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DOE/RL-2008-61
Draft Rev. 1

Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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Richland, Washington 99352

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Date Published
September 2015

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APPROVED
By Ashley R Jenkins at 7:34 am, Sep 01, 2015

Release Approval | Date

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Executive Summary

This document presents a revision to the 216-S-10 Pond and Ditch (hereinafter referred to as the S-10 unit) 2010 groundwater monitoring plan[1]. This revised monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976*[2] (RCRA) and the implementing requirements in WAC 173-303-400[3], which in turn, specifies groundwater monitoring regulations under 40 CFR 265[4]. The U.S. Department of Energy, Richland Operations Office has undertaken revision of this RCRA groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford groundwater monitoring information for the treatment, storage, and disposal (TSD) unit. This indicator evaluation program groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at the S-10 unit.

The S-10 unit is a non-operating interim status TSD unit in the 200-OA-1 Soil Operable Unit (OU) (formerly it was in the 200-CS-1 Soil OU) located above the 200-UP-1 Groundwater OU. The S-10 unit is located south-southwest of the 200 West Area, outside of the perimeter fence. The 216-S-10 Ditch (S-10 Ditch) began receiving nonregulated wastewater from the Reduction-Oxidation (REDOX) Facility in August 1951. The 216-S-10 Pond (S-10 Pond) was added to the southwest end of the S-10 Ditch in 1954 and, like the ditch, served as an evaporation/infiltration basin for liquid discharges. Wastewater discharged to the S-10 Ditch flowed into the S-10 Pond and infiltrated into the ground, which created perched water in the vadose zone and created a groundwater mound on the underlying aquifer.

The S-10 unit received one documented dangerous waste discharge. The discharge occurred in September 1983 and consisted of synthetic double-shell tank slurry from the Chemical Engineering Laboratory. The S-10 Pond and the southwest end of the

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[1] DOE/RL-2008-61, 2010, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

[2] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

[3] WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-400.

[4] 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-part265.xml.

S-10 Ditch were decommissioned, backfilled, and stabilized in October 1985. The northern portion of the S-10 Ditch remained operational and received nondangerous chemical sewer waste from the REDOX Facility until October 1991. The remaining portion of the S-10 Ditch was decommissioned in 1991. In July 1994, the effluent supply pipeline was plugged with concrete near the outfall.

As the S-10 unit received wastewater contaminated with dangerous waste or dangerous waste constituents, a groundwater monitoring program in accordance with 40 CFR 265 was implemented in 1991. To date, statistical analyses of the RCRA parameters used as indicators of groundwater contamination have not shown an exceedance relative to the statistical comparison value (as defined in 40 CFR 265.93[b]); therefore, the site remains under the indicator evaluation program described in 40 CFR 265.92[5]. Currently, chromium occurs in downgradient Well 299-W26-13 at about 120 µg/L, which is above the 48 µg/L cleanup level for hexavalent chromium and above the 100 µg/L drinking water standard for total chromium. However, none of the indicator parameters required to be monitored under interim status are sensitive to chromium at these concentrations, so the elevated chromium has not resulted in an indicator parameter exceedance. While the S-10 unit is the probable source of this chromium, it cannot be conclusively linked to the S-10 unit because there are other potential sources of chromium nearby, particularly the 216-S-11 Pond. Carbon tetrachloride is also detected in some of the network monitoring wells, but this constituent originates from other sources in the 200 West Area.

This revised RCRA groundwater monitoring plan presents a revised indicator evaluation program for detection monitoring of the uppermost aquifer beneath the S-10 unit. This plan addresses the following:

- Number, locations, and depths of wells in the S-10 unit groundwater monitoring network
- Sampling and analytical methods of parameters required for groundwater contamination detection monitoring

[5] 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-sec265-92.xml.

- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at the S-10 unit

This revised plan uses the existing groundwater monitoring well network as identified in the previous groundwater monitoring plan (DOE/RL-2008-61, Rev. 0). Groundwater flow direction determinations indicate flow toward the east-southeast beneath the S-10 unit. Groundwater in the S-10 unit monitoring wells will be sampled and analyzed semiannually for the parameters used as indicators of groundwater contamination (pH, specific conductance, total organic carbon, and total organic halogen) and annually for parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) in accordance with 40 CFR 265.92(b)(2)&(3) and (d). Site-specific constituents chromium, nitrate, carbon tetrachloride, and nickel, major anions and cations will also be monitored. Water-level measurements will be taken each time a sample is collected to satisfy 40 CFR 265.92(e).

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Terms

AEA	*Atomic Energy Act of 1954*
bgs	below ground surface
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CSM	conceptual site model
DOE	U.S. Department of Energy
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
OU	operable unit
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Facility)
TOC	total organic carbon
TOX	total organic halide
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*

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1 Introduction

This document presents the revised groundwater monitoring plan for the 216-S-10 Pond and Ditch (hereinafter referred to as the S-10 unit) and supersedes the previous plan, DOE/RL-2008-61, Rev. 0, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*. This groundwater monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA), with regulations promulgated by the Washington State Department of Ecology (Ecology) in the *Washington Administrative Code* (WAC), and the *Code of Federal Regulations* (CFR) by reference (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"; 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring"). This plan monitors indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan also monitors parameters used in establishing groundwater quality.

The S-10 unit is a non-operating interim status treatment, storage, and disposal (TSD) unit regulated as a surface impoundment, as defined in WAC 173-303-040, "Definitions." For regulatory purposes, the TSD unit boundary of the S-10 unit is identified on the current Hanford Facility Dangerous Waste Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*) Part A Form.

Closure of the S-10 unit will be coordinated with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as part of the 200-OA-1 Soil Operable Unit (OU). Groundwater cleanup will be addressed under the 200-UP-1 Groundwater OU. A draft closure plan has been prepared (DOE/RL-2006-12, Draft B, *216-S-10 Pond and Ditch Closure Plan*).

The S-10 unit is located south-southwest of the 200 West Area, outside of the perimeter fence (Figure 1-1). The 216-S-10 Ditch (S-10 Ditch) began receiving wastewater from the Reduction-Oxidation (REDOX) Facility in August 1951. The 216-S-10 Pond (S-10 Pond) was added to the southwest end of the S-10 Ditch in February 1954. Wastewater discharged to the S-10 Ditch flowed into the S-10 Pond and infiltrated into the ground, which created perched water in the vadose zone and created a groundwater mound on the underlying aquifer. The S-10 unit received one documented dangerous waste discharge in September 1983, which consisted of synthetic double-shell tank (DST) slurry from the Chemical Engineering Laboratory. The S-10 Pond and the southwest end of the S-10 Ditch were decommissioned, backfilled, and stabilized in October 1985. The northern portion of the S-10 Ditch remained operational and received nondangerous chemical sewer waste from the REDOX Facility until October 1991 (BHI-00176, *S Plant Aggregate Area Management Study Technical Baseline Report*). The remaining portion of the S-10 Ditch was decommissioned in 1991.

The purpose of this RCRA plan is to present an updated groundwater monitoring program for parameters used as indicators of groundwater contamination from the S-10 unit, commonly referred to as an indicator evaluation program. This plan is intended specifically to satisfy monitoring requirements for interim status TSD units, as required by WAC 173-303-400(3) and 40 CFR 265.92. This monitoring plan is the principal controlling document for conducting groundwater monitoring at the S-10 unit. The indicator evaluation program detailed in this plan requires semiannual sampling for parameters used as indicators of groundwater contamination, as well as annual sampling for parameters establishing groundwater quality for the single upgradient and five downgradient wells. Also, water level measurements are required each time a sample is collected to satisfy 40 CFR 265.92(e).

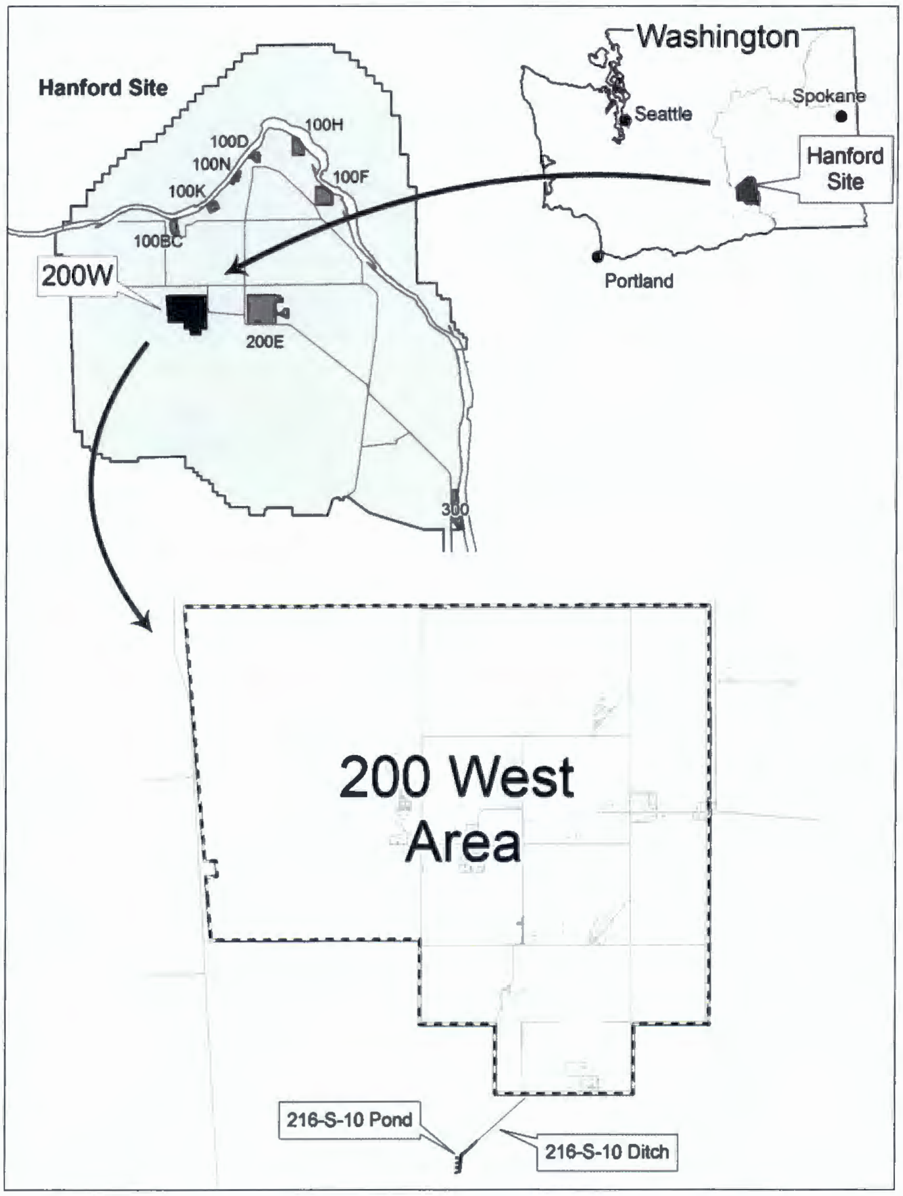


Figure 1-1. Location Map for the 216-S-10 Pond and Ditch

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the site and incorporates knowledge about the potential for contamination originating from the S-10 unit. Chapter 2 of this plan summarizes background information and references other documents that contain more detailed or additional information. Chapter 2 also describes the S-10 unit and the regulatory basis, types of waste present, the pertinent geology and hydrogeology beneath the facility and provides a brief history of groundwater monitoring. All of this information is summarized as a CSM to aid in development of the groundwater monitoring program. Chapter 3 describes the RCRA groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols. Chapter 4 describes the data evaluation and reporting, Chapter 5 provides an updated outline for a groundwater quality assessment plan, and Chapter 6 contains the references cited in this plan. Appendix A provides the quality assurance project plan (QAPjP), Appendix B contains sampling protocols, and Appendix C provides information for the wells within the groundwater monitoring network.

2 Background

This chapter describes the S-10 unit and its operating history, regulatory basis, wastes and waste characteristics associated with the facility, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM. It also addresses site-specific constituents that are sampled as part of the monitoring program.

The information contained in this chapter was obtained from several sources, including the Waste Information Data System general summary reports, previous groundwater monitoring plans listed in Table 2-1, and the following documents:

- BHI-00176, *S Plant Aggregate Area Management Study Technical Baseline Report*
- DOE/RL-91-60, *S Plant Aggregate Area Management Study Report*
- DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*
- DOE/RL-2005-63, *Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit*
- DOE/RL-2005-64, *Proposed Plan for the 200-CS-1 Chemical Sewer Group Unit*
- PNNL-15731, *Post-Closure Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*
- RHO-CD-673, *Handbook 200 Areas Waste Sites*

2.1 Facility Description and Operational History

The S-10 unit is located south-southwest of the 200 West Area, directly outside of the perimeter fence (Figure 2-1). The initial configuration of the S-10 unit was a single, open, unlined ditch (S-10 Ditch), approximately 1.2 m (4 ft) wide at its base, at least 1.8 m (6 ft) deep, and 686 m (2,250 ft) long. The ditch began receiving wastewater in August 1951. Discharge to the ditch was through a 30.5 cm (12 in.) vitrified clay pipeline from the REDOX Facility. The S-10 Pond was added to the southwest end of the S-10 unit in February 1954 to provide additional wastewater capacity. The S-10 Pond covered 20,234 m^2 (5 ac) and resembled a backwards "E" with an extra leg; each "leg" was a separate leaching trench. The pond was approximately 2.4 m (8 ft) deep at its deepest point. Like the ditch, the pond was unlined and served as an evaporation/infiltration basin for liquid effluent discharges. Wastewater discharged into the S-10 Ditch then flowed into the S-10 Pond where it evaporated or infiltrated into the ground. This infiltration created perched water in the vadose zone and created a groundwater mound on the underlying aquifer.

Starting in August 1951, nonregulated wastewater from the REDOX Facility chemical sewer was routed to the S-10 Ditch for disposal. In May 1954, increases in discharge to the S-10 unit necessitated the excavation of two additional ponds on the southeast side of the S-10 Ditch (i.e., 216-S-11 Ponds [S-11 Ponds]). An inadvertent release of ammonium nitrate nonahydrate reduced the infiltration capacity in the S-10 unit. To improve infiltration in the S-10 Ditch, 0.6 m (2 ft) of sediment was dredged from the bottom of the ditch in 1955. The contaminated sediment was buried in excavation pits along the sides of the ditch.

Table 2-1. Previous Monitoring Plans

Document	Date Issued	Monitoring Program* (and Change Description)
WHC-SD-EN-AP-018, Rev. 0, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*	1990	Indicator evaluation program
ECN-113816	4/12/1990	Added perched zone well (299-W26-11)
ECN-618168	11/14/1994	Added text allowing changes to the constituent list and sampling frequency after the first year of monitoring
ECN-618188	9/20/1995	Changes to sampling procedures, analyte lists, and sample frequencies
PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*	2002	Indicator evaluation program
PNNL-14070-ICN-1	11/24/2003	Updated because one well became dry (299-W26-7) and a new well was installed (299-W26-14)
PNNL-14070-ICN-2	11/1/2006	Updated for sample frequency changes and to include current wells in network, as well as planned wells to be drilled
DOE/RL-2008-61, Rev. 0, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*	2010	Indicator evaluation program

* The indicator evaluation program satisfies the requirements of 40 CFR 265.92(b)(2), (b)(3), (d)(1), (d)(2) and (e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

In 1965, discharges decreased so wastewater no longer flowed into the S-11 Ponds. The southernmost portion of the S-11 Ponds was surveyed, determined to be free of radioactive contamination, and backfilled during the summer of 1975. The entire S-11 Ponds were stabilized by September 30, 1983, and they are not part of the S-10 unit RCRA facility. The REDOX Facility was closed in 1967, and at that time, effluent to the S-10 unit was reduced primarily to chemical sewer waste. When the REDOX Facility was deactivated in 1972, physical controls were in place to eliminate dangerous waste discharges from the REDOX Facility to the S-10 unit. These controls reduced discharges from the REDOX Facility to only nondangerous chemical sewer effluent.

In September 1983, the S-10 unit received one documented discharge of dangerous waste, which came from the Chemical Engineering Laboratory. This laboratory produced synthetic waste tank slurry to test methods for recovering slurry from DSTs (PNNL-15731). This discharge is described in more detail in Section 2.3.

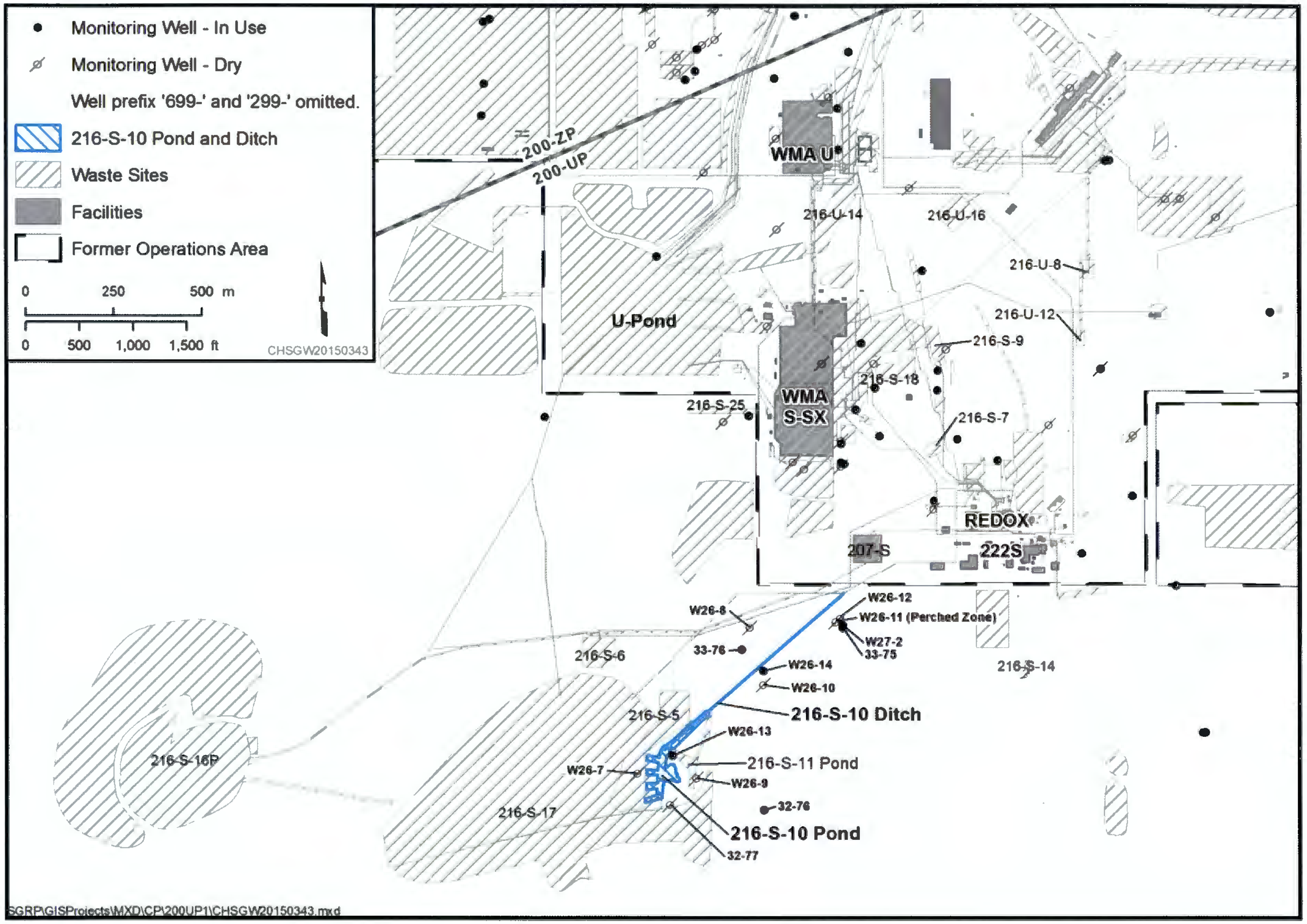


Figure 2-1. Map of the 216-S-10 Pond and Ditch

The S-10 Pond and southwest end of the S-10 Ditch were decommissioned, backfilled, and stabilized in October 1985. The northern portion of the ditch remained operational and received nondangerous chemical sewer waste from the REDOX Facility until October 1991 (BHI-00176), when the remaining portion of the ditch was decommissioned. In July 1994, the effluent supply pipeline was plugged with concrete near the outfall. Figure 2-2 shows the annual and cumulative liquid effluent volumes discharged to the S-10 unit from the REDOX Plant chemical sewer.

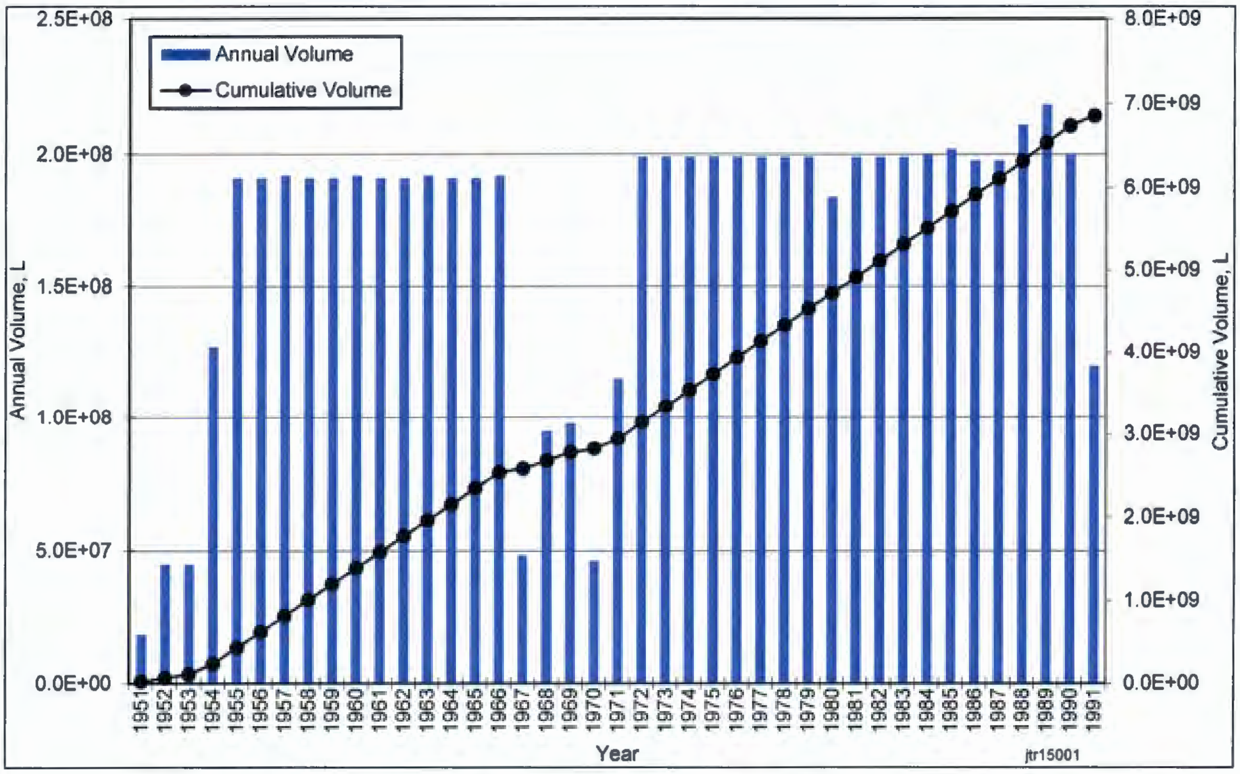


Figure 2-2. Liquid Effluent Volumes Discharged to the 216-S-10 Pond and Ditch from the REDOX Plant Chemical Sewer

Since 1991, RCRA groundwater monitoring has been conducted in accordance with interim status requirements of WAC 173-303-400 (which incorporate 40 CFR 265, Subpart F by reference). The S-10 unit is currently monitored under interim status indicator parameter evaluation.

