3c. Anion Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split.

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT=94-16 Result (μg/L)	DL1/DL2 (μg/L)
Chloride[1]	16887-00-6	9,400	9,800	250/20
Fluoride[1]	16984-48-8	490	560	100/50
Nitrate[1]	14797-55-8	4,100	3,700	200/20
Nitrite[1]	7632-00-0	58	56	20/10
o-Phosphate[1]	7778-77-0	<1,000	<43	1,000/100
Sulfate[1]	14808-79-8	23,900	23,000	1,000/100
Sulfide[2]	18496-25-8	310	<1000	200/3000

Anions (EPA Method 300.0[1] and Method 9030[2]).
CAS = Chemical Abstract Services.
DL1 = detection limit, first sample
DL2 = detection limit, second sample-split.

Table A1-3d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (3 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT-94-16 Result (μg/L)	DL1/DL2 (μg/L)
Dichlorodifluoromethane	75-71-8	<5	<5	5/5
Chloromethane	74-87-3	<10	<10	10/10
Bromomethane	74-83-9	<10	<10	10/10
Vinyl Chloride	75-01-4	<10	<10	10/10
Chloroethane	75-00-3	<10	<10	10/10
Acrolein	107-02-8	<100	<50	100/50
Methylene Chloride	75-09-2	<5	<5	5/5
Acetone	67-64-1	<100	<100	100/100
Trichlorofluoromethane	75-69-4	<5	<5	5/5
Allyl Chloride	107-95-1	<5	<20	5/20
Carbon Disulfide	75-15-0	<5	<5	5/5
trans-1,2-Dichloroethene	156-60-5	<5	<5	5/5
1,1-Dichloroethene	75-35-4	<5	<5	5/5
Acetonitrile	75-05-8	<100	<10	100/10
Acrylonitrile	107-13-1	<100	<15	100/15
Propionitrile	107-12-0	<100	<5	100/5
1,1-Dichloroethane	75-34-3	<5	<5	5/5
Iodomethane	74-88-4	<5	<5	5/5
Chloroform	67-66-3	7	5.5	5/5
1,2-Dichloroethane	107-06-2	<5	<5	5/5
2-Chloro-1,3-butadiene	126-99-8	<5	<10	5/10
Methacrylonitrile	126-98-7	<100	<20	100/20
2-Butanone	78-93-3	<100	<50	100/50
Isobutyl Alcohol	78-83-1	<500	<250	500/250
1,1,1-Trichloroethane	71-55-6	<5	<5	5/5

Table A1-3d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (3 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT-94-16 Result (μg/L)	DL1/DL2 (μg/L)
Carbon Tetrachloride	56-23-5	50	38	5/5
Vinyl Acetate	108-05-4	<50	<10	50/10
Bromodichloromethane	75-27-4	<5	<5	5/5
1,2-Dichloropropane	78-87-5	<5	<5	5/5
cis-1,3-Dichloropropene	10061-01-5	<5	<5	5/5
Methyl methacrylate	80-62-6	<5	<20	5/20
Trichloroethene	79-01-6	<5	<5	5/5
Ethyl methacrylate	97-63-2	<5	<20	5/20
1,1,2-Trichloroethane	79-00-5	<5	<5	5/5
Benzene	71-43-2	<5	<5	5/5
Dibromomethane	74-95-3	<5	<5	5/5
trans-1,3-Dichloropropene	10061-02-6	<5	<5	5/5
Bromoform	75-25-2	<5	<5	5/5
1,2-Dibromomethane	106-93-4	<5	<5	5/5
1,4-Dioxane	23-91-1	<500	<150	500/150
4-Methyl-2-Pentanone	108-10-1	<50	<50	50/50
2-Hexanone	591-78-6	<50	<50	50/50
Tetrachloroethene	127-18-4	<5	<5	5/5
1,1,2,2-Tetrachloroethane	79-34-5	<5	<5	5/5
Dibromochloromethane	124-48-1	<5	<5	5/5
Toluene	108-88-3	<5	<5	5/5
Chlorobenzene	108-90-7	<5	<5	5/5
Ethyl benzene	100-41-4	<5	<5	5/5
Styrene	100-42-5	<5	<5	5/5
trans-1,4-Dichloro-2-butene	764-41-0	<100	<5	100/5

Table A1-3d. Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (3 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT-94-16 Result (μg/L)	DL1/DL2 (μg/L)
Xylenes (total)	1330-20-7	<5	<5	5/5
Pentachloroethane	76-01-7	<5	<20	10/20
1,2,3-Trichloropropane	96-18-4	<5	<5	5/5
1,2-Dibromo-3-chloropropane	96-12-8A	<100	<5	100/5
1,1,1,2-Tetrachloroethane	630-20-6	---	---	---/---

Volatiles (Method EPA 8240).
CAS = Chemical Abstract Services.
DL1 = detection limit, first sample.
DL2 = detection limit, second sample-split.

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT=94-16 Result (μg/L)	DL1/DL2 (μg/L)
n-Nitrosodimethylamine	62-75-9	<10	<20	10/20
Pyridine	110-86-1	<10	<50	10/50
Phenol	108-95-2	<10	<20	10/20
Aniline	62-53-3	<10	<30	10/30
bis(2-Chloroethyl) Ether	111-44-4	<10	<20	10/20
2-Chlorophenol	95-57-8	<10	<40	10/40
1,3-Dichlorobenzene	541-73-1	<10	<5	10/5
1,4-Dichlorobenzene	106-46-7	<10	<5	10/5
Benzyl Alcohol	100-51-6	<20	<25	20/25
1,2-Dichlorobenzene	95-50-1	<10	<5	10/5
2-Methylphenol	95-48-7	<10	<30	10/30
bis(2-Chloroisopropyl) Ether	108-60-1	<10	<20	10/20
4-Methylphenol	65794-96-9	<10	<100	10/100
n-Nitroso-di-n-propylamine	621-64-7	<10	<30	10/30
Hexachloroethane	67-72-1	<10	<20	10/20
Nitrobenzene	98-95-3	<10	<20	10/20
Isophorone	78-59-1	<10	<20	10/20
2-Nitrophenol	88-75-5	<10	<30	10/30
2,4-Dimethylphenol	105-67-9	<10	<30	10/30
bis(2-Chloroethoxy)Methane	111-91-1	<10	<30	10/30
2,4-Dichlorophenol	120-83-2	<10	<30	10/30
1,2,4-Trichlorobenzene	120-82-1	<10	<5	10/5
Naphthalene	91-20-3	<10	<10	10/10
4-Chloroaniline	106-47-8	<20	<30	20/30
Hexachlorobutadiene	87-68-3	<10	<10	10/10

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (µg/L)	HT-94-16 Result (µg/L)	DL1/DL2 (µg/L)
4-Chloro-3-Methylphenol	59-50-7	<20	<30	20/30
2-Methylnaphthalene	91-57-6	<10	<20	10/20
Hexachlorocyclopentadiene	77-47-4	<10	<10	10/10
2,4,6-Trichlorophenol	88-06-2	<10	<30	10/30
2,4,5-Trichlorophenol	95-95-4	<10	<40	10/40
2-Chloronaphthalene	91-58-7	<10	<10	10/10
2-Nitroaniline	88-74-4	<50	<50	50/50
Dimethyl Phthlate	131-11-3	<10	<20	10/20
Acenaphthylene	208-96-8	<10	<10	10/10
2,6-Dinitrotoluene	606-20-2	<10	<10	10/10
3-Nitroaniline	99-09-2	<50	<50	50/50
Acenaphthene	83-32-9	<10	<10	10/10
2,4-Dinitrophenol	51-28-5	<50	<50	50/50
4-Nitrophenol	100-02-7	<50	<50	50/50
Dibenzofuran	132-64-9	<10	<10	10/10
2,4-Dinitrotoluene	121-14-2	<10	<10	10/10
Diethylphthlate	84-66-2	<10	<10	10/10
4-Chlorophenyl Phenyl Ether	7005-72-3	<10	<10	10/10
Fluorene	86-73-7	<10	<10	10/10
4-Nitroaniline	100-01-6	<20	<50	20/50
4,6-Dinitro-2-Methylphenol	534-52-1	<50	<50	50/50
n-Nitrosodiphenylamine	86-30-6	<10	---	10/--
4-Bromophenyl Phenyl Ether	101-55-3	<10	---	10/--
Hexachlorobenzene	118-74-1	<10	<10	10/10
Pentachlorophenol	87-86-5	<50	<50	50/50

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT=94-16 Result (μg/L)	DL1/DL2 (μg/L)
Phenanthrene	85-01-8	<10	<10	10/10
Anthracene	120-12-7	<10	<10	10/10
di-N-Butylphthlate	84-74-2	<10	4.2[a,b]	10/10
Fluoranthene	206-44-0	<10	<10	10/10
Pyrene	129-00-0	<10	<10	10/10
Butyl Benzyl Phthlate	85-68-7	<10	<10	10/10
3,3-Dichlorobenzidine	91-94-1	<20	<40	20/40
Benzo(a)Anthracene	56-55-3	<10	<10	10/10
Chrysene	218-01-9	<10	<10	10/10
bis(2-Ethylhexyl)Phthlate	117-81-7	3[b]	<30	10/30
di-N-Octyl Phthlate	117-84-0	<10	<10	10/10
Benzo(b)Fluoranthene	205-99-2	<10	<10	10/10
Benzo(k)Fluoranthene	207-08-9	<10	<10	10/10
Benzo(a)Pyrene	50-32-8	<10	<10	10/10
Indeno(1,2,3-CD)Pyrene	193-39-5	<10	<10	10/10
Dibenzo(a,h)Anthracene	53-70-3	<10	<10	10/10
Benzo(g,h,i)Perylene	191-24-2	<10	<10	10/10
Acetophenone	10383-88-7	<10	<15	10/15
2-Acetylaminofluorene	53-96-3	<20	<20	20/20
4-Aminobiphenyl	92-67-1	<20	<50	20/50
Aramite I	140-57-8A	<20	<30	20/30
Aramite II	140-57-8B	<20	<30	20/30
Chlorobenzilate	510-15-6	<10	<20	10/20
Diallate I	2303-16-4A	<20	<20	20/20
Diallate II	2303-16-4B	<20	<20	20/20

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (µg/L)	HT-94-16 Result (µg/L)	DL1/DL2 (µg/L)
2,6-Dichlorophenol	87-65-0	<10	<30	10/30
Dimethoate	60-51-5	<20	<10	20/10
p-Dimethylaminoazobenzene	60-11-7	<10	---	10/--
7,12-Dimethylbenz(a)Anthracene	57-97-6	<10	<10	10/10
3,3-Dimethylbenzidine	119-93-7	<10	<160	10/160
a,a-Dimethylphenethylalamine	122-09-8	<10	<30	10/30
1,3-Dinitrobenzene	99-65-0	<20	<10	20/10
Dinoseb	88-85-7	<20	<30	20/30
Disulfoton	298-04-4	<10	<20	10/20
Ethyl Methanesulfonate	62-50-0	<20	<20	20/20
Famphur	52-85-7	<50	<20	50/20
Hexachloropropene	1888-71-7	<10	<10	10/10
Isodrin	465-73-6	<20	---	20/--
Isosafrole	120-58-1	<10	<10	10/10
D-Kepone	143-50-0	<50	---	50/--
Methapyrilene	91-80-5	<100	<100	100/100
3-Methylcholanthrene	56-49-5	<10	<10	10/10
Methyl Methanesulfonate	66-27-3	<10	<20	10/20
Methyl Parathion	298-00-0	<10	<20	10/20
1,4-Naphthoquinone	130-15-4	<10	<20	10/20
1-Naphthylamine	134-32-7	<10	<50	10/50
2-Naphthylamine	91-59-8	<10	<50	10/50
5-Nitro-o-toluidine	99-55-8	<10	<30	10/30
4-Nitroquinoline-1-oxide	56-57-5	<40	<20	40/20
n-Nitroso-di-n-butylamine	924-16-3	<10	<20	10/20

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT=94-16 Result (μg/L)	DL1/DL2 (μg/L)
n-Nitrosodiethylamine	55-18-5	<20	<30	20/30
n-Nitrosopiperdine	100-75-4	<20	<20	20/20
n-Nitrosopyrrolidine	930-55-2	<40	<40	40/40
Parathion	56-38-2	<10	<20	10/20
Pentachlorobenzene	608-93-5	<10	<10	10/10
Pentachloroethane	76-01-7	---	---	10/--
Pentachloronitrobenzene	82-68-8	<20	<10	20/10
Phenacetin	62-44-2	<20	<30	20/30
1,4-Phenylenediamine	106-50-3	<100	<160	100/160
n-Nitrosomethylethylamine	10595-95-6	<10	<30	10/30
n-Nitrosomorpholine	59-89-2	<10	<40	10/40
Pronamide	23950-58-5	<20	<20	20/20
Safrole	94-59-7	<10	<10	10/10
1,2,4,5-Tetrachlorobenzene	95-94-3	<10	<10	10/10
2,3,4,6-Tetrachlorophenol	58-90-2	<10	<30	10/30
Sulfotepp	3689-24-5	<40	---	40/--
Thioazin	297-97-2	<20	<20	20/20
o-Toluidine	95-53-4	<10	<30	10/30
1,3,5-Trinitrobenzene	99-35-4	<50	<10	50/10
o,o,o-triethyl Phosphorothioat	126-68-1	<20	<30	20/30
Phorate	298-02-2	<10	<20	10/20
2-Picoline	109-06-8	<10	<30	10/30

Table A1-3e. Semi-Volatile Organic Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split. (6 sheets)

Constituent	CAS Number	HT-94-15 Result (μg/L)	HT-94-16 Result (μg/L)	DL1/DL2 (μg/L)
Hexachlorophene	70-30-4	<100	<160	100/160
Phthalic Anhydride	85-44-9	---	<1000	---/1000
Diphenylamine	122-39-4	---	<30	---/30

[a]Result is from blank contamination.
[b]Value is estimated, because it is below a detection limit.
Semi-volatiles (Method EPA 8270).
CAS = Chemical Abstract Services.
DL1 = detection limit, first sample.
DL2 = detection limit, second sample-split.

Table A1-3f. Tritium Laboratory Results for Groundwater Samples HT-94-15 and HT-94-16-Split.

Constituent-Tritium	Result	Counting error (2σ)	Total error (2σ)	MDA	Units	Yield (%)	Method number
Sample HT-94-15	337.0	114.0	217.0	242.0	pCi/L	97.7	RD3303
Sample HT-94-16	380.0	190.0	---	260.0	pCi/L	---	?

Radioisotopes (Method - Laboratory Specific).
MDA = Minimum detectable activity.
? = unknown laboratory method number.

APPENDIX A2

GROUNDWATER DATA - FIELD AND LABORATORY RESULTS FOR WELL 299-W11-14 (UPGRADIENT WELL FOR 216-T-1 DITCH)

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GROUNDWATER DATA - FIELD AND LABORATORY RESULTS FOR WELL 299-W11-14 (UPGRADIENT WELL FOR 216-T-1 DITCH)

The results given on the following pages are from a sample collected during the early fall of 1994, for the purpose of obtaining recent chemistry data from well 299-W11-14, which is located upgradient from the 216-T-1 Ditch. The results are given in table form as a whole sample set, in the following order of analysis type:

1. Field Analyses (Table A2-2).

   a. Field parameters measured at the well head:

      - depth to water
      - pH
      - temperature
      - specific conductance (conductivity)
      - dissolved oxygen
      - oxidation-reduction potential
      - turbidity.

   b. Field parameters measured in portable field laboratory:

      - sulfate
      - nitrate
      - total iron
      - total chromium
      - copper
      - chloride
      - sulfide
      - nitrite
      - ferrous iron
      - hexavalent chromium
      - phosphate
      - alkalinity.

2. Laboratory Analyses (Table A2-3).

   a. Inductively Coupled Plasma (ICP) Metals - Unfiltered and Filtered: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc

   b. Atomic Absorption (AA) Metals - Unfiltered and Filtered: arsenic, lead, mercury, selenium, and thallium

   c. Anions - Unfiltered: chloride, fluoride, nitrate, nitrite, orthophosphate, sulfate, and sulfide

   d. Volatile Organics - Unfiltered

   e. Semi-Volatile Organics - Unfiltered

   f. Herbicides - Unfiltered

   g. Organophosphate Pesticides - Unfiltered

   h. Pesticides and polychlorinated biphenyls (PCBs) - Unfiltered

i. Radionuclides - Unfiltered: total alpha, total beta, gamma spectroscopy, Americium-241, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, tritium, and Technetium-99

j. Total Activity Screening - 222-S Laboratory.

Table A2-1 lists all the samples taken at this well and gives all of the identification numbers used for each sample set. The following is an explanation of three of the most common types of sample numbers these samples were given.

- HC Number - A number assigned to all samples collected by Hydrochemistry and Geochemistry personnel performing special projects. The numbers are assigned in consecutive order and have the following format:

  HC-94-xx

  where:

  HC = Hydrochemistry.
  94 = Year sample was taken.
  xx = Next consecutive number, starting with 1 and ending with last number used in a given year.

- HEIS Number - A number assigned by Hanford Analytical Services Management (HASM) for samples being submitted to an offsite laboratory. Numbers are chosen from lists controlled by HASM and following their format (DOE-RL 1994a, 1994b). Usually has a six-digit format, using a combination of letters and numbers.

- 222-S Laboratory Number - For total activity analysis. Number has the following format:

  N-xxxx

  where:

  N = 222-S Laboratory Designation.
  xxxx = next consecutive number in 222-S logbook.

REFERENCES

DOE-RL, 1994a, *Hanford Environmental Information System (HEIS): Volume 1 User's Guide*, DOE-RL-93-24-1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994b, *Hanford Environmental Information System (HEIS): Volume 2 Operator' Guide*, DOE-RL-93-24-2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Table A2-1. List of Sample(s) Taken at Well 299-W11-14.

HC Number	Other Identifying Number(s) (HEIS/222-S)	Description of Sample
HC-94-17	B0D0J7 N2962	Groundwater at 299-W11-14; Depth = 258.76 ft; Date = 9-27-94

Table A2-2a. Field Results from Well Head and Portable Field Laboratory for Groundwater Sample HT-94-17.

