RCRA-CN-01_DOE/RL-2008-61_R1

Interim Status Change Number 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

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Prepared for the U.S. Department of Energy
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RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN INTERIM CHANGE FORM

Change Number: *(Obtain Change Number From Interim Change Custodian)*		Date:
RCRA-CN-01_DOE/RL-2008-61_R1		4/30/2020
Document Number: DOE/RL-2008-61	**Title:** Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch	**Rev:** 1
Originator: Tessa Clark		**Phone:** 3605203189

Description of Change: This form is used only for RCRA interim status groundwater monitoring plans *(i.e., shall not be used for final status groundwater monitoring plans)*. Describe the interim changes made to the RCRA interim status groundwater monitoring plan; consider any previous interim changes made to the plan. Changes cannot be made to the plan that conflict with the requirements of 40 CFR 265, Subpart F.

-Change section reference from "A1.6 and A2.6" to "A2.5" in Table 2-2, page 2-27, in main text.
-Add "molybdenum" to corrosion constituents in the Executive Summary on pg. ix, Section 2.5.1 on pg. 2-17, Section 2.7 on pg. 2-28, Table 2-3 on pg. 2-28, Section 3.1, able 3-1 (footnote f), Section 3.2, Section 3.3, and Table 3-3 on pg. 3-11.
-In Table 3-1, add superscript "k" to "Phenols" with footnote "k. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-1a."
-Add Table 3-1a, "Phenols Analyzed as Groundwater Quality Constituents" to pg. 3-4a and Table of Contents (Tables).
-Replace Appendix A in its entirety with an updated version of Quality Assurance Project Plan.
-Remove "The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group" from Section B5.3 in Appendix B.

NOTE: For form use see CHPRC-03210, *Review of RCRA Groundwater Data and Management Plans.* Identify page(s), section(s), and table(s) that changed. Attach redline/strikeout of entire groundwater monitoring plan. Post interim change form(s) and redline/strikeout of entire groundwater monitoring plan on the S&GRP webpage as the current plan and place in Facility Operating Record.

Justification and Impacts of Change: State the reason and justification for the change(s) to the issued groundwater monitoring plans. Identify any impacts or actions that may result from this change.

-Reference in Table 2-2 is changed to Section A2.5 to reference the applicable section in the updated Appendix A.
-Table 3-1a added to clarify what phenols will be analyzed as groundwater quality constituents.
-Appendix A (Quality Assurance Project Plan) is replaced in its entirety due to multiple updates since issuance of the monitoring plan.
-Sentence removed from Section B5.3 is not applicable to the monitoring plan.

RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN
INTERIM CHANGE FORM (Continued)

Approvals: Include "Other" approvals as appropriate *(e.g., Obtain SMR approvals on changes to "Field and Laboratory Quality Control Elements and Acceptance Criteria" table).*

Other:

Print First and Last Name	Signature	Date
Kelly Whitley	email approval attached -	06/08/2020

S&GRP Environmental Compliance Officer:

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Comment: To comply with CHPRC's electronic signature directive, we are resending the RCRA groundwater monitoring plan redlines for secondary approval. This is required to process the plans in clearance.

Approved by Whitley, Kelly M on 6/8/2020 1:41 PM
Comment:

Approved by Sexton, Sean M on 6/8/2020 1:53 PM
Comment:

Approved by Faught, William R on 6/8/2020 2:34 PM
Comment:

Approved by Hildebrand, R D (Doug) on 6/8/2020 3:12 PM
Comment:

Change History of Interim Status Monitoring Plan DOE/RL-2008-61, Rev. 1, for the 216-S-10 Pond and Ditch

Title	Document Number	Revision Number	Interim Change Number	Effective Date
Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch	DOE/RL-2008-61	1	6/8/2017	6/8/2017
Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch	DOE/RL-2008-61	1	RCRA-CN-01_DOE/RL-2008-61_R1	4/30/2020

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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 is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the treatment, storage, and disposal (TSD) unit (updated constituents and frequency of monitoring). 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 an inactive 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

[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.epw.senate.gov/rcra.pdf.

[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.ecfr.gov/cgi-bin/text-idx?SID=24aad4966ac52acbeba416c2c1114889&mc=true&node=pt40.26.265&rgn=div5.

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 TSD unit 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 groundwater monitoring plan presents an updated 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 that 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 (carbon tetrachloride, chromium, hexavalent chromium, iron, manganese, molybdenum, nickel, nitrate, and major anions and cations) will also be monitored. Water-level measurements will be taken each time that a sample is collected to satisfy the requirements of 40 CFR 265.92(e).

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Terms

AEA	*Atomic Energy Act of 1954*
AMSL	above mean sea level
bgs	below ground surface
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
NAD83	*North American Datum of 1983*
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 halogen
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*, Ecology et al., 1989)
TSD	treatment, storage, and disposal

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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*. The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL), is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the treatment, storage, and disposal (TSD) unit (updated constituents and frequency of monitoring). 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* , and the *Code of Federal Regulations* 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 is used to monitor the indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan is also used for monitoring the parameters used to establish groundwater quality.

The S-10 unit is an inactive interim status treatment, storage, and disposal (TSD) unit regulated as a surface impoundment, as defined in WAC 173-303-040, "Definitions." In accordance with Section I.A of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereafter referred to as the Hanford Facility RCRA Permit), the S-10 unit will continue to be considered an interim status unit until is it incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit, or until interim status is terminated. Therefore, groundwater monitoring for the S-10 unit continues under interim status requirements. For regulatory purposes, the TSD unit boundary of the S-10 unit is identified on the current Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*) Part A Form.

The S-10 unit is located within the 200-OA-1 Operable Unit (OU), and south-southwest of the 200 West Area 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 216-S-10 Ditch has not yet been closed.