The S-10 unit overlies the CERCLA 200-UP-1 Groundwater OU. In addition, the site is part of the CERCLA 200-OA-1 Soil OU (it was formerly in the 200-CS-1 Soil OU). A remedial investigation, which included the S-10 unit, was conducted for the 200-CS-1 OU, and the results were presented in DOE/RL-2004-17. Comprehensive chemical and radiological analyses were performed on soil samples collected from boreholes and trenches excavated within the S-10 unit. Results of the chemical analyses are discussed in Section 2.5.2.

2.2 Regulatory Basis

In May 1987, the U.S. Department of Energy (DOE) issued a final rule (10 CFR 962, "Byproduct Material"), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized Ecology to regulate these hazardous waste components within the State of Washington (51 FR 24504, "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste"). In 1996, the Washington State Attorney General determined that the effective date for regulation of mixed waste in Washington State was August 19, 1987.

In May 1989, DOE, EPA, and Ecology signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989,). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the S-10 unit. Groundwater monitoring is conducted at the S-10 unit in accordance with WAC 173-303-400(3) (and by reference, 40 CFR 265, Subpart F), which requires monitoring to determine whether the dangerous waste constituents from the waste site have entered the groundwater.

Dangerous waste is regulated under the RCRA, as modified in 40 CFR 265 ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities") and RCW 70.105 ("Public Health and Safety," "Hazardous Waste Management") and its implementing requirements in Washington State's dangerous waste regulations (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"). Radionuclides in the mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). Both RCRA and AEA state that these radionuclide materials are regulated at DOE facilities exclusively by the DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the State of Washington under RCRA or the Washington State *Hazardous Waste Management Act of 1976* (RCW 70.105).

Groundwater monitoring at S-10 unit was initiated in 1991 (WHC-SD-EN-AP-018, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*) based on the interim status indicator parameter evaluation program requirements of 40 CFR 265, Subpart F and WAC 173-303-400. The groundwater monitoring plan was revised in 2002 (PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*) and again in 2010 (DOE/RL-2008-61, Rev. 0).

Groundwater monitoring at the S-10 unit has been conducted in accordance with the above-referenced RCRA requirements since 1991. To date, there has been no verified statistically significant exceedance of an indicator parameter (pH, specific conductance, total organic carbon [TOC], or total organic halides [TOXs]) above (or below for pH) background values. Therefore, the site continues to be monitored for indicator parameter evaluation, as specified in 40 CFR 265.92(b).

2.3 Waste Characteristics

The S-10 unit received nonregulated wastewater discharges consisting of water tower overflow, cooling water, and rainwater. The unit was designed to percolate approximately 567,800 L (150,000 gal) of waste per day. The process design capacity reflects the maximum volume of water discharged daily rather than the physical capacity of the S-10 unit.

The S-10 Ditch last received nonregulated wastewater discharge in October 1991. One documented dangerous waste discharge to the S-10 unit occurred in September 1983 (PNNL-15731), and the waste was allowed to percolate into the soil column underlying the unit. In this incident, 420 L (110 gal) of synthetic DST slurry was discharged to the S-10 unit from the Chemical Engineering Laboratory. The waste consisted largely of sodium nitrate ($NaNO_3$) (46 percent) and sodium hydroxide (NaOH) (41 percent), with small quantities of sodium phosphate (Na_3PO_4), sodium fluoride (NaF), sodium chloride (NaCl), and potassium chromate ($K_2Cr_2O_7$). Samples of this slurry taken from feed tanks TK-505 and TK-509 were analyzed before the discharge occurred. The synthetic tank slurry constituents comprise the chemical compounds identified in the Part A Permit Application submitted for the S-10 unit

(WA7890008967) and include characteristic dangerous waste (ignitable [D001], corrosive [D002], and characteristic [D007]) and state-only toxic waste (WT01 and WT02).

As shown in Figure 2-1, several past waste disposal sites are located in the immediate vicinity of the S-10 unit, including the 216-S-5 and 216-S-6 Cribs; the 216-S-11, 216-S-16, and 216-S-17 Ponds; and associated ditches. Historical discharges to these sites may have influenced the groundwater chemistry beneath the S-10 unit. It is not currently possible to conclusively distinguish the effects of these surrounding waste sites from that of the S-10 unit due to co-mingling of the discharges in the subsurface.

2.4 Geology and Hydrogeology

The geology and hydrogeology of the 200 West Area, including the region of the S-10 unit, are described in detail in the following documents. Also included are documents describing the suprabasalt geologic units present beneath the facility:

- BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*
- DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*
- PNNL-13858, 2002, *Revised Hydrogeology for the Supra-Basalt Aquifer System, 200 West Area and Vicinity, Hanford Site, Washington*
- RHO-ST-23, 1979, *Geology of the Separation Areas, Hanford Site, South-Central Washington*
- RHO-ST-42, 1981, *Hydrology of the Separations Area*
- WHC-SD-EN-AP-018, 1990, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*

2.4.1 Stratigraphy

The 200 West Area, including the S-10 unit, is located on a broad, flat area that constitutes a local topographic high known as the Central Plateau. The Central Plateau is a flood bar formed during the cataclysmic flooding events of the Glacial Lake Missoula that occurred over 13,000 years ago (PNNL-13858). The S-10 unit lies at an elevation of approximately 200 m (650 ft) above mean sea level. The three major sedimentary stratigraphic units beneath the S-10 unit are (from oldest to youngest) the Ringold Formation, the Cold Creek unit (CCU), and the Hanford formation (Figure 2-3).

The uppermost surface of the Elephant Mountain Member of the Saddle Mountain Basalt is considered the base of the suprabasalt aquifer system (bedrock) because of its dense, low-permeability interior relative to the overlying sediments. The basalt surface beneath the S-10 unit dips south-southwest, forming the southern limb of the Gable Mountain/Gable Butte anticline and the northeast flank of the Cold Creek syncline (Fecht et al., 1987, "Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State – A Summary"). Figures 2-4 and 2-5 provide detailed hydrogeologic profiles beneath the S-10 unit.

The uppermost aquifer system is contained in the Ringold Formation, which consists of continental fluvial and lacustrine sediments deposited by the ancestral Columbia and Salmon-Clearwater Rivers during late Miocene to Pliocene time periods (BHI-00184). Within the area of the S-10 unit, only Ringold stratigraphic units A, E, and the lower mud unit of this sequence are present. These units all belong to the Ringold Formation member of Wooded Island and generally correspond to hydrostratigraphic units 9, 5, and 8, respectively (PNNL-13858). The Ringold lower mud unit separates the suprabasalt aquifer system into a confined and unconfined aquifer (PNNL-13858).

Sediments beneath the S-10 unit consist of Ringold unit A, Ringold lower mud unit, Ringold unit E, CCU, and the Hanford formation, in ascending sequence. Ringold units A and E correspond to facies association I, as described in BHI-00184. These units were deposited in a channel environment and consist of variably cemented clast- and matrix-supported pebble to cobble gravel in a fine- to coarse-grained sand matrix. Between these units is the Ringold lower mud unit, which corresponds to facies association III, as described in BHI-00184. It consists of fine-grained silts deposited in a floodplain-overbank environment.

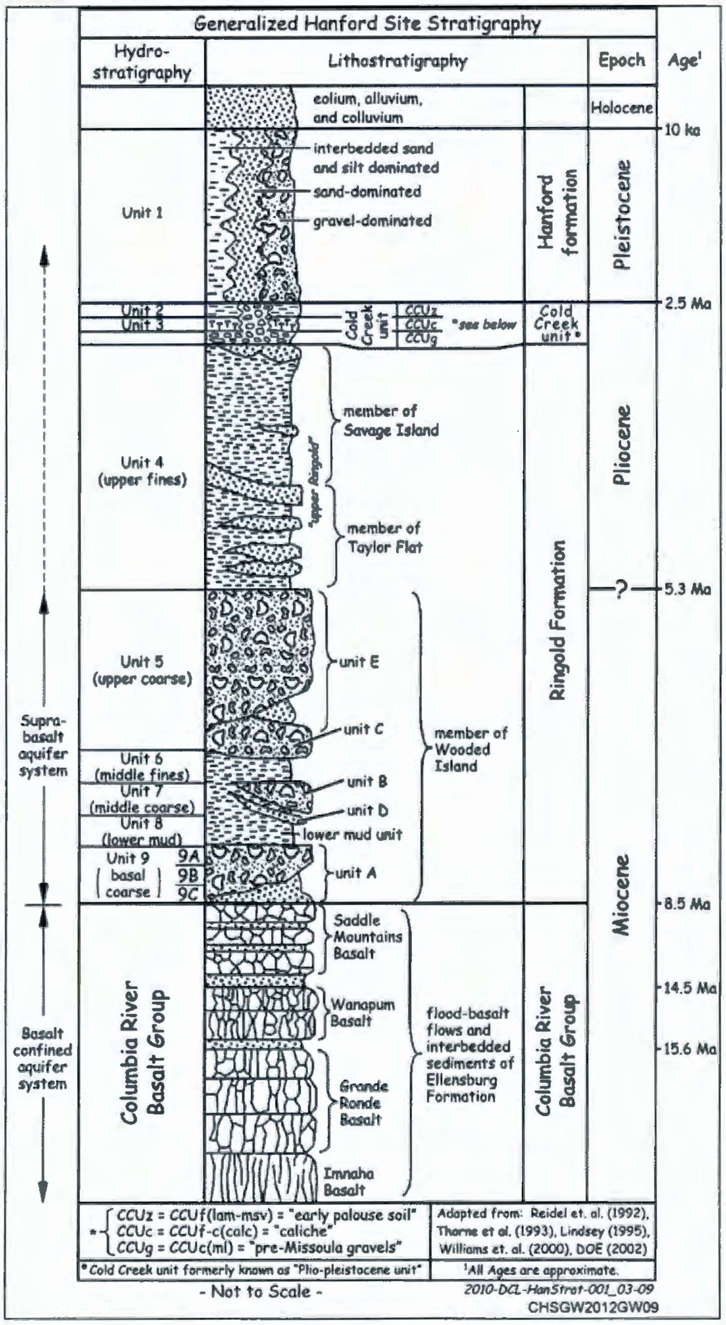


Figure 2-3. General Stratigraphy at the Hanford Site

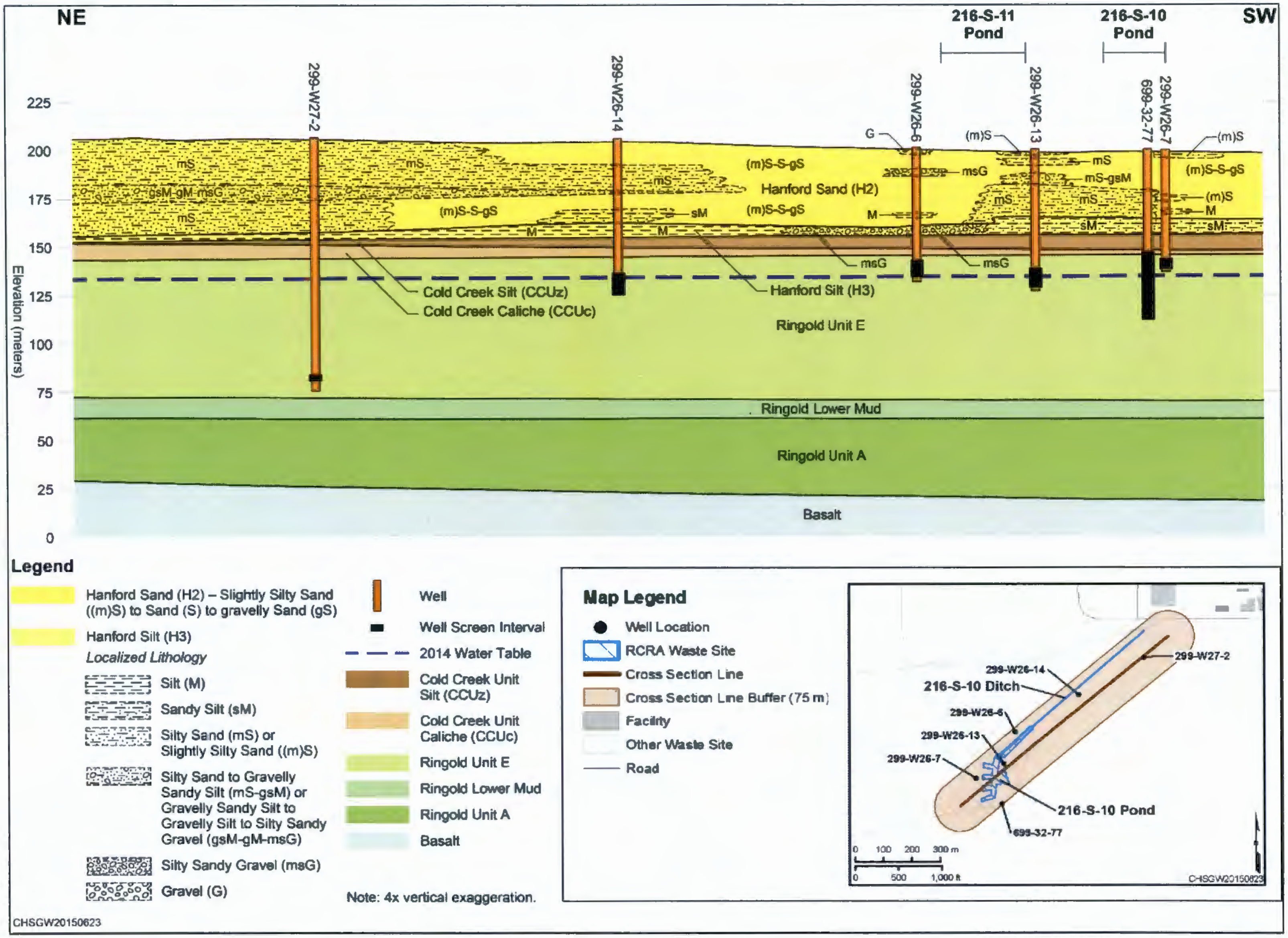


Figure 2-4. North to South Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch

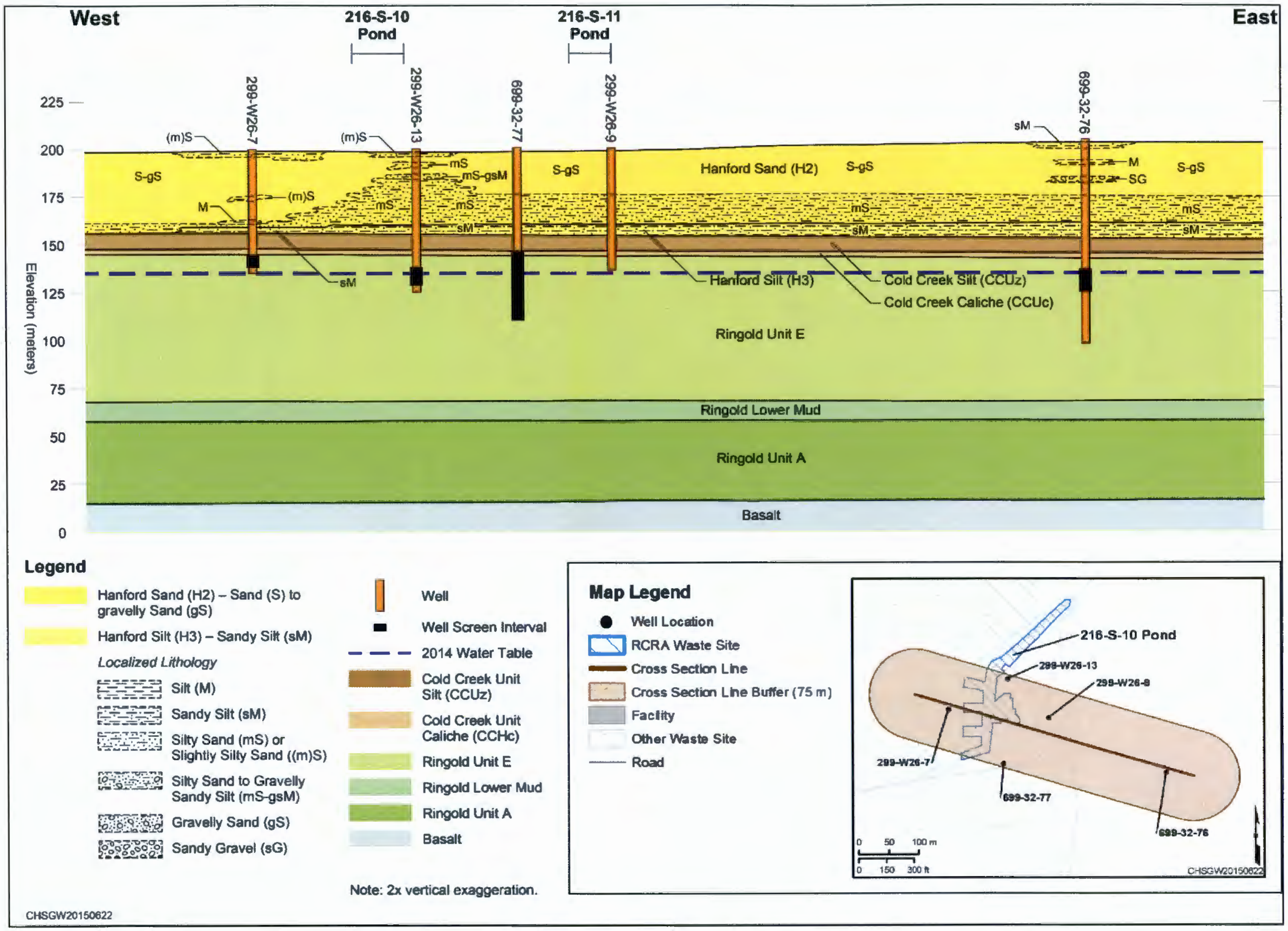


Figure 2-5. West to East Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch

The CCU represents a relatively thin but significant post-Ringold and pre-Hanford depositional unit (DOE/RL-2002-39). The lower CCU (lithofacies CCUc) is a calcic paleosol horizon that developed on the eroded surface of the Ringold Formation. This unit is commonly referred to as the "calcic sequence" (caliche zone) or the lower CCU. The upper CCU (lithofacies CCUz) is described as a fine-grained, eolian or fluvial overbank sequence; it is equivalent to what was formerly called the "early Palouse soil." At the S-10 unit, the lower CCU is less than 1 m (3.3 ft) thick, while the upper CCU ranges from 10 to 15 m (33 to 50 ft) in thickness. The upper CCU is located from approximately 33 to 43 m (110 to 140 ft) below the surface.

The Hanford formation (hydrostratigraphic unit 1) is the informal name given to Pleistocene-age cataclysmic flood deposits in the Pasco Basin (DOE/RL-2002-39). Across the Hanford Site, these deposits consist predominantly of unconsolidated sediments, which cover a wide range in grain size: from pebble- to boulder-size gravel; to fine- to coarse-grained pebbly sand; to sand, silty sand, and silt. Gravel clasts are composed of mostly sub-angular to sub-rounded basalt. At the Hanford Site, the Hanford formation is generally divided into an upper gravel-dominated lithofacies (H1), a middle sand-dominated lithofacies (H2), and a lower gravel-dominated lithofacies (H3). Beneath the S-10 unit, the Hanford formation consists of essentially the sand-dominated lithofacies (H2).

2.4.2 Hydrogeology

Groundwater beneath the southern 200 West Area and vicinity of the S-10 unit consists of unconfined and confined aquifers. The water table is located within Ringold unit E, and the base of the unconfined aquifer is the lower mud unit (Figures 2-4 and 2-5). The unconfined aquifer beneath the S-10 unit is approximately 60 to 70 m (200 to 230 ft) thick. The uppermost confined aquifer occurs in Ringold unit A, which is confined above by the lower mud unit and below by the Elephant Mountain Member of the Saddle Mountains Basalt. Intercommunication between the unconfined and Ringold Formation confined aquifers is assumed to be insignificant because groundwater flow through the lower mud unit is extremely low due to the thickness and relatively low permeability of this confining unit. Thus, the unconfined aquifer is the only aquifer that could be potentially affected by releases from the S-10 unit.

The vadose zone beneath the S-10 unit is up to 73 m (240 ft) thick and consists of the Hanford formation, CCU, and the upper unsaturated portion of Ringold unit E. Perched water above the CCU was observed during well drilling when the S-10 unit was operating (i.e., prior to 1992). One well, 299-W26-11, was completed within the perched water near the pipeline outlet at the north end of the S-10 Ditch. It was used to monitor dissipation of the perched water after liquid effluent disposal ceased at the facility in 1991. This well was found to be dry in 1993, and perched water has not been encountered in any wells drilled since that time.

Natural recharge from precipitation is currently the only source of recharge to the vadose zone beneath the S-10 unit. Lysimeter studies across the Hanford Site have shown that natural recharge varies from near zero to 8.6 cm/yr (3.4 in./yr) depending on soil texture and vegetation (PNNL-18807, *Soil Water Balance and Recharge Monitoring at the Hanford Site – FY09 Status Report*). Recharge at the S-10 unit is likely toward the higher end of this range because of the surface covering of coarse sand and sparse vegetation. The normal annual precipitation is 17.2 cm/yr (6.8 in./yr) (PNNL-18807).

2.4.3 Groundwater Flow Interpretation

The average direction of groundwater flow beneath the S-10 unit has been determined by trend surface analysis of water level measurements from the monitoring wells. Groundwater flow beneath the S-10 unit is toward the east-southeast (Figure 2-6). The flow direction has been fairly stable since the facility was constructed in 1951, even while the 216-U-10 Pond (U Pond), located in the southwest part of the 200 West Area, was active. During 2014, the average direction of groundwater flow was calculated to be east-southeast (104 degrees azimuth) with a hydraulic gradient magnitude of 2.9×10^{-3} m/m. Using a hydraulic conductivity range of 2 to 42.7 m/d (7 to 140 ft/d) (range of 14 hydraulic test results in the upper part of the aquifer at the S-10 unit, excluding the high and low values) and an assumed effective porosity range of 0.1 to 0.2, the average linear velocity was estimated to range from 0.029 to 1.2 m/d (0.095 to 3.9 ft/d, or 11 to 450 m/yr). Using a best hydraulic conductivity value of 10.4 m/d (34.1 ft/d) (constant rate discharge test at 299-W27-2 performed within a temporary open interval near the water table [WHC-SD-EN-DP-052, *Borehole Completion Data Package for the 216-S-10 Facility, CY 1992*]) and an assumed effective porosity of 0.15, the best estimate average linear velocity is 0.20 m/d (0.66 ft/d, or 74 m/yr).