Sample Numbers	HT-94-17	Depth	258.76 feet	Date	9-27-94
Location	299-W11-14	Sampling Method		Submersible Pump	
Constituent (units)	Results	Constituent (units)		Results	
Well Head Measurements					
pH	7.70	DO (mg/L)		7.75	
Temperature (°C)	20.7	ORP (mV)		+275.6	
SC (μmhos/cm)	825	Turbidity (NTU)		NM	
Portable Field Laboratory Measurments					
Nitrate (ppb)	23,800	Nitrite (ppb)		4.3	
Sulfate (ppp)	86,700	Sulfide (ppb)		2	
Total Chromium (ppb)	10	Hexavalent Chromium (ppb)		10	
Total Fe (ppb)	10	Ferrous Fe (ppb)		<10	
Chloride (ppb)	71,750	Alkalinity (ppb)		107,700	
Phosphate (ppb)	70	---		---	

DO = dissolved oxygen.
NM = not measured.
ORP = oxidation-reduction potential.
SC = specific conductance or conductivity.
NTU = Nephelometric Turbidity Unit.
ND = not detected.

Table A2-2b. ICP and AA Metals Laboratory Results for Groundwater Sample HT-94-17. (2 sheets

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Aluminum[1] - Unfiltered (U)	7429-90-5	24.9	200
Aluminum[2] - Filtered (F)	7429-90-5	24.9	200
Antimony[1] - U	7440-36-0	46.2	100
Antimony[2] - F	7440-36-0	46.2	100
Arsenic[3] - U	7440-38-2	1.8	3.0
Arsenic[3] - F	7440-38-2	1.8	3.0
Barium[1] - U	7440-39-3	58.8	200
Barium[2] - F	7440-39-3	64.00	200
Beryllium[1] - U	7440-41-7	0.90	7.0
Beryllium[2] - F	7440-41-7	0.90	7.0
Cadmium[1] - U	7440-43-9	3.7	20.0
Cadmium[2] - F	7440-43-9	3.7	20.0
Calcium[1] - U	7440-70-2	82,700	5,000
Calcium[2] - F	7440-70-2	90,400	5,000
Chromium[1] - U	7440-47-3	4.4	20.0
Chromium[2] - F	7440-47-3	3.4	2.0
Cobalt[1] - U	7440-48-4	3.2	20.0
Cobalt[2] - F	7440-48-4	3.2	2.0
Copper[1] - U	7440-50-8	15.3	20.0
Copper[2] - F	7440-50-8	16.3	2.0
Iron[1] - U	7439-89-6	235	100
Iron[2] - F	7439-89-6	39.8	100
Lead[4] - U	7439-92-1	1.1	3.0
Lead[4] - F	7439-92-1	1.0	3.0
Magnesium[1] - U	7439-95-4	28,100	5,000
Magnesium[2] - F	7439-95-4	30,600	5,000

Table A2-2b. ICP and AA Metals Laboratory Results for Groundwater Sample HT-94-17. (2 sheets

Constituent	CAS Number	Result (µg/L)	DL (µg/L)
Manganese[1] - U	7439-96-5	6.9	10.0
Manganese[2] - F	7439-96-5	6.8	10.0
Mercury[5] - U	7439-97-6	0.10	0.2
Mercury[5] - F	7439-97-6	0.10	0.2
Nickel[1] - U	7440-02-0	15.5	40.0
Nickel[2] - F	7440-02-0	15.5	40.0
Potassium[1] - U	7440-09-7	2,630	5,000
Potassium[2] - F	7440-09-7	4,520	1,000
Selenium[6] - U	7782-49-2	3.4	3.0
Selenium[6] - F	7782-49-2	3.4	3.0
Silver[1] - U	7440-22-4	3.7	200
Silver[2] - F	7440-22-4	3.7	200
Sodium[1] - U	7440-23-5	33,200	1,000
Sodium[2] - F	7440-23-5	36,300	1,000
Thallium[7] - U	7440-28-0	0.70	3.0
Thallium[7] - F	7440-28-0	0.70	3.0
Vanadium[1] - U	7440-62-2	30.6	20.0
Vanadium[2] - F	7440-62-2	34.7	20.0
Zinc[1] - U	7440-66-6	17.3	20.0
Zinc[2] - F	7440-66-6	5.8	20.0

Inductively Coupled Plasma metals (EPA Method 6010[1] and EPA CLP ICAP Metals[2]).

Atomic Absorption (AA) metals (EPA Methods 7060[3], 7421[4], 7470[5], 7740[6], 7841[7]).

CAS = Chemical Abstract Services.

DL = detection limit.

Table A2-2c. Anion Laboratory Results for Groundwater Sample HT-94-17.

Constituent	CAS Number	Result (mg/L)	DL (mg/L)
Chloride[1]	16887-00-6	66.9	0.25
Fluoride[1]	16984-48-8	0.57	0.10
Nitrate[1]	14797-55-8	28.5	0.20
Nitrite[1]	7632-00-0	<0.02	0.02
o-Phosphate[1]	7778-77-0	<1.00	1.00
Sulfate[1]	14808-79-8	71.5	1.00
Sulfide[2]	18496-25-8	0.43	0.20

Anions (EPA Method 300.0[1] and Method 9030[2]).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2d. Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (3 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Dichlorodifluoromethane	75-71-8	<5	5
Chloromethane	74-87-3	<10	10
Bromomethane	74-83-9	<10	10
Vinyl Chloride	75-01-4	<10	10
Chloroethane	75-00-3	<10	10
Acrolein	107-02-8	<100	100
Methylene Chloride	75-09-2	2[a]	5
Acetone	67-64-1	10[a]	100
Trichlorofluoromethane	75-69-4	<5	5
Allyl Chloride	107-95-1	<5	5
Carbon Disulfide	75-15-0	<5	5
trans-1,2-Dichloroethene	156-60-5	<5	5
1,1-Dichloroethene	75-35-4	<5	5
Acetonitrile	75-05-8	<100	100
Acrylonitrile	107-13-1	<100	100
Propionitrile	107-12-0	<100	100
1,1-Dichloroethane	75-34-3	<5	5
Iodomethane	74-88-4	<5	5
Chloroform	67-66-3	<5	5
1,2-Dichloroethane	107-06-2	<5	5
2-Chloro-1,3-butadiene	126-99-8	<5	5
Methacrylonitrile	126-98-7	<100	100
2-Butanone	78-93-3	<100	100
Isobutyl Alcohol	78-83-1	<500	500
1,1,1-Trichloroethane	71-55-6	<5	5
Carbon Tetrachloride	56-23-5	<5	5

Table A2-2d. Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (3 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Vinyl Acetate	108-05-4	<50	50
Bromodichloromethane	75-27-4	<5	5
1,2-Dichloropropane	78-87-5	<5	5
cis-1,3-Dichloropropene	10061-01-5	<5	5
Methyl methacrylate	80-62-6	<5	5
Trichloroethene	79-01-6	<5	5
Ethyl methacrylate	97-63-2	<5	5
1,1,2-Trichloroethane	79-00-5	<5	5
Benzene	71-43-2	<5	5
Dibromomethane	74-95-3	<5	5
trans-1,3-Dichloropropene	10061-02-6	<5	5
Bromoform	75-25-2	<5	5
1,2-Dibromomethane	106-93-4	<5	5
1,4-Dioxane	23-91-1	<500	500
4-Methyl-2-Pentanone	108-10-1	<50	50
2-Hexanone	591-78-6	<50	50
Tetrachloroethene	127-18-4	<5	5
1,1,2,2-Tetrachloroethane	79-34-5	<5	5
Dibromochloromethane	124-48-1	<5	5
Toluene	108-88-3	1[a]	5
Chlorobenzene	108-90-7	<5	5
Ethyl benzene	100-41-4	<5	5
Styrene	100-42-5	<5	5
trans-1,4-Dichloro-2-butene	764-41-0	<100	100
Xylenes (total)	1330-20-7	<5	5
Pentachloroethane	76-01-7	<10	10

Table A2-2d. Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (3 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
1,2,3-Trichloropropane	96-18-4	<5	5
1,2-Dibromo-3-chloropropane	96-12-8A	<100	100

[a]Value is estimated, because it is below a detection limit.
Volatiles (Method EPA 8240).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2e. Semi-Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (5 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
n-Nitrosodimethylamine	62-75-9	<10	10
Pyridine	110-86-1	<10	10
Phenol	108-95-2	<10	10
Aniline	62-53-3	<10	10
bis(2-Chloroethyl) Ether	111-44-4	<10	10
2-Chlorophenol	95-57-8	<10	10
1,3-Dichlorobenzene	541-73-1	<10	10
1,4-Dichlorobenzene	106-46-7	<10	10
Benzyl Alcohol	100-51-6	<20	20
1,2-Dichlorobenzene	95-50-1	<10	10
2-Methylphenol	95-48-7	<10	10
bis(2-Chloroisopropyl) Ether	108-60-1	<10	10
4-Methylphenol	65794-96-9	<10	10
n-Nitroso-di-n-propylamine	621-64-7	<10	10
Hexachloroethane	67-72-1	<10	10
Nitrobenzene	98-95-3	<10	10
Isophorone	78-59-1	<10	10
2-Nitrophenol	88-75-5	<10	10
2,4-Dimethylphenol	105-67-9	<10	10
bis(2-Chloroethoxy)Methane	111-91-1	<10	10
2,4-Dichlorophenol	120-83-2	<10	10
1,2,4-Trichlorobenzene	120-82-1	<10	10
Naphthalene	91-20-3	<10	10
4-Chloroaniline	106-47-8	<20	20
Hexachlorobutadiene	87-68-3	<10	10

Table A2-2e. Semi-Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (5 sheets)

Constituent	CAS Number	Result (µg/L)	DL (µg/L)
4-Chloro-3-Methylphenol	59-50-7	<20	20
2-Methylnaphthalene	91-57-6	<10	10
Hexachlorocyclopentadiene	77-47-4	<10	10
2,4,6-Trichlorophenol	88-06-2	<10	10
2,4,5-Trichlorophenol	95-95-4	<10	10
2-Chloronaphthalene	91-58-7	<10	10
2-Nitroaniline	88-74-4	<50	50
Dimethyl Phthlate	131-11-3	<10	10
Acenaphthylene	208-96-8	<10	10
2,6-Dinitrotoluene	606-20-2	<10	10
3-Nitroaniline	99-09-2	<50	50
Acenaphthene	83-32-9	<10	10
2,4-Dinitrophenol	51-28-5	<50	50
4-Nitrophenol	100-02-7	<50	50
Dibenzofuran	132-64-9	<10	10
2,4-Dinitrotoluene	121-14-2	<10	10
Diethylphthlate	84-66-2	<10	10
4-Chlorophenyl Phenyl Ether	7005-72-3	<10	10
Fluorene	86-73-7	<10	10
4-Nitroaniline	100-01-6	<20	20
4,6-Dinitro-2-Methylphenol	534-52-1	<50	50
n-Nitrosodiphenylamine	86-30-6	<10	10
4-Bromophenyl Phenyl Ether	101-55-3	<10	10
Hexachlorobenzene	118-74-1	<10	10
Pentachlorophenol	87-86-5	<50	50

Table A2-2e. Semi-Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (5 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Phenanthrene	85-01-8	<10	10
Anthracene	120-12-7	<10	10
di-N-Butylphthlate	84-74-2	<10	10
Fluoranthene	206-44-0	<10	10
Pyrene	129-00-0	<10	10
Butyl Benzyl Phthlate	85-68-7	<10	10
3,3-Dichlorobenzidine	91-94-1	<20	20
Benzo(a)Anthracene	56-55-3	<10	10
Chrysene	218-01-9	<10	10
bis(2-Ethylhexyl)Phthlate	117-81-7	<10	10
di-N-Octyl Phthlate	117-84-0	<10	10
Benzo(b)Fluoranthene	205-99-2	<10	10
Benzo(k)Fluoranthene	207-08-9	<10	10
Benzo(a)Pyrene	50-32-8	<10	10
Indeno(1,2,3-CD)Pyrene	193-39-5	<10	10
Dibenzo(a,h)Anthracene	53-70-3	<10	10
Benzo(g,h,i)Perylene	191-24-2	<10	10
Acetophenone	10383-88-7	<10	10
2-Acetylaminofluorene	53-96-3	<20	20
4-Aminobiphenyl	92-67-1	<20	20
Aramite I	140-57-8A	<20	20
Aramite II	140-57-8B	<20	20
Chlorobenzilate	510-15-6	<10	10
Diallate I	2303-16-4A	<20	20
Diallate II	2303-16-4B	<20	20

Table A2-2e. Semi-Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (5 sheets)

Constituent	CAS Number	Result (µg/L)	DL (µg/L)
2,6-Dichlorophenol	87-65-0	<10	10
Dimethoate	60-51-5	<20	20
p-Dimethylaminoazobenzene	60-11-7	<10	10
7,12-Dimethylbenz(a)Anthracene	57-97-6	<10	10
3,3-Dimethylbenzidine	119-93-7	<10	10
a,a-Dimethylphenethylalamine	122-09-8	<10	10
1,3-Dinitrobenzene	99-65-0	<20	20
Dinoseb	88-85-7	<20	20
Disulfoton	298-04-4	<10	10
Ethyl Methanesulfonate	62-50-0	<20	20
Famphur	52-85-7	<50	50
Hexachloropropene	1888-71-7	<10	10
Isodrin	465-73-6	<20	20
Isosafrole	120-58-1	<10	10
D-Kepone	143-50-0	<50	50
Methapyrilene	91-80-5	<100	100
3-Methylcholanthrene	56-49-5	<10	10
Methyl Methanesulfonate	66-27-3	<10	10
Methyl Parathion	298-00-0	<10	10
1,4-Naphthoquinone	130-15-4	<10	10
1-Naphthylamine	134-32-7	<10	10
2-Naphthylamine	91-59-8	<10	10
5-Nitro-o-toluidine	99-55-8	<10	10
4-Nitroquinoline-1-oxide	56-57-5	<40	40
n-Nitroso-di-n-butylamine	924-16-3	<10	10

Table A2-2e. Semi-Volatile Organic Laboratory Results for Groundwater Sample HT-94-17. (5 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
n-Nitrosodiethylamine	55-18-5	<20	20
n-Nitrosopiperdine	100-75-4	<20	20
n-Nitrosopyrrolidine	930-55-2	<40	40
Parathion	56-38-2	<10	10
Pentachlorobenzene	608-93-5	<10	10
Pentachloroethane	76-01-7	<10	10
Pentachloronitrobenzene	82-68-8	<20	20
Phenacetin	62-44-2	<20	20
1,4-Phenylenediamine	106-50-3	<100	100
n-Nitrosomethylethylamine	10595-95-6	<10	10
n-Nitrosomorpholine	59-89-2	<10	10
Pronamide	23950-58-5	<20	20
Safrole	94-59-7	<10	10
1,2,4,5-Tetrachlorobenzene	95-94-3	<10	10
2,3,4,6-Tetrachlorophenol	58-90-2	<10	10
Sulfotepp	3689-24-5	<40	40
Thioazin	297-97-2	<20	20
o-Toluidine	95-53-4	<10	10
1,3,5-Trinitrobenzene	99-35-4	<50	50
o,o,o-triethyl Phosphorothioat	126-68-1	<20	20
Phorate	298-02-2	<10	10
2-Picoline	109-06-8	<10	10
Hexachlorophene	70-30-4	<100	100

Semi-volatiles (Method EPA 8270).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2f. Herbicide Laboratory Results for Groundwater Sample HT-94-17.

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Dalapon	75-99-0	<58	58
Dicamba	1918-00-9	<2.7	2.7
MCPA	94-74-6	<2,500	2,500
MCPP	93-65-2	<1,900	1,900
2,2-Dichloropropionic acid	120-36-5	<6.5	6.5
2,4-D	94-75-7	<12	12
2,4,5-TP (Silvex)	93-72-1	<1.7	1.7
2,4,5-T	93-76-5	<2.0	2.0
Dinoseb	88-85-7	<0.7	0.7
2,4-DB	94-82-6	<9.1	9.1

Herbicides (Method SW 8150).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2g. Organophosphate Pesticide Laboratory Results for Groundwater Sample HT-94-17.

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Demeton #1	298-03-3A	<1.2	1.2
Demeton #2	298-03-3B	<1.2	1.2
Diazinon	333-41-5	<2.0	2.0
Disulfoton	298-04-4	<0.7	0.7
Methyl Parathion	298-00-0	<1.2	1.2
Malathion	121-75-5	<1.1	1.1
Parathion	56-38-2	<0.6	0.6
Ethion	563-12-2	<0.6	0.6
Azinphos-methyl	86-50-0	<1.0	1.0

Organophosphate pesticides (Method EPA 8140).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2h. Pesticides and Polychlorinated Biphenyls (PCBs) Laboratory Results for Groundwater Sample HT-94-17. (2 sheets)

Constituent	CAS Number	Result (µg/L)	DL (µg/L)
alpha-BHC	319-84-6	<0.03	0.03
beta-BHC	319-85-7	<0.06	0.06
delta-BHC	319-86-8	<0.09	0.09
gamma-BHC (Lindane)	58-89-9	<0.04	0.04
Heptachlor	76-44-8	<0.03	0.03
Aldrin	309-00-2	<0.04	0.04
Heptachlor Epoxide	1024-57-3	<0.83	0.83
Endosulfan I	959-98-8	<0.14	0.14
Dieldrin	60-57-1	<0.02	0.02
4,4-DDE	72-55-9	<0.04	0.04
Endrin	72-43-5	<0.06	0.06
Endosulfan II	33213-65-9	<0.04	0.04
4,4-DDD	72-54-8	<0.11	0.11
Endosulfan Sulfate	1031-07-8	<0.66	0.66
4,4-DDT	50-29-3	<0.12	0.12
Methoxychlor	72-43-5	<1.8	1.8
Endrin Aldehyde	7421-93-4	<0.23	0.23
Chlordane	57-74-9	<0.14	0.14
Toxaphene	8001-35-2	<2.4	2.4
Arochlor-1016	12674-11-2	<0.65	0.65
Arochlor-1221	11104-28-2	<1.0	1.0
Arochlor-1232	11141-16-5	<1.0	1.0

Table A2-2h. Pesticides and Polychlorinated Biphenyls (PCBs) Laboratory Results for Groundwater Sample HT-94-17. (2 sheets)

Constituent	CAS Number	Result (μg/L)	DL (μg/L)
Arochlor-1242	53469-21-9	<0.65	0.65
Arochlor-1248	12672-29-6	<1.0	1.0
Arochlor-1254	11097-69-1	<1.0	1.0
Arochlor-1260	11096-82-5	<1.0	1.0

Pesticides and polychlorinated biphenyls (EPA Method 8080).
CAS = Chemical Abstract Services.
DL = detection limit.