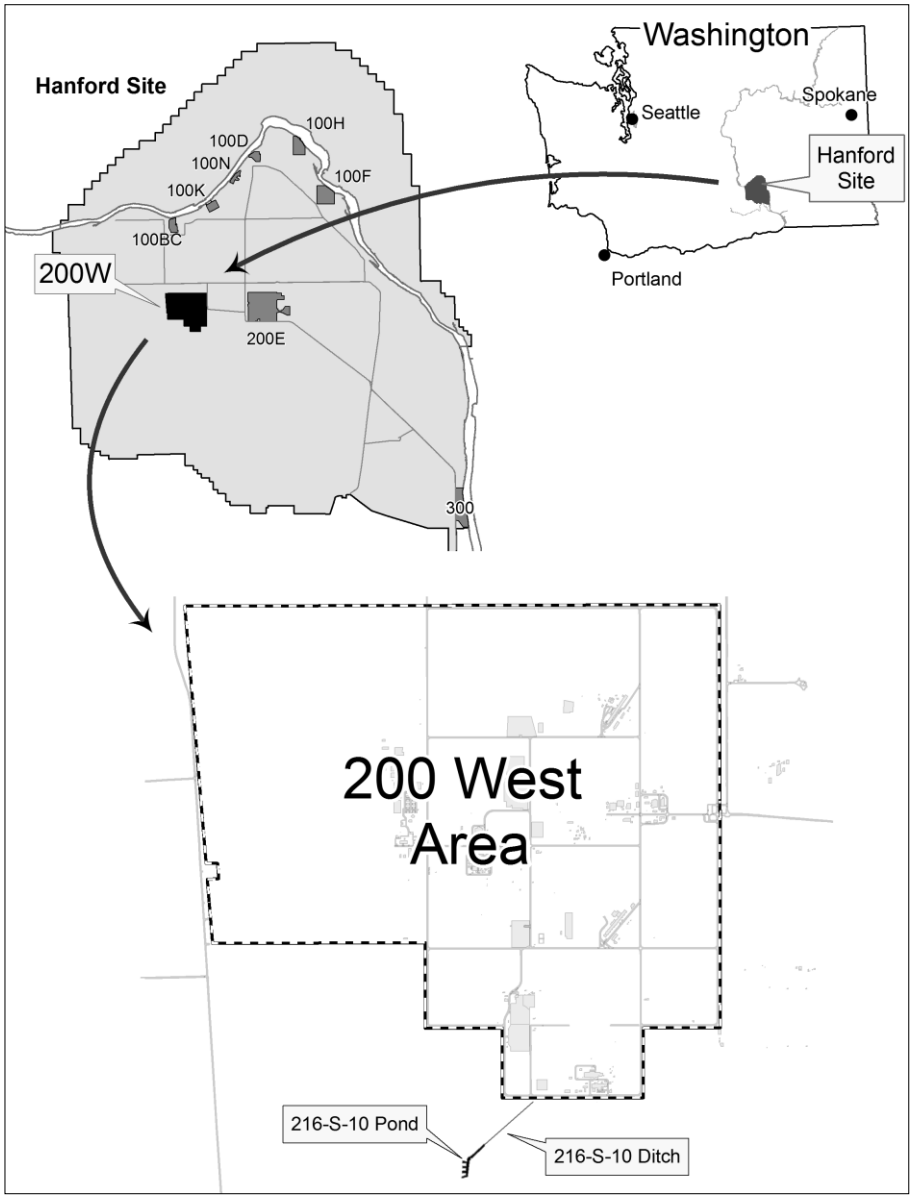

Figure 1-1. Location Map for the 216-S-10 Pond and Ditch

The purpose of this groundwater monitoring plan is to present an updated groundwater monitoring program for the parameters used as indicators of groundwater contamination and groundwater quality from the S-10 unit, commonly referred to as an indicator evaluation program under interim status. This plan is required by 40 CFR 265.90, "Applicability," (a) and (b) and is intended specifically to satisfy monitoring requirements applicable to interim status TSD units that are not impacting groundwater, as required by WAC 173-303-400(3) and 40 CFR 265, Subpart F, "Groundwater Monitoring". 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. Water-level measurements are also required each time that a sample is collected in accordance with 40 CFR 265.92(e), "Sampling and Analysis."

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the TSD unit and incorporates knowledge about the potential for contamination originating from the S-10 unit and includes the following chapters and appendices:

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

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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 previous groundwater monitoring plans listed in Section 2.5, and the following documents:

- BHI-00176, *S Plant Aggregate Area Management Study Technical Baseline Report*
- DOE, 1987, *216-S-10 Ditch and Pond Preliminary Closure/Post-Closure Plan*
- 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*
- 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 chemical sewer. 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.

Starting in August 1951, 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 unplanned release of ammonium nitrate nonahydrate reduced the infiltration capacity in the S-10 unit. As presented in RHO-CD-673, Section III. S200-W, 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; however, locations and depths of the excavation pits are unknown (RHO-CD-673, Section III. S200-W).

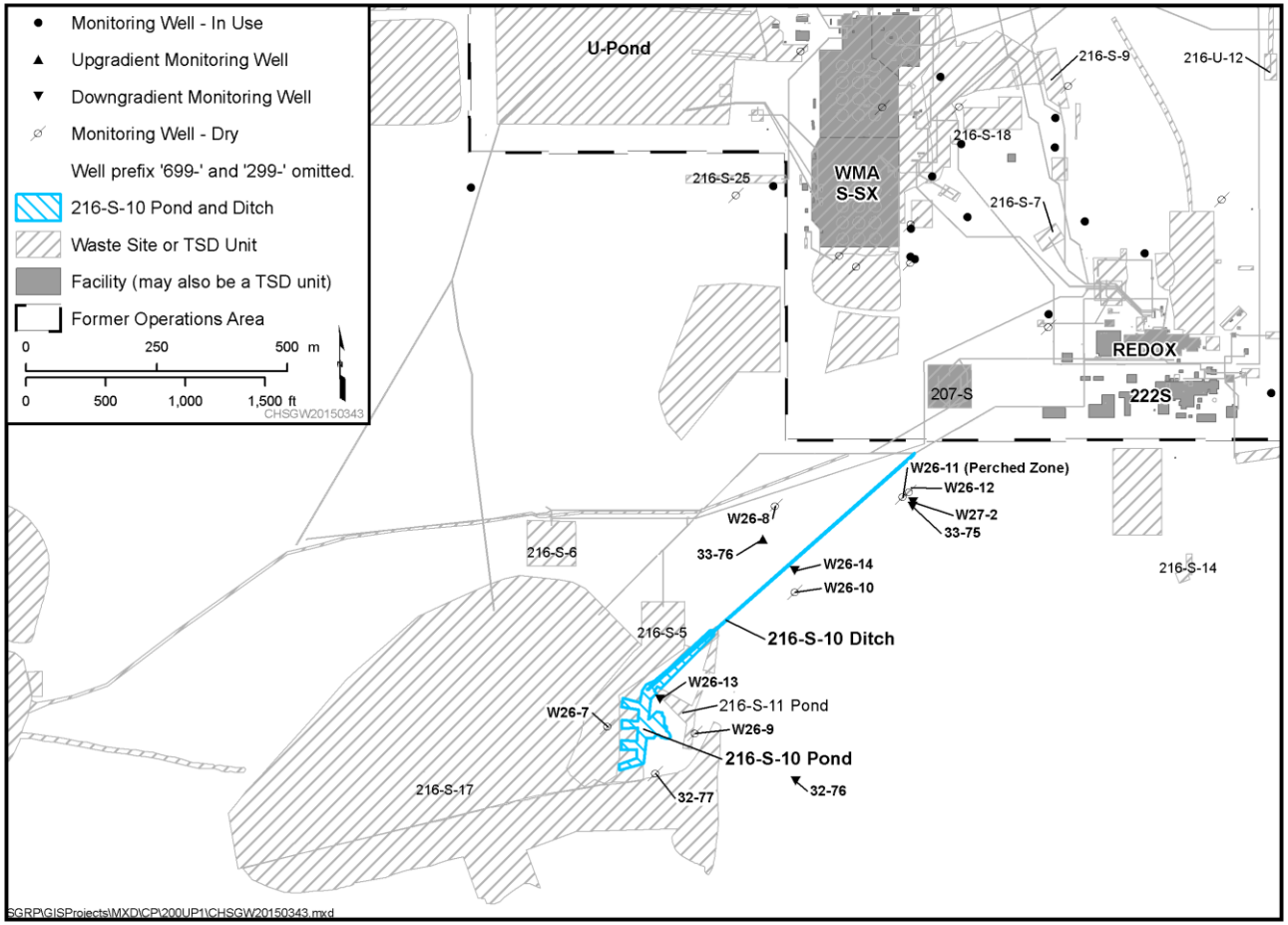

Figure 2-1. Map of the 216-S-10 Pond and Ditch

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. Stabilization at the S-11 Ponds comprised backfilling with soil to 0.3 to 0.6 m (12 to 24 in.) above grade and seeding with grass (BHI-00176, Section 4.5). The REDOX Facility was closed in 1967, and at that time, effluent to the S-10 unit was reduced primarily to chemical sewer waste. The REDOX Facility was deactivated in 1972. Deactivation included numerous steps to remove potentially hazardous substances from the plant (including cleanout of process vessels), and otherwise reduce the risk of dangerous chemicals accidently entering the S-10 Ditch (DOE, 1987, Section 4.0). Physical controls, including disconnection and/or capping of pipes in the REDOX Facility, were also performed (DOE, 1987, Table 4-1). 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 (DOE, 1987). This discharge is described in more detail in Section 2.3.