The water table has been declining at the S-10 unit since the shutdown of U Pond in 1984[6]. The average rate of decline between 2010 and 2014 was 0.23 m/yr (0.75 ft/yr). Hydrographs for monitoring wells near the S-10 unit are presented in Figure 2-7. The declining water levels caused many of the original network monitoring wells at the S-10 unit to go dry. New wells were drilled in 1999 (299-W26-13), in 2003 (299-W26-14), and in 2008 (699-32-76, 699-33-75, and 699-33-76).

2.5 Summary of Previous Groundwater Monitoring

Table 2-1 lists the previous groundwater monitoring plans implemented at the S-10 unit. RCRA groundwater monitoring was initiated at the S-10 unit in 1991 in accordance with WHC-SD-EN-AP-018. The original monitoring well network consisted of upgradient Wells 299-W26-7 and 299-W26-8; downgradient Wells 299-W26-9, 299-W26-10, 299-W26-12, and 299-W27-2; and one well completed in the perched water zone, 299-W26-11 (see Figure 2-1 for well locations). With the exception of 299-W27-2, the unconfined aquifer wells monitored the upper 4.5 to 6 m (15 to 20 ft) of the aquifer. Well 299-W27-2 was installed in 1992 and monitors the lower 3 m (10 ft) of the uppermost aquifer, just above the Ringold lower mud unit. Due to declining water levels, none of the original five wells monitoring the upper part of the unconfined aquifer remain in service today. The last usable well was 299-W26-7, which became dry in 2003. Two downgradient replacement wells, 299-W26-13 and 299-W26-14, were added to the monitoring network in 2000 and 2003, respectively. A new upgradient well (699-33-76) and two downgradient wells (699-32-76 and 699-33-75) were drilled and added to the network in 2008. Five wells now monitor the upper portion of the unconfined aquifer at the S-10 unit, and Well 299-W27-2 continues to be used to monitor the lower portion of the aquifer. Well 299-W26-11 was found to be dry during 1993 because the perched zone it was monitoring dewatered following shutdown of the S-10 unit in 1991.

[6] U Pond is located approximately 900 m (3,000 ft) north-northwest of the S-10 unit and received 165 billion L (43.6 billion gal) of effluent from 1944 to 1984. These discharges substantially increased the water table in the 200 West Area and vicinity when U Pond was operating. The water table is now declining as the groundwater mound formed by U Pond continues to dissipate.

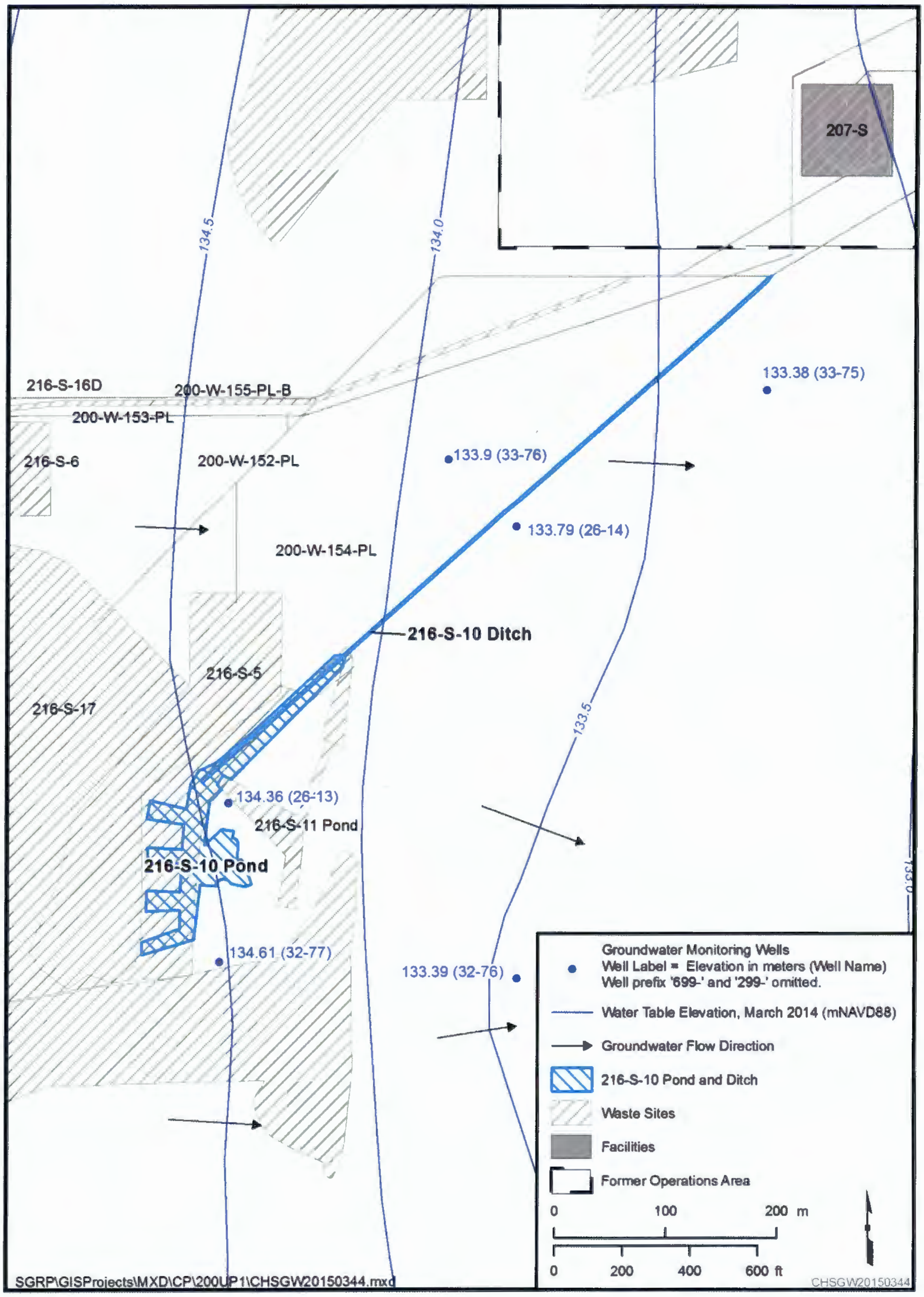


Figure 2-6. Water Table Map for the 216-S-10 Pond and Ditch

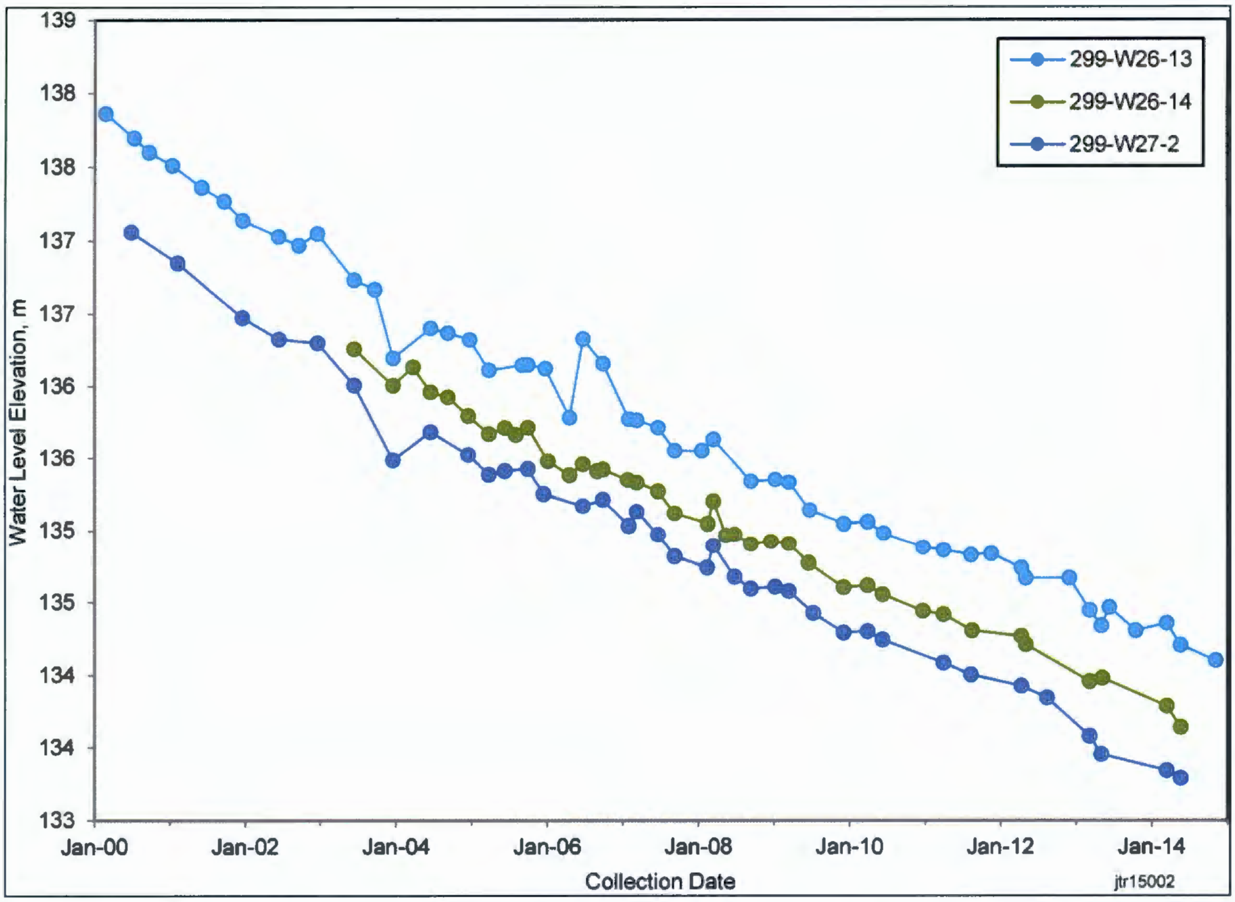


Figure 2-7. Hydrographs for Selected Wells at the 216-S-10 Pond and Ditch

The groundwater monitoring activities at the S-10 unit currently consist of collecting samples from a network of six wells, including deep Well 299-W27-2. Samples from wells monitoring the upper part of the aquifer are analyzed semiannually for parameters used as indicators of groundwater contamination and annually for parameters establishing groundwater quality. The deep monitoring well is sampled annually for information purposes. Sampling frequencies for site-specific constituents are provided in Chapter 3. Water-level measurements are collected each time a sample is obtained from a network well. The network wells are also included in the annual comprehensive March water-level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results are summarized annually for the S-10 unit in the annual groundwater monitoring report (e.g., DOE/RL-2014-32, *Hanford Site Groundwater Monitoring and Remediation for 2013*).

2.5.1 Groundwater Contamination

Required statistical evaluations of the contamination indicator parameters (specific conductance, pH, TOC, and TOX) have been conducted since 1992, immediately after background values were established. To date, there have been no verified statistically significant exceedances of an indicator parameter in the upgradient/downgradient well comparisons.

Chromium and carbon tetrachloride, both dangerous waste constituents, are routinely detected in some of the S-10 unit monitoring wells. When monitoring began in 1991, chromium concentrations in upgradient Well 299-W26-7 were found to be above the 100 µg/L drinking water standard (DWS) for total chromium (Figure 2-8). Concentrations increased to a maximum of 576 µg/L in 1997, declined to below the DWS in 2000 and 2001, and then increased to above the standard before the well became dry in 2003. The sudden increase in 1997 suggested a transient release event. In September 1983, a release occurred to the S-10 unit of synthetic DST slurry (a high-salt waste) containing potassium chromate (Section 2.3). Assuming a transport time of several years through the vadose zone to groundwater, and considering the volume of water and mass of chromium, the observed transient and approximate chromium concentrations detected are consistent with this historical release event. Even though Well 299-W26-7 was an upgradient well, it was located very close to one lobe of the pond system. Wastewater from the S-10 unit may have easily reached this well by spreading laterally in the subsurface, particularly on the CCU. This interpretation is based on the fact that perched water was observed above the CCU during drilling of monitoring wells in 1991, at which time the S-10 Ditch was still active (Section 2.4.2).

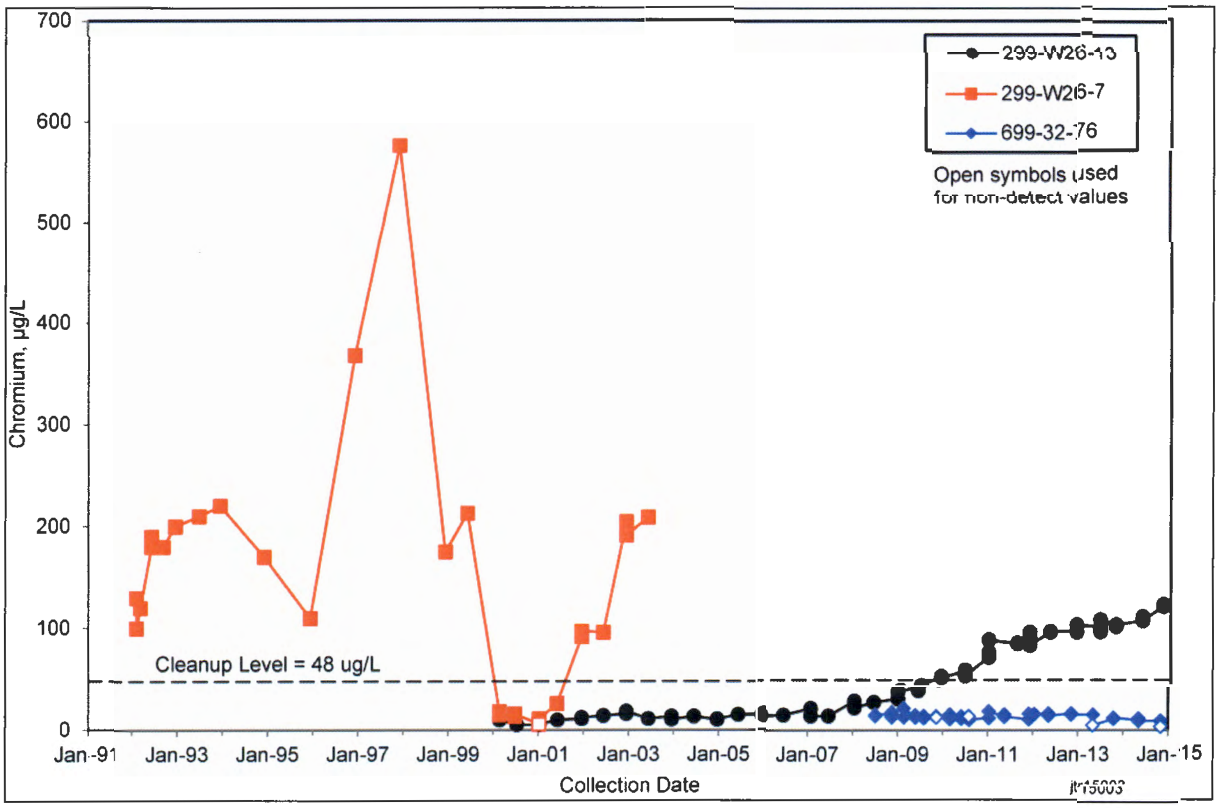
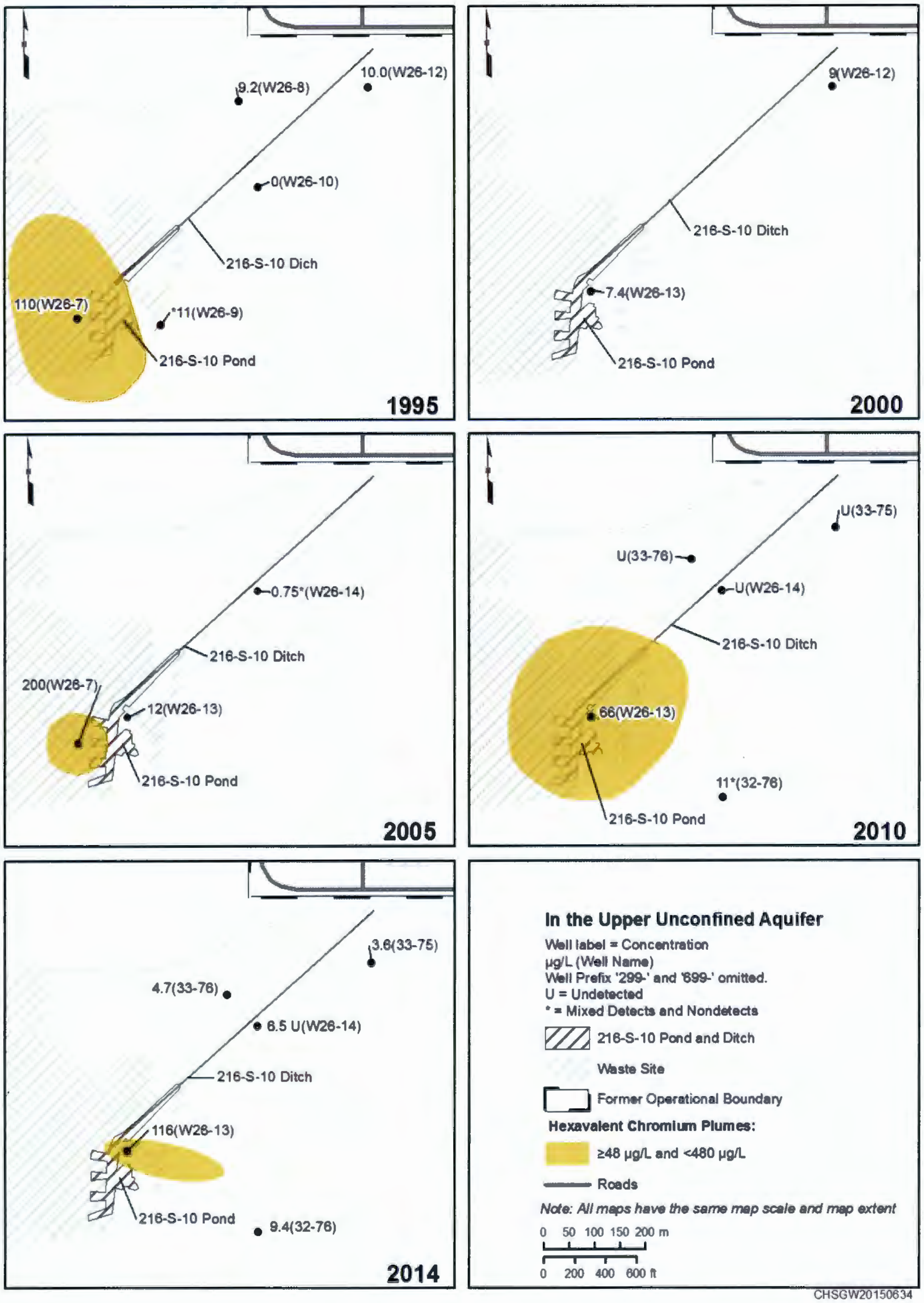


Figure 2-8. Chromium Concentrations in Wells 299-W26-7, 299-W26-13, and 699-32-76

Currently, chromium occurs in downgradient Well 299-W26-13 at about 120 µg/L, which is above the 48 µg/L cleanup level for hexavalent chromium and above the 100 µg/L DWS for total chromium (Figures 2-8 and 2-9). A chromium plume has been mapped at this site since 1995 (Figure 2-9). However, none of the indicator parameters required to be monitored under interim status are sensitive to chromium at these concentrations, so the elevated chromium has not resulted in an indicator parameter exceedance. While the S-10 unit is the probable source of this chromium, it cannot be conclusively linked to the S-10 unit because there are other potential sources of chromium nearby, particularly the S-11 Ponds (Sections 2.3 and 2.6).



1
2 Figure 2-9. Chromium Plume Maps for the 216-S-10 Pond and Ditch

Chromium, along with nickel, manganese, and iron, is routinely detected in deep Well 299-W27-2. This well is constructed of 304 stainless steel, and all four of these constituents are the primary components of 304 stainless steel. Thus, the source of the chromium is corrosion of the well screen, which has been confirmed by a camera survey (Figure 2-10).

Figure 2-10. Well Screen Corrosion in 299-W27-2

The only other constituent that has exceeded a DWS is carbon tetrachloride. The highest concentrations were in Well 699-33-75, where carbon tetrachloride was 45 µg/L in 2008. Concentrations have steadily declined since then to 6.54 µg/L in November 2014. Well 299-W27-2 has had carbon tetrachloride results slightly above the 5 µg/L DWS, the highest of which was 7.8 µg/L in 2013. The only other result above the carbon tetrachloride DWS occurred in Well 299-W26-12 at 6.0 µg/L in 1999 before the well became dry. All other wells in the network have produced at least one detectable result of carbon tetrachloride. The carbon tetrachloride is part of the plume beneath the 200 West Area emanating from the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs near the Plutonium Finishing Plant and potentially from U Pond, well to the north of the S-10 unit.

2.5.2 Vadose Zone Contamination

A two-phased investigation of soil contamination was completed in 2003 for the S-10 unit as part of an integrated process for characterizing the RCRA-regulated unit within CERCLA OUs. The first phase of the field characterization involved deep sediment sampling in one borehole drilled at the S-10 Pond. The borehole was completed as a RCRA downgradient monitoring well (299-W26-13) to replace Well 299-W26-9, which had gone dry. A second phase of the characterization was completed in 2003, which included seven test pit excavations for soil sampling along the ditch and pond, and one characterization borehole. This borehole was also completed as downgradient Well 299-W26-14. The results of this investigation were published in DOE/RL-2004-17.

Nonradiological contaminants found in the vadose zone during the remedial investigation and identified as risk drivers for the S-10 unit under CERCLA were Aroclor 1254, benzo(a)pyrene, chromium (total), copper, mercury, and zinc (DOE/RL-2005-64). All these constituents pose an impact via the direct contact and/or ecological exposure pathways, but Aroclor 1254 was the only constituent found to pose a potential impact to groundwater. However, groundwater impacts were assessed using the fixed-parameter, three-phase equilibrium partitioning model (WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection," referenced by WAC 173-340, "Model Toxics Control Act – Cleanup," for calculation of Method B soil cleanup levels). This model considers phase partitioning as well as dilution (when the leachate enters the aquifer), but it does not consider vadose zone transport. Aroclor 1254 was found only in the surface soils at the S-10 unit, and this constituent is essentially immobile in the subsurface. The travel time for Aroclor 1254 from the surface soils at S-10 to groundwater has been estimated to be at least 47,500 years (ECF-200W-15-0056, *Estimate of the Travel Time for the Migration of Aroclor 1254 from Surface Soils to Groundwater at the 216-S-10 Pond and Ditch*). Thus, Aroclor 1254 will not impact the groundwater beneath the S-10 unit.

2.6 Conceptual Site Model

This section describes the S-10 unit CSM for potential contaminant transport to guide future groundwater monitoring. The CSM is shown in Figure 2-11. The CSM describes the current understanding of contaminant release and transport and includes the following assumptions:

- The volume of water discharged to the S-10 unit was sufficient to reach groundwater.
- The discharged wastewater caused perched conditions to occur in the subsurface above the CCU, which led to lateral spreading of the wastewater. This aspect of the CSM is based on the fact that perched water on the CCU was observed during drilling of monitoring wells in 1991, at which time the S-10 Ditch was still active (Section 2.4.2).
- The groundwater flow direction beneath the S-10 unit will likely continue toward the south-southeast, even after the current water table has declined to a new equilibrium position.