Table A2-2i. Radionuclide Laboratory Results for Groundwater Sample HT-94-17. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Am-241	0.0435	0.0948	0.0951	0.190	pCi/L	76.8	RD3302
Pu-238	0.0799	0.160	0.161	0.216	pCi/L	52.2	RD3209
Pu-239/40	-0.0639	0.0639	0.0650	0.549	pCi/L	52.2	RD3209
U-234	35.2	7.06	15.5	1.99	pCi/L	11.8	RD3234
U-235	2.42	1.87	2.10	1.61	pCi/L	11.8	RD3234
U-238DA	39.8	7.51	17.3	1.99	pCi/L	11.8	RD3234
Co-58	1.81	3.22	3.23	6.69	pCi/L	N/A	RD3219
Co-60	-2.01	3.75	3.75	6.59	pCi/L	N/A	RD3219
Cs-137DA	-0.344	4.19	4.19	6.96	pCi/L	N/A	RD3219
Eu-152	1.82	8.82	8.82	16.4	pCi/L	N/A	RD3219
Eu-154	-18.1	15.2	15.3	21.0	pCi/L	N/A	RD3219
Eu-155	-1.26	7.10	7.10	11.5	pCi/L	N/A	RD3219
Fe-59	-1.41	8.32	8.32	15.6	pCi/L	N/A	RD3219
Alpha	71.7	9.36	11.4	2.49	pCi/L	100.0	RD3214
Beta	27.4	2.96	3.53	3.19	pCi/L	100.0	RD3214

Table A2-2i. Radionuclide Laboratory Results for Groundwater Sample HT-94-17. (2 sheets)

Constituent	Result	Counting Error (2σ)	Total Error (2σ)	MDA	Units	Yield (%)	Method Number
Strontium	-0.0084	0.333	0.333	1.11	pCi/L	64.9	ITAS-IT-RS-001
Tc-99	82.1	2.41	13.8	5.38	pCi/L	95.1	RD3205
Tritium	8630.0	270.0	770.0	234.0	pCi/L	97.3	RD4003

Radioisotopes (Method - Laboratory Specific).
MDA = Minimum detectable activity.

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APPENDIX A3

GROUNDWATER DATA FOR SELECTED UPGRADIENT WELLS AND ONE DOWNGRADIENT WELL FROM THE 216-T-1 DITCH

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GROUNDWATER DATA FOR SELECTED UPGRADIENT WELLS AND ONE DOWNGRADIENT WELL FROM THE 216-T-1 DITCH

Appendix A3 contains a Paradox[1] database print out of groundwater monitoring data for selected upgradient and downgraydient wells. Analytical results for four upgradient monitoring wells and one downgradient monitoring well near the 216-T-1 Ditch location are listed by well number, constituent name, and sampling date. Results are reported in the Hanford Environmental Information System database, which was queried for results in February of 1995. The time period covered by these results goes from January of 1980 through February of 1995.

Data Qualifiers. Qualifiers concerning the data are indicated with a letter code in the seventh column and are defined as follows:

B - Blank assoiated with analyte is elevated in concentration
D - Sample was diluted before analysis
E - Concentration is out of instrument calibration range
J - Concentration is estimated
U - Analyte concentration below contract required quantification limit
H - Laboratory holding time exceeded
R - Suspect data; currently under review
Q - Result associated with suspect quality control data
P - Potential problem.

It should also be noted that not all of the data in the table were reviewed at the time this report was prepared. Thus, some unflagged "suspect" data may exist in the table.

Significant Figures. No more than three significant figures are justified; any additional places are database format related.

Reference Levels. A summary of reference levels for constituents at the end of this appendix. Monitoring results listed in Tables A3-1 through A3-5 can be compared with either:

- the average natural background concentrations or the provisional threshold values (Johnson 1993), Table A3-6.
- the 95% Upper Confidence Interval/Bowen's Background Numbers, Table A3-7.
- the Maximum Contamination Levels and the 1/25 Derived Concentration Guide, Table A3-8.

[1]Paradox is a trademark of the Borland Company.

Table A3-1. Upgradient Well 299-W11-3. (5 sheets)

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-3	Aluminum	6/26/92	35			
299-W11-3	Aluminum, filtered	6/26/92	35		Y	
299-W11-3	Antimony	6/26/92	46			
299-W11-3	Antimony, filtered	6/26/92	44		Y	
299-W11-3	Arsenic	6/26/92	2			
299-W11-3	Arsenic, filtered	6/26/92	2		Y	
299-W11-3	Barium	6/26/92	52			
299-W11-3	Barium, filtered	6/26/92	51		Y	
299-W11-3	Beryllium	6/26/92	1			
299-W11-3	Beryllium, filtered	6/26/92	1		Y	
299-W11-3	Bromide	11/17/93	200	ppb		L
299-W11-3	Cadmium	6/26/92	4			
299-W11-3	Cadmium, filtered	6/26/92	4		Y	
299-W11-3	Calcium	6/26/92	71600			
299-W11-3	Calcium, filtered	6/26/92	71400		Y	
299-W11-3	Carbon tetrachloride	6/26/92	570			E
299-W11-3	Carbon tetrachloride	11/17/93	520	ppb		D
299-W11-3	Carbon tetrachloride	1/12/95	490	ppb		D

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-3	Chloride	11/17/93	59000	ppb		D
299-W11-3	Chloroform	6/26/92	3			J
299-W11-3	Chloroform	11/17/93	3	ppb		
299-W11-3	Chloroform	1/12/95	2	ppb		
299-W11-3	Chromium	6/26/92	8			
299-W11-3	Chromium, filtered	6/26/92	8		Y	
299-W11-3	Cobalt	6/26/92	6			
299-W11-3	Cobalt, filtered	6/26/92	6		Y	
299-W11-3	Copper	6/26/92	5			
299-W11-3	Copper, filtered	6/26/92	5		Y	
299-W11-3	Cyanide	6/26/92	400			
299-W11-3	Di-n-butylphthalate	6/26/92	2			JB
299-W11-3	Ethylbenzene	11/17/93	0	ppb		L
299-W11-3	Fluoride	11/17/93	700	ppb		
299-W11-3	Gross beta	11/17/93	7	pCi/L		
299-W11-3	Iodine-129	9/26/88	0	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-3	Iron	6/26/92	691			
299-W11-3	Iron, filtered	6/26/92	19		Y	
299-W11-3	Lead	6/26/92	2			*
299-W11-3	Lead, filtered	6/26/92	6		Y	*
299-W11-3	Magnesium	6/26/92	25600			
299-W11-3	Magnesium, filtered	6/26/92	25800		Y	
299-W11-3	Manganese	6/26/92	13			
299-W11-3	Manganese, filtered	6/26/92	2		Y	
299-W11-3	Mercury	6/26/92	0			
299-W11-3	Mercury, filtered	6/26/92	0		Y	
299-W11-3	Methylene chloride	6/26/92	1			J
299-W11-3	Methylene chloride	11/17/93	1	ppb		BL
299-W11-3	Nickel	6/26/92	18			
299-W11-3	Nickel, filtered	6/26/92	18		Y	
299-W11-3	Nitrate	9/17/87	94600	ppb		
299-W11-3	Nitrate	2/25/88	85900	ppb		
299-W11-3	Nitrate	9/26/88	82700	ppb		
299-W11-3	Nitrate	11/17/93	81000	ppb		D

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-3	Potassium	6/26/92	4590			
299-W11-3	Potassium, filtered	6/26/92	4530		Y	
299-W11-3	Selenium	6/26/92	2			NW
299-W11-3	Selenium, filtered	6/26/92	2		Y	N
299-W11-3	Silver	6/26/92	6			
299-W11-3	Silver, filtered	6/26/92	6		Y	
299-W11-3	Sodium	6/26/92	13200			
299-W11-3	Sodium, filtered	6/26/92	13500		Y	
299-W11-3	Specific conductance	11/17/93	650	umhos		
299-W11-3	Specific conductance	11/17/93	688	umhos		
299-W11-3	Sulfate	11/17/93	56000	ppb		D
299-W11-3	Tetrachloroethene	11/17/93	0	ppb		L
299-W11-3	Thallium	6/26/92	2			NW
299-W11-3	Thallium, filtered	6/26/92	2		Y	NW
299-W11-3	Trichloroethene	11/17/93	1	ppb		L
299-W11-3	Trichloroethene	1/12/95	1	ppb		L
299-W11-3	Tritium	9/17/87	443	pCi/L		
299-W11-3	Tritium	9/26/88	560	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-3	Tritium	11/17/93	603	pCi/L		
299-W11-3	Uranium	1/21/87	1	pCi/L		
299-W11-3	Uranium	9/17/87	1	pCi/L		
299-W11-3	Uranium	2/25/88	1	pCi/L		
299-W11-3	Uranium	9/26/88	1	pCi/L		
299-W11-3	Vanadium	6/26/92	44			
299-W11-3	Vanadium, filtered	6/26/92	39		Y	
299-W11-3	Zinc	6/26/92	6			
299-W11-3	Zinc, filtered	6/26/92	6		Y	
299-W11-3	pH	6/26/92	7			
299-W11-3	pH	11/17/93	7			

Table A3-2. Upgradient Well 299-W11-7. (4 sheets)

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-7	Alkalinity	6/30/88	111000	ppb		
299-W11-7	Alkalinity	11/10/88	117000	ppb		
299-W11-7	Barium	6/30/88	79	ppb		
299-W11-7	Benzene	1/06/94	0	ppb		L
299-W11-7	Calcium	6/30/88	97800	ppb		
299-W11-7	Carbon tetrachloride	6/30/88	2080	ppb		
299-W11-7	Carbon tetrachloride	11/10/88	2500	ppb		
299-W11-7	Carbon tetrachloride	1/06/94	1200	ppb		D
299-W11-7	Chloride	6/30/88	52700	ppb		
299-W11-7	Chloride	11/10/88	45900	ppb		
299-W11-7	Chloride	1/06/94	65000	ppb		D
299-W11-7	Chloroform	6/30/88	15	ppb		
299-W11-7	Chloroform	11/10/88	37	ppb		
299-W11-7	Chloroform	1/06/94	8	ppb		
299-W11-7	Chromium	6/30/88	47	ppb		
299-W11-7	Fluoride	1/06/94	1400	ppb		
299-W11-7	Fluorine	6/30/88	1300	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-7	Fluorine	11/10/88	1200	ppb		
299-W11-7	Gross alpha	2/26/88	2	pCi/L		
299-W11-7	Gross alpha	5/16/88	1	pCi/L		
299-W11-7	Gross alpha	7/27/88	1	pCi/L		
299-W11-7	Gross alpha	11/17/88	2	pCi/L		
299-W11-7	Gross alpha	3/09/89	13	pCi/L		
299-W11-7	Gross alpha	1/06/94	3	pCi/L		
299-W11-7	Gross beta	2/26/88	66	pCi/L		
299-W11-7	Gross beta	5/16/88	61	pCi/L		
299-W11-7	Gross beta	7/27/88	52	pCi/L		
299-W11-7	Gross beta	11/17/88	53	pCi/L		
299-W11-7	Gross beta	3/09/89	48	pCi/L		
299-W11-7	Gross beta	8/24/89	22	pCi/L		
299-W11-7	Gross beta	1/06/94	49	pCi/L		
299-W11-7	Iron	6/30/88	2680	ppb		
299-W11-7	Lead	6/30/88	6	ppb		
299-W11-7	Magnesium	6/30/88	32400	ppb		
299-W11-7	Manganese	6/30/88	91	ppb		
299-W11-7	Nitrate	6/30/88	215000	ppb		
299-W11-7	Nitrate	11/10/88	203000	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-7	Nitrate	1/06/94	180000	ppb		D
299-W11-7	Potassium	6/30/88	5840	ppb		
299-W11-7	Sodium	6/30/88	27400	ppb		
299-W11-7	Specific conductance	6/30/88	738	umhos		
299-W11-7	Specific conductance	11/10/88	774	umhos		
299-W11-7	Specific conductance	12/18/90	926	umhos		
299-W11-7	Specific conductance	1/06/94	880	umhos		
299-W11-7	Strontium	6/30/88	436	ppb		
299-W11-7	Sulfate	6/30/88	46300	ppb		
299-W11-7	Sulfate	11/10/88	47300	ppb		
299-W11-7	Sulfate	1/06/94	65000	ppb		D
299-W11-7	Tetrachloroethene	1/06/94	0	ppb		L
299-W11-7	Toluene	1/06/94	0	ppb		L
299-W11-7	Total Carbon	6/30/88	30200	ppb		
299-W11-7	Total Carbon	11/10/88	26000	ppb		
299-W11-7	Trichloroethene	6/30/88	6	ppb		
299-W11-7	Trichloroethene	11/10/88	7	ppb		
299-W11-7	Trichloroethene	1/06/94	6	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-7	Tritium	12/18/90	41700	pCi/L		
299-W11-7	Tritium	1/06/94	21800	pCi/L		
299-W11-7	Vanadium	6/30/88	23	ppb		
299-W11-7	Zinc	6/30/88	36	ppb		
299-W11-7	pH	6/30/88	8			
299-W11-7	pH	6/30/88	8			
299-W11-7	pH	11/10/88	8			
299-W11-7	pH	11/10/88	8			
299-W11-7	pH	12/18/90	8			

Table A3-3. Upgradient Well 299-W11-10. (4 sheets)

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-10	Aluminum	8/24/92	3370			
299-W11-10	Aluminum, filtered	8/24/92	49		Y	
299-W11-10	Antimony	8/24/92	60			
299-W11-10	Antimony, filtered	8/24/92	60		Y	
299-W11-10	Arsenic	8/24/92	4			
299-W11-10	Arsenic, filtered	8/24/92	2		Y	
299-W11-10	Barium	8/24/92	87			
299-W11-10	Barium, filtered	8/24/92	40		Y	
299-W11-10	Benzene	12/29/93	0	ppb		BL
299-W11-10	Beryllium	8/24/92	1			
299-W11-10	Beryllium, filtered	8/24/92	1		Y	
299-W11-10	Bromide	12/29/93	100	ppb		L
299-W11-10	Cadmium	8/24/92	7			
299-W11-10	Cadmium, filtered	8/24/92	7		Y	
299-W11-10	Calcium	8/24/92	54100			
299-W11-10	Calcium, filtered	8/24/92	54300		Y	
299-W11-10	Carbon tetrachloride	12/29/93	560	ppb		D

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-10	Chloride	12/29/93	37000	ppb		D
299-W11-10	Chloroform	12/29/93	6	ppb		
299-W11-10	Chromium	8/24/92	38			
299-W11-10	Chromium, filtered	8/24/92	9		Y	
299-W11-10	Cobalt	8/24/92	9			
299-W11-10	Cobalt, filtered	8/24/92	9		Y	
299-W11-10	Copper	8/24/92	13			
299-W11-10	Copper, filtered	8/24/92	8		Y	
299-W11-10	Fluoride	12/29/93	500	ppb		
299-W11-10	Gross beta	12/29/93	7	pCi/L		
299-W11-10	Iron	8/24/92	17500			
299-W11-10	Iron, filtered	8/24/92	28		Y	
299-W11-10	Lead	8/24/92	8			NS
299-W11-10	Lead, filtered	8/24/92	2		Y	NW
299-W11-10	Magnesium	8/24/92	20500			
299-W11-10	Magnesium, filtered	8/24/92	20100		Y	

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-10	Manganese	8/24/92	412			
299-W11-10	Manganese, filtered	8/24/92	4		Y	
299-W11-10	Mercury	8/24/92	0			
299-W11-10	Mercury, filtered	8/24/92	0		Y	
299-W11-10	Nickel	8/24/92	20			
299-W11-10	Nickel, filtered	8/24/92	20		Y	
299-W11-10	Nitrate	12/29/93	48000	ppb		D
299-W11-10	Potassium	8/24/92	4580			
299-W11-10	Potassium, filtered	8/24/92	4320		Y	
299-W11-10	Selenium	8/24/92	2			NW
299-W11-10	Selenium, filtered	8/24/92	3		Y	NW
299-W11-10	Silver	8/24/92	10			
299-W11-10	Silver, filtered	8/24/92	10		Y	
299-W11-10	Sodium	8/24/92	12600			
299-W11-10	Sodium, filtered	8/24/92	12200		Y	
299-W11-10	Specific conductance	12/29/93	520	umhos		
299-W11-10	Sulfate	12/29/93	54000	ppb		D

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-10	Tetrachloroethene	12/29/93	0	ppb		L
299-W11-10	Thallium	8/24/92	20			NW
299-W11-10	Thallium, filtered	8/24/92	2		Y	N
299-W11-10	Toluene	12/29/93	0	ppb		BL
299-W11-10	Trichloroethene	12/29/93	2	ppb		X
299-W11-10	Tritium	12/29/93	191	pCi/L		
299-W11-10	Vanadium	8/24/92	57			
299-W11-10	Vanadium, filtered	8/24/92	30		Y	
299-W11-10	Zinc	8/24/92	22			
299-W11-10	Zinc, filtered	8/24/92	7		Y	

Table A3-4. Upgradient Well 299-W11-14. (8 sheeets)