The S-10 Pond and southwest end of the S-10 Ditch were stabilized in October 1985. Stabilization at the S-10 Ditch comprised adding 0.3 to 0.6 m (12 to 24 in.) of soil and grass seed (BHI-00176, Section 4.3). Stabilization at the S-10 Pond comprised backfilling with soil to 0.3 to 0.6 m (12 to 24 in.) above grade and seeding with grass (BHI-00176, Section 4.4). 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.

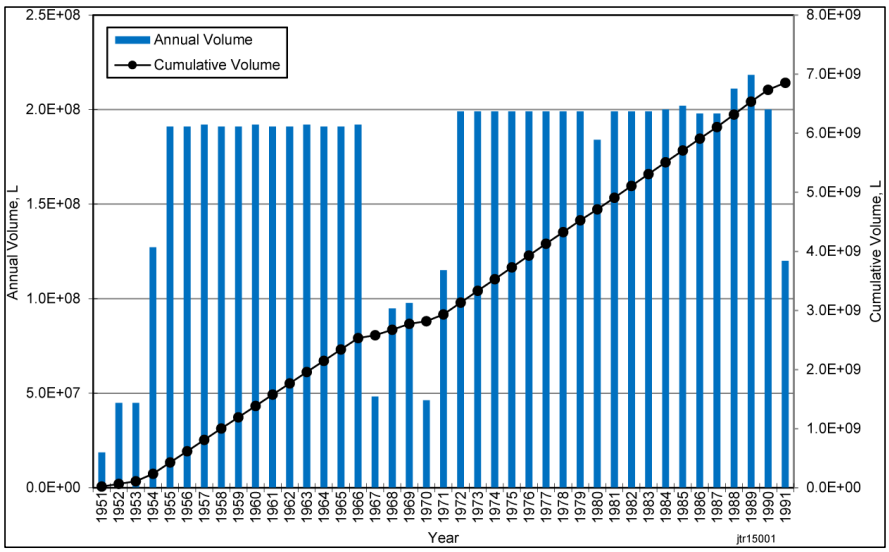

Figure 2-2. Liquid Effluent Volumes Discharged to the 216-S-10 Pond and Ditch from the REDOX Plant Chemical Sewer

Since 1991, 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 an interim status indicator evaluation program.

The S-10 unit overlies the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (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, DOE issued a final rule (10 CFR 962, “Byproduct Material”), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. The hazardous waste components of mixed waste were determined to be subject to Ecology authority to regulate these wastes since August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). 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 TSD unit have entered the groundwater in the uppermost aquifer underlying the TSD unit.

Dangerous waste is regulated under RCW 70.105, “Hazardous Waste Management,” and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). The AEA states 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 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).

To date, there has been no verified statistically significant exceedance of an indicator parameter (pH, specific conductance, total organic carbon [TOC], or total organic halogen [TOX]) 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). Results and evaluation of groundwater analysis results have been reported in the Hanford Site annual groundwater monitoring report (e.g., DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*) and the Hanford Site RCRA annual monitoring report (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*) per 40 CFR 265.94, “Recordkeeping and Reporting,” reporting requirements.

2.3 Waste Characteristics

The S-10 unit received 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 wastewater discharge in October 1991. One documented dangerous waste discharge to the S-10 unit occurred in September 1983 (DOE, 1987), 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 (Hanford Facility RCRA Permit) and include characteristic dangerous waste (ignitable [D001], corrosive [D002], and characteristic waste [D007 (chromium)]) and state-only toxic waste (WT01 and WT02). Approximately 50 waste streams contributed to the 216-S-10 Ditch (DOE/RL-2004-17, Section 1.4.3). The routine waste stream sources include the compressor cooling water from the 202-S Building and the sanitary water overflow from the water tower. The remaining sources were infrequent additions and include 202-S Building floor drains and funnel drains, 211-S Tank Farm (a storage area) pump drains, tank drains, station drains, chemical sewer line man-holes, and 276-S Building floor drains. The effluent to the chemical sewer was composed of approximately 60 percent REDOX Facility raw water, 20 percent sanitary water, and 20 percent steam condensate (DOE/RL-2004-17, Section 1.4.3).

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).

Geologic cross sections, which include selected wells in the southern portion of the 200 West Area, present the stratigraphy underlying and adjacent to the 216-S-10 unit (Figures 2-4 and 2-5; Section 2.6). Stratigraphic contacts shown below wells presented in the cross sections are based on interpolated contacts using the Leapfrog Hydro® geologic three-dimensional software (ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site Washington*) and the cross section generation tool provided in the web-based version of DOE/RL-2015-07. As indicated in each cross section figure legend, geologic information associated with a well is projected to the cross section within a buffer zone extending 75 m (246 ft) from either side of the cross section line, resulting in approximate depths for stratigraphic contacts. Definition of the stratigraphic units present is based on the most current, integrated understanding of the subsurface geologic framework beneath an area and in some cases utilizes projected geologic contacts and stratigraphy from adjacent areas where data is available, utilizing the Leapfrog® geologic three-dimensional software. The depiction of the CCU is derived from drill logs collected during installation of the S-10 unit network wells beginning in 1990, which additionally identified perched water in the CCU as presented in Section 2.4.2. The basalt contact at the S-10 unit is derived from deep wells located within the region surrounding the S-10 unit, which depict the top of basalt dipping to the south into the Cold Creek Syncline.

The uppermost surface of the Elephant Mountain Member of the Saddle Mountain Basalt is considered the base of the suprabasalt aquifer (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 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 Wooded Island member of the Ringold Formation and generally correspond to hydrostratigraphic units 9, 5, and 8, respectively (PNNL-13858). The Ringold lower mud unit separates the suprabasalt aquifer into a confined and unconfined aquifer (PNNL-13858).