The S-10 unit was one of several conveyances from the REDOX Plant that discharged wastewater to the ground surface. The open and unlined ditch allowed liquid effluents to evaporate and percolate into the vadose sediments along its entire length, while the unlined pond also allowed for evaporation and infiltration to the subsurface. The CSM assumes that the large volume of wastewater discharged (which included 6.9×10^9 L [1.8×10^9 gal] from the REDOX Plant chemical sewer) to the S-10 unit was sufficient to percolate through the soil column to groundwater beneath both the unlined ditch and the pond. It is also likely that perched water conditions occurred on the fine-grained, low-permeability CCU in the vadose zone, which allowed for lateral spreading of the wastewater in the subsurface. The top of the CCU, on average, dips slightly toward the east-southeast, so there may have been some preferential movement of water in this direction. However, the magnitude of the dip is relatively small (average of approximately 1 m [3 ft] of elevation change per 60 m [200 ft] horizontal distance), so spreading of wastewater in all directions was possible.

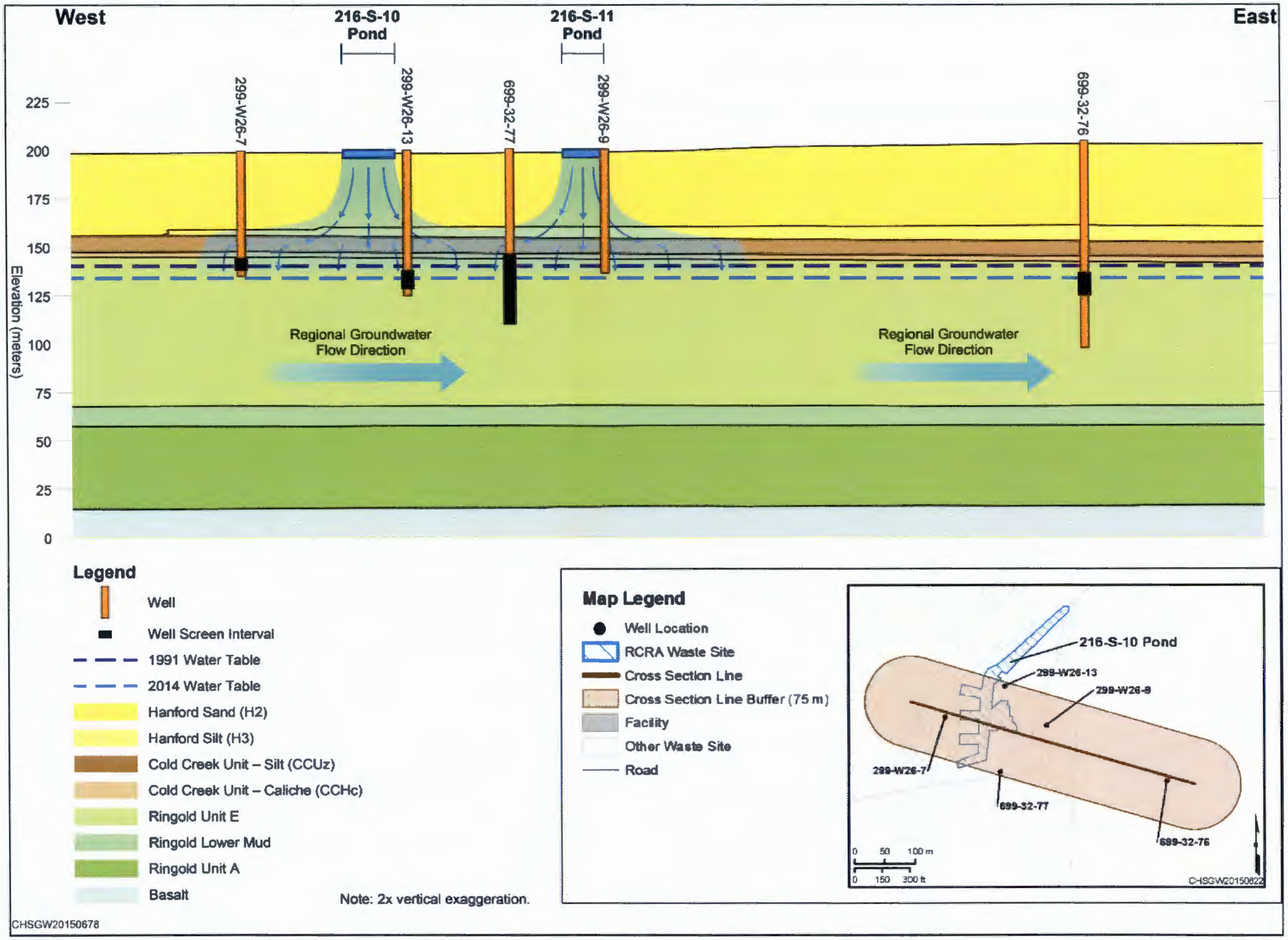


Figure 2-11. CSM for the 216-S-10 Pond and Ditch

An important consideration for the S-10 unit CSM is the close proximity of the S-11 Ponds (Figure 2-1). As explained in Section 2.1, these were overflow ponds for the S-10 unit, so they received the same wastewater as the S-10 unit. The S-11 Ponds were connected to the S-10 Ditch, and the western edge of one of the S-11 Ponds is located only about 20 m (65 ft) from the S-10 Pond. This close proximity, combined with the potential for lateral spreading of wastewater on the CCU, means that there is a potential that subsurface contamination beneath the S-10 unit may have originated from the S-11 Ponds, which are not part of the S-10 unit TSD. In addition, other waste sites occur upgradient from the S-10 unit (Figure 2-1), and these may also have affected the groundwater chemistry beneath the facility. These factors complicate interpretations of groundwater contamination beneath the S-10 unit. However, it should be noted that the S-10 unit and the S-11 Ponds are estimated to have received much more chromium than was discharged to upgradient sources (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*).

Based on the hydrogeology of the site, operational history, and the assumptions and conditions noted above, a schematic representation of contaminant transport through the vadose zone to groundwater is illustrated in Figure 2-11. During operation, the CSM shows that wastewater percolated vertically beneath the ponds and spread laterally on the CCU. Mobile contaminants such as hexavalent chromium and nitrate are assumed to have reached groundwater when the facility was operating. The S-10 unit is one of the interpreted sources of the chromium plume located east-southeast of the 200 West Area (DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*; DOE/RL-2014-32).

Lateral spreading of wastewater in the vadose zone may also have brought waste constituents to former upgradient Well 299-W26-7, which was in use from 1991 through 2002. This well exhibited covariate chromium and nitrate concentrations (Figure 2-12), likely due to the release of potassium dichromate (hexavalent chromium) in wastewater discharged to the S-10 Ditch in September 1983 from a simulated DST waste (see Section 2.3). Hexavalent chromium has occurred in both upgradient and downgradient monitoring wells at the S-10 unit (Figure 2-8). Although the S-10 unit is the probable source, this cannot be conclusively established because of the presence of nearby waste sites, particularly the S-11 Ponds.

The potential for continued migration of residual contamination from the vadose zone to groundwater is small due to the cessation of liquid effluent discharges to the S-10 unit and the lack of any other sources of artificial recharge. Thus, infiltration of natural precipitation is the only potential driving force. The mean precipitation rate at the Hanford Site is 17.2 cm/yr (6.8 in/yr.), with over half of this occurring from November through February (PNNL-18807). Recharge in the area of the S-10 unit is estimated to be 5.5 cm/yr (2.2 in./yr), which is the infiltration rate given for sandy soil in disturbed areas (i.e., no vegetation) in PNL-10285, *Estimated Recharge Rates at the Hanford Site*.

2.7 Monitoring Objectives

The groundwater monitoring program at the S-10 unit is conducted with the objectives of providing a program capable of determining the facility's impact, if any, on the quality of the underlying groundwater, and complying with applicable RCRA requirements for interim status TSD units where no impact to groundwater has been identified. The regulatory requirements applicable to this groundwater monitoring plan are found in WAC 173-303-400(3) and 40 CFR 265.90, "Applicability," through 40 CFR 265.94, "Recordkeeping and Reporting." Table 2-2 identifies where each groundwater monitoring element of the pertinent applicable regulations is addressed within this plan.

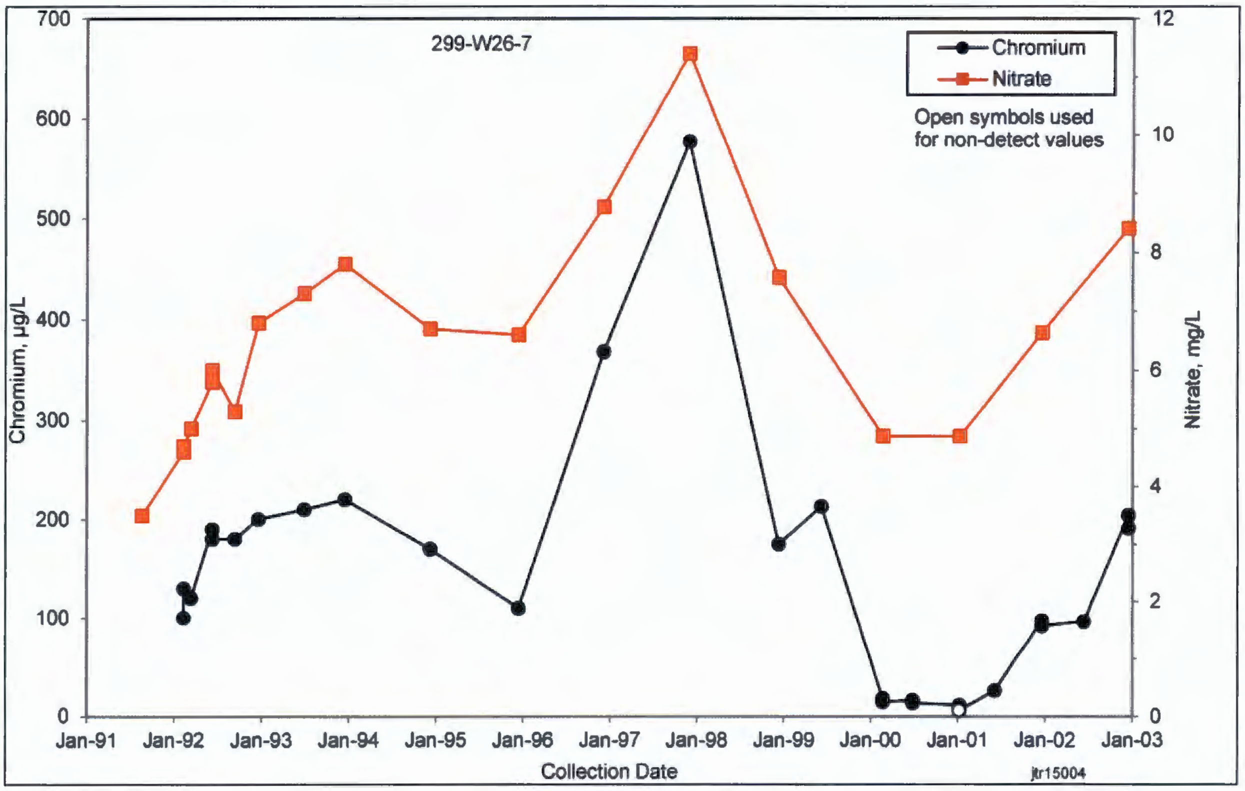


Figure 2-12. Chromium and Nitrate Concentrations in Former Upgradient Well 299-26-7

Table 2-2. Pertinent RCRA Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Number and location of wells	40 CFR 265.91, "Ground-Water Monitoring System": (a) A ground-water monitoring system must be capable of yielding ground-water samples for analysis and must consist of: (1) Monitoring wells (at least one) installed hydraulically upgradient (i.e., in the direction of increasing static head) from the limit of the waste management area. Their number, locations, and depths must be sufficient to yield ground-water samples that are: (i) Representative of background ground-water quality in the uppermost aquifer near the facility; and (ii) Not affected by the facility; and (2) Monitoring wells (at least three) installed hydraulically downgradient (i.e., in the direction of decreasing static head) at the limit of the waste management area. Their numbers, locations, and depths must ensure that they immediately detect any statistically significant amounts of dangerous waste or dangerous waste constituents that migrate from the waste management area to the uppermost aquifer.	Section 3.2

Table 2-2. Pertinent RCRA Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Well configuration	40 CFR 265.91: (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must be screened or perforated, and packed with gravel or sand, where necessary, to enable sample collection at depths where appropriate aquifer flow zones exist. The annular space (i.e., the space between the bore hole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground water. Additional requirements from WAC 173-303-400(3)(c)(v)(C), "Dangerous Waste Regulations," "Interim Status Facility Standards": Ground water monitoring wells must be designed, constructed, and operated so as to prevent ground water contamination. Chapter 173-160 WAC may be used as guidance in the installation of wells.	Section 3.2 and Appendix C
Parameters to be sampled Frequency of sampling Water-level measurements	40 CFR 265.92, "Sampling and Analysis": (b) The owner or operator must determine the concentration or value of the following parameters in ground-water samples in accordance with paragraphs (c) and (d) of this section: (1) Parameters characterizing the suitability of the ground water as a drinking water supply, as specified in Appendix III[b]. (2) Parameters establishing ground-water quality: (i) Chloride (ii) Iron (iii) Manganese (iv) Phenols (v) Sodium (vi) Sulfate [Comment: These parameters are to be used as a basis for comparison in the event a ground-water quality assessment is required under §265.93(d).] (3) Parameters used as indicators of ground-water contamination: (i) pH (ii) Specific conductance (iii) Total organic carbon (iv) Total organic halogen (c)(1) For all monitoring wells, the owner or operator must establish initial background concentrations or values of all parameters specified in paragraph (b) of this section. He must do this quarterly for one year.	Section 3.1 and Appendix B, Section B2.2

Table 2-2. Pertinent RCRA Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	(2) For each of the indicator parameters specified in paragraph (b)(3) of this section, at least four replicate measurements must be obtained for each sample and the initial background arithmetic mean and variance must be determined by pooling the replicate measurements for the respective parameter concentrations or values in samples obtained from upgradient wells during the first year. (d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies: (1) Samples collected to establish ground-water quality must be obtained and analyzed for the parameters specified in paragraph (b)(2) of this section at least annually. (2) Samples collected to indicate ground-water contamination must be obtained and analyzed for the parameters specified in paragraph (b)(3) of this section at least semi-annually. (e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.	
Methods used to evaluate the collected data and responses	40 CFR 265.93, "Preparation, Evaluation, and Response": (b) For each indicator parameter specified in §265.92(b)(3), the owner or operator must calculate the arithmetic mean and variance, based on at least four replicate measurements on each sample, for each well monitored in accordance with §265.92(d)(2), and compare these results with its initial background arithmetic mean. The comparison must consider individually each of the wells in the monitoring system, and must use the Student's t-test at the 0.01 level of significance (see appendix IV) to determine statistically significant increases (and decreases, in the case of pH) over initial background. (c)(2) If the comparison for downgradient wells made under paragraph (b) of this section show a significant increase (or pH decrease), the owner or operator must then immediately obtain additional ground-water samples from those downgradient wells where a significant difference was detected, split the samples in two, and obtain analyses of all additional samples to determine whether the significant difference was a result of laboratory error. (d)(1) If the analyses performed under paragraph (c)(2) of this section confirm the significant increase (or pH decrease), the owner or operator must provide written notice to the department-within seven days of the date of such confirmation-that the facility may be affecting ground-water quality. (d)(2) Within 15 days after the notification under paragraph (d)(1) of this section, the owner or operator must develop a specific plan, based on the outline required under paragraph (a) of this section and certified by a qualified geologist or geotechnical engineer, for a ground-water quality assessment at the facility.	Section 4.1, 4.2, and 4.3; and Appendix A

Table 2-2. Pertinent RCRA Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Recordkeeping and reporting	40 CFR 265.94, "Recordkeeping and Reporting": (a)(1) Keep records of the analyses required in §265.92(c) and (d), the associated ground-water surface elevations required in §265.92(b) throughout the active life of the facility. (a)(2) Report the following ground-water monitoring information to the department: (ii) Annually: Concentrations or values of the parameters listed in §265.92(b)(3) for each ground-water monitoring well, along with the required evaluations for these parameters under §265.92(b). The owner or operator must separately identify any significant differences from the initial background found in the upgradient wells, in accordance with §265.92(c)(1).	Section 4.5; Appendix A, Sections A1.6 and A2.6

Note: The references cited in this table are listed in the reference section (Chapter 6) of this plan.

a. RCRA regulatory requirements for interim status TSD units, where no impact to groundwater has been identified, are found in WAC 173-303-400(3), "Dangerous Waste Regulations," "Interim Status Facility Standards," and 40 CFR 265.90, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Applicability," through 40 CFR 265.94, "Recordkeeping and Reporting," which are applicable to this groundwater monitoring plan.

b. The parameters characterizing the suitability of the groundwater as a drinking water supply, as specified in 40 CFR 265, Appendix III, "EPA Interim Primary Drinking Water Standards," are not listed because, in accordance with 40 CFR 265.92(c)(1), "Sampling and Analysis," these analyses are conducted only during the first year of monitoring.

CFR = *Code of Federal Regulations*

RCRA = *Resource Conservation and Recovery Act of 1976*

TSD = treatment, storage, and disposal

In addition to the required indicator parameters (TOC, TOX, pH, and specific conductance) and constituents to determine groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate), site-specific constituents will be monitored in groundwater at the S-10 unit. As noted in Section 2.6, chromium is present in groundwater near the S-10 Pond, and concentrations of chromium were covariate with nitrate at former upgradient Well 299-W26-7. Both of these constituents will continue to be monitored. Carbon tetrachloride is also present in groundwater. This constituent originates from the 200-ZP-1 OU and potentially from U Pond, but it will continue to be monitored to provide a check on the indicator parameter TOX. Major anions (chloride, nitrate, sulfate, and alkalinity to represent bicarbonate and carbonate) and cations (calcium, magnesium, sodium, and potassium) will also be monitored to provide a check on the indicator parameter specific conductance. One well in the network, deep Well 299-W27-2, has elevated metals due to corrosion of the well screen. Monitoring will also be performed for stainless-steel corrosion products (iron, chromium, nickel, and manganese) to provide the data needed to assess corrosion in all of the network wells. These site-specific constituents are listed in Table 2-3.

Table 2-3. Additional Monitoring Objectives

Monitoring Objective	Site-Specific Constituent
Track contaminants potentially from the S-10 unit	Chromium Nitrate
Track carbon tetrachloride concentrations (affects total organic halides)	Carbon tetrachloride
Track major anions and cations (affects specific conductance)	Alkalinity (to represent bicarbonate and carbonate) Chloride Nitrate Sulfate Calcium Magnesium Sodium Potassium
Assess potential corrosion of stainless-steel well screens	Iron Chromium Nickel Manganese

3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for the S-10 unit consisting of a monitoring well network, parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, site-specific constituents, and sampling and analysis protocols. The monitoring program presented herein has been revised from that presented in the previous plan (DOE/RL-2008-61, Rev. 0).

It should be noted that the S-10 unit will be closed through an approved RCRA closure plan; after which if clean closure performance standards are not achieved, this RCRA interim status groundwater monitoring plan will be replaced according to a schedule identified in the Hanford Facility Dangerous Waste Permit (WA 7890008967) conditions for the S-10 unit, as appropriate. At that time, groundwater monitoring requirements (pursuant to WAC 173-303-645, "Releases from Regulated Units") if applicable to the S-10 unit will be determined. A draft closure plan has been prepared (DOE/RL-2006-12, Draft B).

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, the parameters analyzed as required for RCRA monitoring, and the sampling frequency for monitoring of the S-10 unit. Parameters used as indicators of groundwater contamination (pH, specific conductance, total organic carbon, and total organic halogen) will be sampled and analyzed semiannually (40 CFR 265.92[b][3] and [d][2]). Parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) will be sampled and analyzed annually (40 CFR 265.92[b][2] and [d][1]). Water-level measurements at each monitoring well will be determined each time a sample is obtained (40 CFR 265.92[e]).

Site-specific constituents will also be monitored (Section 2.7). Chromium and nitrate will be sampled and analyzed semiannually as potential contaminants from the S-10 unit. Carbon tetrachloride will be sampled and analyzed annually due to its presence in groundwater (from the 200-ZP-1 OU) and its effects on the indicator parameter TOX. Major anions (chloride, nitrate, sulfate, and alkalinity to represent bicarbonate and carbonate) and cations (calcium, magnesium, sodium, and potassium) will be monitored semiannually to provide a check on the indicator parameter specific conductance. Monitoring will also be performed at least annually for stainless-steel corrosion products (iron, nickel, and manganese, in addition to chromium) to assess corrosion in the network wells.

Maintenance problems and sampling logistics sometime delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well is sampled. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sampling Management and Reporting group, along with the project scientist, consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling in the following month. Missed or cancelled sampling events are reported to DOE-RL, at the appropriate Unit Managers Meeting, and in the annual groundwater monitoring report.

Table 3-1. Monitoring Well Network for the 216-S-10 Pond and Ditch

			RCRA-Required Parameters[a]												Site-Specific Constituents[b]					
				Contamination Indicator Parameters				Groundwater Quality Parameters											
Well Name	Purpose	WAC Compliant	Water Level	pH[c]	Specific Conductance[c]	TOC	TOX	Chloride	Iron (Filtered and Unfiltered)	Manganese (Filtered and Unfiltered)	Phenols	Sodium (Filtered and Unfiltered)	Sulfate	Chromium (Total) (Filtered and Unfiltered)	Anions[d]	Metals[e] (Filtered and Unfiltered)	Alkalinity[f]	Carbon Tetrachloride	Field Parameters[g]
699-33-76	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A	A	S
299-W26-13	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A	A	S
299-W26-14	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A	A	S
299-W27-2[h]	Downgradient	Y	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
699-32-76	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A	A	S
699-33-75	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A	A	S

Table 3-1. Monitoring Well Network for the 216-S-10 Pond and Ditch

a. Constituents and parameters required by 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

b. Constituents not required by RCRA but are needed to support data interpretation.

c. Field measurement.

d. For anions, analytes include (but are not limited to) chloride, nitrate, and sulfate. Chloride and sulfate are already listed for annual sampling as groundwater quality parameters, but a semiannual frequency is needed for the shallow wells for comparisons with specific conductance. Nitrate is also needed for this purpose, and it is also a co-contaminant with chromium.

e. For metals, analytes include (but are not limited to) calcium, magnesium, sodium, potassium, chromium, iron, manganese, and nickel. Although listed for annual sampling as groundwater quality parameters, sodium is needed (along with calcium, magnesium, and potassium) semiannually for the shallow wells for comparison with specific conductance, and iron and manganese (along with nickel and chromium) are needed to evaluate well corrosion.

f. Alkalinity used to provide information on bicarbonate and carbonate for comparison to specific conductance.

g. Temperature and turbidity.

h. Well completed deep in the unconfined aquifer just above the Ringold lower mud unit. Because the sample results are for information only and are not used in statistical comparisons, this well is specified for annual sampling and the indicator parameters are not collected in quadruplicate.