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Acetone	6/27/92	6			JB
299-W11-14	Acetone	6/27/92	18			B
299-W11-14	Alkalinity	6/27/88	60200	ppb		
299-W11-14	Alkalinity	11/10/88	111000	ppb		
299-W11-14	Aluminum	6/27/92	39			
299-W11-14	Aluminum, filtered	6/27/92	35		Y	
299-W11-14	Antimony	6/27/92	44			
299-W11-14	Antimony, filtered	6/27/92	44		Y	
299-W11-14	Arsenic	6/27/92	2			NW
299-W11-14	Arsenic, filtered	6/27/92	2		Y	N
299-W11-14	Barium	6/27/88	99	ppb		
299-W11-14	Barium	6/27/92	66			
299-W11-14	Barium, filtered	6/27/92	60		Y	
299-W11-14	Beryllium	6/27/92	1			
299-W11-14	Beryllium, filtered	6/27/92	1		Y	
299-W11-14	Bis(2-ethylhexyl) ph	6/27/92	9			JB
299-W11-14	Cadmium	6/27/88	4	ppb		
299-W11-14	Cadmium	6/27/92	4			

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Cadmium, filtered	6/27/92	4		Y	
299-W11-14	Calcium	6/27/88	83400	ppb		
299-W11-14	Calcium	6/27/92	78900			E
299-W11-14	Calcium, filtered	6/27/92	79300		Y	E
299-W11-14	Carbon tetrachloride	6/27/88	650	ppb		
299-W11-14	Carbon tetrachloride	11/10/88	860	ppb		
299-W11-14	Carbon tetrachloride	4/13/90	790	ppb		
299-W11-14	Carbon tetrachloride	6/19/92	1252	ppb		
299-W11-14	Carbon tetrachloride	6/27/92	800			E
299-W11-14	Carbon tetrachloride	12/16/93	790	ppb		D
299-W11-14	Chloride	6/27/88	59400	ppb		
299-W11-14	Chloride	11/10/88	65500	ppb		
299-W11-14	Chloride	4/13/90	66900	ppb		
299-W11-14	Chloride	5/17/91	52	ppm		
299-W11-14	Chloride	6/19/92	65000	ppb		
299-W11-14	Chloride	4/07/93	18000	ppb		
299-W11-14	Chloride	12/16/93	66000	ppb		D
299-W11-14	Chloroform	11/10/88	10	ppb		
299-W11-14	Chloroform	6/19/92	4	ppb		
299-W11-14	Chloroform	6/27/92	3			J
299-W11-14	Chloroform	12/16/93	5	ppb		D
299-W11-14	Chromium	6/27/88	46	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Chromium	6/27/92	12			
299-W11-14	Chromium, filtered	6/27/92	8		Y	
299-W11-14	Cobalt	6/27/92	6			
299-W11-14	Cobalt, filtered	6/27/92	6		Y	
299-W11-14	Copper	6/27/92	5			
299-W11-14	Copper, filtered	6/27/92	5		Y	
299-W11-14	Di-n-butylphthalate	6/27/92	1			J
299-W11-14	Fluoride	5/17/91	1	ppm		
299-W11-14	Fluoride	6/19/92	800	ppb		
299-W11-14	Fluoride	4/07/93	600	ppb		
299-W11-14	Fluoride	12/16/93	1000	ppb		
299-W11-14	Fluorine	6/27/88	962	ppb		
299-W11-14	Fluorine	11/10/88	700	ppb		
299-W11-14	Gross alpha	2/25/88	265	pCi/L		
299-W11-14	Gross alpha	5/16/88	233	pCi/L		
299-W11-14	Gross alpha	7/25/88	273	pCi/L		
299-W11-14	Gross alpha	11/17/88	255	pCi/L		
299-W11-14	Gross alpha	3/09/89	173	pCi/L		
299-W11-14	Gross alpha	8/24/89	220	pCi/L		
299-W11-14	Gross alpha	4/13/90	207	pCi/L		
299-W11-14	Gross alpha	12/16/93	73	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Gross beta	2/25/88	193	pCi/L		
299-W11-14	Gross beta	5/16/88	158	pCi/L		
299-W1114	Gross beta	7/25/88	139	pCi/L		
299-W11-14	Gross beta	11/17/88	98	pCi/L		
299-W11-14	Gross beta	3/09/89	73	pCi/L		
299-W11-14	Gross beta	8/24/89	105	pCi/L		
299-W11-14	Gross beta	4/13/90	113	pCi/L		
299-W11-14	Gross beta	12/16/93	32	pCi/L		
299-W11-14	Iodine-129	4/13/90	2	pCi/L		
299-W11-14	Iodine-129	6/19/92	4	pCi/L		
299-W11-14	Iron	6/27/88	26300	ppb		
299-W11-14	Iron	6/27/92	1430			E
299-W11-14	Iron, filtered	6/27/92	19		Y	E
299-W11-14	Lead	6/27/92	2			W
299-W11-14	Lead, filtered	6/27/92	2		Y	W
299-W11-14	Magnesium	6/27/88	28100	ppb		
299-W11-14	Magnesium	6/27/92	26100			E
299-W11-14	Magnesium, filtered	6/27/92	26100		Y	E
299-W11-14	Manganese	6/27/88	766	ppb		
299-W11-14	Manganese	6/27/92	28			
299-W11-14	Manganese, filtered	6/27/92	3		Y	

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Mercury	6/27/92	0			
299-W11-14	Mercury, filtered	6/27/92	0		Y	
299-W11-14	Methyl ethyl ketone	6/27/92	7			J
299-W11-14	Methylene chloride	6/27/92	11			B
299-W11-14	Nickel	6/27/92	18			
299-W11-14	Nickel, filtered	6/27/92	18		Y	
299-W11-14	Nitrate	6/27/88	116000	ppb		
299-W11-14	Nitrate	11/10/88	125000	ppb		
299-W11-14	Nitrate	4/13/90	123000	ppb		
299-W11-14	Nitrate	5/17/91	109	ppm		
299-W11-14	Nitrate	6/19/92	110000	ppb		
299-W11-14	Nitrate	4/07/93	310000	ppb		
299-W11-14	Nitrate	12/16/93	140000	ppb		D
299-W11-14	Potassium	6/27/88	5420	ppb		
299-W11-14	Potassium	6/27/92	5120			
299-W11-14	Potassium, filtered	6/27/92	5230		Y	
299-W11-14	Radium	6/27/88	1	pCi/L		
299-W11-14	Selenium	6/27/88	7	ppb		
299-W11-14	Selenium	6/27/92	3			NW

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Selenium, filtered	6/27/92	3		Y	NW
299-W11-14	Silver	6/27/92	6			N
299-W11-14	Silver, filtered	6/27/92	6		Y	N
299-W11-14	Sodium	6/27/88	36500	ppb		
299-W11-14	Sodium	6/27/92	33800			E
299-W11-14	Sodium, filtered	6/27/92	33900		Y	E
299-W11-14	Specific conductance	6/27/88	758	umhos		
299-W11-14	Specific conductance	11/10/88	742	umhos		
299-W11-14	Specific conductance	4/13/90	813	umhos		
299-W11-14	Specific conductance	4/13/90	826	umhos		
299-W11-14	Specific conductance	5/17/91	794	umhos		
299-W11-14	Specific conductance	6/19/92	800	umhos		
299-W11-14	Specific conductance	4/07/93	992	umhos		
299-W11-14	Specific conductance	12/16/93	832	umhos		
299-W11-14	Strontium	6/27/88	431	ppb		
299-W11-14	Sulfate	6/27/88	64900	ppb		
299-W11-14	Sulfate	11/10/88	74200	ppb		
299-W11-14	Sulfate	4/13/90	76100	ppb		
299-W11-14	Sulfate	5/17/91	73	ppm		
299-W11-14	Sulfate	6/19/92	73000	ppb		
299-W11-14	Sulfate	4/07/93	63000	ppb		
299-W11-14	Sulfate	12/16/93	81000	ppb		D

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Technetium-99	6/19/92	61	pCi/L		
299-W11-14	Technetium-99	12/16/93	88	pCi/L		
299-W11-14	Tetrachloroethene	6/19/92	0	ppb		
299-W11-14	Thallium	6/27/92	2			W
299-W11-14	Thallium, filtered	6/27/92	2		Y	W
299-W11-14	Total Carbon	6/27/88	28600	ppb		
299-W11-14	Total Carbon	11/10/88	25100	ppb		
299-W11-14	Total Organic Haloge	6/27/88	148	ppb		
299-W11-14	Total Organic Haloge	4/13/90	561	ppb		
299-W11-14	Trichloroethene	6/19/92	2	ppb		
299-W11-14	Trichloroethene	6/27/92	1			J
299-W11-14	Trichloroethene	12/16/93	3	ppb		DL
299-W11-14	Tritium	4/13/90	6890	pCi/L		
299-W11-14	Tritium	5/17/91	6730	pCi/L		
299-W11-14	Tritium	6/19/92	6910	pCi/L		
299-W11-14	Tritium	4/07/93	210000	pCi/L		
299-W11-14	Tritium	12/16/93	14300	pCi/L		
299-W11-14	Uranium	4/13/90	207	pCi/L		
299-W11-14	Uranium	6/19/92	106	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W11-14	Uranium	12/16/93	11	ppb		
299-W11-14	Vanadium	6/27/88	57	ppb		
299-W11-14	Vanadium	6/27/92	46			
299-W11-14	Vanadium, filtered	6/27/92	46		Y	
299-W11-14	Zinc	6/27/88	41	ppb		
299-W11-14	Zinc	6/27/92	8			
299-W11-14	Zinc, filtered	6/27/92	6		Y	
299-W11-14	pH	6/27/88	8			
299-W11-14	pH	11/10/88	7			
299-W11-14	pH	11/10/88	8			
299-W11-14	pH	4/13/90	7			
299-W11-14	pH	4/13/90	8			
299-W11-14	pH	5/17/91	6			
299-W11-14	pH	6/19/92	8			
299-W11-14	pH	6/27/92	7			
299-W11-14	pH	4/07/93	8			
299-W11-14	pH	12/16/93	8			

Table A2-5. Downgradient Well 299-W12-1. (9 sheets)

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Acetone	6/27/92	6			JB
299-W12-1	Acetone	6/27/92	7			JB
299-W12-1	Alkalinity	6/04/87	74400	ppb		
299-W12-1	Aluminum	6/27/92	35			
299-W12-1	Aluminum, filtered	6/27/92	35		Y	
299-W12-1	Antimony	6/27/92	44			
299-W12-1	Antimony, filtered	6/27/92	44		Y	
299-W12-1	Arsenic	6/27/92	2			N
299-W12-1	Arsenic, filtered	6/27/92	2		Y	N
299-W12-1	Barium	6/27/92	66			
299-W12-1	Barium, filtered	6/04/87	67	ppb	Y	
299-W12-1	Barium, filtered	6/27/92	66		Y	
299-W12-1	Beryllium	6/27/92	1			
299-W12-1	Beryllium, filtered	6/27/92	1		Y	
299-W12-1	Bis(2-ethylhexyl) ph	6/27/92	10			B
299-W12-1	Cadmium	6/27/92	4			
299-W12-1	Cadmium, filtered	6/27/92	4		Y	

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Calcium	6/27/92	101000			E
299-W12-1	Calcium, filtered	6/04/87	94700	ppb	Y	
299-W12-1	Calcium, filtered	6/27/92	101000		Y	E
299-W12-1	Carbon tetrachloride	6/19/92	9	ppb		
299-W12-1	Carbon tetrachloride	6/27/92	7			
299-W12-1	Carbon tetrachloride	11/15/93	8	ppb		
299-W12-1	Cesium-137	9/17/87	4	pCi/L		
299-W12-1	Chloride	6/04/87	19900	ppb		
299-W12-1	Chloride	6/19/92	22000	ppb		
299-W12-1	Chloride	4/07/93	22000	ppb		
299-W12-1	Chloride	11/15/93	23000	ppb		D
299-W12-1	Chloroform	6/19/92	2	ppb		
299-W12-1	Chloroform	6/27/92	1			J
299-W12-1	Chloroform	11/15/93	1	ppb		
299-W12-1	Chromium	6/27/92	64			
299-W12-1	Chromium, filtered	6/04/87	64	ppb	Y	
299-W12-1	Chromium, filtered	6/27/92	61		Y	
299-W12-1	Cobalt	6/27/92	6			
299-W12-1	Cobalt, filtered	6/27/92	6		Y	
299-W12-1	Cobalt-60	4/30/80	18	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Cobalt-60	7/22/80	25	pCi/L		
299-W12-1	Cobalt-60	10/15/80	13	pCi/L		
299-W12-1	Cobalt-60	4/27/81	13	pCi/L		
299-W12-1	Cobalt-60	7/13/83	3	pCi/L		
299-W12-1	Cobalt-60	10/18/83	3	pCi/L		
299-W12-1	Cobalt-60	1/30/84	10	pCi/L		
299-W12-1	Cobalt-60	4/27/84	4	pCi/L		
299-W12-1	Cobalt-60	4/22/85	3	pCi/L		
299-W12-1	Cobalt-60	9/07/85	22	pCi/L		
299-W12-1	Cobalt-60	1/20/87	6	pCi/L		
299-W12-1	Copper	6/27/92	5			
299-W12-1	Copper, filtered	6/27/92	5		Y	
299-W12-1	Cyanide	6/04/87	34	ppb		
299-W12-1	Dissolved Oxygen	6/04/87	9	??		
299-W12-1	Dissolved Oxygen	6/04/87	9	??		
299-W12-1	Dissolved Oxygen	6/04/87	9	??		
299-W12-1	Dissolved Oxygen	6/04/87	9	??		
299-W12-1	Ethylbenzene	11/15/93	0	ppb		L
299-W12-1	Fluoride	6/19/92	700	ppb		
299-W12-1	Fluoride	4/07/93	600	ppb		
299-W12-1	Fluoride	11/15/93	500	ppb		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Fluorine	6/04/87	590	ppb		
299-W12-1	Gross beta	2/07/80	75	pCi/L		
299-W12-1	Gross beta	4/30/80	75	pCi/L		
299-W12-1	Gross beta	7/22/80	75	pCi/L		
299-W12-1	Gross beta	10/15/80	75	pCi/L		
299-W12-1	Gross beta	2/05/81	75	pCi/L		
299-W12-1	Gross beta	4/27/81	75	pCi/L		
299-W12-1	Gross beta	8/19/81	75	pCi/L		
299-W12-1	Gross beta	10/15/81	75	pCi/L		
299-W12-1	Gross beta	6/04/87	35	pCi/L		
299-W12-1	Gross beta	11/15/93	40	pCi/L		
299-W12-1	Iodine-129	9/26/88	0	pCi/L		
299-W12-1	Iron	6/27/92	43			E
299-W12-1	Iron, filtered	6/27/92	24		Y	E
299-W12-1	Lead	6/27/92	2			
299-W12-1	Lead, filtered	6/27/92	2		Y	
299-W12-1	Magnesium	6/27/92	41100			E
299-W12-1	Magnesium, filtered	6/04/87	40600	ppb	Y	
299-W12-1	Magnesium, filtered	6/27/92	40700		Y	E
299-W12-1	Manganese	6/27/92	2			
299-W12-1	Manganese, filtered	6/27/92	2		Y	

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Mercury	6/27/92	0			
299-W12-1	Mercury, filtered	6/27/92	0		Y	
299-W12-1	Methyl ethyl ketone	6/27/92	4			J
299-W12-1	Methylene chloride	6/27/92	11			B
299-W12-1	Methylene chloride	6/27/92	12			B
299-W12-1	Methylene chloride	11/15/93	0	ppb		BL
299-W12-1	Nickel	6/27/92	18			
299-W12-1	Nickel, filtered	6/27/92	18		Y	
299-W12-1	Nitrate	2/07/80	220	ppm		
299-W12-1	Nitrate	4/30/80	200	ppm		
299-W12-1	Nitrate	7/22/80	210	ppm		
299-W12-1	Nitrate	10/15/80	210	ppm		
299-W12-1	Nitrate	2/05/81	210	ppm		
299-W12-1	Nitrate	4/27/81	250	ppm		
299-W12-1	Nitrate	8/19/81	240	ppm		
299-W12-1	Nitrate	10/15/81	230	ppm		
299-W12-1	Nitrate	1/28/82	260	ppm		
299-W12-1	Nitrate	4/22/82	220	ppm		
299-W12-1	Nitrate	7/26/82	82	ppm		
299-W12-1	Nitrate	10/12/82	250	ppm		
299-W12-1	Nitrate	1/04/83	250	ppm		
299-W12-1	Nitrate	1/26/83	270	ppm		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Nitrate	4/25/83	300	ppm		
299-W12-1	Nitrate	10/18/83	240	ppm		
299-W12-1	Nitrate	1/30/84	290	ppm		
299-W12-1	Nitrate	4/27/84	320	ppm		
299-W12-1	Nitrate	7/09/84	295	ppm		
299-W12-1	Nitrate	10/25/84	260	ppm		
299-W12-1	Nitrate	1/18/85	360	ppm		
299-W12-1	Nitrate	4/22/85	330	ppm		
299-W12-1	Nitrate	9/07/85	500	ppm		
299-W12-1	Nitrate	3/26/86	360	ppm		
299-W12-1	Nitrate	11/06/86	346000	ppb		
299-W12-1	Nitrate	1/20/87	353000	ppb		
299-W12-1	Nitrate	6/04/87	350000	ppb		
299-W12-1	Nitrate	9/17/87	345000	ppb		
299-W12-1	Nitrate	2/25/88	377000	ppb		
299-W12-1	Nitrate	2/29/88		ppb		
299-W12-1	Nitrate	9/26/88	331000	ppb		
299-W12-1	Nitrate	6/19/92	300000	ppb		
299-W12-1	Nitrate	4/07/93	290000	ppb		
299-W12-1	Nitrate	11/15/93	340000	ppb		D
299-W12-1	Potassium	6/27/92	4920			
299-W12-1	Potassium, filtered	6/04/87	4640	ppb	Y	
299-W12-1	Potassium, filtered	6/27/92	4550		Y	
299-W12-1	Radium-226	6/19/92	22	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Selenium	6/27/92	5			NS
299-W12-1	Selenium, filtered	6/27/92	5		Y	NS
299-W12-1	Silver	6/27/92	6			N
299-W12-1	Silver, filtered	6/27/92	6		Y	N
299-W12-1	Sodium	6/27/92	15200			E
299-W12-1	Sodium, filtered	6/04/87	15000	ppb	Y	
299-W12-1	Sodium, filtered	6/27/92	15100		Y	E
299-W12-1	Specific conductance	6/04/87	964	umhos		
299-W12-1	Specific conductance	6/04/87	965	umhos		
299-W12-1	Specific conductance	6/04/87	966	umhos		
299-W12-1	Specific conductance	6/19/92	930	umhos		
299-W12-1	Specific conductance	4/07/93	921	umhos		
299-W12-1	Specific conductance	11/15/93	940	umhos		
299-W12-1	Specific conductance	11/15/93	1130	umhos		
299-W12-1	Strontium, filtered	6/04/87	543	ppb	Y	
299-W12-1	Sulfate	6/04/87	56100	ppb		
299-W12-1	Sulfate	6/19/92	66000	ppb		
299-W12-1	Sulfate	4/07/93	63000	ppb		
299-W12-1	Sulfate	11/15/93	71000	ppb		D
299-W12-1	Thallium	6/27/92	2			
299-W12-1	Thallium, filtered	6/27/92	2		Y	