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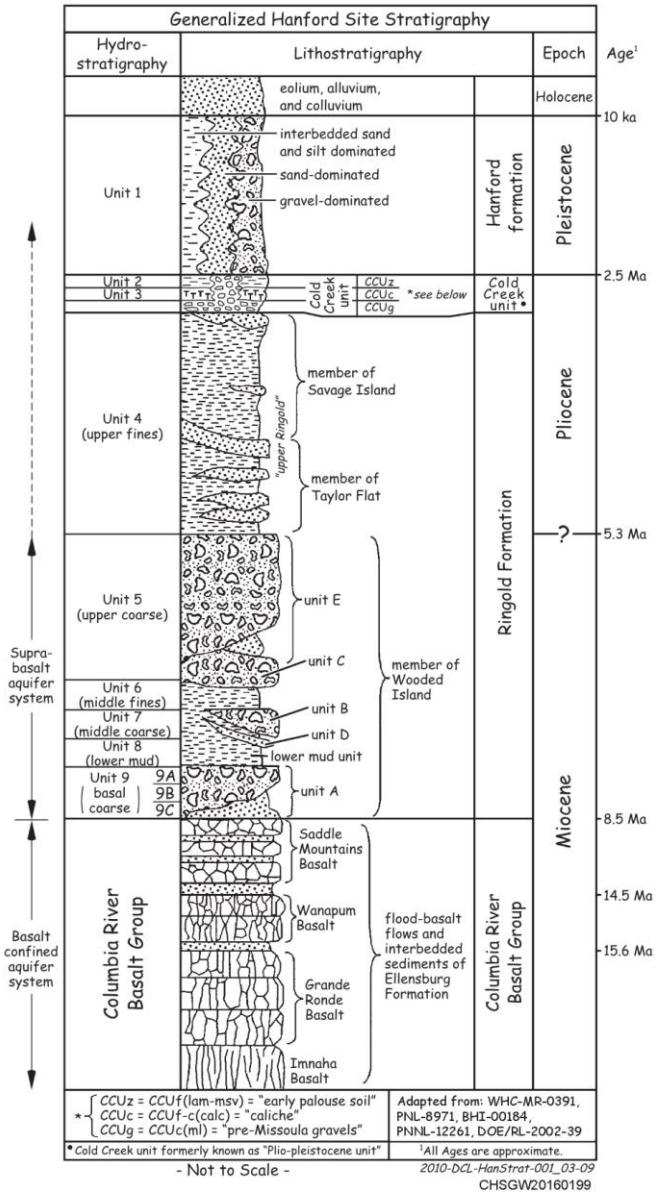

Note: Complete reference citations are provided in Chapter 6.

Figure 2-3. General Stratigraphy at the Hanford Site

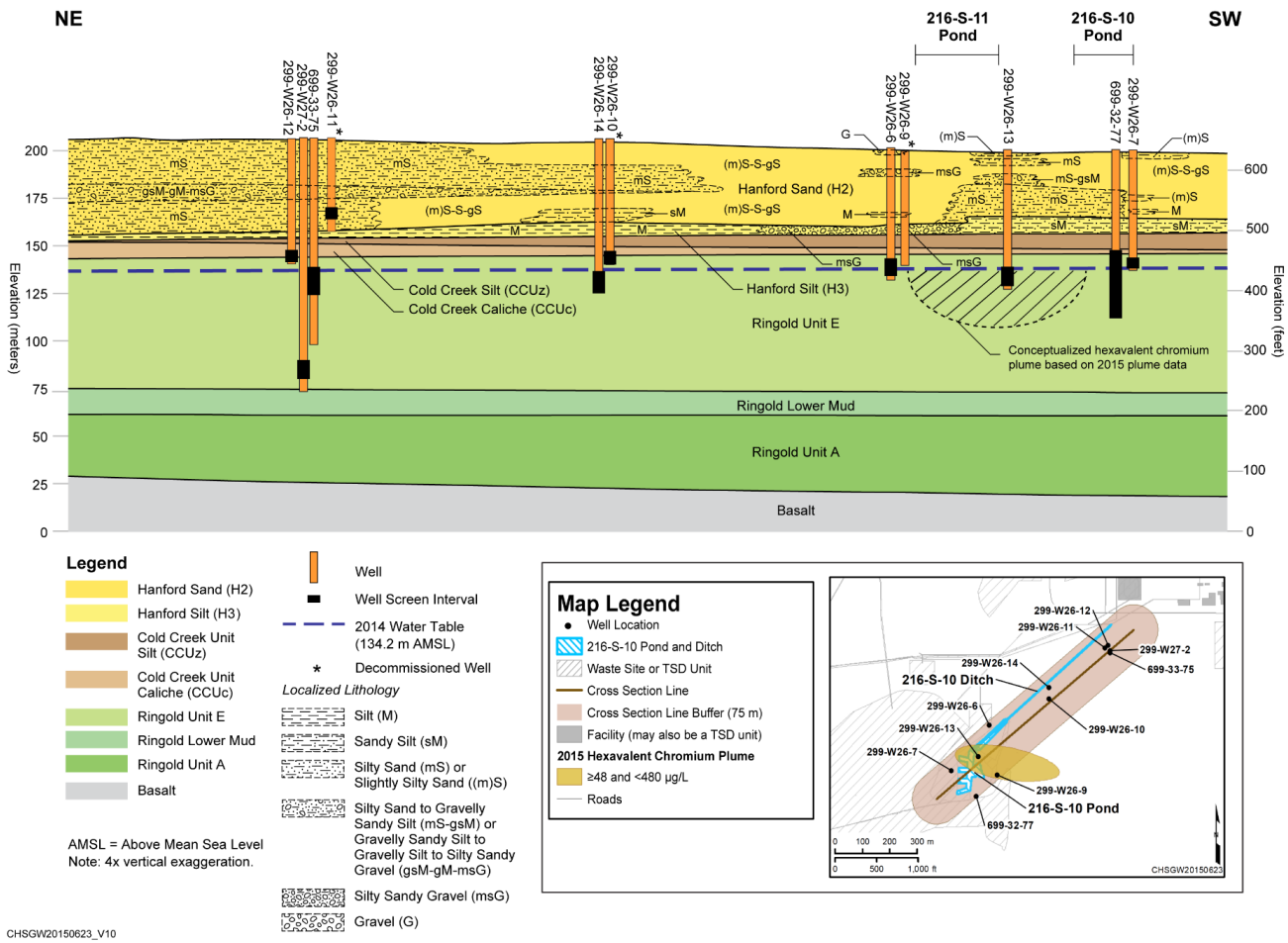

Figure 2-4. Northeast to Southwest Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch

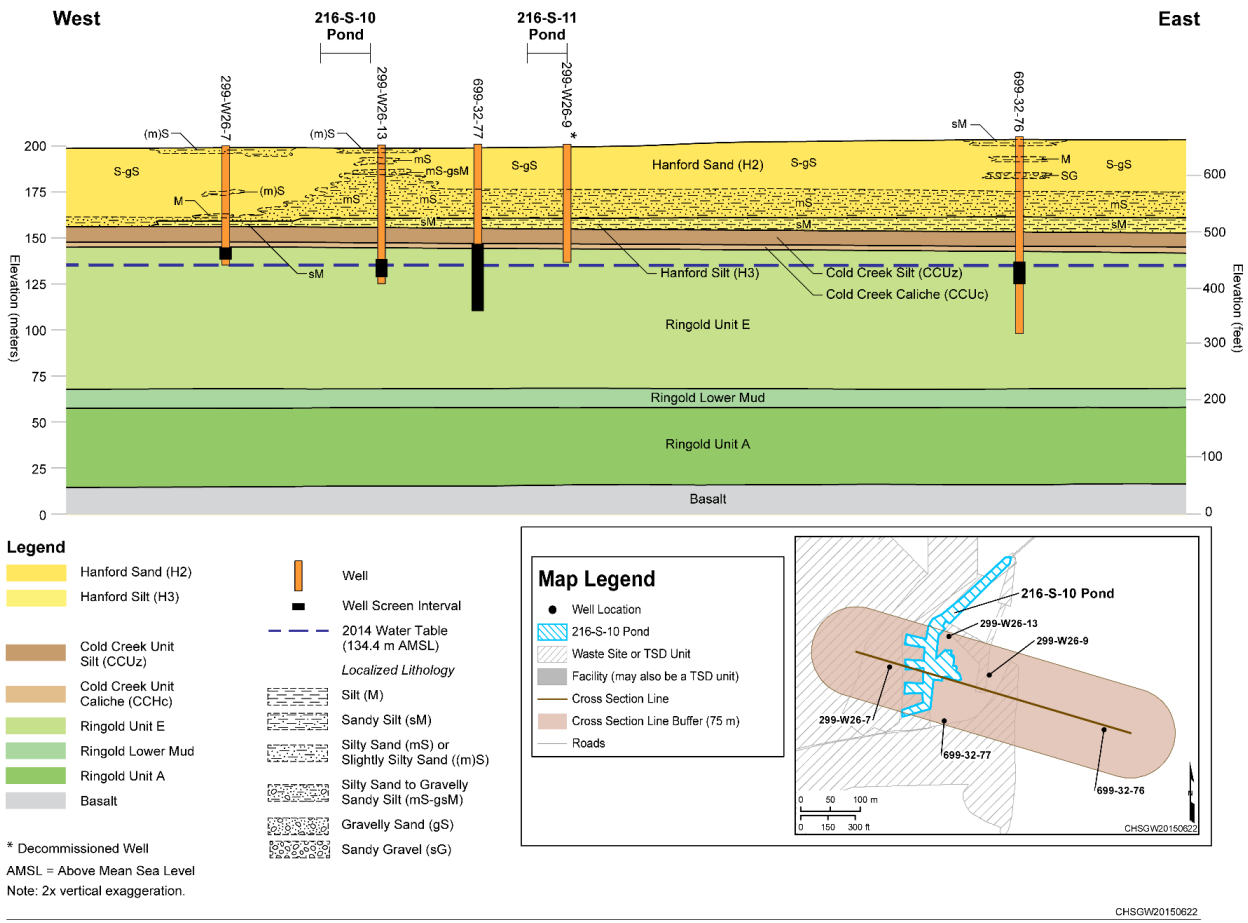

Figure 2-5. West to East Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch

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 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 consists of fine-grained silts deposited in a floodplain-overbank environment.

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). 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) thick. The upper CCU is present approximately 33 to 43 m (110 to 140 ft) below ground 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 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 predominantly of the sand-dominated lithofacies (H2). Clastic dikes have been identified within the geologic logs for boreholes in the 200 West Area (RHO-ST-23, Subsection 3.5). Clastic dikes can provide a preferential pathway for contaminant migration in the vadose zone and may result in nonuniform lateral spreading of contaminants.

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 uppermost aquifer is unconfined and located within Ringold unit E (Figures 2-4 and 2-5). The base of the unconfined aquifer is in the lower mud unit. The unconfined aquifer beneath the S-10 unit is 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. Communication between the unconfined and Ringold Formation confined aquifers is assumed to be insignificant due to the thickness and relatively low permeability of this confining unit. As presented in PNNL-13858 (p. 3.5), based on hydrochemistry and hydrogeologic data, groundwater within the Hanford unconfined aquifer does not flow vertically through the lower mud 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 measured with groundwater at a depth of 40.9 m (134.1 ft) in 1990 and found to be dry at a depth of 42.4 m (138.95 ft) in 1993. Perched water has not been encountered in any wells drilled since that time. Reference points for the perched groundwater measurements, and consequently for the elevations for the groundwater, are not available. Well 299-W26-11 was decommissioned in 2010.

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. Between 1947 and 2008, annual precipitation at the Hanford Meteorological Station averaged 172 mm (6.8 in.) and varied between 76 and 313 mm (3.0 and 12.3 in.) (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 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 (36 to 1,476 ft/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, including upgradient wells 299-W26-7 and 299-W26-8 and downgradient wells 299-W26-9, 299-W26-10, and 299-W26-12. New wells were drilled in 1999 (299-W26-13), 2003 (299-W26-14 replacing 299-W26-10), and 2008 (699-32-76; 699-33-75 replacing 299-W26-12; and 699-33-76 replacing 299-W26-8). Dry wells 299-W26-9, 299-W26-10, and 299-W26-11 have been decommissioned. Dry wells 299-W26-7, 299-W26-8, and 299-W26-12 are on hold pending overdrilling. Historical changes in the potentiometric surface and flow direction at the Hanford Site (including 200 West Area) are further described in SGW-60338, *Historical Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*.

The S-10 unit is located south and cross-gradient to the 200 West pump and treat extraction and injection well network and beyond the area of influence of groundwater elevation and gradients. The water table maps have been reported in the Hanford Site annual report (e.g., DOE/RL-2015-07, Figures 11-30 and 12-21) and the annual Hanford Site RCRA groundwater monitoring report (e.g. DOE/RL-2016-12, Section 2.9) for the S-10 unit and confirm the absence of significant impact at the S-10 unit from the 200 West pump and treat system.

[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.