A = to be sampled annually

CFR = *Code of Federal Regulations*

RCRA = *Resource Conservation and Recovery Act of 1976*

S =to be sampled semiannually

S4 = to be sampled semiannually, with quadruplicate samples (or measurements) collected during each event

TOC = total organic carbon

TOX = total organic halide

WAC = *Washington Administrative Code*

Y = well is constructed as a resource protection well (WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells")

3.2 Monitoring Well Network

The current S-10 unit monitoring network consists of a single upgradient well and five downgradient wells, including deep monitoring Well 299-W27-2. Information on these wells is summarized in Table 3-2, and Figure 3-1 shows the well locations. All of the wells are screened across the water table, except for downgradient Well 299-W27-2, which is completed deep in the aquifer just above the Ringold lower mud unit. Sampling of this well is for informational purposes only, and the results are not used for statistical comparisons with the upgradient well.

If a well is within approximately 2 years of going dry, a replacement well will be proposed. All new RCRA wells proposed for installation at the Hanford Site are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement (Ecology et al., 1989) Milestone M-24-00. None of the wells in the S-10 unit monitoring well network are expected to become dry during the next 30 years.

Construction details and pertinent information for the wells are provided in Appendix C. Some wells are co-sampled with other monitoring programs (e.g., monitored to meet CERCLA requirements). Monitoring requirements for those other monitoring programs are described in separate plans. The reported data from those other monitoring programs are supplementary to information gathered under this plan.

3.3 Differences Between This Plan and Previous Plan

Table 3-3 identifies the main differences between this plan and the previous groundwater monitoring plan (DOE/RL-2008-61, Rev. 0). Two substantial changes were made to the monitoring program for this plan update.

First, the frequency of sampling downgradient Well 299-W26-14 was changed from annual to semiannual. This well is used for statistical evaluations, and sampling of downgradient wells for indicator parameters used in statistical evaluations is required semiannually (40 CFR 265.92[d][2]).

Second, changes were made to the site-specific constituents for sampling. Copper, mercury, zinc, and benzo(a)pyrene were removed from the monitoring program. These constituents were added to the RCRA monitoring program because they had been cited as risk drivers for the S-10 unit under the CERCLA program; however, they are risk drivers only for exposure scenarios involving direct contact with the source, not for the groundwater pathway (DOE/RL-2005-64). Aroclor 1254 was also removed; this constituent was found to be a risk driver for the groundwater pathway under CERCLA, but that determination was overly conservative because it was found only in the surface soil and is not mobile in the subsurface (ECF-200W-15-0056). Analyses for hexavalent chromium were removed (total chromium analyses were retained). Where chromium occurs in Hanford Site groundwater, it occurs in the mobile hexavalent form, which can be determined by both hexavalent and total chromium analyses. Thus, hexavalent chromium analyses are redundant with total chromium analyses. Carbon tetrachloride was added to the monitoring program because this constituent occurs in groundwater (from the 200-ZP-1 OU and potentially from U Pond) and its presence affects the indicator parameter TOX. Fluoride and nitrite were removed as required analytes; they are not substantial contributors to the indicator parameter specific conductance due to their low concentrations in groundwater. Oxidation-reduction potential was removed. This field parameter is useful for identifying reducing conditions, but it is known that oxidizing conditions prevail in the aquifer beneath the S-10 unit and there is no reason for these conditions not to persist. Finally, nickel and manganese were added to evaluate corrosion of the monitoring well screens (these constituents, along with iron and chromium, are the major components of the stainless steel used to construct the wells). All of these changes are listed in Table 3-3.

Table 3-2. Attributes for Wells in the 216-S-10 Pond and Ditch Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Screen Top (m [ft] bgs)	Screen Bottom (m [ft] bgs)	Water Depth (m [ft] bgs)	Remaining Water Column (m [ft])	Water-Level Date
699-33-76[b]	3/27/2008	566,621.21	133,600.43	67.7 (222)	78.3 (257)	69.6 (228)	8.7 (29)	11/3/2014
299-W26-13	12/28/1999	566,424.387	133,293.598	61.6 (202)	72.3 (237)	64.9 (213)	7.4 (24)	11/4/2014
299-W26-14	4/3/2003	566,682.69	133,539.21	68.1 (223)	78.8 (259)	71.0 (233)	7.8 (26)	5/20/2014
299-W27-2	12/18/1992	566,908.267	133,670.351	123.8 (406)	127.0 (417)	73.2 (240)	53.8 (177)	5/20/2014
699-32-76	1/4/2008	566,683.94	133,137.73	69.2 (227)	79.9 (262)	70.8 (232)	9.1 (30)	11/3/2014
699-33-75	1/31/2008	566,907.78	133,662.48	71.6 (235)	82.3 (270)	73.5 (241)	8.8 (29)	11/3/2014

a. Coordinates are in the *North American Datum of 1983*, Washington South Zone (4602).

b. Upgradient well.

bgs = below ground surface

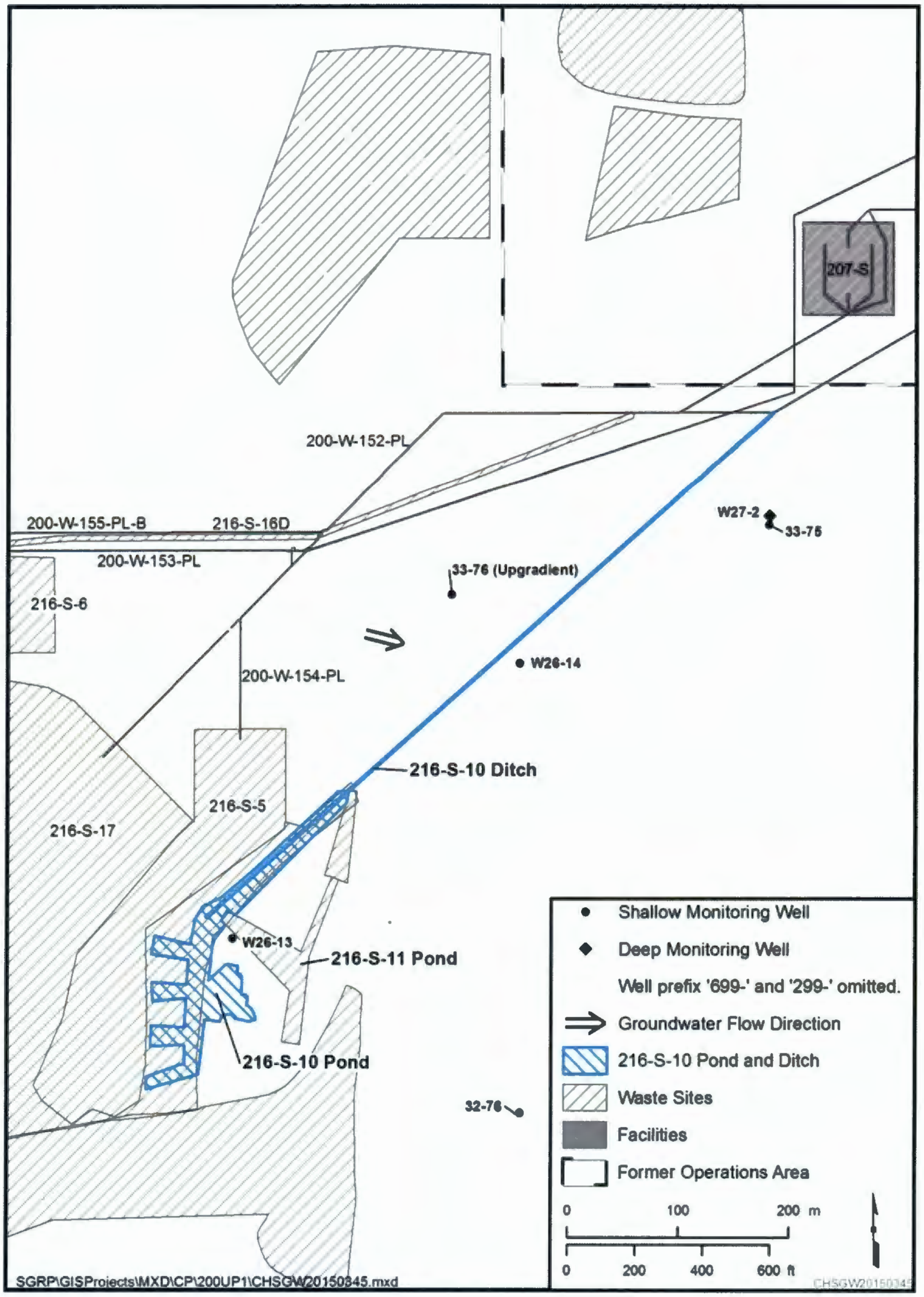


Figure 3-1. Monitoring Well Network for the 216-S-10 Pond and Ditch

Table 3-3. Main Differences Between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Constituents	Indicator parameters	Indicator parameters	Same.
	Groundwater quality parameters	Groundwater quality parameters	Same.
	Chromium (total)	Chromium (total)	Same.
	Hexavalent chromium	—	Chromium is present in groundwater only in the hexavalent form, so total chromium analyses yield essentially the same result as hexavalent chromium analyses. No need to sample with both methods.
	Copper	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway.
	Mercury	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway.
	Zinc	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway.
	Aroclor 1254	—	Removed as a site-specific constituent; was identified as a risk driver under CERCLA for the groundwater pathway, but this determination was overly conservative. Aroclor 1254 was found only in surface soils at the S-10 unit and is essentially immobile in the subsurface and will not impact groundwater.
	Benzo(a)pyrene	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway.
	Alkalinity	Alkalinity	Same.

Table 3-3. Main Differences Between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
	Anions (chloride, fluoride, nitrate, nitrite, and sulfate)	Anions (chloride, nitrate, and sulfate)	Fluoride and nitrite removed; not substantial contributors to any of the indicator parameters due to low concentrations in groundwater.
	—	Carbon tetrachloride	Present in groundwater (from the 200-ZP-1 OU and potentially from U Pond); added to provide supporting information for TOX analyses.
	Field parameters (pH, specific conductance, temperature, turbidity, and oxidation-reduction potential)	Field parameters (pH, specific conductance, temperature, and turbidity)	Oxidation-reduction potential no longer required. This parameter is useful for distinguishing between reducing and oxidizing conditions, but there is no reason to suspect that reducing conditions occur in any of the network wells.
	Additional metals (calcium, magnesium, and potassium)	Additional metals (calcium, magnesium, nickel, and potassium)	Nickel added to support evaluations of well corrosion.
Sampling Frequency	299-W26-14 (annual)	299-W26-14 (semiannual)	Downgradient wells used in statistical comparisons are required to be sampled semiannually by 40 CFR 265.92(d)(2).
	Alkalinity (semiannual)	Alkalinity (annual)	Alkalinity exhibits stable trends, so a single annual result can be used for comparison to semiannual specific conductance results.
Well Network	One upgradient well, four shallow downgradient wells, and one deep downgradient well	One upgradient well, four shallow downgradient wells, and one deep downgradient well	Same.
Groundwater Flow Direction	East-southeast	East-southeast	Same.
Type of Groundwater Monitoring Program	Interim status indicator parameter evaluation	Interim status indicator parameter evaluation	Same.

Table 3-3. Main Differences Between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Background Arithmetic Mean Recalculated	Calculated annually using the single upgradient well	Calculated annually using the single upgradient well	Same.
Groundwater Quality Assessment Plan Outline	Was included in the first monitoring plan (WCH-SD-EN-AP-018[b])	Included	Outline updated to current format.

a. Previous plan was DOE/RL-2008-61, Rev. 0.

b. WCH-SD-EN-AP-018, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch.*

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

OU = operable unit

TOX = total organic halide

3.4 Sampling and Analysis Protocol

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status TSD units. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

The goal of the RCRA groundwater monitoring indicator evaluation program is to determine if the S-10 unit operations have affected groundwater quality beneath the site, which is determined based on the results of specified statistical tests. Under this plan, sampling activities and statistical evaluation methods are based on 40 CFR 265, Subpart F (incorporated by reference into WAC 173-303-400). These interim status regulations require the use of a statistical method that compares mean concentrations of the four general groundwater contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halogen) to background levels to test for potential impact to groundwater. Each time a monitoring well is sampled, four replicate samples for total organic carbon and total organic halogen are collected, and four replicate field measurements are made for pH and specific conductance.

The basic procedure for statistical comparisons is as follows: twice each year, monitoring data from downgradient wells are compared to the upgradient (background) results for each of the four indicator parameters. The owner or operator must calculate the arithmetic mean and variance, based on at least four replicate measurements on each sample, for each well monitored, and then compare these results with the background arithmetic mean obtained (40 CFR 265.92[c][2]) and updated as discussed in Chapter 5 of EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. The comparison must consider each of the individual wells in the monitoring system and must use the Student's t-test at the 0.01 level of significance to determine statistically significant increases (and decreases, in the case of pH) over background (40 CFR 265.93[b]). Implementation of the statistical test method at the Hanford Site, including at the S-10 unit, is generally consistent with EPA 530/R-09-007. The background statistical analysis is updated annually to establish comparative values for indicator parameters. A rolling mean is used because of changing groundwater flow conditions due to groundwater remedial actions currently being implemented at the Hanford Site.

If a comparison for a downgradient well shows a significant increase (or pH decrease), then the well is resampled. For TOC and TOX, split samples are sent to different laboratories to determine if the exceedance of the comparison value was the result of laboratory error.

If the exceedance of the statistical comparison value is confirmed by resampling, then written notifications are made as detailed in Section 4.5 and in accordance with 40 CFR 265.

4.3 Interpretation

Data are used to interpret groundwater conditions at the S-10 unit. Interpretive techniques include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential on the maps.

- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps:** Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.
- **Contaminant ratios:** Can sometimes be used to distinguish among different sources of contamination.

4.4 Annual Determination of Monitoring Network

RCRA groundwater monitoring requirements include an annual evaluation of the network to determine if it remains adequate to monitor the facility's impact on the quality of the groundwater in the uppermost aquifer underlying the facility (40 CFR 265.93[f]). The network must include at least one upgradient and at least three downgradient wells in the uppermost aquifer (40 CFR 265.91[a][1] and [2]).

The current groundwater monitoring network will continue to be re-evaluated to ensure that it is adequate to monitor any changing hydrogeologic conditions beneath the unit. If flow changes are observed, the S-10 unit CSM and groundwater constituents will be re-evaluated to determine network efficiency and any necessary modification requirements for the network.

Water-level measurements will continue to be collected before each sampling event. An additional and more comprehensive set of water-level measurements is made annually for selected wells on the Hanford Site, and the data are presented in the annual groundwater monitoring reports.

4.5 Reporting and Notification

Groundwater monitoring results are reported annually in accordance with the requirements of 40 CFR 265.94. Reporting will be made in the annual groundwater monitoring reports.

If a comparison for an upgradient well shows a significant increase (or pH decrease) relative to the statistical comparison value, that information is also reported in the annual groundwater monitoring report.

If the exceedance of the statistical comparison value is confirmed, written notice is then provided to Ecology within 7 days (40 CFR 265.93[d][1]) stating that the facility may be affecting groundwater quality. Within 15 days after the notification, a groundwater quality assessment program must be developed and submitted to Ecology (40 CFR 265.93[d][2] and WAC 173-303-400[3][c][v][D]). In some instances, it is possible to determine immediately that the statistical finding is not the result of contamination from the facility. In that case, Ecology is notified, and a groundwater quality assessment program is not instituted.

5 Outline for Groundwater Quality Assessment Plan

If a groundwater contamination indicator parameter at a downgradient well significantly exceeds the background value or if pH decreases and is confirmed by verification sampling, a detailed assessment plan will be prepared and submitted to Ecology and the facility monitoring will be elevated to assessment monitoring status. The assessment program must be capable of determining whether dangerous waste or dangerous waste constituents from the facility have entered the groundwater, their rate and extent of migration and their concentration. This chapter presents a revision of the groundwater quality assessment monitoring plan outline prepared during the first year after the effective date of the regulations, as required by 40 CFR 265.93(a). An outline for the assessment plan is presented in Table 5-1.

The groundwater quality assessment program may include the following elements:

- Description of the hydrogeologic conditions and identification of potential contaminant pathways
- Description of the investigative approach for making first determination to decide if dangerous waste or dangerous waste constituents from the facility have entered the groundwater or if the exceedance was caused by other sources (false positive rationale)
- Description of the approach to fully characterize rate and extent of contaminant migration
- Number, locations, and depths of wells in the monitoring network
- Sampling and analytical methods used
- Data evaluation methods
- Implementation schedule

The results of assessment determinations will be made as soon as technically feasible and a report of the findings will be sent to Ecology. The determinations will then be updated annually as required by 40 CFR 265.94(b).

Table 5-1. Revised Groundwater Quality Assessment Plan Outline

- Introduction
- Background
    - Facility Description and Operational History
    - Regulatory Basis
    - Waste Characteristics
    - Geology and Hydrogeology
    - Summary of Previous Groundwater Monitoring and Results
    - Conceptual Site Model
    - Monitoring Objectives
- Groundwater Monitoring
    - Constituent List and Sampling Frequency
    - Well Network
    - Sampling and Analysis Protocol
- Data Evaluation and Reporting
    - Evaluation of Dangerous Waste Constituents
    - Interpretation
    - Annual Determination of Monitoring Network
    - Reporting and Notification
- References
- Appendix A – Quality Assurance Project Plan
- Appendix B – As-Built Drawings of Wells in Well Network

6 References

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40 CFR 265.91, "Ground-Water Monitoring System."

40 CFR 265.92, "Sampling and Analysis."

40 CFR 265.93, "Preparation, Evaluation, and Response."

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Appendix A

Quality Assurance Project Plan

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Figure A-1. Project Organization A-2

Terms

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEAD	format for electronic analytical data
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
GC/MS	gas chromatography/mass spectrometry
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductively coupled plasma
ICP-AES	inductively coupled plasma/atomic emission spectrometry
LCS	laboratory control sample
MDL	method detection limit
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
PQL	practical quantitation limit
PS	post-digestion spike
PSD	post-digestion spike duplicate
QA	quality assurance

QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	request for data review
S&GRP	Soil and Groundwater Remediation Project
SAF	sample authorization form
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*

A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan) (Ecology et al., 1989b) require the QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. This QAPjP also describes the applicable requirements and controls based on guidance found in Washington State Department of Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to the 216-S-10 Pond and Ditch groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Review and Usability.

A2 Project Management

This chapter addresses the management approaches planned, project goals, and planned output documentation.

A2.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the groundwater monitoring plan and assisting the U.S. Department of Energy (DOE), Richland Operations Office (RL) project manager in obtaining approval of the groundwater monitoring plan and future proposed revisions. Project organization (regarding routine groundwater monitoring) is described in the following sections and illustrated in Figure A-1.

A2.1.1 DOE-RL Project Manager

Hanford Site cleanup is the responsibility of DOE-RL. The DOE-RL project manager is responsible for authorizing the contractor to perform activities under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Atomic Energy Act of 1954*, and the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a) for the Hanford Site.

A2.1.2 DOE-RL Technical Lead

The DOE-RL technical lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to the DOE-RL project manager.

A2.1.3 Soil and Groundwater Remediation Project Manager

The Soil and Groundwater Remediation Project (S&GRP) manager provides oversight for all activities and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The S&GRP manager also provides support to the S&GRP RCRA groundwater manager to ensure that work is performed safely and cost effectively.

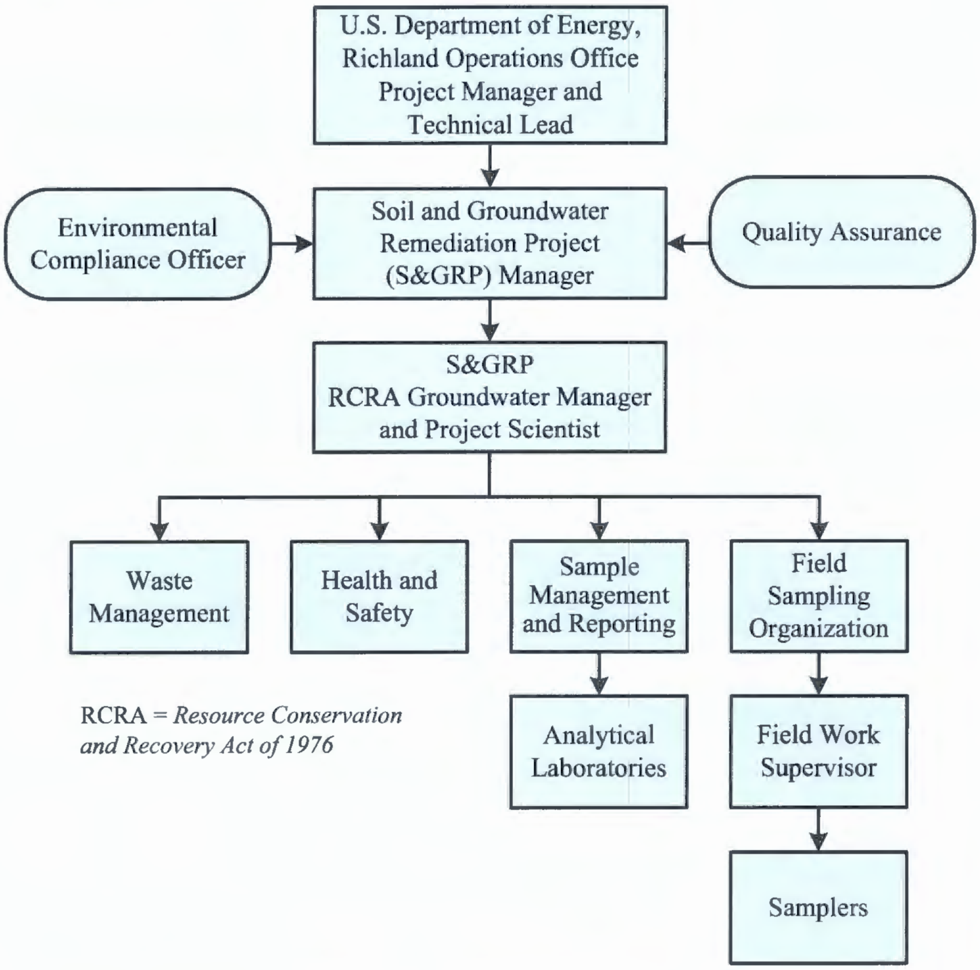

Figure A-1. Project Organization

A2.1.4 S&GRP RCRA Groundwater Manager

The S&GRP RCRA groundwater manager is responsible for direct management of activities performed to meet RCRA TSD monitoring requirements. The S&GRP RCRA groundwater manager coordinates with, and reports to, DOE-RL and primary contractor management regarding RCRA TSD monitoring requirements. The S&GRP RCRA groundwater manager (or delegate) works closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The S&GRP RCRA groundwater manager assigns scientists to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the Sample Authorization Form (SAF), which provides information and instruction to the analytical laboratories. The SMR group receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with the Field Sampling Organization, laboratories, or other entities. The SMR group is responsible for informing the S&GRP RCRA groundwater manager of any issues reported by the analytical laboratories.

A2.1.6 Field Sampling Organization

The Field Sampling Organization is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect groundwater samples in accordance with this groundwater monitoring plan and in accordance with corresponding standard procedures and work packages. The FWS ensures that samplers are appropriately trained and available. The samplers collect all salient samples in accordance with sampling documentation. The samplers also complete field logbooks and chain-of-custody forms, including any shipping paperwork, and ensure delivery of the samples to the analytical laboratory.