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Tritium	2/07/80	740	pCi/L		
299-W12-1	Tritium	4/30/80	530	pCi/L		
299-W12-1	Tritium	7/22/80	420	pCi/L		
299-W12-1	Tritium	10/15/80	870	pCi/L		
299-W12-1	Tritium	2/05/81	540	pCi/L		
299-W12-1	Tritium	4/27/81	640	pCi/L		
299-W12-1	Tritium	8/19/81	860	pCi/L		
299-W12-1	Tritium	10/15/81	520	pCi/L		
299-W12-1	Tritium	1/28/82	1500	pCi/L		
299-W12-1	Tritium	4/22/82	1300	pCi/L		
299-W12-1	Tritium	7/26/82	680	pCi/L		
299-W12-1	Tritium	10/12/82	730	pCi/L		
299-W12-1	Tritium	1/04/83	1400	pCi/L		
299-W12-1	Tritium	1/26/83	2200	pCi/L		
299-W12-1	Tritium	4/25/83	1800	pCi/L		
299-W12-1	Tritium	7/13/83	1200	pCi/L		
299-W12-1	Tritium	10/18/83	1400	pCi/L		
299-W12-1	Tritium	1/30/84	2000	pCi/L		
299-W12-1	Tritium	4/27/84	2100	pCi/L		
299-W12-1	Tritium	7/09/84	1500	pCi/L		
299-W12-1	Tritium	10/25/84	2200	pCi/L		
299-W12-1	Tritium	1/18/85	2400	pCi/L		
299-W12-1	Tritium	4/22/85	1900	pCi/L		
299-W12-1	Tritium	9/07/85	2000	pCi/L		
299-W12-1	Tritium	3/26/86	2300	pCi/L		
299-W12-1	Tritium	11/06/86	3240	pCi/L		

Well	Constituent Name	Collect Date	Result	Units	Filtered	Qualifier
299-W12-1	Tritium	1/20/87	4010	pCi/L		
299-W12-1	Tritium	6/04/87	4710	pCi/L		
299-W12-1	Tritium	9/17/87	5520	pCi/L		
299-W12-1	Tritium	2/25/88	5650	pCi/L		
299-W12-1	Tritium	9/26/88	6730	pCi/L		
299-W12-1	Tritium	6/19/92	9050	pCi/L		
299-W12-1	Tritium	4/07/93	9190	pCi/L		
299-W12-1	Tritium	11/15/93	9130	pCi/L		
299-W12-1	Vanadium	6/27/92	47			
299-W12-1	Vanadium, filtered	6/04/87	23	ppb	Y	
299-W12-1	Vanadium, filtered	6/27/92	47		Y	
299-W12-1	Zinc	6/27/92	6			
299-W12-1	Zinc, filtered	6/27/92	6		Y	
299-W12-1	pH	6/04/87	8			
299-W12-1	pH	6/04/87	8			
299-W12-1	pH	6/04/87	8			
299-W12-1	pH	6/04/87	8			
299-W12-1	pH	6/19/92	8			
299-W12-1	pH	6/27/92	7			
299-W12-1	pH	4/07/93	8			
299-W12-1	pH	11/15/93	8			

Table A3-6. Summary of Provisional Hanford Site Groundwater Background Values[a] (Johnson, 1993). (3 sheets)

Constituent (concentration)	PNL Results[b]	USGS Results[b] (sample size)	WHC Unconfined[b] (sample size)	WHC Provisional Threshold Values
Aluminum (ppb)	<2	110 ± 139 (12)	<200 (50)	<200
Ammonium (ppb)	<50	NA	<50 (18)	<120
Arsenic (ppb)	3.9±2.4	6.7 ± 3.7 (7)	<5 (14)	10
Barium (ppb)	42±20	53 ± 14 (11)	41±20 (53)	68.5
Beryllium (ppb)	<0.3	NA	<5 (16)	<5
Bismuth (ppb)	<0.02	NA	<5 (4)	<5
Boron (ppb)	<50	<50 (14)	<100 (35)	<100
Cadmium (ppb)	<0.2	<10 (1)	<10 (16)	<10
Calcium (ppb)	40,400 ± 10,300	40,857 ± 8,282 (14)	38,542 ± 11,023 (53)	63,600
Chloride-low (ppb)	NA	5,825 ± 1,355 (8)	5,032 ± 1,774 (53)	8,690
Chloride-high (ppb)	NA	20,667 ± 2,503 (6)	23,296 ± 2,463 (14)	28,500
Chloride-all (ppb)	10,300 ± 6,500	12,186 ± 7,842 (14)	8,848 ± 7,723 (67)	NC
Chromium (ppb)	4±2	<50 (11)	<30 (8)	<30
Copper (ppb)	<1	<10 (10)	<30 (50)	<30
Fluoride (ppb)	370 ± 100	550 ± 330 (14)	437 ± 131[c] (47)	1,340 775[c]
Iron-low (ppb)	NA	22 ± 16[c]	<50 (34)	86
Iron-mid (ppb)	NA	NA	115 ± 52 (7)	291
Iron-high (ppb)	NA	NA	494 ± 118 (12)	818
Iron-all (ppb)	NA	NA	149 ± 199 (53)	NC
Lead (ppb)	<0.5	<30[c] (6)	<5 (15)	<5
Magnesium (ppb)	11,800 ± 3,400	10,814 ± 1,813 (14)	11,190 ± 2,578 (14)	16,840
Manganese-low (ppb)	NA	26 ± 27 (8)	<20 (33)	24.5
Manganese-high (ppb)	NA	150 ± 87 (3)	118 ± 17 (20)	163.5

Table A3-6. Summary of Provisional Hanford Site Groundwater Background Values[a] (Johnson, 1993). (3 sheets)

Constituent (concentration)	PNL Results[b]	USGS Results[b] (sample size)	WHC Unconfined[b] (sample size)	WHC Provisional Threshold Values
Manganese-all (ppb)	---	60 ± 73 (11)	50 ± 55 (53)	NC
Mercury (ppb)	---	NA	<0.1 (14)	<0.1
Nickel (ppb)	<4	<50 (14)	<30 (23)	<30
Nitrate (ppb)	NA	3,224 ± 3,380 (13)	5,170 ± 3,576 (78)	12,400
Phosphate (ppb)	<1000	140 ± 62 (3)	<1,000	<1,000
Potassium (ppb)	4,950 ± 1,240	5,900 ± 1,253 (14)	4,993 ± 1,453 (53)	7.975
Selenium (ppb)	<2	NA	<5 (14)	<5
Silver (ppb)	<10	NA	<10	<10
Silicon (ppb)	NA	16,786 ± 3,683 (14)	18,152 ± 4,974 (35)	26,500
Sodium (ppb)	18,260 ± 10.150	20,286 ± 7,907 (14)	15,774 ± 6,784 (53)	33,500
Strontium (ppb)	236 ± 102	159 ± 78 (14)	164 ± 47 (43)	264.1
Sulfate (ppb)	34,300 ± 16,900	41,286 ± 27,880 (14)	30,605 ± 22,611 (67)	90,500
Uranium (pCi/L)	1.7 ± 0.8	NA	1.7 ± 1.2 (10)	3.43
Vanadium (ppb)	17 ± 9	NA	9 ± 4 (18)	15
Zinc-low (ppb)	NA	14 ± 20 (11)	<50 (36)	<50
Zinc-high (ppb)	NA	373 ± 284 (3)	247 ± 165 (17)	673
Zinc-all (ppb)	6 ± 2	91 ± 190 (14)	95 ± 140 (53)	NC
Field alkalinity (ppb)	NA	134,100 ± 20,469 (10)	137,758 ± 33,656 (31)	215,000
Lab alkalinity (ppb)	123,000 ± 21,000	130,000 ± 8,165 (4)	133,717 ± 29,399 (52)	210,000
Field pH	NA	NA	7.57 ± 0.29 (57)	[6.90, 8.24]
Lab pH	7.64 ± 0.16	NA	7.75 ± 0.21 (52)	[7.25, 8.25]
Total organic carbon (ppb)	586 ± 347	NA	519 ± 367[c] (62)	2,610 1,610[c]

Table A3-6. Summary of Provisional Hanford Site Groundwater Background Values[a] (Johnson, 1993). (3 sheets)

Constituent (concentration)	PNL Results[b]	USGS Results[b] (sample size)	WHC Unconfined[b] (sample size)	WHC Provisional Threshold Values
Field conductivity (μmhos/cm)	NA	NA	344 ± 83 (22)	539
Lab conductivity (μmhos/cm)	380 ± 82	NA	332 ± 93 (36)	530
Total organic halogen, lower detection limit (ppb)	NA	NA	<20[c] (14)	60.8 37.6[c]
Total carbon (ppb)	NA	NA	31,772 ± 7,022 (48)	50,100
Gross alpha (pCi/L)	2.5 ± 1.4	NA	2.5 ± 1.5[c] (36)	63 5.79[c]
Gross beta (pCi/L)	19 ± 12	NA	7.1 ± 2.6[c] (44)	35.5 12.62[c]
Radium (pCi/L)	<0.2	NA	ND (10)	0.23

Note: Johnson, V. G., 1993, Westinghouse Hanford Company Operational Groundwater Status Report, WHC-EP-0595, Westinghouse Hanford Company, Richland, Washington.

[a] Source: From Tables 5-9 and 5-11 (DOE-RL, 1992, Hanford Site Groundwater Background, DOE/RL-92-23, U.S. Department of Energy, Richland Operations Office, Richland, Washington).

[b] Results shown are mean ± one standard deviation.

[c] Potential outlier observation(s) were removed.

NA = not available.
NC = not calculated.
ND = not detected.
PNL = Pacific Northwest Laboratory.
ppb = parts per billion.
USGS = United States Geological Survey.
WHC = Westinghouse Hanford Company.

Table A3-7. Background Level 95% Upper Confidence Limit and Bowen's Background Numbers.

Constituent	CAS Number	90P[1] (mg/Kg)	90PUCL[1] (mg/Kg)	Bowen's Background Numbers[2]		
				Igneous (ppm)	Shale (ppm)	Sandstone (ppm)
Aluminum	7429-90-5	12200	13400	82000	---	25000
Antimony	7440-36-0			0.2	1.5	0.05
Arsenic	7440-38-2	6.41	7.27	1.8	13	1.0
Barium	7440-39-3	136	148	425	580	50
Beryllium	7440-41-7	1.48	1.58	2.8	3	<1
Cadmium	7440-43-9			0.2	0.3	0.05
Calcium	7440-70-2	17230	19500	41500	22100	39110
Chromium	7440-47-3	19.4	22.2	100	90	35
Cobalt	7440-48-4	16.3	17.5	25	19	0.3
Copper	7440-50-8	22.5	24.5	55	45	5
Iron	7439-89-6	32920	35150	56300	47200	9800
Lead	7439-92-1	10.41	11.88	12.5	20	7
Magnesium	7439-95-4	7210	7760	23300	15000	10700
Manganese	7439-96-5	514	549	950	850	50
Mercury	7439-97-6	0.287	0.502	0.08	0.4	0.03
Nickel	7440-02-0	19.7	21.6	75	68	2
Potassium	7440-09-7	2250	22550	20900	26600	10700
Selenium	7782-49-2			0.05	0.6	0.05
Silver	7440-22-4	0.64	1.1	0.07	0.1-soil	0.07
Sodium	7440-23-5	630 705	721 887	23600	9600	3300
Thallium	7440-28-0			0.45	1.4	0.82
Vanadium	7440-62-2	86.5	94.9	135	130	20
Zinc	7440-66-6	67.8	71.8	70	95	16
Lithium	7439-93-2	33.4	35	20	66	15
Molybdenum	7439-98-7			1.5	2.6	0.2
Titanium	7440-32-6	2580	2940	5700	4600	1500
Zirconium	7440-67-7	38.97	45.8	165	160	220

[1] 90th Percentile, 90th Percentile Upper Confidence Limit; Reference: DOE/RL-92-24, Rev. 1.220
[2] Reference: Bowen, H.J.M., "Trace Elements in Biochemistry", Academic Press, Inc., New York, 241 pp.

Table A3-8. Maximum Contamination Levels and Derived Concentration Guidelines (WHC 1990b). (4 sheets)

Reference	Constituent	Guideline Limit	Units	Source of Guideline
40 CFR 141	1,1,1-trichloroethane	200	ppb	MCLG
Primary	1,1-dichloroethylene	7	ppb	MCLG
Drinking	1,2-dichloroethane	5	ppb	MCL
Water	2,4-D	100	ppb	MCL
Standards	2,4,5 Silvex	10	ppb	MCL
	Alpha, high detec. level	15	pCi/L	MCL
	Arsenic	50	ppb	MCL
	Arsenic, filtered	50	ppb	MCL
	Barium	1,000	ppb	MCL
	Barium, filtered	1,000	ppb	MCL
	Benzene	5	ppb	MCL
	Bromodichloromethane	100	ppb	MCL
	Bromoform	100	ppb	MCL
	Cadmium	10	ppb	MCL
	Cadmium, filtered	10	ppb	MCL
	Carbon tetrachloride	5	ppb	MCL
	Chloroform	100	ppb	MCL
	Chromium	50	ppb	MCL
	Chromium, filtered	50	ppb	MCL
	Chromium-6	.05	ppb	MCL
	Coliform (membrane filter)	1	ppb	MCL
	Coliform bacteria	1	MPN	MCL
	Dibromochloromethane	100	ppb	MCL
	Endrin	.2	ppb	MCL
	Fluoride	4,000	ppb	MCL
	Fluoride, low detec. level	4,000	ppb	MCL
	Gross alpha[b]	15	pCi/L	MCL
	Gross beta[b]	50	pCi/L	MCL[a]
	Lead (graphite furnace)	50	ppb	MCL
	Lead, filtered	50	ppb	MCL
	Lindane, alpha-BHC	4	ppb	MCL
	Lindane, beta-BHC	4	ppb	MCL
	Lindane, delta-BHC	4	ppb	MCL
	Lindane, gamma-BHC	4	ppb	MCL
	Mercury	2	ppb	MCL
	Mercury, filtered	2	ppb	MCL
	Methoxychlor	100	ppb	MCL
	Nitrate	45,000	ppb	MCL
	Nitrate, high detec. level	45,000	ppb	MCL
	Nitrate, phenodisulfonic acid	45	mg/L	MCL
	Nitrate-ion	45	mg/L	MCL
	Selenium	10	ppb	MCL
	Selenium, filtered	10	ppb	MCL
	Silver	50	ppb	MCL
	Silver, filtered	50	ppb	MCL
	Toxaphene	5	ppb	MCL
	Trichloroethylene	5	ppb	MCL

Table A3-8. Maximum Contamination Levels and Derived Concentration Guidelines (WHC 1990b). (4 sheets)

Reference	Constituent	Guideline Limit	Units	Source of Guideline
40 CFR 141 (Contd)	Turbidity[b]	5	NTU	MCL
	p-Dichlorobenzene	750	ppb	MCL
	Vinyl chloride	2	ppb	MCL
40 CFR 143 Secondary Drinking Water Standards	Chloride	250,000	ppb	SMCL
	Copper	1,000	ppb	SMCL
	Copper, filtered	1,000	ppb	SMCL
	Iron	300	ppb	SMCL
	Iron, filtered	300	ppb	SMCL
	Manganese	50	ppb	SMCL
	Manganese, filtered	50	ppb	SMCL
	Sulfate	250,000	ppb	SMCL
	Total dissolved solids[b]	500,000	ppb	SMCL
	Zinc	5,000	ppb	SMCL
	Zinc, filtered	5,000	ppb	SMCL
	pH, field measurement, max.[b]	8.5		SMCL
	pH, lab. measurement, max.[b]	8.5		SMCL
54 FR 22062 Proposed Primary and Secondary Drinking Water Standards	1,2-dibromo-3-chloropropane	.2	ppb	MCL prop
	1,2-dichloropropane	5	ppb	MCL prop
	Alachlor	2	ppb	MCL prop
	Aluminum	50	ppb	SMCL prop
	Aluminum, filtered	50	ppb	MCL prop
	Arochlor 1016	.5	ppb	MCL prop
	Arochlor 1221	.5	ppb	MCL prop
	Arochlor 1232	.5	ppb	MCL prop
	Arochlor 1242	.5	ppb	MCL prop
	Arochlor 1248	.5	ppb	MCL prop
	Arochlor 1254	.5	ppb	MCL prop
	Arochlor 1260	.5	ppb	MCL prop
	Chlordane	2	ppb	MCL prop
	Chlorobenzene	100	ppb	MCL prop
	Chlorobenzene (by ABN)	60	ppb	MCL prop
	Ethyl benzene	700	ppb	MCL prop
	Heptachlor	.4	ppb	MCL prop
	Nitrite	3,300	ppb	MCL prop
	Pentachlorophenol	200	ppb	MCL prop
	Styrene	5	ppb	MCL prop
	Tetrachloroethylene	5	ppb	MCL prop
	Toluene	2,000	ppb	MCL prop
	Xylene-m	10,000	ppb	MCL prop
	Xylene-o,p	10,000	ppb	MCL prop
	trans-1,2 Dichloroethylene	100	ppb	MCL prop