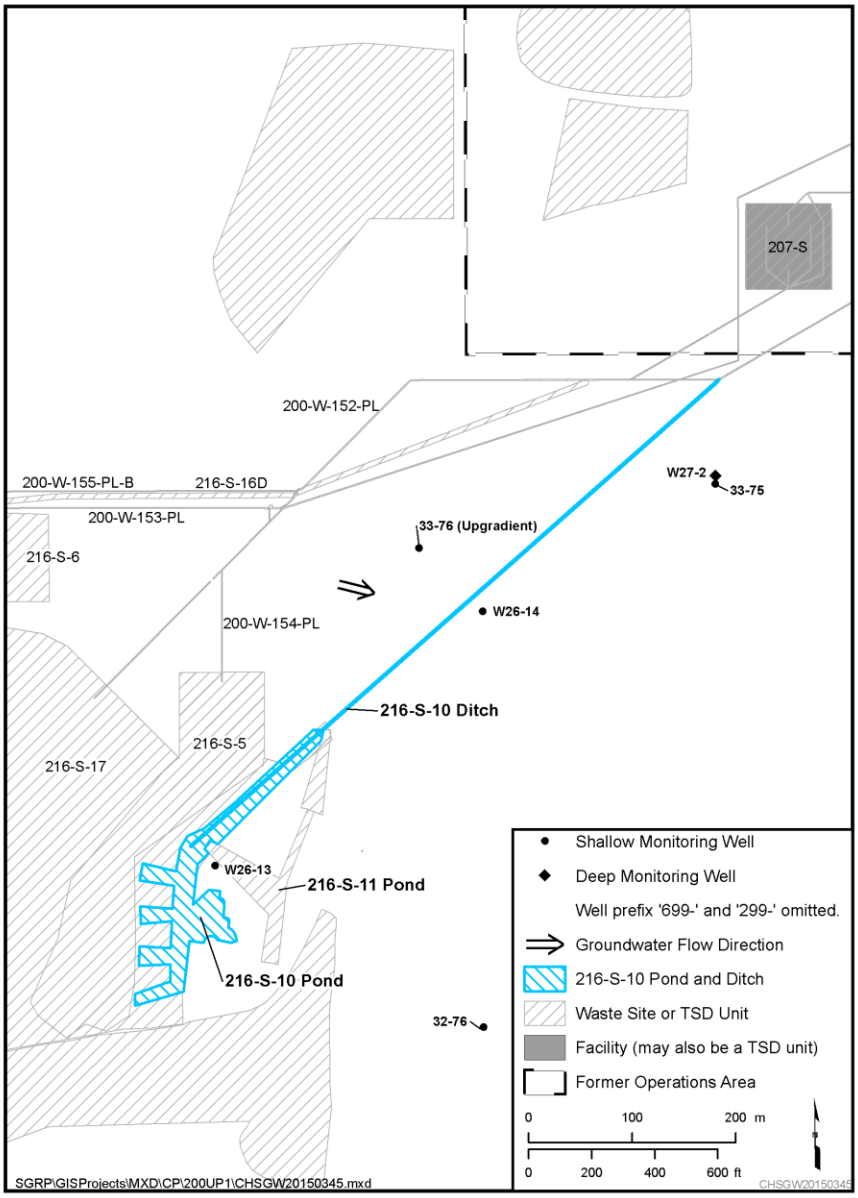

Figure 2-6. Groundwater Contour Map for the 216-S-10 Pond and Ditch

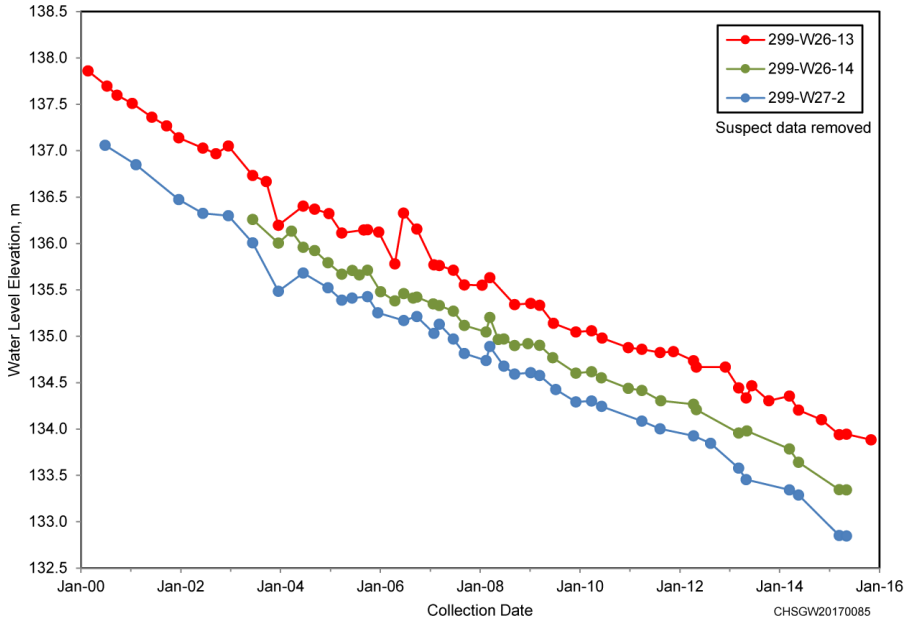

Figure 2-7. Hydrographs for Selected Wells at the 216-S-10 Pond and Ditch

2.5 Summary of Previous Groundwater Monitoring

Table 2-1 lists the previous groundwater monitoring plans implemented at the S-10 unit. 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 (Figure 2-1). 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.

Table 2-1. Previous Monitoring Plans

Document	Date Issued	Monitoring Program* (and Change Description)
WHC-SD-EN-AP-018, *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."

The groundwater monitoring activities at the S-10 unit under this groundwater monitoring plan currently sample 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 Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

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 up to 6 cm/day (2.4 in./day) and about 2 to 3 years through the vadose zone to groundwater as presented in WHC-EP-0367, *Liquid Effluent Study Final Project Report* (Section 2.16.3 and Appendix B), 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 (Section 2.4.2), at which time the S-10 Ditch was still active.

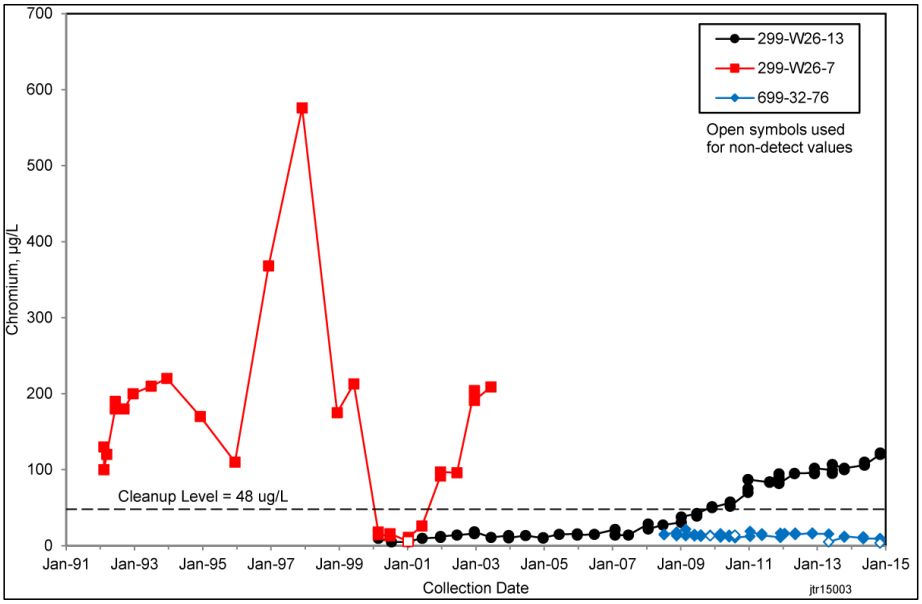

Figure 2-8. Chromium Concentrations in Wells 299-W26-7, 299-W26-13, and 699-32-76

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 (pH, specific conductance, TOC, or TOX) 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 contributor 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 and 216-S-5 Crib (Sections 2.3 and 2.6).