In addition, pre-job briefings are conducted by the Field Sampling Organization, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering various factors including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

A2.1.7 Quality Assurance

The QA point of contact is responsible for addressing QA issues on the project and overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents, including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

A2.1.8 Environmental Compliance Officer

The ECO provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A2.1.9 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or by internal primary contractor work requirements.

A2.1.10 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements, to ensure regulatory compliance, and interpreting data to determine waste designations and profiles. Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost effective manner.

A2.1.11 Analytical Laboratories

The analytical laboratories analyze samples, in accordance with established procedures and the requirements of this plan, and provide necessary data packages containing analytical and QC results. The laboratories provide explanations of results to support data review and in response to resolution of analytical issues. The laboratories are evaluated under the DOE Consolidated Audit Program and must be accredited by Ecology for the analyses performed for S&GRP.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy the requirements of *Washington Administrative Code* (WAC) 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," and Title 40 *Code of Federal Regulations* (CFR 265), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring," Specifics on the activities to satisfy the requirements are provided in the main body of the monitoring plan including in Chapter 1 and Sections 2.7, 3.1, 3.2, and 4.2. Background information on monitoring is also provided in the main body of this plan including in Sections 2.2, 2.5, and 3.3.

A2.3 Project/Task Description

The project description is provided in Chapters 2, 3, and 4 of this monitoring plan and includes the parameter indicators as required by 40 CFR 265.92 for establishing groundwater quality and groundwater contamination detection, evaluation of the monitoring network, interpretation of analytical results, and reporting. The parameter indicators to be monitored, along with the monitoring wells and frequency of sampling, are provided in Chapter 3. Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B. In addition to the required indicator parameters of 40 CFR 265.92, a selection of added dangerous waste or dangerous waste constituents as well as site-specific constituents to be monitored is included in Chapter 3.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the monitoring plan. In support of this objective, statistics and data descriptors known as data quality indicators (DQIs) are used to help determine the acceptability and utility of data to the user. The principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These DQIs are defined for the purposes of this document in Table A-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section A5.3).

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or re-measurement • Qualify the data before use
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use • Request reanalysis or re-measurement
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for them not being representative • Flag for further review • Review data for usability • If data are usable, qualify the data for limited use and define the portion of the system that the data represent • If data are not usable, flag as appropriate • Redefine sampling and measurement requirements and protocols Resample and reanalyze, as appropriate

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future completeness

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Bias	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (MS).	For sampling bias: • Properly select and use sampling tools • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other labs for analysis.
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[a] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation • Qualify/reject the data before use

Source: SW-846, Pending, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

a. For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

DQI = data quality indicator

MS = matrix spike

QA = quality assurance

1

A2.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, "Dangerous Waste Regulations," "Personnel Training." The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs to satisfy multiple training drivers imposed by the applicable CFR and WAC requirements. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely.

Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up-to-date prior to performing any field work.

A2.6 Documents and Records

The S&GRP RCRA groundwater manager (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Changes to elements of the monitoring plan that are required by 40 CFR 265.92 are not allowed, except as unintentional changes as described in Table A-2.

Table A-2. Change Control for Monitoring Plans

Type of Change*	Action	Documentation
Temporary addition of wells or site-specific constituents, or increased sampling frequency that do not impact the requirements of 40 CFR 265.92.	S&GRP RCRA groundwater manager approves temporary change; provides informal notice to Ecology.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, and loss of samples in transit.	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL.	Annual groundwater monitoring report
Planned change to groundwater monitoring activities, including addition or deletion of site-specific constituents, change of sampling frequency for site-specific constituents, or changes to well network.	S&GRP RCRA groundwater manager obtains DOE-RL approval; revise monitoring plan.	Revised RCRA groundwater monitoring plan
Anticipated unavoidable changes (e.g., dry wells).	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL; revise monitoring plan.	Annual groundwater monitoring report and revised RCRA groundwater monitoring plan

Note: 40 CFR 265.93, "Preparation, Evaluation, and Response," contains additional sampling and notification requirements should indicator parameter results demonstrate a significant increase (or pH decrease).

Table A-2. Change Control for Monitoring Plans

Type of Change*	Action	Documentation

* "Site-specific constituents" are any constituents that may be included in this monitoring plan as additional analytes that are not required by 40 CFR 265.92, "Sampling and Analysis.".

CFR = *Code of Federal Regulations*
Ecology = Washington State Department of Ecology
RCRA = *Resource Conservation and Recovery Act of 1976*
DOE-RL = U.S. Department of Energy, Richland Operations Office
S&GRP = Soil and Groundwater Remediation Project
SMR = Sample Management and Reporting

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The FWS, SMR, and any field crew supervisors are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the groundwater monitoring plan. The SMR group will ensure that any deviations from the plan are reflected in revised field sampling documents for the samplers and analytical laboratory. The FWS or appropriate field crew supervisors will ensure that deviations from the plan or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The S&GRP RCRA groundwater manager, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The S&GRP RCRA groundwater manager is also responsible for ensuring that project files are setup, as appropriate, and/or maintained. The project files will contain project records or references to their storage locations. Project files generally include, as appropriate, the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract

The following records are managed and maintained by SMR personnel:

- Field sampling logbooks
- Groundwater sample reports and field sample reports
- Chain-of-custody forms

- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information

Convenience copies of laboratory analytical results are kept in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

The results of groundwater monitoring are reported annually in accordance with the requirements of 40 CFR 265.94, "Recordkeeping and Reporting." Reporting will be made in the annual groundwater monitoring reports.

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition to ensure that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

A3.1 Analytical Method Requirements

Analytical method requirements for samples collected are presented in Table A-3. Updated U.S. Environmental Protection Agency (EPA) methods may be substituted for analytical methods identified in Table A-3.

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Groundwater Quality Parameters (40 CFR 265.92[b][2])		
Chloride	EPA/600 Method 300.0	400
Sulfate		550
Iron	SW-846 Method 6010B/C	50
Manganese		5
Sodium		500
Phenols	SW-846 Method 8270D	5
Contamination Indicator Parameters (40 CFR 265.92[b][3])		
pH	Field measurement Instrument/meter	N/A
Specific Conductance		N/A
Total Organic Carbon	SW-846 Method 9060	1,000
Total Organic Halogen	SW-846 Method 9020	10
Site-Specific Constituents[c]		
Alkalinity	EPA/600 Method 310.1 or Standard Method 2320	5,000
Nitrate	EPA/600 Method 300.0	250
Calcium	SW-846 Method 6010B/C	1,000
Chromium		10
Magnesium		750
Nickel		40
Potassium		4,000
Carbon tetrachloride	SW-846 Method 8260B	3.4

Reference: 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis"

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Equivalent methods may be substituted.

b. Highest allowable practical quantitation limits are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower than required contractually. Method detection limits are three to five times lower than quantitation limits.

c. Site-specific constituents not required by RCRA but used to support interpretation.

CFR = *Code of Federal Regulations*
EPA = U.S. Environmental Protection Agency
PQL = practical quantitation limit
RCRA = *Resource Conservation and Recovery Act of 1976*

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)

N/A = not applicable

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with HASQARD (DOE/RL-96-68) requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Appendix B provides the parameters identified for field measurements.

A3.3 Quality Control

QC requirements specified in the plan must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample requirements are summarized in Table A-4. Acceptance criteria for laboratory QC is shown in Table A-5. Data will be qualified and flagged in HEIS, as appropriate.

Table A-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field splits	As needed When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the Analytical Performance Requirements table (Table A-3)	Precision, including sampling, analytical, and interlaboratory
Full trip blanks	One in 20 well trips	Cross-contamination from containers or transportation
Field transfer blanks	One each day volatile organic compounds are sampled	Contamination from sampling site
Equipment blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an EB is not required Otherwise, one for every 20 samples[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[b]		
Laboratory duplicates	1 per analytical batch[c]	Laboratory reproducibility and precision

Table A-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Matrix spikes	1 per analytical batch[c]	Matrix effect/laboratory accuracy
Post-digestion spike	1 per analytical batch[c]	Matrix effect/laboratory accuracy
Post-digestion spike duplicates	1 per analytical batch[c]	Laboratory accuracy and precision
Matrix spike duplicates	1 per analytical batch[c]	Laboratory accuracy and precision
Laboratory control samples	1 per analytical batch[c]	Laboratory accuracy
Method blanks	1 per analytical batch[c]	Laboratory contamination
Surrogates	1 per analytical batch[c]	Recovery/yield

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. For portable pumps, equipment blanks are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

b. Batching across projects is allowed for similar matrices (e.g., all Hanford groundwater).

c. Unless not required by, or different frequency is called out in, laboratory analysis methods.

EPA = U.S. Environmental Protection Agency

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analysis	Quality Control	Acceptance Criteria	Corrective Action
General Chemical Analyses			
Alkalinity	MB	<MDL <5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory duplicate	≤20% RPD[b]	Data reviewed[a]
	MS	75–125% recovery	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Total Organic Carbon	MB	<MDL <5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory duplicate or MS/MSD	≤20% RPD[b]	Data reviewed[a]

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analysis	Quality Control	Acceptance Criteria	Corrective Action
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Total Organic Halogen	MB	<MDL <5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory duplicate or MS/MSD	≤20% RPD[b]	Data reviewed[a]
	MS and MSD	75–125% recovery	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Anions			
Anions by IC (chloride, nitrate, and sulfate)	MB	<MDL <5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory duplicate or MS/MSD	≤20% RPD[b]	Data reviewed[a]
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Metals			
ICP-AES metals (calcium, chromium, iron, magnesium, manganese, nickel, potassium, and sodium)	MB	<RDL <5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	MS/MSD	≤20% RPD	Data reviewed[a]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS (carbon tetrachloride)	MB	<MDL <5% sample concentration	Flagged with "B"

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analysis	Quality Control	Acceptance Criteria	Corrective Action
	LCS	Statistically derived[c]	Data reviewed[a]
	MS or PS and MSD or PSD	% recovery statistically derived[c]	Flagged with "T" if analyzed by GC/MS; otherwise "N" based on FEAD
	MS/MSD or PS/PSD	% RPD statistically derived[c]	Data reviewed[a]
	SUR	Statistically derived[c]	Data reviewed[a]
	EB, FTB, FXR	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"
Semivolatile Organic Compounds			
Phenols by GC or GC/MS	MB	<MDL <5% sample concentration	Flagged with "B"
	LCS	Statistically derived[c]	Data reviewed[a]
	MS and MSD	% recovery statistically derived[c]	Flagged with "T" if analyzed by GC/MS; otherwise "N" based on FEAD
	MS/MSD	% RPD statistically derived[c]	Data reviewed[a]
	SUR	Statistically derived[c]	Data reviewed[a]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[b]	Flagged with "Q"

Notes:

The information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Specific conductance and pH are not listed as they are measured in the field.

a. After review, corrective actions are determined on a case-by-case basis.

b. Applies only in cases where both results are greater than 5 times the method detection limit.

c. Determined by the laboratory based on historical data or statistically derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.

EB = equipment blank
EPA = U.S. Environmental Protection Agency
FEAD = format for electronic analytical data
FTB = full trip blank
FXR = field transfer blank
GC = gas chromatography
GC/MS = gas chromatography/mass spectrometry
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PS = post-digestion spike
PSD = post-digestion spike duplicate
QC = quality control

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analysis	Quality Control	Acceptance Criteria	Corrective Action

IC = ion chromatography

ICP-AES = inductively coupled plasma atomic emission spectrometry

LCS = laboratory control sample

RDL = required detection limit

RPD = relative percent difference

SUR = surrogate

Data flags:

B (organics) = analyte was detected in both the associated QC blank and the sample)

C (inorganics/Wetchem) = analyte was detected in both the sample and the associated QC blank and the blank value exceeds 5% of the measured concentration present in the associated sample.

N = all except GC/MS – matrix spike outlier

T = volatile organic analysis and semivolatile organic analysis GC/MS – matrix spike outlier

Q = associated QC sample is out of limits

A3.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure that reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and three types of field blanks (full trip blanks [FTBs], field transfer blacks [FXRs], and equipment blanks [EBs]). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described in this section:

Field duplicates: Independent samples collected as close as possible to the same time and same location as the scheduled sample, and are intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field splits: Two samples collected as close as possible to the same time and same location and are intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

Full trip blanks: Bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity reagent water, and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Field transfer blanks: Preserved volatile organic analysis sample vials filled with high-purity reagent water at the sample collection site where volatile organic compounds are collected. The samples will be prepared during sampling to evaluate potential contamination attributable to field conditions. After collection FXR sample vials will be sealed and placed in the same storage containers with the samples collected the same day for the associated sampling event. FXR samples will be analyzed for volatile organic compounds only.

Equipment blanks: Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. EB samples will be analyzed for the same constituents as the samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by the laboratories utilized by the project. Laboratory QA includes a comprehensive QC program that includes the use of matrix spikes (MSs), matrix duplicates, matrix spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), post-digestion spikes (PSs), post-digestion spike duplicates (PSDs), and method blanks (MBs). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC and their typical frequencies are listed in Table A-4. Acceptance criteria are shown in Table A-5. The various laboratory QC samples:

Laboratory duplicate: An intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix spike: An aliquot of a sample spiked with a known concentration of target analyte(s). An MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate: A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Post-digestion spike: The same as MS; however, the spiking occurs after sample preparation and before analysis.

Post-digestion spike duplicate: The same as MSD; however the spiking occurs after sample preparation and before analysis.

Laboratory control sample: A control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.

Method blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Surrogate: A compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, yet are not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Laboratories are required to analyze samples within the holding time specified in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilizing, decomposing, or other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an "H."

Table A-6. Preservation, Container, and Holding Time Guidelines for Laboratory Analyses

Constituent/ Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time
Alkalinity	500 mL	Narrow mouth poly or glass	Store ≤6°C	14 days
Total organic carbon	250 mL	Narrow mouth amber glass with Teflon®-lined lid	Store ≤6°C, adjust pH to <2 with H_2SO_4 or HCl	28 days
Total organic Halogen	1 L	Narrow mouth glass with Teflon®-lined lid	Store ≤6°C, adjust pH to <2 with H_2SO_4	28 days
Anions by IC (chloride, nitrate, and sulfate)	60 mL	Narrow mouth poly or glass	Store ≤6°C	48 hours
ICP metals (calcium, chromium, iron, magnesium, manganese, nickel, potassium, and sodium)	250 mL	Narrow mouth poly or glass	Adjust pH to <2 with nitric acid	6 months
Volatiles by GC/MS (carbon tetrachloride)	1 × 40 mL	Amber glass VOA vial	Store ≤6°C, adjust pH to <2 with H_2SO_4 or HCl	14 days
Phenols by GC or GC/MS	4 × 1 L	Narrow mouth amber glass with Teflon®-lined lid	Store ≤6°C	7 days before extraction 40 days after extraction

Notes:

Teflon® is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

The information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Specific conductance and pH are not listed as they are measured in the field.

a. Under the "Container" heading, the term "poly" stands for EPA clean polyethylene bottles.

b. For preservation identified as stored at ≤6°C, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

EPA = U.S. Environmental Protection Agency

GC = gas chromatography

GC/MS = gas chromatography/mass spectrometry

H_2SO_4 = sulfuric acid

HCl = hydrochloric acid

IC = ion chromatography

ICP = inductively coupled plasma

VOA = volatile organic analysis

A3.4 Measurement Equipment

Each user of the measuring equipment is responsible to ensure that equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with manufacturer specifications and other approved methods.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or should have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with applicable Hanford Site requirements.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with test methods in SW-846 and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

A3.8 Nondirect Measurements

Data obtained from sources, such as computer databases, programs, literature files, and historical databases, will be technically reviewed to the same extent as the data generated as part of any sampling and analysis QA/QC effort. All data used in evaluations will be identified by source.

A3.9 Data Management

The SMR group, in coordination with the S&GRP RCRA groundwater manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management methods.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group on a routine basis. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the S&GRP RCRA groundwater manager. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

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A4 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this plan, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies resolutions in accordance with the QA program, corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the S&GRP RCRA groundwater manager.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with laboratory QA plans. The contractor oversees offsite analytical laboratories and verifies that laboratories are qualified for performing Hanford Site analytical work.

A4.2 Reports to Management

Management will be made aware of deficiencies identified by self assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues reported by the laboratories are communicated to the SMR group, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the S&GRP RCRA groundwater manager.

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A5 Data Review and Usability

This section addresses the QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A5.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met, and reviewing QC data to determine whether analyses have met the data quality requirements specified in this plan.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results also will be reviewed to ensure that they are usable.

The project scientist, assigned by the S&GRP RCRA groundwater manager, will perform a data review to help determine if observed changes reflect improved/degraded groundwater quality or potential data errors and may result in submittal of a request for data review (RDR) on questionable data. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the RDR process are used to flag the data appropriately in the HEIS database and/or to add comments.

A5.2 Data Validation

Data validation activities may be performed at the discretion of the S&GRP RCRA groundwater manager and under the direction of the SMR group. If performed, data validation activities will be based on EPA functional guidelines.

A5.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data quality needs. For routine groundwater monitoring undertaken through this groundwater monitoring plan, the DQA is captured in QC associated with the annual Hanford Site groundwater report, which evaluates field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of the S&GRP RCRA groundwater manager and documented in a report overseen by the SMR group.

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A6 References

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Appendix B

Sampling Protocol

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B8 References **B-15**

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Terms

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
RCRA	*Resource Conservation and Recovery Act of 1976*
S&GRP	Soil and Groundwater Remediation Project
SMR	Sampling Management and Reporting

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B1 Introduction

Resource Conservation and Recovery Act of 1976 (RCRA) groundwater monitoring at the Hanford Site has been conducted since the mid 1980's. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken, equipment and its use, cleaning and decontamination, records and documentation, and sample collection, management, and control activities. Appendices A and B, together, provide the sampling and analysis essentials (sample collection, sample preservation, chain of custody control, analytical procedures, and field and laboratory QA/QC) necessary for the groundwater monitoring plan.

This appendix provides more specific elements of the sampling protocols and techniques used for the RCRA groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, the constituents to be analyzed for, and the sampling frequency for the groundwater monitoring at the 216-S-10 Pond and Ditch.

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B2 Sampling Methods

Sampling methods may include, but are not limited to, the following:

- Field screening measurements
- Groundwater sampling
- Water level measurements

Groundwater samples will be collected according to the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- **pH:** Two consecutive measurements agree within 0.2 pH units.
- **Temperature:** Two consecutive measurements agree within 0.2°C.
- **Conductivity:** Two consecutive measurements agree within 10 percent of each other.
- **Turbidity:** Less than 5 nephelometric turbidity units prior to sampling (or project scientist's recommendation).

Absent any special requirements from project scientists, wells are purged utilizing the 3 borehole volume method. Stable field readings are also required as specified above. The default pumping rate is 2 to 12 gpm depending on the pump although this is not practical at every well. On those occasions where the purge volume is extraordinarily large, wells are purged a minimum of an hour and then sampled once stable field readings are obtained.

Field measurements (except for turbidity) are obtained through the use of a flow through cell. Groundwater is pumped directly from the well and to the flow through cell. At the beginning of the sample event field crews attach a clean stainless steel sampling manifold to the riser discharge. The manifold has two valves and two ports. One port is used only for purgewater. The other port is used to supply water to the flow through cell. Probes are inserted into the flow through cell for measurement of pH, temperature, conductivity [and dissolved oxygen]. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow through cell is disconnected and a clean stainless steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles, if any, and to prevent over filling of bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles, if any. Filtered samples are collected after the unfiltered samples. For some constituents, like metals, both filtered and unfiltered samples are analyzed. If additional samples requiring filtration (e.g., at turbidity greater than 5 NTUs), an inline disposable 0.45 μm filter is used.

Typically, three types of environmental grade sampling pumps are used for groundwater sampling at Hanford monitoring wells (i.e., Grundfos, Hydrostar, and submersible electrical pumps). Individual pumps are selected based on the unique characteristics of the well and the sampling requirements. A small number of wells will not support a pumped sample because of yield or the physical characteristics of the well. In these cases, a grab sample may be obtained.

For certain types of samples, preservatives are required. While the preservative may be added to the collection bottles before their use in the field, it is allowable to add the preservative at the sampling vehicle immediately after collection. Samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, the sampling associated with this plan will be performed according to DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), pertaining to sample collection, collection equipment, and sample handling.

Suggested sample container, preservation, and holding time requirements are specified in Appendix A (Table A-6) for groundwater samples. These requirements are in accordance with the analytical method specified in Appendix A (Table A-3). The final container type and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a "sample" as a filled sample bottle for starting the clock for holding time restrictions.

Holding time is the maximum allowable time period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA et al., 2012, *Standard Methods for the Examination of Water and Wastewater*, and SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition; Final Update IV-B*. Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

B2.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with the sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

B2.2 Water Levels

Each time a sample is obtained, measurement of the ground water surface elevation at each monitoring well is required by Title 40 *Code of Federal Regulations* (CFR) 265.92(e) "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." A measurement of depth to water is recorded in each well prior to sampling, using calibrated depth measurement tapes. Two consecutive measurements are taken that agree within 6 mm (0.02 ft); these are recorded along with the date, time, measuring tape number, and other pertinent information. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of casing) to obtain the water level elevation. Tops of casings are known elevation reference points because they have been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks or data forms are required for field activities. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor (FWS), cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, the information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks is as follows:

- The day and date, time the task started, weather conditions, and the names, titles, and organizations of personnel performing the task.
- The purpose of the visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Details of any field tests that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and indicate the preparation, if any, of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation. List location of sample collected, sample type, all label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and the analytical request form number pertinent to each sample or sample set. Note the time and the name of the individual to whom custody of samples was transferred.
- The time, equipment type, and serial or identification number, and the methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook (if any) where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

B3.1 Corrective Actions and Deviations for Sampling Activities

The Soil and Groundwater Remediation Project (S&GRP) RCRA groundwater manager, FWS, appropriate field crew supervisors, and Sampling Management and Reporting (SMR) personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions.

As appropriate, such deviations or problems will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The S&GRP RCRA groundwater manager, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Appendix A (Table A-2).

B4 Calibration of Field Equipment

Field instrumentation, calibration, and quality assurance checks will be performed as follows:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified quality control criteria.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Standards used for calibration will be traceable to a nationally recognized standard agency source or measurement system.

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B5 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and analytical data tracking database is used to track the samples from the point of collection through the laboratory analysis process.

B5.1 Containers

Samples shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the laboratory lot number of the bottles used in sample collection. When commercially pre-cleaned containers are used in the field, the name of the manufacturer, lot identification, and certification shall be retained for documentation.

Containers shall be capped and stored in an environment which minimizes the possibility of contamination of the sample containers. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/ requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified in Appendix A (Table A-6).

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag on the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to the SMR group within 48 hours of shipping.

The following minimum information is required on a completed chain-of-custody form:

- Project name
- Collectors' names

- Unique sample number
- Date and time of collection
- Matrix
- Preservatives
- Chain of possession information (i.e., signatures and printed names of all individuals involved in the transfer of sample custody and storage locations, and dates of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group so that special direction for analysis may be provided to the laboratory if deemed necessary.