Table A3-8. Maximum Contamination Levels and Derived Concentration Guidelines (WHC 1990b). (4 sheets)

Reference	Constituent	Guideline Limit	Units	Source of Guideline
DOE 5400.5 DCG, Adjusted to 4 mrem/yr allowable dose per primary drinking water standards	Americium-241	1.2	pCi/L	1/25 DCG
	Antimony-124	400	pCi/L	1/25 DCG
	Antimony-125	2,000	pCi/L	1/25 DCG
	Barium-140	800	pCi/L	1/25 DCG
	Carbon-14	2,800	pCi/L	1/25 DCG
	Cerium-141	2,000	pCi/L	1/25 DCG
	Cerium-144	280	pCi/L	1/25 DCG
	Cesium-134	80	pCi/L	1/25 DCG
	Cesium-137	120	pCi/L	1/25 DCG
	Cobalt-58	1,600	pCi/L	1/25 DCG
	Cobalt-60	200	pCi/L	1/25 DCG
	Curium-242	40	pCi/L	1/25 DCG
	Curium-244	2.4	pCi/L	1/25 DCG
	Europium-154	800	pCi/L	1/25 DCG
	Europium-155	4,000	pCi/L	1/25 DCG
	Iodine-129, low detec. level	20	pCi/L	1/25 DCG
	Iodine-131	120	pCi/L	1/25 DCG
	Iron-59	800	pCi/L	1/25 DCG
	Lanthanum-140	800	pCi/L	1/25 DCG
	Lead-210	1.2	pCi/L	1/25 DCG
	Manganese-54	2,000	pCi/L	1/25 DCG
	Molybdenum-99	1,200	pCi/L	1/25 DCG
	Nickel-63	12,000	pCi/L	1/25 DCG
	Niobium-95	2,400	pCi/L	1/25 DCG
	Phosphorus-32	800	pCi/L	1/25 DCG
	Plutonium-238	1.6	pCi/L	1/25 DCG
	Plutonium-239/40	1.2	pCi/L	1/25 DCG
	Plutonium-241	80	pCi/L	1/25 DCG
	Praseodymium-144	280	pCi/L	1/25 DCG
	Promethium-147	4,000	pCi/L	1/25 DCG
	Radium-228	4	pCi/L	1/25 DCG
	Ruthenium-103	2,000	pCi/L	1/25 DCG
	Ruthenium-106	240	pCi/L	1/25 DCG
	Silver-110 mestable	400	pCi/L	1/25 DCG
	Sodium-22	400	pCi/L	1/25 DCG
	Strontium-89	800	pCi/L	1/25 DCG
	Strontium-90	40	pCi/L	1/25 DCG
	Strontium-90, low detec. level	40	pCi/L	1/25 DCG
	Technetium-99	4,000	pCi/L	1/25 DCG
	Tin-113 daughter	2,000	pCi/L	1/25 DCG
	Tritium (Hydrogen-3)	80,000	pCi/L	1/25 DCG
	Uranium-234	20	pCi/L	1/25 DCG

Table A3-8. Maximum Contamination Levels and Derived Concentration Guidelines (WHC 1990b). (4 sheets)

Reference	Constituent	Guideline Limit	Units	Source of Guideline
DOE 5400.5 (Contd)	Uranium-235	24	pCi/L	1/25 DCG
	Uranium-236	20	pCi/L	1/25 DCG
	Uranium-238	24	pCi/L	1/25 DCG
	Zinc-65	360	pCi/L	1/25 DCG
	Zirconium-95	1,600	pCi/L	1/25 DCG

[a]This value represents a screening value for assumed compliance with the 4 mrem/yr MCL (WAC 248-54-185).

[b]These parameters not used to select key constituents since they are indicator parameters and not actual discrete chemical or radiological constituents.

ppb = Parts per billion (or micrograms per liter).
MCLG = Maximum contamination level goal.
MCL = Maximum contamination level.
p/Ci/L = Picocuries per liter.
MPN = Most probable number.
NTU = Nephelometric turbidity unit.
SMCL = Secondary maximum contamination level.
MCL prop = Maximum contamination level-proposed.
SMCL prop = Secondary maximum contamination level-proposed.
1/25 DCG = 1/25 Derived concentration guide.

APPENDIX B

CHEMISTRY CONCENTRATION PLOTS

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CHEMISTRY CONCENTRATION PLOTS

Chemistry data correlation plots of the available effluent and groundwater monitoring data were created and are shown in Appendix B. The plots are of two basic types:

1. Plots showing 216-T-1 Ditch effluent data, well 299-W11-37 groundwater data, and the Hanford Site background average concentration data or background 95% upper confidence limit.

2. Plots showing groundwater data for wells near upgradient past-practice disposal sites and contaminant sources in the vicinity of the 216-T-1 Ditch and for comparison, the Hanford Site background average concentration data or background 95% upper confidence limit.

The plots were created to illustrate differences between the different sites sampled. The Hanford Site background average or background 95% upper confidence limit concentration for the unconfined aquifer was plotted to show how the concentration of a given constituent in effluent and/or groundwater compared to the background unconfined aquifer concentration. Where a background value was not available, or did not provide a good basis for comparison, other values were used in place of background values. The two other values that were used are MCLs, which can be used for most chemicals, and 1/25 DCG, used for radionuclides. Concentrations that are lower than the "average value" (either a background, MCL, or 1/25 DCG), are most likely the result of disposal of Hanford Site "system water" or "raw water" (e.g., treated or untreated Columbia River water) with little or no contamination. Concentrations that are higher than the average value are most likely the result of disposal of wastewater from Hanford Site processes and operations (i.e., process facility effluent), which is often elevated in concentration and/or contaminated. The elevated parameters can be used to determine the source of the contamination if enough is known about the composition of the wastewater that was originally discharged to a given facility. Even without this information a general source of contaminants can be determined by tracing a path back upgradient from the well and seeing what facilities it intersects.

The plots show a difference in effluent chemistry versus groundwater chemistry, with the effluent exhibiting lower concentrations than the 95% upper confidence limit value in most cases, and the groundwater exhibiting higher concentrations than the 95% upper confidence limit value. Considering the presence of several groundwater contaminant plumes within the 200 West Area, this is not unexpected. Several of the parameters that were plotted are related to these plumes.

Figure B-1 shows two related parameters, (a) uranium and (b) gross alpha. Both of these parameters have concentrations which are in excess of the background concentration. Well 299-W11-14, which is directly upgradient of the T-1 Ditch exhibits the most dramatic difference. It appears that the concentrations are dropping over time, so the contamination may be part of a plume which is moving through the area.

Figure B-2 also shows two related parameters, (a) technetium-99 and (b) gross beta. The background concentration for gross beta is naturally low,

while the concentration is elevated in the groundwater in upgradient well 299-W11-14 and downgradient well 299-W12-1. This figure is somewhat misleading, in that the 1/25 DCG is so high compared to the groundwater concentrations. It is important to note that while the technetium-99 concentrations do not approach the level of the 1/25 DCG, they are elevated with respect to natural conditions. The last measures value at well 299-W11-14 was in excess of 100 pCi/L.

Figure B-3 shows organic parameters (a) carbon tetrachloride and (b) chloroform. In the case of these two parameters, the MCL was used for comparison purposes, because background values would not exist for these constituents under normal conditions, and comparison to a regulatory limit aids in determining if there are problems with the concentration levels. Both of these parameters are elevated in the upgradient groundwater, and both of them are the result of extensive groundwater contaminant plumes within the 200 West Area.

Figure B-4 shows anion parameters (a) nitrate and (b) sulfate. Nitrate concentrations in the T-1 Ditch effluent are lower than the MCL value. All of the upgradient wells and the down gradient well shown, have elevated concentrations of nitrate. This parameter is part of a major 200 West Area contaminant plume, which underlies the 216-T-1 Ditch area. Sulfate in the 216-T-1 Ditch effluent is well below the background value. Well 299-W11-14, which is directly upgradient of the ditch, and 299-W12-1, which is down gradient of the ditch, both show elevated concentrations of sulfate. Nitrate and sulfate are moving in from upgradient contamination sources as part of groundwater contaminant plumes.

Figure B-5 shows metal parameters (a) aluminum and (b) iron. T-1 Ditch effluent has historically shown elevated concentrations of both constituents. However, this has varied over time, with concentration dipping below the background value in the late 1980's/early 1990's. At this time, both parameters are once again elevated in the effluent. Of the upgradient and downgradient wells, only 299-W11-7 has shown elevated concentrations of iron in the past. Presently, none of these wells have elevated concentrations of either parameter. Only the effluent from the T-1 Ditch appears to be elevated in concentration for these two parameters.

Figure B-1. Concentration Plots of 216-T-1 Ditch Effluent, Groundwater, and the Hanford Site Background Average for the Unconfined Aquifer (Johnson 1993) for (a) Uranium and (b) Gross Alpha.

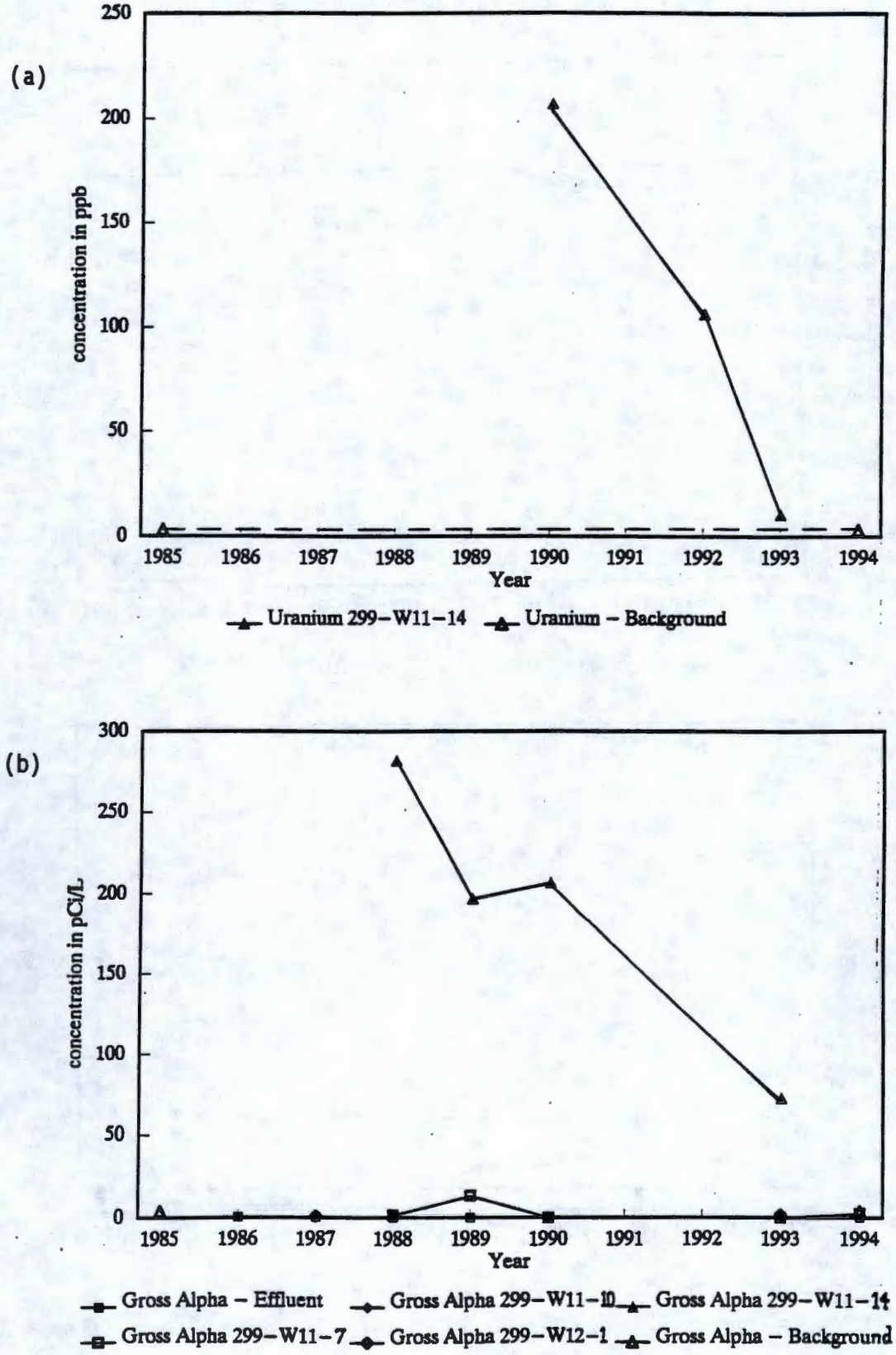
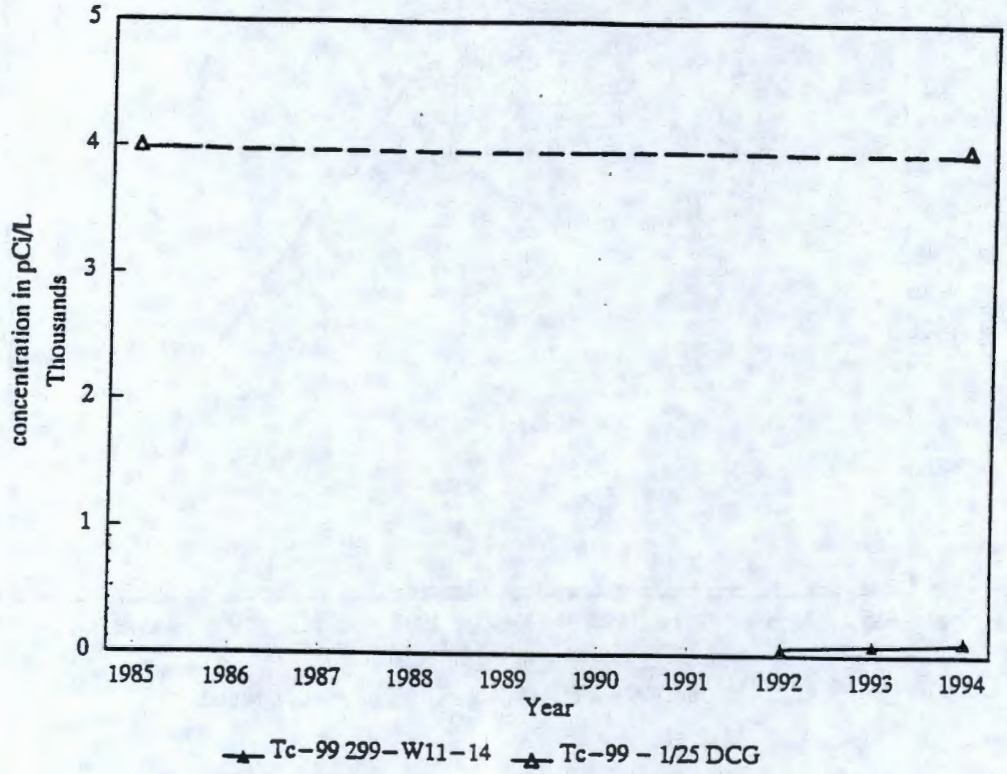


Figure B-2. Concentration Plots of 216-T-1 Ditch Effluent, Groundwater, and 1/25 Derived Concentration Guideline (WHC 1988)/Hanford Site Background Average for the Unconfined Aquifer (Johnson 1993) for (a) Technetium-99 and (b) Gross Beta.

(a)



(b)

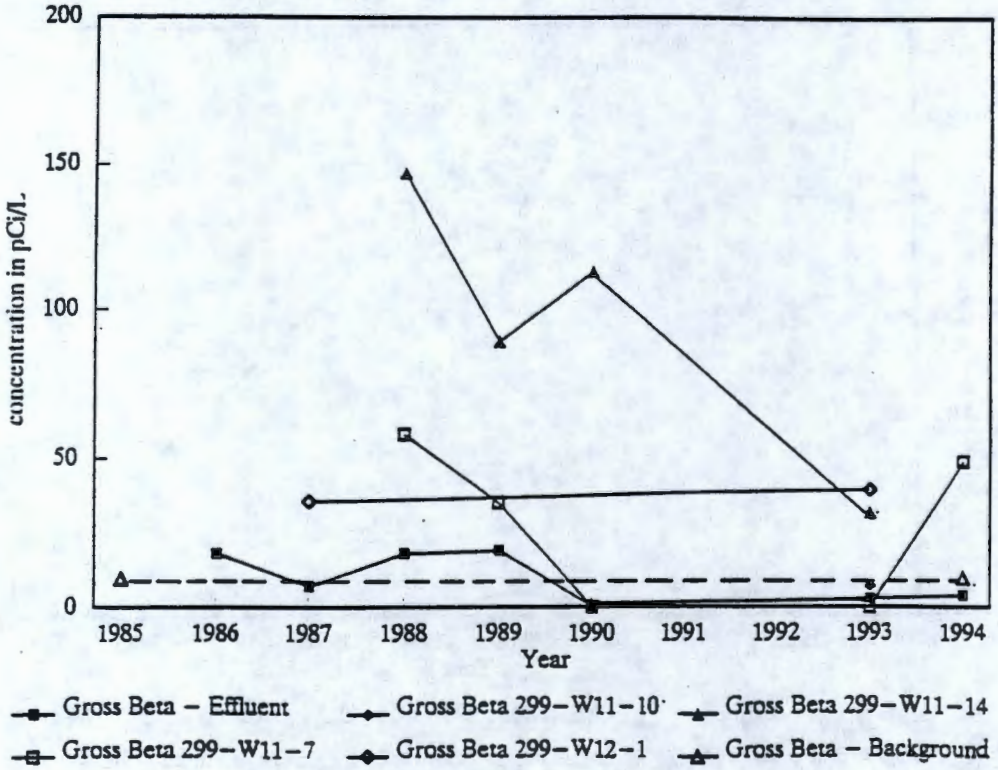


Figure B-3. Concentration Plots of Groundwater and Maximum Concentration Guidelines (40 CFR 141) for (a) Carbon Tetrachloride and (b) Chloroform.