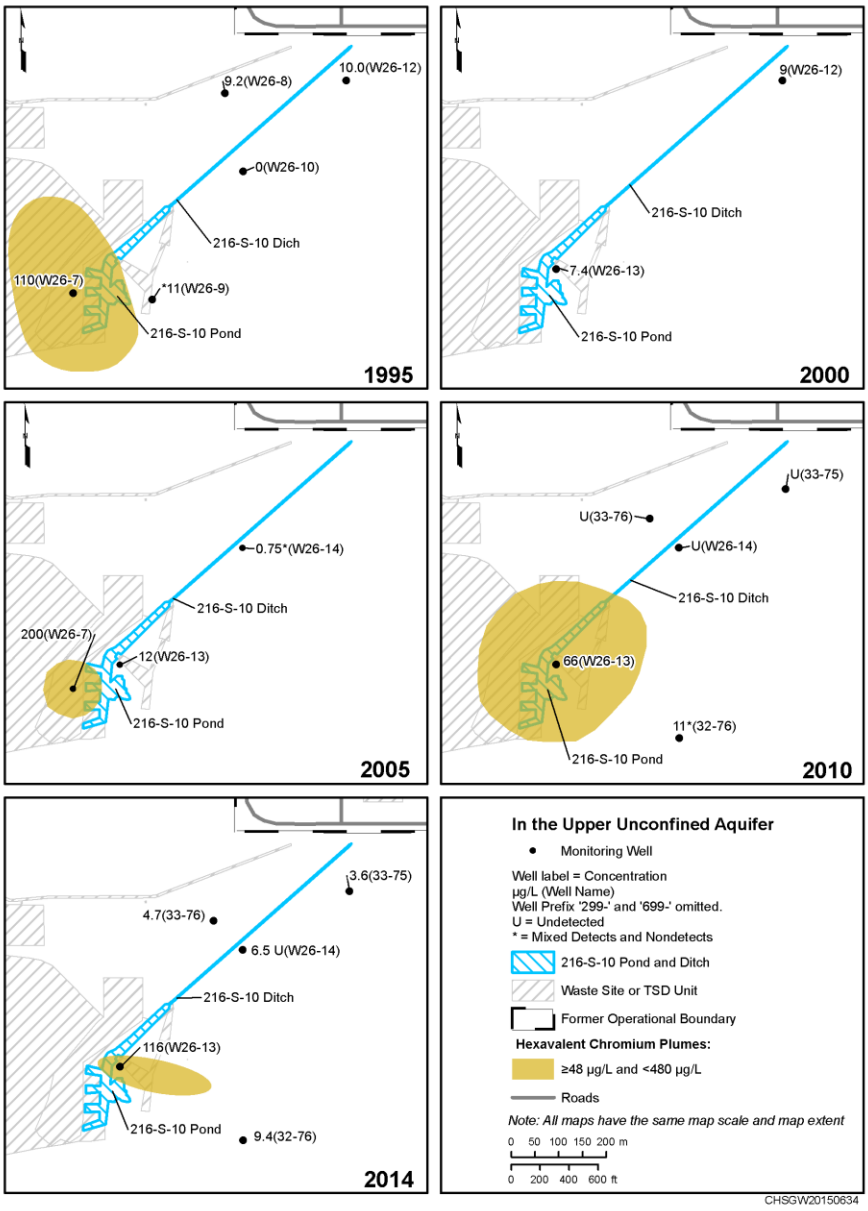

Figure 2-9. Chromium Plume Maps for the 216-S-10 Pond and Ditch

Concentrations of chromium (unfiltered), iron (unfiltered), manganese (unfiltered), and nickel (filtered and unfiltered) continue to be elevated in deep well 299-W27-2. These constituents are stainless steel corrosion products, and this well has stainless steel components.

Total chromium analysis provides a summation of both trivalent chromium, as well as the hexavalent chromium. Analysis of the hexavalent chromium species may be completed via readily available laboratory analysis. However, trivalent chromium concentrations are evaluated by a two-step process which includes: completing total chromium analysis and subtracting the hexavalent chromium concentrations determined by the species-specific analysis.

Trivalent chromium is not readily dissolved in water and has low mobility in the subsurface. Filtering of chromium samples removes a major portion of the trivalent chromium from water samples. Hexavalent chromium does not occur naturally and is indicative of waste processes. Hexavalent chromium is readily dissolved in water and is highly mobile in the subsurface. The chromium plume the vicinity of the S-10 Pond is characterized by hexavalent chromium.

Contribution of trivalent chromium, as well as nickel, manganese, molybdenum, and undissolved iron occur during reducing conditions within a well casing. Both geochemical and biologic conditions can produce a reducing environment within a well, resulting in corrosion of the steel casing and subsequently an increase in chromium, nickel, molybdenum, and iron concentrations in the water. Additionally, manganese is not readily dissolved or mobile in the subsurface under the oxidizing conditions normally found in Hanford groundwater, but under reducing conditions manganese becomes mobile within the groundwater. The presence of elevated manganese can be utilized as a geochemical indicator that reducing conditions likely exist.

Commented [CTJ3]: RCRA-CN-01_DOE/RL-2008-61_R1

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Chromium analyses completed for well 299-W27-2 has included filtered and unfiltered total chromium, as well as filtered and unfiltered hexavalent chromium. The elevated chromium identified in well 299-W27-2 comprised primarily undissolved trivalent chromium and is indicative of well corrosion and is not attributed to the hexavalent chromium plume in the vicinity of the S-10 Pond. Additionally, the maximum concentrations of undissolved trivalent chromium of 90.1 µg/L in 2016 at well 299-W27-2 are consistent with values attributable to well corrosion. A downhole video of the well screen confirmed that the source of the elevated metals is corrosion (Figure 2-10).

The only other constituent that has exceeded a DWS is carbon tetrachloride (DOE/RL-2006-24, *Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit*, Section 4.3.1). 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 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.

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

The results of this investigation were published in DOE/RL-2004-17 and DOE/RL-2005-64. 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 and 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 within the 1,000 year time frame.

Subsequent to publication of the remedial investigation results in November 2004 (DOE/RL-2004-17), additional network wells were installed at the S-10 unit. On March 14, 2005, one additional upgradient well (699-33-76) and two additional downgradient wells (699-32-76 and 699-33-75) were initially sited in discussion with Ecology. Placement of wells, particularly upgradient well 699-33-76, was limited by the presence of waste sites immediately west of the S-10 unit, reducing accessible areas for well drilling. The downgradient wells at the time were placed to provide representative coverage of the S-10 unit.

Chromium was identified as a risk driver for the direct contact exposure pathway within the remedial investigation, and was not identified as a risk driver for impact to groundwater. However, based on the presence of hexavalent chromium in groundwater within the vicinity of the S-10 unit, chromium is retained in this revised groundwater monitoring plan as a potential vadose zone source contaminant.

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 in the subsurface above the CCU, which led to lateral spreading of the wastewater. This aspect of the CSM is based on perched water on the CCU 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 at about 1 degree toward the east-southeast, so there may have been some preferential movement of water in this direction. However, the magnitude of the dip is small (average of 1 m [3 ft] of elevation change per 60 m [200 ft] horizontal distance) relative to potential effects of localized mounded groundwater within the perched zone; as such, spreading of wastewater in all directions was possible.

The maximum groundwater elevation at the S-10 unit is estimated with a low degree of certainty to be 146.7 m (481.3 ft) above mean sea level (AMSL), and occurred in 1967. This groundwater elevation data in 1967 was limited to one well (699-32-77) located within the vicinity, and is downgradient and southeast of the S-10 unit. During this time period well density was not sufficient to conclusively determine groundwater elevation or the extent of mounding beneath the infiltration areas. As presented in Section 2.4.2, perched water was identified in the CCU during well drilling in 1990 and was measured at an elevation of approximately 166.6 m (546.6 ft) AMSL within well 299-W26-11 completed in the perched water zone. Static groundwater beneath the perched water was identified at an elevation of approximately 141.4 m (463.9 ft) AMSL in 1991 and is presented on Figure 2-11. The network of wells at the S-10 Pond in 1991 included: established well 699-32-77 and newly installed wells: 299-W26-6, 299-W26-8, 299-W26-9, 299-W26-7, 299-W26-10, and 299-W26-12.