B5.4 Sample Transportation

All packaging and transportation instructions shall be in compliance with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway." Carrier specific requirements defined in the International Air Transport Association (IATA) *Dangerous Goods Regulations* (IATA, current edition) shall also be used when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material and appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2000-51, *Interim Action Waste Management Plan for the 200-UP-1 Operable Unit.* For waste designation purposes, the wells listed in Table 3-1 will be surveyed in the Hanford Environmental Information System and the maximum concentration for each analyte within the most recent 5 years evaluated for use in creating a waste profile, if required. Offsite analytical laboratories are responsible for disposal of unused sample quantities. Pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the DOE Richland Operations Office is required before returning unused samples or waste from offsite laboratories.

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B7 Health and Safety

The safety and health program is designed to ensure the safety and health of workers including those involved in dangerous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," and 10 CFR 835, "Occupational Radiation Protection" (Chapter III, "Energy"). The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training, control of industrial safety and radiological hazards, personal protective equipment, site control, and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

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B8 References

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Appendix C

Well Construction

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Figure C-1. Well 299-W26-13 Well Summary Sheet C-2

Figure C-2. Well 299-W26-14 Well Summary Sheet C-3

Figure C-3. Well 299-W27-2 Well Summary Sheet C-5

Figure C-4. Well 699-32-76 Well Summary Sheet C-8

Figure C-5. Well 699-33-75 Well Summary Sheet C-12

Figure C-6. Well 699-33-76 Well Summary Sheet C-16

Tables

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme C-1

Table C-2. Sampling Interval Information for Wells within the 216-S-10 Pond and Ditch Network C-1

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C1 Introduction

This appendix provides the following information for the 216-S-10 Pond and Ditch groundwater monitoring wells:

- Well name
- Hydrogeologic unit monitored – the portion of the aquifer that is located at the well screen or perforated casing (Table C-1)
- The following sampling interval information, as shown in Table C-2:
  - Elevation at top of the screen or perforated interval
  - Elevation at the bottom of the screen or perforated interval
  - Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)

Figures C-1 through C-6 provide the well summary sheets (as-built diagrams) for the network wells.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
LU	**Lower unconfined:** Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse hydrogeologic unit or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
TU	**Top of unconfined:** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-2. Sampling Interval Information for Wells within the 216-S-10 Pond and Ditch Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m [ft])
299-W26-13	TU	137.4	126.7	10.7 (35)
299-W26-14	TU	136.6	125.9	10.7 (35)
299-W27-2	LU	82.7	79.5	3.2 (10)
699-32-76	TU	134.8	124.1	10.7 (35)
699-33-75	TU	135.0	124.3	10.7 (35)
699-33-76	TU	135.5	124.9	10.7 (35)

NAVD88, *North American Vertical Datum of 1988*.

TU = top of unconfined, as described in Table C-1

LU = lower unconfined, as described in Table C-1

0515345

WELL SUMMARY SHEET

Page 1 of 1

Date: 14 Dec 99

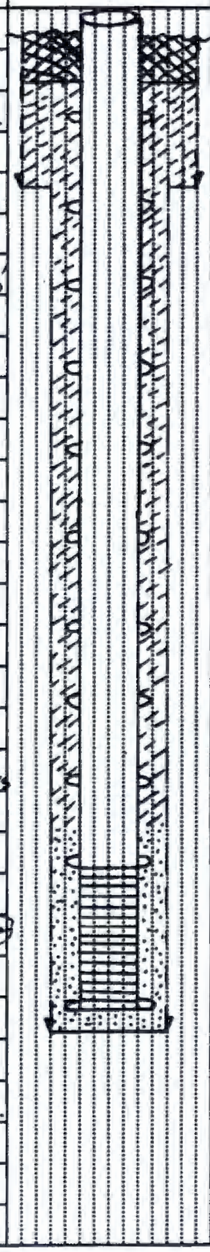
Well ID: B8817		Well Name: 299-W26-13	
Location: 216-S-10 Pond		Project: 200-CS-1/RCRA	
Prepared By: T.A. Lee	Date: 14 Dec 99	Reviewed By: DC Weekes	Date: 12/29/99
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description

- SS 304 Riser Pipe, 4½" OD, 4" ID, from +2.9 to 202.2 ft. bgs.
- Temporary casings: 11¾" carbon steel 0'-36.3'; 8⅝" carbon steel 0'-240.0'
- Portland cement from 0' to 10.3'
- Bentonite crumbles from 10.3 to 185.2 ft bgs
- Bentonite holeplug from 185.2 to 190.7 ft bgs.
- 20-40 Colorado Silica Sand from 190.7 to 237.8 ft bgs.
- W.L. = 200.1' bgs, 13 Dec 99, 0800 hrs
- SS 304 Screen, 4½" OD 4" ID, 0.010" slot, from 202.2 to 237.3 ft bgs.
- SLOUGH 237.3 TO 240.7 ft (+ cap)
- PVC Schedule 40 tail pipe from 237.3 to 237.8 ft bgs.
- All depths in ft. below ground.
- All Temporary casings removed.

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 50, 100, 150, 200, 250

Graphic Log

Lithologic Description

- 0.0'-7.5' Slightly Silty SAND
- 7.5'-12.0' Gravelly SAND
- 12.0'-22.0' Silty SAND
- 22.0'-36.5' SAND
- 36.5'-47.0' Silty SAND
- 47.0'-51.0' Gravelly Sandy SILT
- 51.0'-110.0' Silty SAND
- 110.0'-134.0' Sandy SILT
- 134.0'-139.0' CALICHE ZONE
- 139.0'-~~234.0~~ 148.0' Silty Sandy GRAVEL
- 148.0'-234.0' Sandy GRAVEL
- Water level = 200.05' (12/13/99)
- 234.0'-237.0' SAND
- 237.0'-240.7' Sandy GRAVEL
- T.D. = 240.7' bgs.

Figure C-1. Well 299-W26-13 Well Summary Sheet

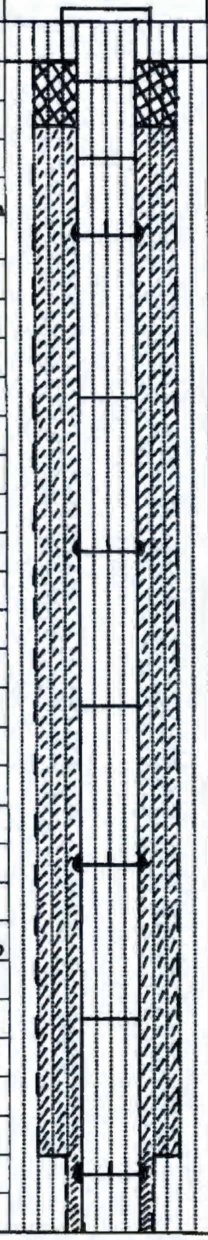
WELL SUMMARY SHEET	Start Date: 3/6/03	Page: 1 of 2
	Finish Date: 4/3/03	

Well ID: B8828		Well Name: 299-W26-14	
Location: 216-S-10 ditch		Project: FY2003 CERCLA CS-1 DRILLING	
Prepared By: Jess Hocking	Date: 4/3/03	Reviewed By: L.D. Walker	Date: 4/29/03
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description
4" TP-304/304L sch 05s Riser +2.00' → 223.37'
4" TP-304/304L sch 05s 0.020" Cont. Wire Wrap screen 223.37' → 258.37'
4" TP-304/304L sch 05s Sump 258.37' → 260.47'
Type I/II Portland Cement 0 → 9.65'
Pure Wyoming Bentonite Crumbles 9.65' → 200.98'
American Bentonite Pellets 200.98' → 211.05'
10-20 mesh Colorado Silica Sand 211.05' → 267'
Temporary Casing, 10¾" OD 0' → 143'
NOTE: ALL DEPTHS REPORTED IN FT. BELOW GROUND SURFACE.

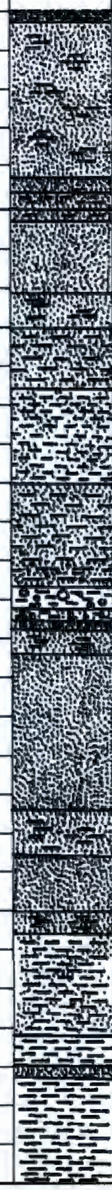
Diagram



Depth in Feet: 0, 25, 50, 75, 100, 125

GEOLOGIC/HYDROLOGIC DATA

Graphic Log

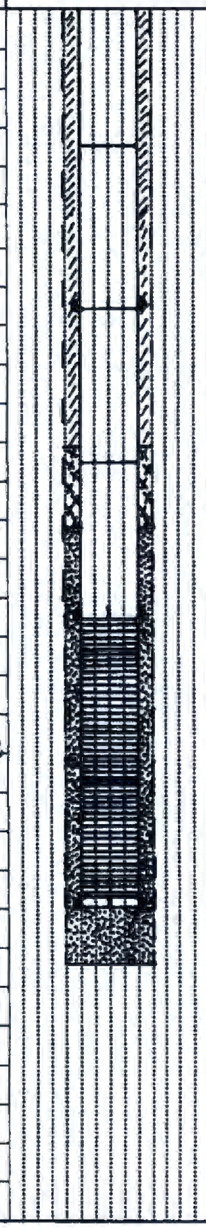


Lithologic Description
0-1' Drill Pad: Misc. Fill
1-22' Slightly Silty Sand (m)S
22-24' Sand S
24-25' Silty Sand mS
25-26' Slightly Silty Sand (m)S
26-35.5' Sand S
35.5-40' Slightly Silty Sand (m)S
40-48' Silty Sand mS
48-60' Sandy Silt sM
60-74' Silty Sand mS
74-76' Gravelly Silt gM
76-77' Gravelly Sandy Silt gsM
77-78.5' Gravelly Sand gS
78.5-83' Slightly Silty Sand (m)S
83-103.5' Sand S
103.5-108' Slightly Silty Sand (m)S
108-115' Sand S
115-118' Slightly Silty Sand (m)S
118-131' Sandy Silt sM
131-135' Silt M
135-135.5' Sand S
135.5-163' Silt M

Figure C-2. Well 299-W26-14 Well Summary Sheet (sheet 1 of 2)

WELL SUMMARY SHEET		Start Date: 3/6/03 Finish Date: 4/3/03	Page: 2 of 2
Well ID: B8828		Well Name: 299-W26-14	
Location: 216-S-10 ditch.		Project: FY 2003 CERCLA CS-1 DRILLING	
Prepared By: Jess Hocking	Date: 4/3/03	Reviewed By: L. D. Walker	Date: 4/29/03
Signature: Jess Hocking		Signature: LD Walker	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description
		150		163 - 168' Sandy Gravel sG
				168 - 182' Gravelly Sand gS
				182 - 183' Slightly Silt Gravelly Sand (m)gS
				183 - 190' Gravelly Silty Sand gmS
		175		190 - 192' Silty Sand mS
				192 - 214' Silty Sandy Gravel msG
				214 - 217' Sandy Gravel sG
		200		217 - 219' Silty Sandy Gravel msG
				219 - 220' Sand S
				220 - 224' Sandy Gravel sG
				224 - 257' Silty Sandy Gravel msG
		225		257 - 258' Sand S
				258 - 259' Silty Sandy Gravel msG
Temporary Casing, 8 5/8" OD, to 267'				
				259 - 260' Sandy Gravel sG
		250		260 - 267' Sand S
				267 - Silty Sandy Gravel msG
				TD = 267.0' bgs
				DTW = 223' bgs (3/31/03)
		275		
NOTE: ALL TEMP. CASING REMOVED FROM GROUND.				
NOT TO SCALE				



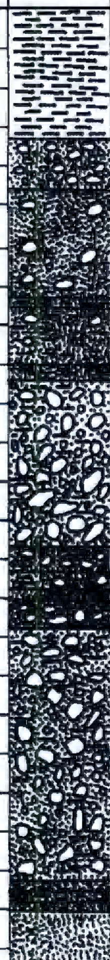


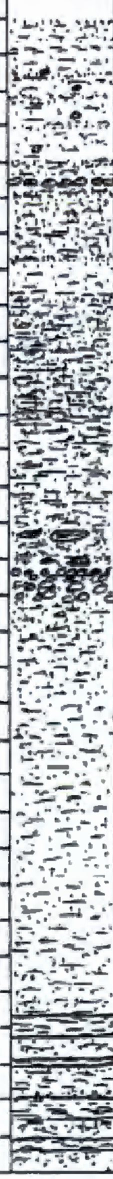
Figure C-2. Well 299-W26-14 Well Summary Sheet (sheet 2 of 2)

WELL SUMMARY SHEET

0500615

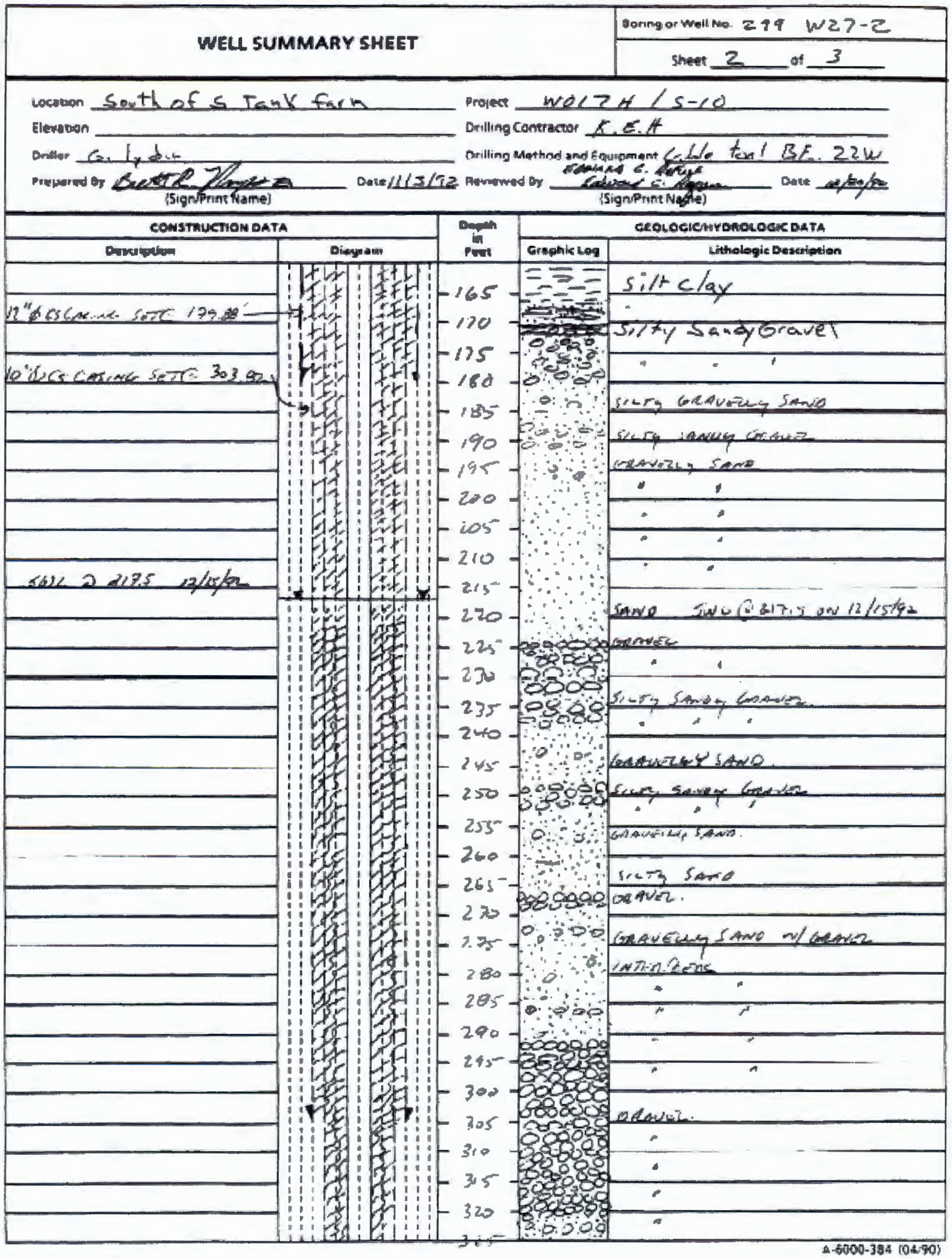
Boring or Well No. 299-W27-2
Sheet 1 of 2

Location South of S tank farm
Project WAC?? / S-10 ditch
Elevation
Drilling Contractor K.E.H.
Driller G. Howell/S. Lydin
Drilling Method and Equipment cable tool B.E. 22W
Prepared By [signature] / Brett Thompson (Sign/Print Name) Date 10-6-92
Reviewed By Edward C. Rafuse (Sign/Print Name) Date [illegible]



CONSTRUCTION DATA – Description	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA – Lithologic Description
	0	Silty Sand with occasional pebble
	5	" "
16" Ø C.S Casing set at 98.5	10	" "
	15	" "
12" Ø C.S casing set at 179.88	20	Pebble or Gravel/ loose
10" Ø CS CASING SET @ 302.92	25	Silty Sand
	30	" "
8" Ø CS CASING SET @ 426.56	35	" "
	40	" "
4" STAINLESS STEEL PERMANENT	45	" "
CASING - SET @ 416.56'	50	" "
SCREENED INTERVAL SET	55	" "
@ 416.56 - 406.14	60	" "
STICKUP = 3.7 w/CAP ON	65	" "
12/05/92.	70	silt clay ripup clasts
	75	silty Sandy Gravel
	80	Gravel silty Sand
	85	" " "
	90	" " "
	95	
	100	silty Sand
	105	" "
	110	" "
	115	" "
	120	" "
	125	" "
	130	" "
	135	" "
	140	silt clay
	145	silty Sand
	150	" "
	155	" "
		" "

Figure C-3. Well 299-W27-2 Well Summary Sheet (sheet 1 of 3)



WELL SUMMARY SHEET

Boring or Well No. 299 W27-2
Sheet 2 of 3

Location South of S Tank Farm
Project W017H / S-10
Elevation
Drilling Contractor K.E.H
Driller G. Lyda
Drilling Method and Equipment Cable tool BE 22W
Prepared By (Sign/Print Name) Date 11/13/92
Reviewed By (Sign/Print Name) Date

CONSTRUCTION DATA Description	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA Lithologic Description
	165	Silt clay
12" Ø CS Casing Set @ 179.88'	170	Silty Sandy Gravel
	175	" " "
10" Ø CS Casing Set @ 303.80'	180	
	185	Silty Gravelly Sand
	190	Silty Sandy Gravel
	195	Gravelly Sand
	200	" "
	205	" "
	210	" "
SWL @ 217.5 12/15/92	215	
	220	Sand SWL @ 217.5 on 12/15/92
	225	Gravel
	230	" "
	235	Silty Sandy Gravel
	240	" " "
	245	Gravelly Sand
	250	Silty Sandy Gravel
	255	Gravelly Sand.
	260	
	265	Silty Sand
	270	Gravel.
	275	Gravelly Sand w/ Gravel
	280	interbeds
	285	" "
	290	" "
	295	" "
	300	
	305	Gravel.
	310	"
	315	"
	320	"
	325	"

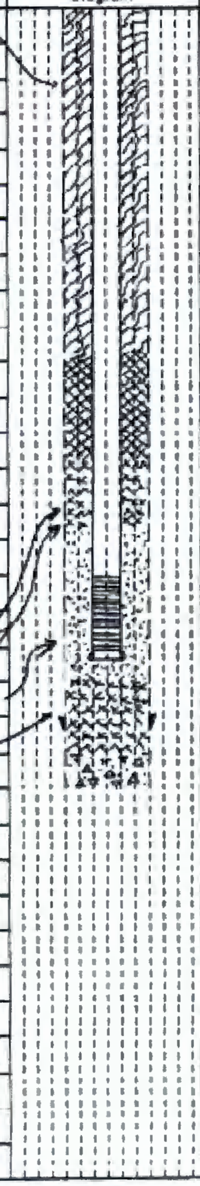
A-6000-384 (04/90)

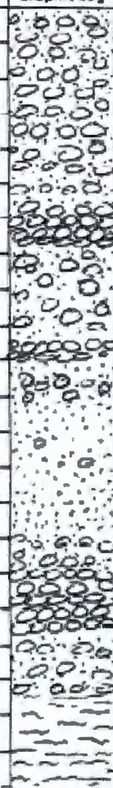
Figure C-3. Well 299-W27-2 Well Summary Sheet (sheet 2 of 3)

WELL SUMMARY SHEET

Boring or Well No. 299-W27-2
Sheet 3 of 3

Location: South of "S" Tank Farm
Project: W017H/S-10
Elevation:
Drilling Contractor: Jensen
Driller: D. Mendez
Drilling Method and Equipment: Cable/Air Rotary
Prepared By (Sign/Print Name): M. Sweeney
Date: 12/10/92
Reviewed By (Sign/Print Name): Edward C. Rojas
Date: 2/24/92





CONSTRUCTION DATA – Description	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA – Lithologic Description
8" ⌀ CS CASING SET TO 426.2	330	SANDY GRAVEL
	335	" "
	340	" "
	345	" "
	350	" "
	355	GRAVEL.
	360	
	365	SANDY GRAVEL. " "
	370	
	375	GRAVEL.
	380	SANDY GRAVEL. " "
	385	
	390	GRAVELLY SAND. " "
SCREEN SET @ 416.56 TO 406.14	395	SAND
PORTLAND CEMENT 9.7'-20'	400	SANDY GRAVEL.
BENTONITE CRUMBLES (3 w) 221.9-9.7	405	
BENTONITE CLEARY 374.5-221.8	410	GRAVEL "
PORTLAND CEMENT 389.4-374.5	415	
BENTONITE HOLE PLUG 399.4-389.4	420	SANDY GRAVEL. " "
10/20 SAND 420 - ~~399.4~~ 399.4	425	
BENTONITE PLUG 428.2-420.0	430	CLAY/SILT
HOLE COLLAPSED TO 428.2	435	
	440	TD = 435.0' 11/20/92
		REDRILLED FROM 396' TO 414.5'
		12/4/92 - 12/9/92 w/ 13E22W
		RIG # 11-12

A-6000-384 (04/90)

Figure C-3. Well 299-W27-2 Well Summary Sheet (sheet 3 of 3)

WELL SUMMARY SHEET		Start Date: 11/8/07 Finish Date: 01/4/08	Page 1 of 4
Well ID: C4975		Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L. D. Walker	Date: 4/17/08
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
6-in Concrete Pad	
6-in I.D. Type 304/304L Stainless Steel Protective Casing: +2.42 ft above Ground Surface	
Portland Cement Type I/II: 0 - 10.8 ft	
Granular Bentonite Crumbles: 10.8 - 212.4 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-1 Gravel, G (Fill)
		1-8 Sandy Silt, sM
		8-24 Sand, S
10		
20		
		24-30 Silt, M
30		30-50 Sand, S
40		
50		50-55 Sandy Gravel, sG
		55-74 Sand, S
60		
70		
		74-130 Silty Sand, mS
80		

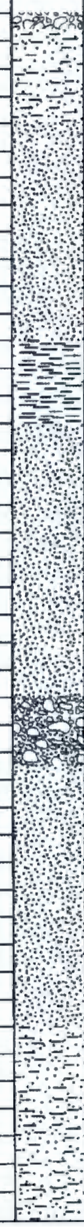


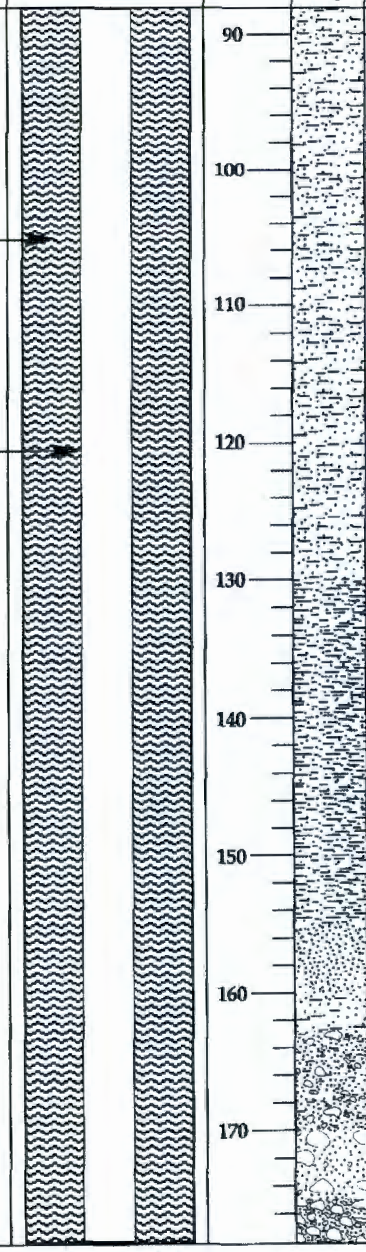
Figure C-4. Well 699-32-76 Well Summary Sheet (sheet 1 of 4)

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 2 of 4

Well ID: C4975		Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R		Signature: LD Walker	

CONSTRUCTION DATA | **Depth in Feet** | **GEOLOGIC/HYDROLOGIC DATA**

Description | Diagram | Graphic Log | Lithologic Description/Groundwater Sample Depths (ft bgs)



Granular Bentonite Crumbles: 10.8 - 212.4 ft

4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft

All depths are in feet below ground surface.