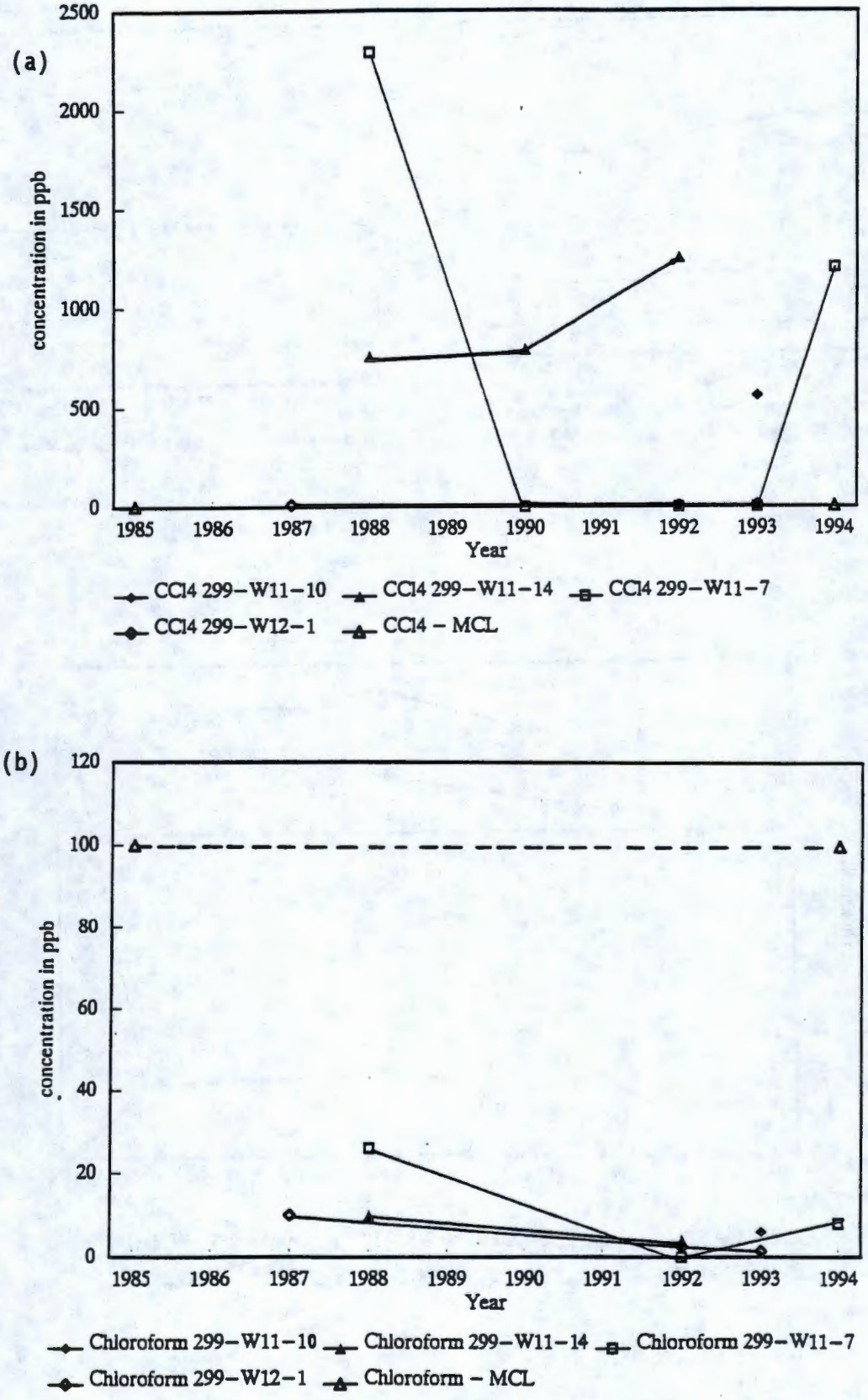
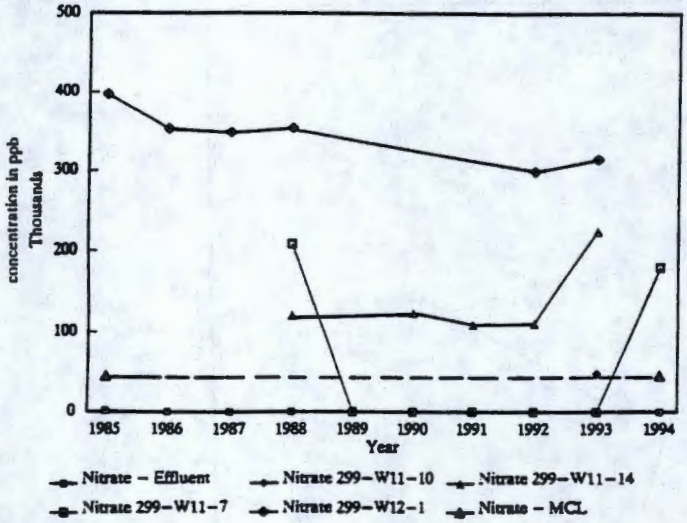
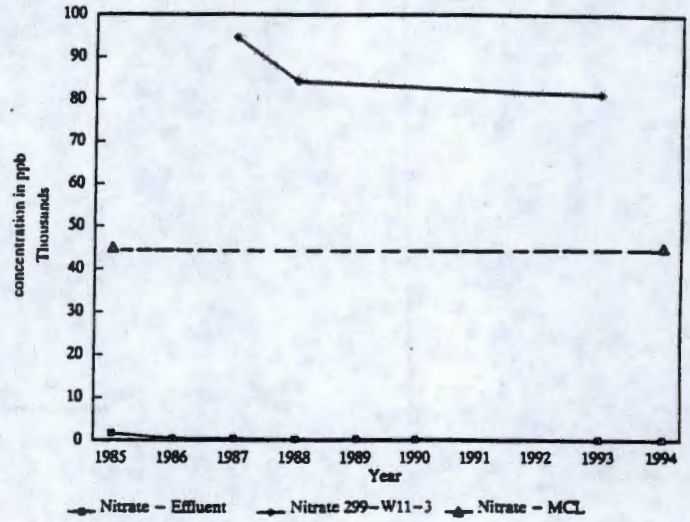


Figure B-4. Concentration Plots of 216-T-1 Ditch Effluent, Groundwater, and Maximum Concentration Guidelines (40 CFR 141)/Hanford Site Background Average for the Unconfined Aquifer (Johnson 1993) for (a) Nitrate and (b) Sulfate.

(a)





(b)

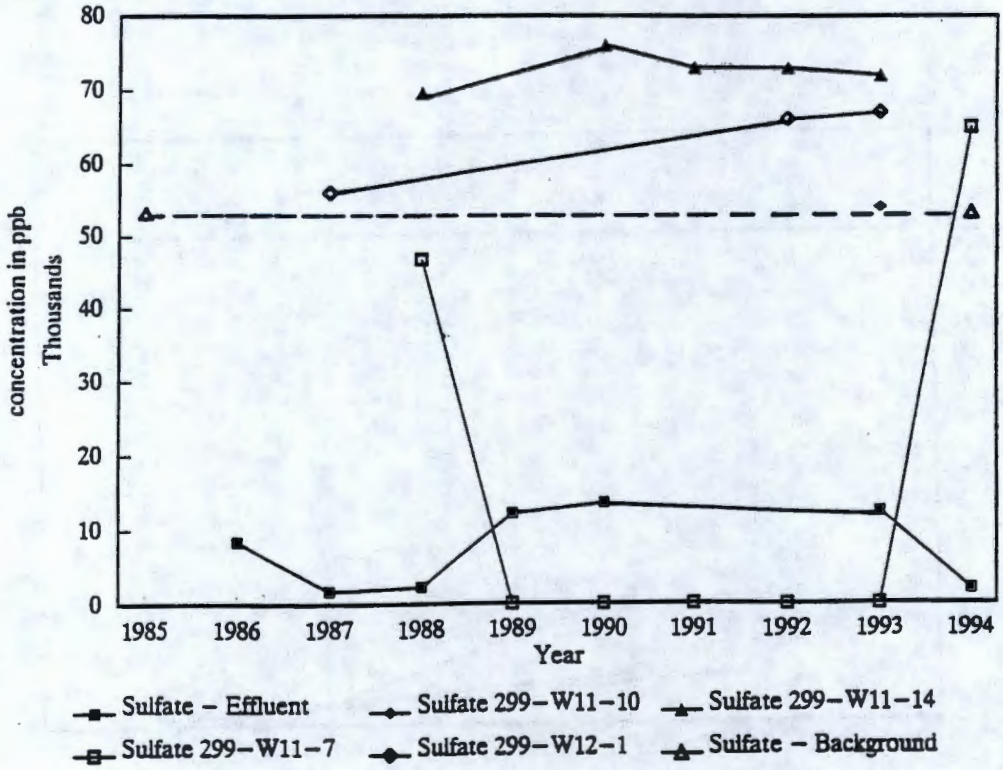
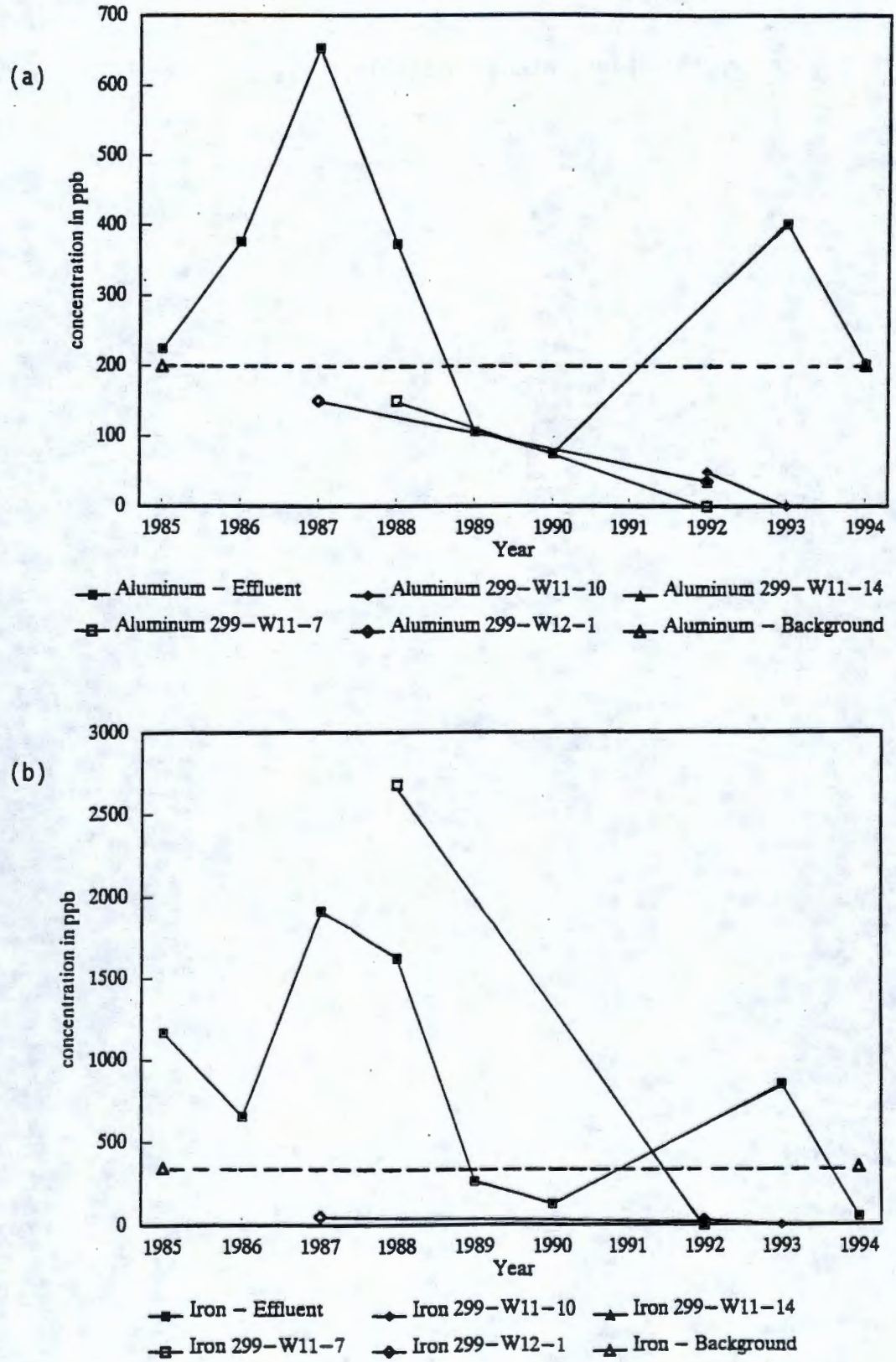


Figure B-5. Concentration Plots of 216-T-1 Ditch Effluent, Groundwater, and Hanford Site Background Average for the Unconfined Aquifer (Johnson 1993) for (a) Aluminum and (b) Iron.



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APPENDIX C

ANNUAL AVERAGE TIME-SERIES PLOTS

CHEMICAL CONSTITUENTS DETECTED IN THE WASTEWATER EFFLUENT (1985 TO PRESENT)

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ANNUAL AVERAGE TIME-SERIES PLOTS

CHEMICAL CONSTITUENTS DETECTED IN THE WASTEWATER EFFLUENT (1985 TO PRESENT)

Appendix C contains plots the major cation, miscellaneous, heavy metals, radionuclides, regulated, and major anion chemical constituents detected in the wastewater effluent from 1985 to the present time.

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Figure C-1. Major Cation Chemical Constituents.

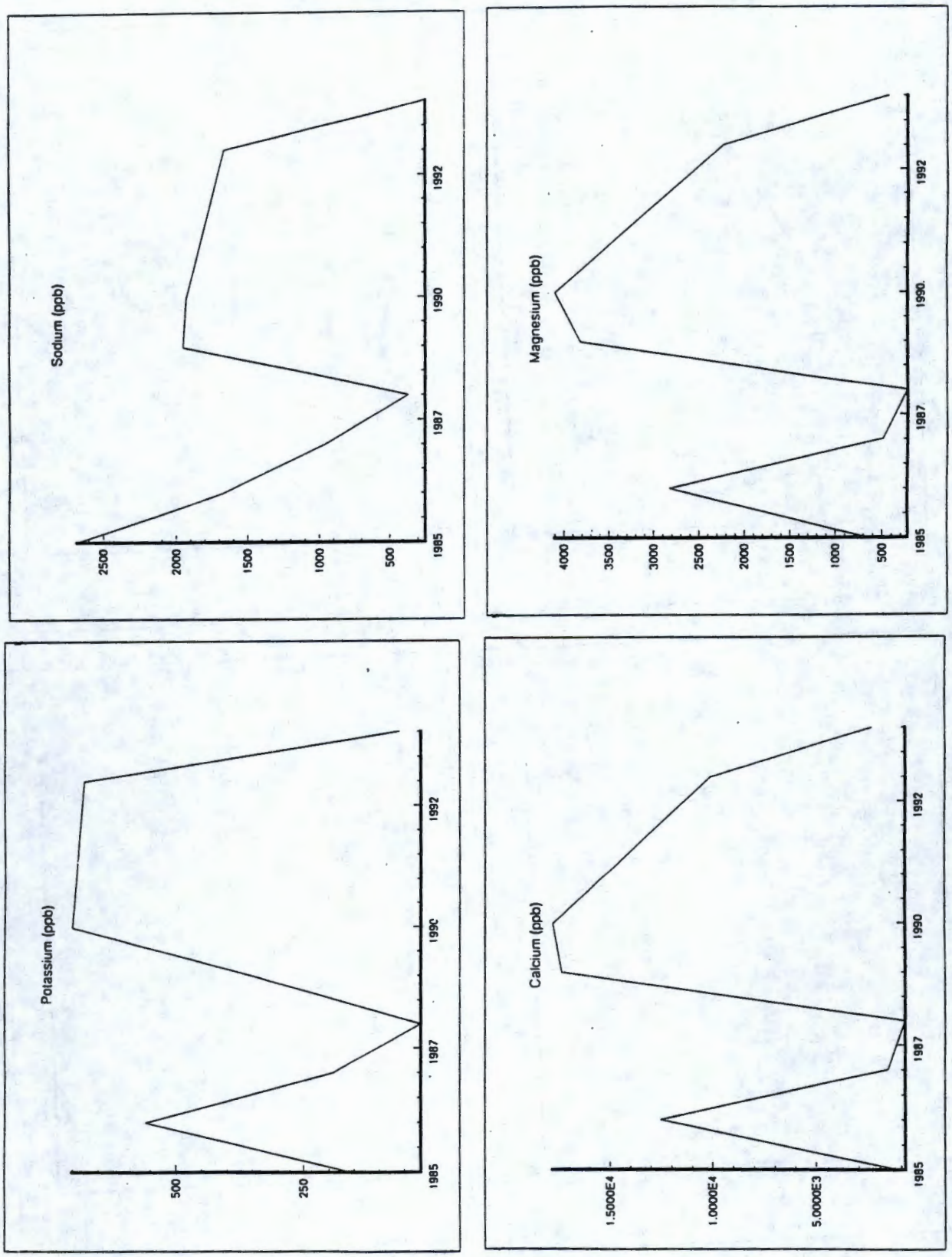

Figure C-2. Miscellaneous Chemical Constituents.

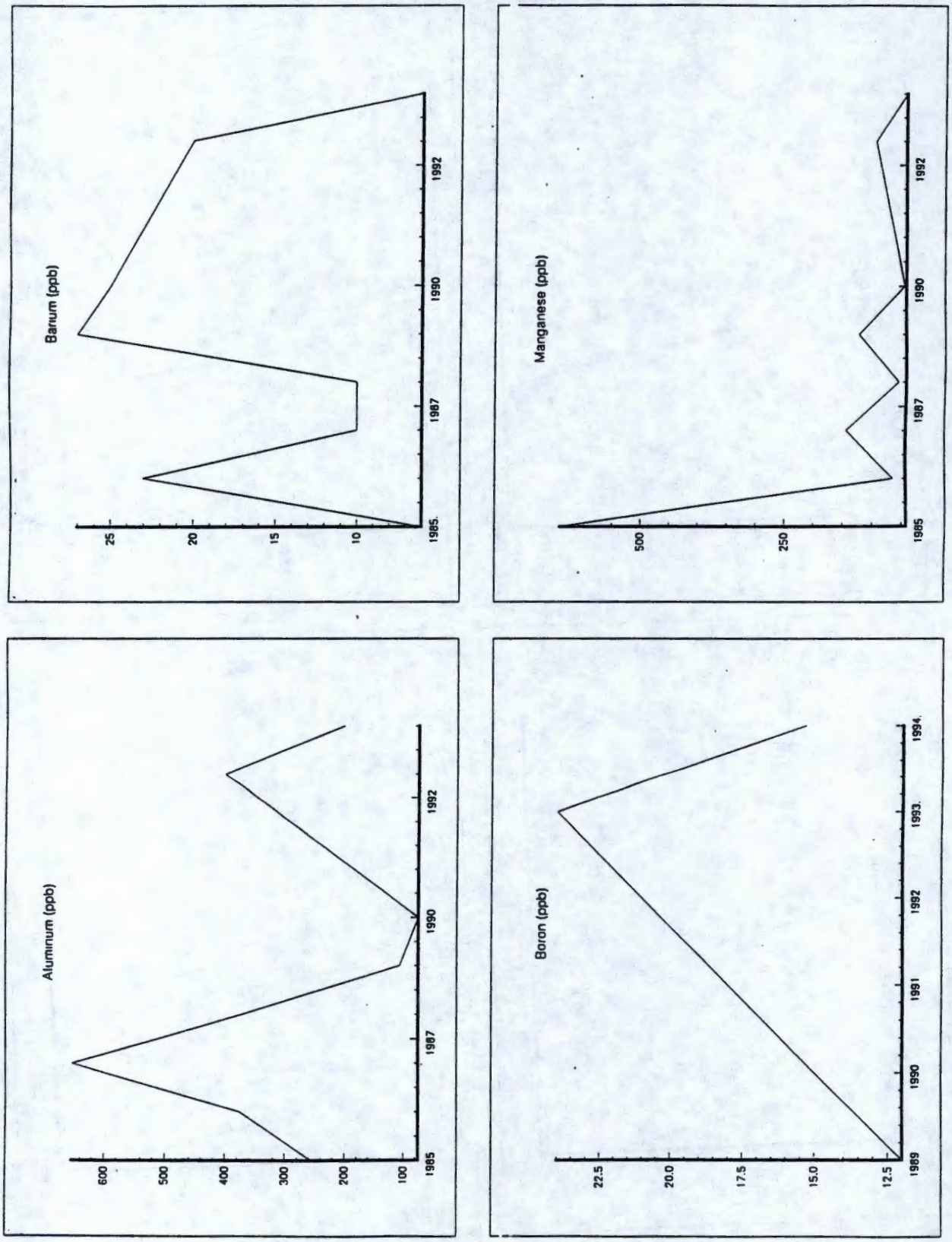

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Figure C-5. Regulated Chemical Constituents.

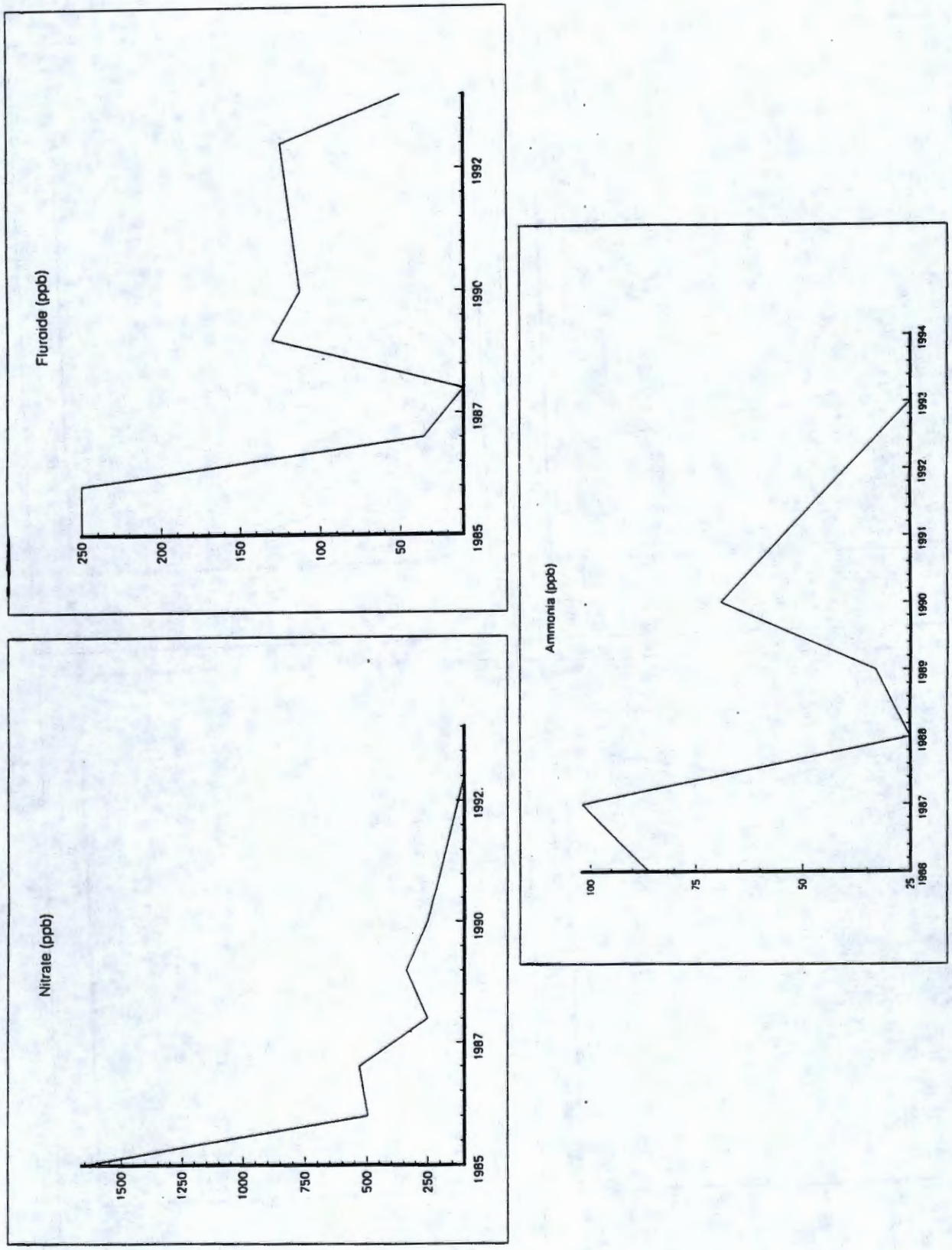

Figure C-6. Major Anion Chemical Constituents.

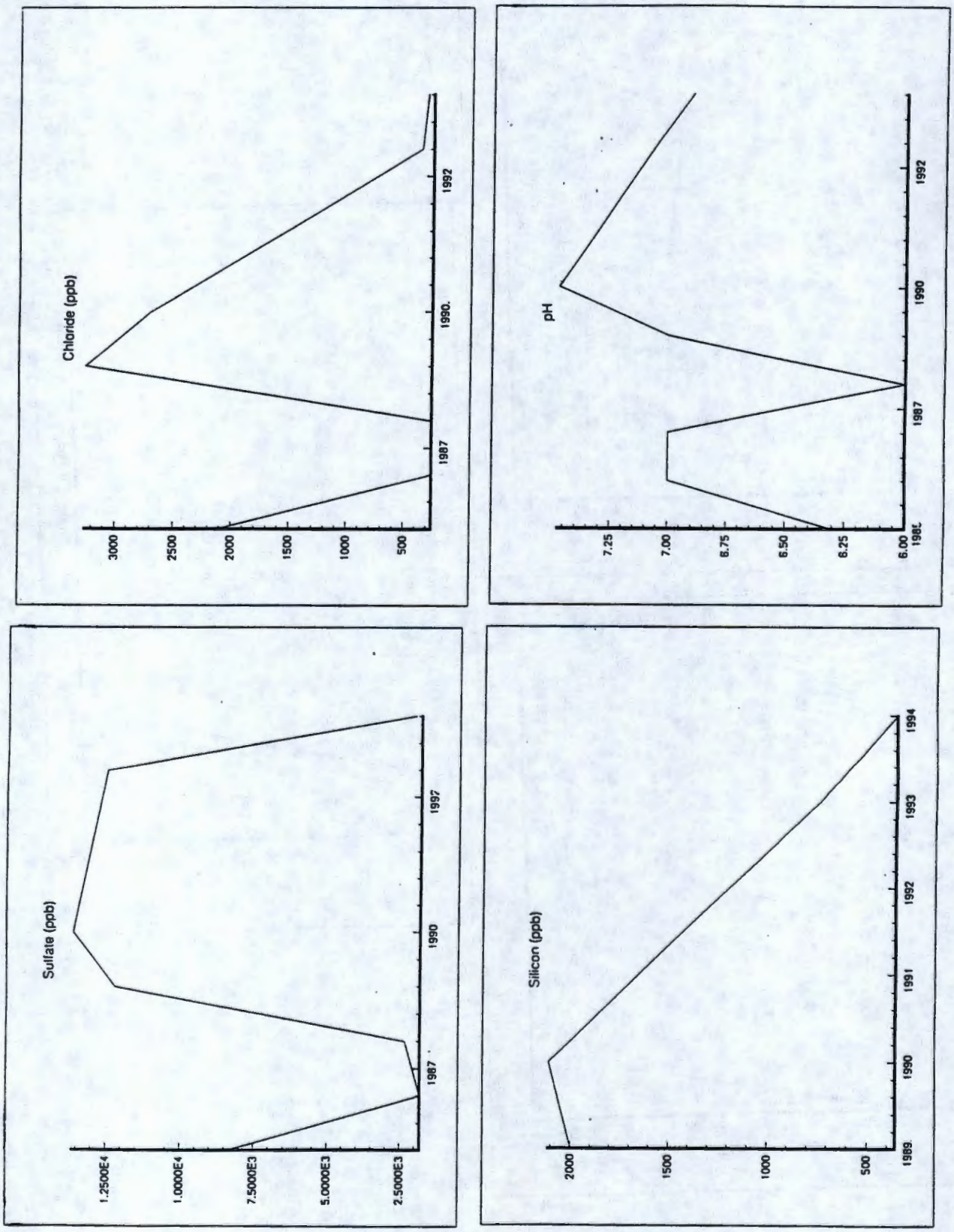

Figure C-3. Heavy Metal Chemical Constituents.

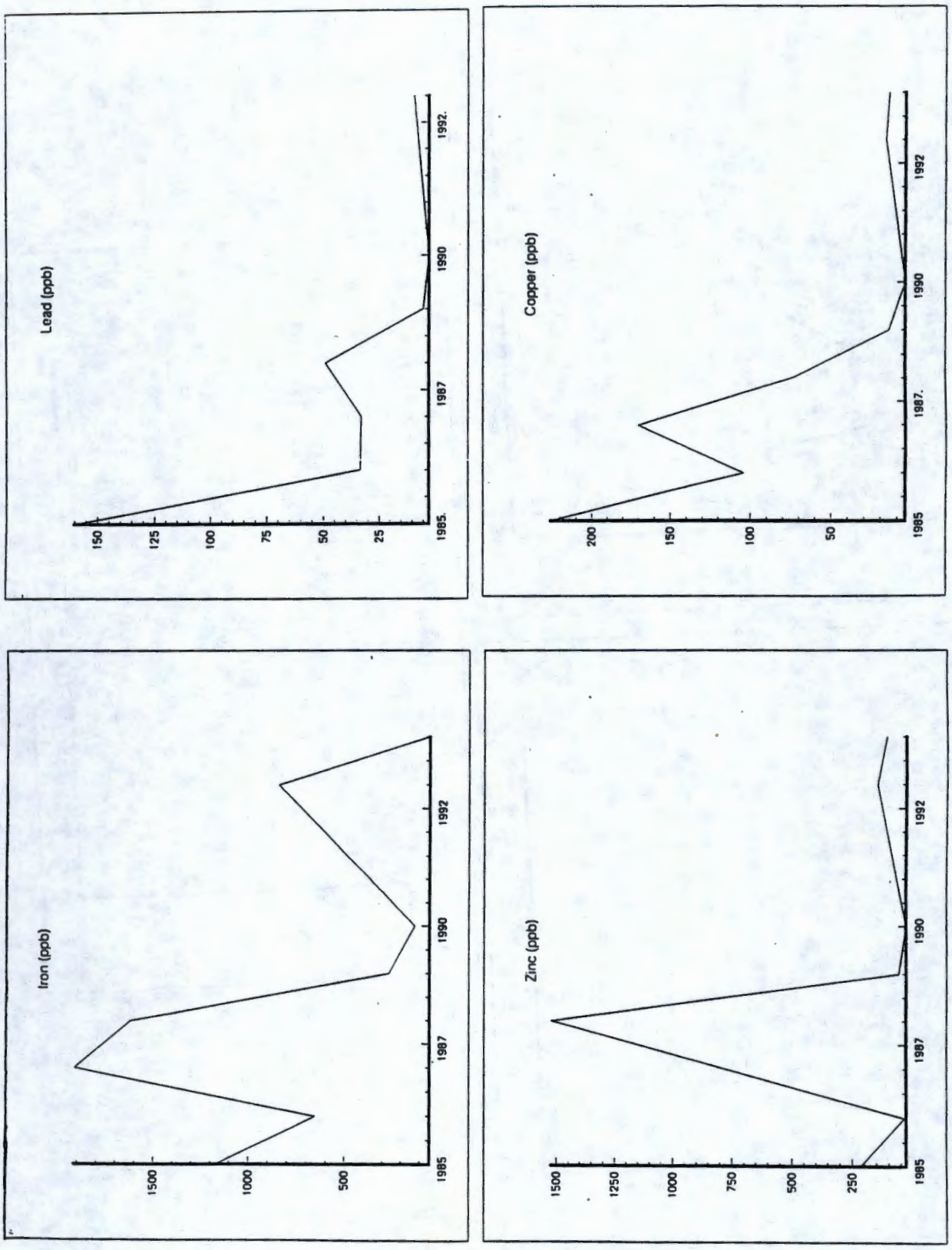
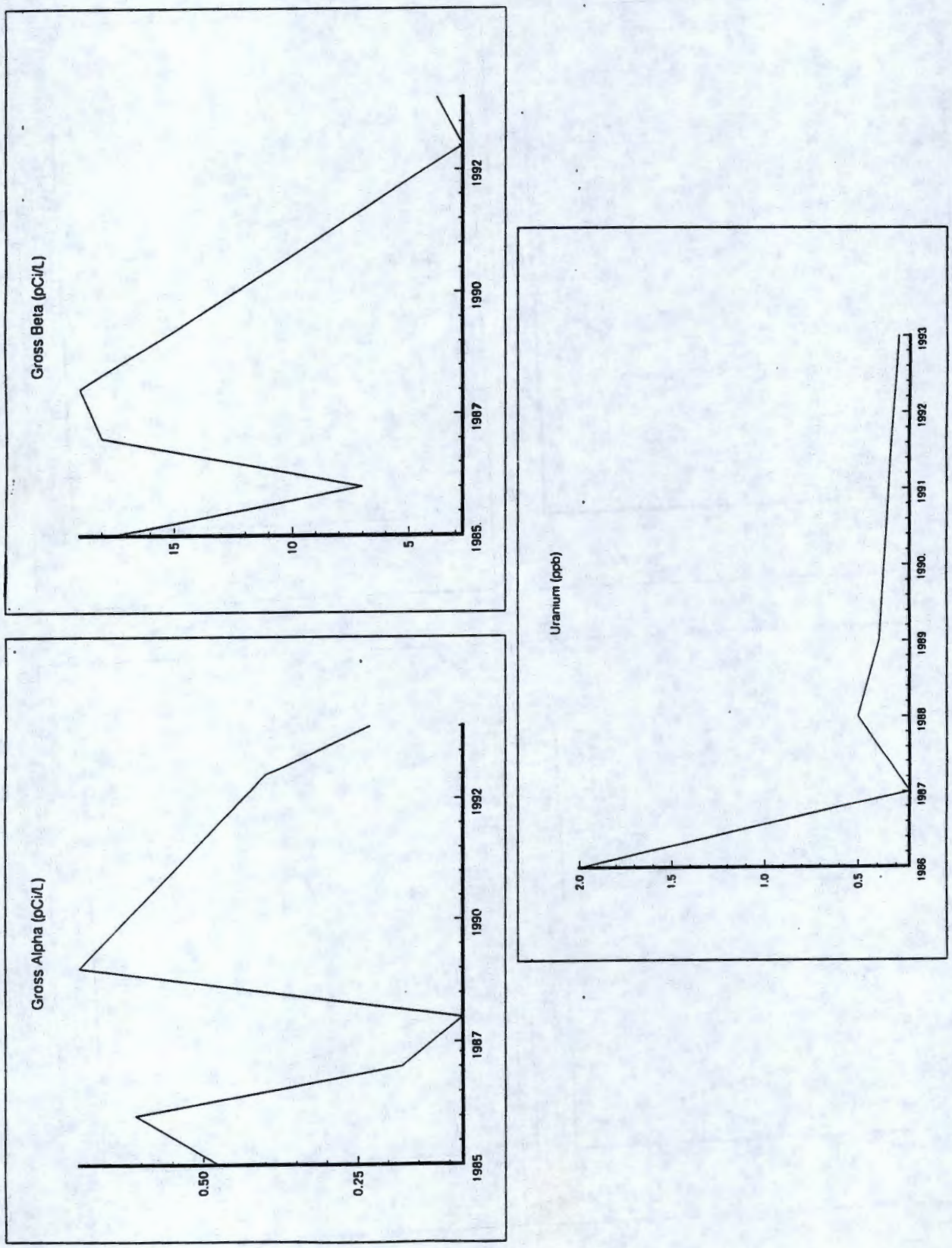
Figure C-4. Radionuclides Chemical Constituents.