130-155 Sandy Silt, sM

155-160 Sand, S

160-163 Silty Sand, mS

163-170 Silty Gravely Sand, mgS

170-175 Gravely Sand, gS

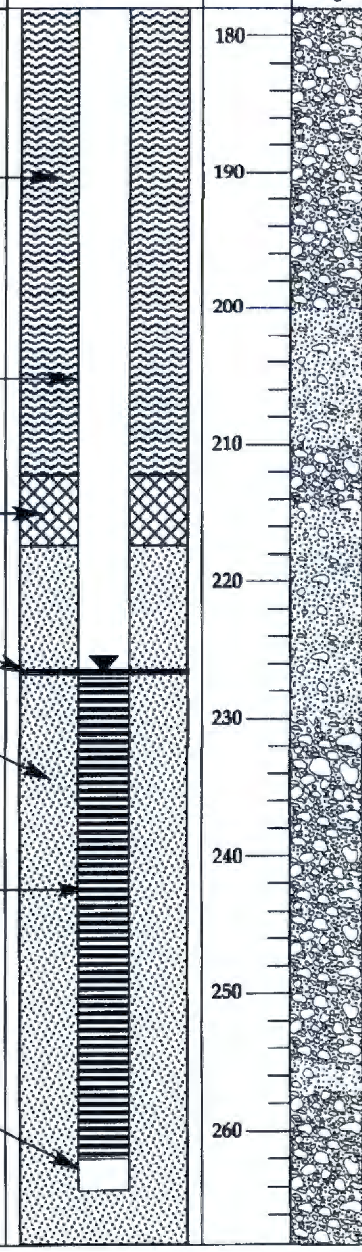
175-200.5 Sandy Gravel, sG

Figure C-4. Well 699-32-76 Well Summary Sheet (sheet 2 of 4)

WELL SUMMARY SHEET		Start Date: 11/8/07	Page 3 of 4
		Finish Date: 01/4/08	
Well ID: C4975		Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA | **GEOLOGIC/HYDROLOGIC DATA**

Description
Granular Bentonite Crumbles: 10.8 - 212.4 ft
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft
3/8-in Bentonite Pellets: 212.4 - 217.0 ft
Static Water Level: 226.40 ft bgs (12-10-2007)
Primary Filter pack 10-20 Mesh Colorado Silica Sand: 217.0 - 267.2 ft
4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 227.0 - 262.0 ft bgs
4-in I.D. Stainless Steel, Type 304, Schedule 10 Sump: 262.0 - 264.0 ft bgs
All depths are in feet below ground surface.



Lithologic Description/Groundwater Sample Depths (ft bgs)
200.5-210 Gravely Sand, gS
210-215 Sandy Gravel, sG
215-230 Gravely Sand, gS
230-236 Silty Sandy Gravel, msG
236-237 Grab Sample for Sieve Analysis
236-255 Sandy Gravel, sG
244 Water Sample HEIS: B1PM57 & B1PM85
255-257 Gravelly Silty Sand, gmS
257-280 Silt Sandy Gravel, msG
257 Grab Sample for Sieve Analysis

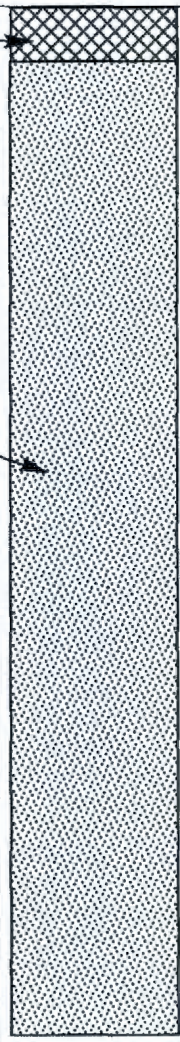
Figure C-4. Well 699-32-76 Well Summary Sheet (sheet 3 of 4)

WELL SUMMARY SHEET	Start Date: 11/8/07	Page 4 of 4
	Finish Date: 01/4/08	

ell ID: C4975	Well Name: 699-32-76
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.
Prepared By: Erika Rincon Date: 1/11/08	Reviewed By: L.D. Walker Date: 4/17/08
Signature: Erika R	Signature: LD Walker

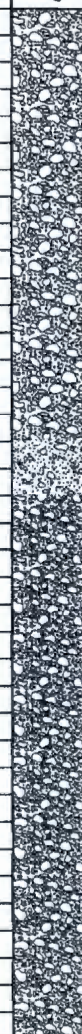
CONSTRUCTION DATA

Description	Diagram
3/8-in Bentonite Pellets: 267.2 - 272.0 ft	
8-12 Mesh Colorado Silica Sand (Backfill): 272.0 - 344.0 ft	
All depths are in feet below ground surface.	
rehole drilled with 13-in threaded casing 0-198 ft and 10¾-in threaded casing 198-344 ft	
All temporary drill casing was removed from the ground.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 270, 280, 290, 300, 310, 320, 330, 340, 350



Lithologic Description/Groundwater Sample Depths (ft bgs)
273 Water Sample HEIS: B1PM54, B1PM58 & B1PM86
280-300 Sandy Gravel, sG
299 Water Sample HEIS: B1PM59 & B1PM87
300-304 Silty Gravely Sand, mgS
304-344 Sandy Gravel, sG
342 Water Sample HEIS: B1PM60 & B1PM88
344 Total Depth (12/13/2007)

Figure C-4. Well 699-32-76 Well Summary Sheet (sheet 4 of 4)

WELL SUMMARY SHEET		Start Date: 01/08/08 Finish Date: 01/31/08	Page 1 of 4
Well ID: C4974		Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 2/1/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R		Signature: LD Walker	

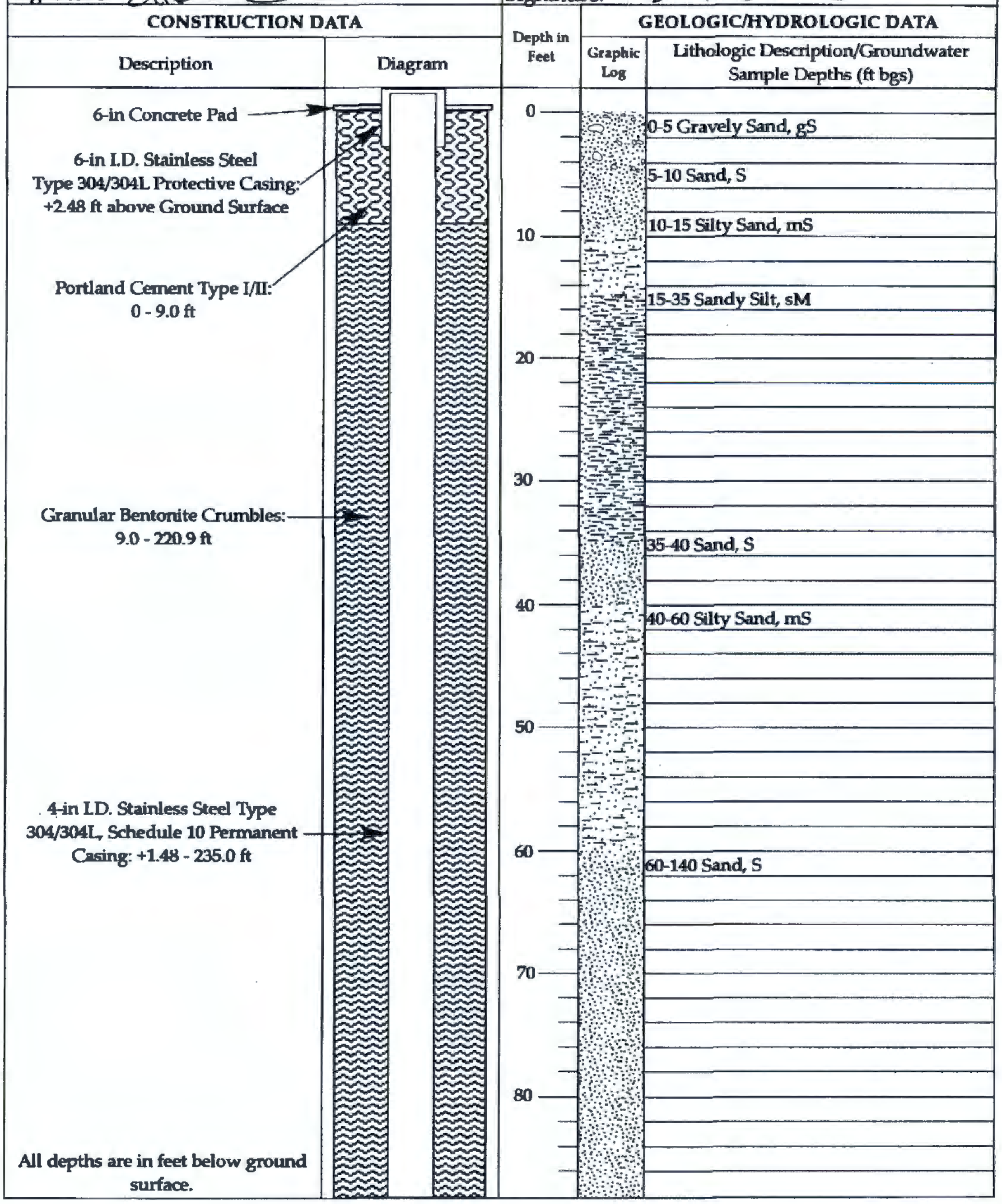


Figure C-5. Well 699-33-75 Well Summary Sheet (sheet 1 of 4)

WELL SUMMARY SHEET	Start Date: 01/08/08 Finish Date: 01/31/08	Page 2 of 4

Well ID: C4974	Well Name: 699-33-75
Location: 1/4 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.
Prepared By: Erika Rincon — Date: 2/1/08	Reviewed By: L.D. Walker — Date: 4/17/08
Signature: Erika R	Signature: [signature]

CONSTRUCTION DATA

Description	Diagram
Granular Bentonite Crumbles: 9.0 - 220.9 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
90		
100		
110		
120		
130		
140		140-145 Silty Sand, mS
		145-150 Sand, S
150		150-172 Silty Sand, mS
160		
170		172-180 Silty Gravely Sand, mgS

Figure C-5. Well 699-33-75 Well Summary Sheet (sheet 2 of 4)

WELL SUMMARY SHEET		Start Date: 01/08/08 Finish Date: 01/31/08	Page 3 of 4
Well ID: C4974		Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 2/1/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: [signature]		Signature: [signature]	

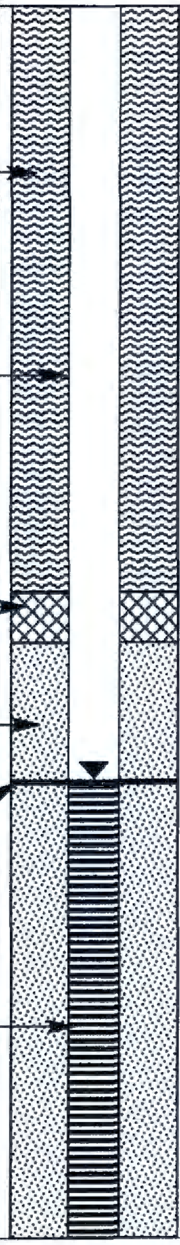
CONSTRUCTION DATA

Description:

- Granular Bentonite Crumbles: 9.0 - 220.9 ft
- 4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft
- 3/8-in Bentonite Pellets: 220.9 - 224.5 ft
- Primary Filter pack 10-20 Mesh Colorado Silica Sand: 224.5 - 274.0 ft
- Static Water Level: 234.80 ft bgs (01-24-2008)
- 4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 235.0 - 270.0 ft bgs

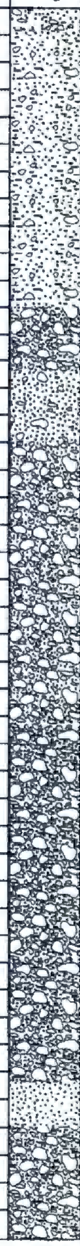
All depths are in feet below ground surface.

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Graphic Log:



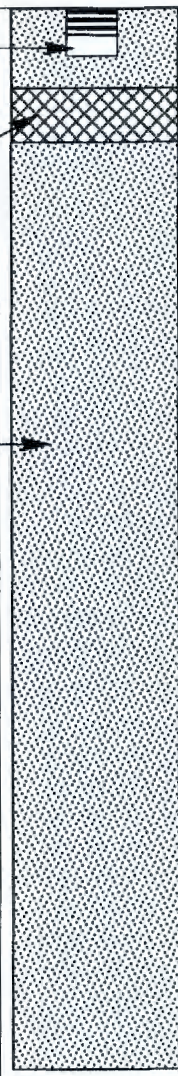
Depth in Feet	Lithologic Description/Groundwater Sample Depths (ft bgs)
180	180-200 Gravely Silty Sand, gmS
190	
200	200-205 Sandy Gravel, sG
	205-210 Gravely Sand, gS
210	210-230 Sandy Gravel, sG
220	
	227-229 Split-Spoon Sample for Sieve Analysis
230	230-257 Silty Sandy Gravel, msG
240	
	244 Water Sample HEIS: B1PM53 & B1PM81
250	
	257-260 Sand, S
	257-259 Split-Spoon Sample for Sieve Analysis
260	260-310 Silt Sandy Gravel, msG

Figure C-5. Well 699-33-75 Well Summary Sheet (sheet 3 of 4)

WELL SUMMARY SHEET		Start Date: 01/08/08 Finish Date: 01/31/08	Page 4 of 4
Well ID: C4974		Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 2/1/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R		Signature: LD Walker	

CONSTRUCTION DATA

Description	Diagram
4-in, I.D. Stainless Steel, Type 304, Schedule 10 Sump: 270.0 - 272.0 ft	
3/8-in Bentonite Pellets: 274.0 - 277.8 ft	
8-12 Mesh Colorado Silica Sand (Backfill): 227.8 - 346.0 ft	
All depths are in feet below ground surface.	
Borehole drilled with 13-in threaded casing 0-198.5 ft and 10¾-in threaded casing 198.5-346 ft	
All temporary drill casing was removed from the ground.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
270		
277		277 Water Sample HEIS: B1PM54, B1PM82
280		
290		
300		
307		307 Water Sample HEIS: B1PM55 & B1PM83
310		310-335 Sandy Gravel, sG
320		
330		
335		335-340 Gravel, G
340		340-346 Sandy Gravel, sG
346		346 Water Sample HEIS: B1PM56 & B1PM84
346		346 Total Depth (01/21/2008)
350		

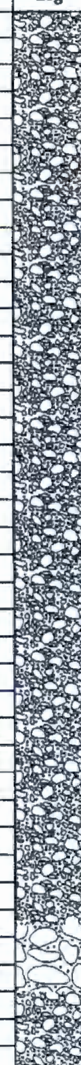


Figure C-5. Well 699-33-75 Well Summary Sheet (sheet 4 of 4)

WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 1 of 4

Well ID: C4976	Well Name: 699-33-76
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.
Prepared By: Erika Garcia — Date: 4/21/08	Reviewed By: L.D. Walker — Date: 6/5/08
Signature:	Signature:

CONSTRUCTION DATA

Description	Diagram
6-in Concrete Pad	
6-in I.D. Type 304/304L Stainless Steel Protective Casing: +2.42 ft above Ground Surface	
Portland Cement Type I/II: 0 - 10.0 ft	
Granular Bentonite Crumbles: 10.0 - 206.8 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-2 Gravel, G (Fill)
		2-35 Silty Sand, mS
10		
20		
30		
		35-70 Sandy Silt, sM
40		
50		
60		
70		70-78 Gravely Sandy Silt, gsM
80		78-100 Sandy Silt, sM

Figure C-6. Well 699-33-76 Well Summary Sheet (sheet 1 of 4)

WELL SUMMARY SHEET		Start Date: 01/31/08 Finish Date: 03/27/08	Page 2 of 4
Well ID: C4976		Well Name: 699-33-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Garcia	Date: 4/21/08	Reviewed By: L.D. Walker	Date: 6-5-08
Signature: G.L. Kasza		Signature:	

CONSTRUCTION DATA

Description	Diagram
Granular Bentonite Crumbles: 10.0 - 206.8 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft	
All depths are in feet below ground surface.	

GEOLOGIC/HYDROLOGIC DATA

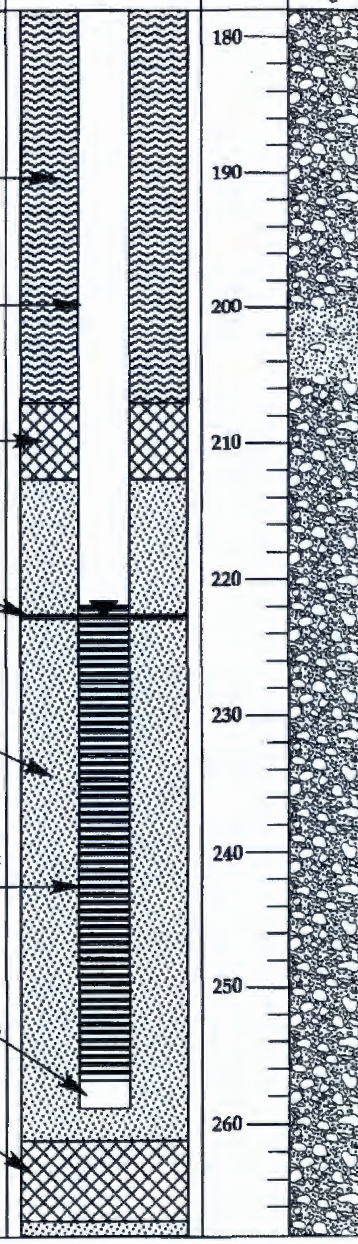
Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
90		
100		100-160 Silty Sand, mS
110		
120		
130		
140		
150		
160		160-165 Sand, S
		165-170 Gravely Silty Sand, gmS
170		175-200 Sandy Gravel, sG

Figure C-6. Well 699-33-76 Well Summary Sheet (sheet 2 of 4)

WELL SUMMARY SHEET		Start Date: 01/31/08	Page 3 of 4
		Finish Date: 03/27/08	
Well ID: C4976		Well Name: 699-33-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Garcia	Date:4/21/08	Reviewed By: L.D. Walker	Date: 6-5-08
Signature: G.L. Kasza [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
Granular Bentonite Crumbles: 10.0 - 206.8 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft	
3/8-in Bentonite Pellets: 206.8 - 212.4 ft	
Static Water Level: 222.75 ft bgs (03/17/2008)	
Primary Filter pack 10-20 Mesh Colorado Silica Sand: 212.4 - 261.3 ft	
4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 222.0 - 257.0 ft bgs	
4-in I.D. Stainless Steel, Type 304, Schedule 10 Sump: 257.0 - 259.0 ft bgs	
3/8-in Bentonite Pellets: 261.3 - 267.2 ft	
All depths are in feet below ground surface.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
200		200-205 Gravely Sand, gS
210		205-342.4 Sandy Gravel, sG
		243 Water Sample HEIS: B1PM61 & B1PM89
		252.5-255 Split-Spoon for Sieve Analysis
		257-280 Silt Sandy Gravel, msG

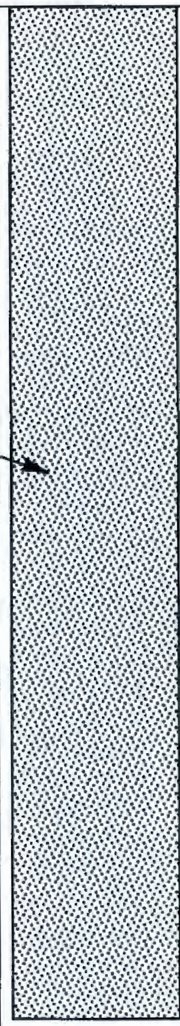
Figure C-6. Well 699-33-76 Well Summary Sheet (sheet 3 of 4)

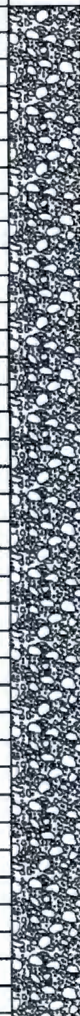
WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 4 of 4

Well ID: C4976	Well Name: 699-33-76
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.
Prepared By: Erika Garcia Date: 4/21/08	Reviewed By: L.D. Walker Date: 6/5/08
Signature: G. L. Kasza [signature]	Signature: [signature]

CONSTRUCTION DATA | **GEOLOGIC/HYDROLOGIC DATA**

Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
		270		205-342.4 Sandy Gravel, sG
				273 Water Sample HEIS: B1PM62 & B1PM90
		280		
		290		
10-20 Mesh Colorado Silica Sand (Backfill): 267.2 - 342.4 ft		300		302 Water Sample HEIS: B1PM63 & B1PM91
		310		
		320		
		330		
		340		342.4 Water Sample HEIS: B1PM64 & B1PM92
				342.4 Total Depth (03/17/2008)
		350		





All depths are in feet below ground surface.

Borehole drilled with 11¾-in threaded casing 0-205 ft and 95/8-in threaded casing 198-344 ft

All temporary drill casing was removed from the ground.

Figure C-6. Well 699-33-76 Well Summary Sheet (sheet 4 of 4)

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C2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988,* National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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