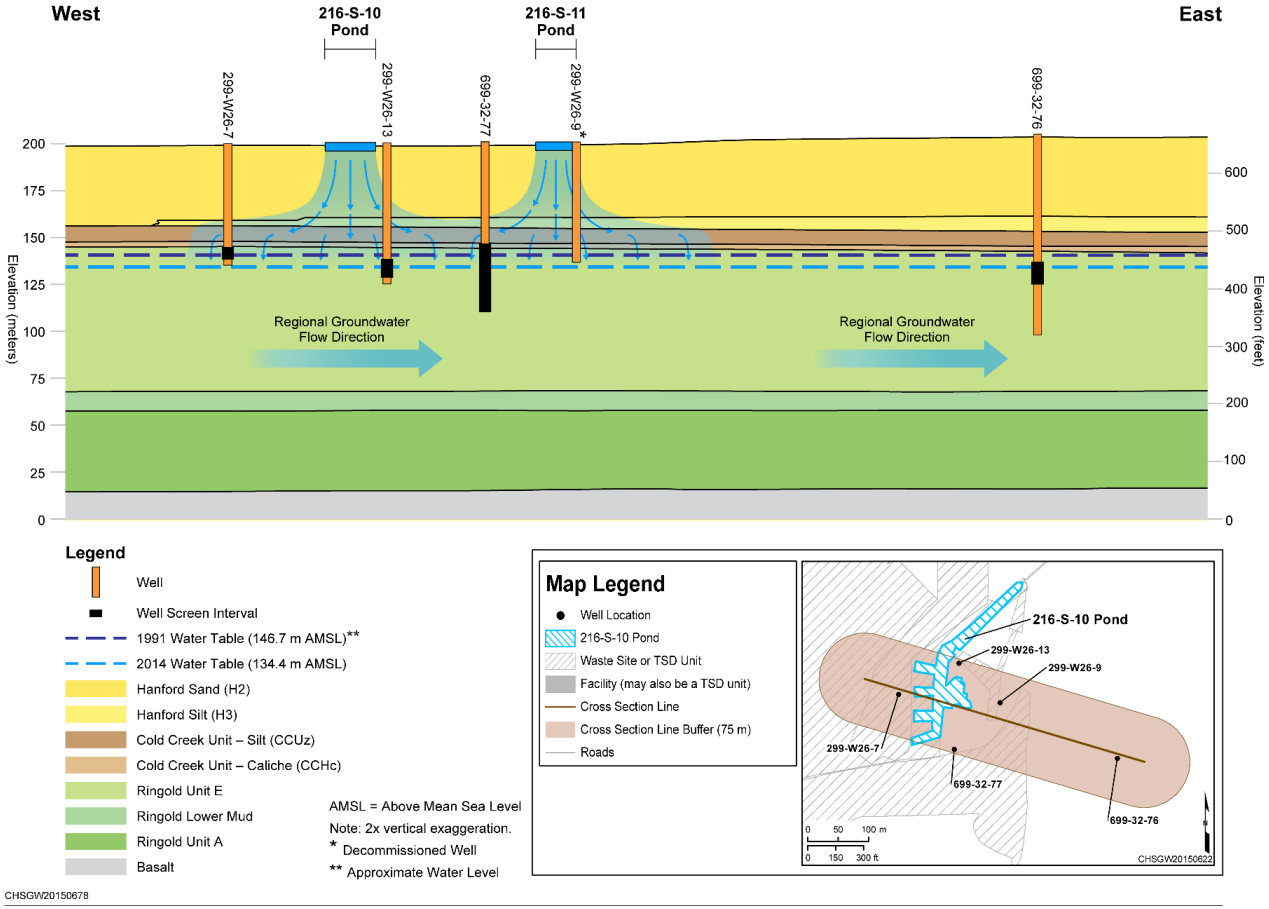

Figure 2-11. Conceptual Site Model for the 216-S-10 Pond and Ditch

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 contributors 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-2015-07).

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), although concentrations of nitrate in well 299-W26-7 are below DWS. The covariate concentrations of chromium and nitrate are likely due to the release of potassium dichromate (hexavalent chromium) and sodium nitrate in wastewater discharged to the S-10 Ditch in September 1983 from a synthetic DST waste (see Section 2.3). Hexavalent chromium has occurred above the DWS in both upgradient and downgradient monitoring wells at the S-10 unit (Figures 2-8 and 2-9). Although the S-10 unit is the probable source of the chromium plume and a likely contributor of nitrate in groundwater, this cannot be conclusively established because of the presence of nearby waste sites which also received chromium and nitrate during the time of the S-10 unit operation, including the adjacent 216-S-11 and 216-S-17 Ponds; upgradient 216-S-16P Pond; and the 216-S-5 Crib.

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. Between 1947 and 2008, annual precipitation at the Hanford Meteorological Station averaged 172 mm (6.8 in.) and varied between 76 and 313 mm (3.0 and 12.3 in.) (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*.

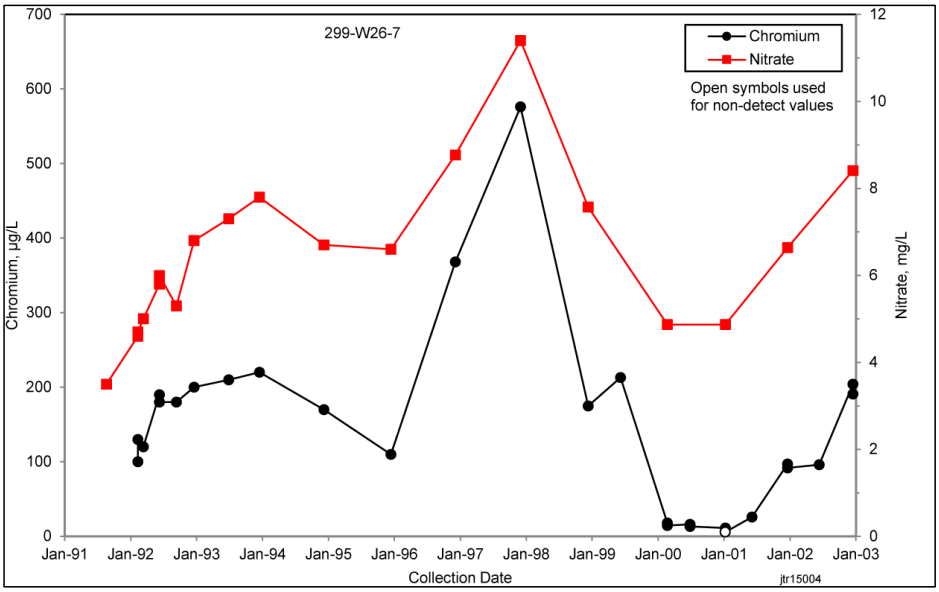

Figure 2-12. Chromium and Nitrate Concentrations in Former Upgradient Well 299-26-7

2.7 Monitoring Objectives

The groundwater monitoring program at the S-10 unit is conducted with the objective of determining the facility's impact, if any, on the quality of the underlying groundwater. This groundwater monitoring plan addresses specifically those applicable dangerous waste 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 through 40 CFR 265.94.
Table 2-2 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan.

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

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Applicability	40 CFR 265.90, "Applicability" (a) Within one year after the effective date of these regulations, the owner or operator of a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility's impact on the quality of ground water in the uppermost aquifer underlying the facility, except as §265.1 and paragraph (c) of this section provide otherwise. (b) Except as paragraphs (c) and (d) of this section provide otherwise, the owner or operator must install, operate, and maintain a ground-water monitoring system which meets the requirements of §265.91, and must comply with §§265.92 through 265.94. This ground-water monitoring program must be carried out during the active life of the facility, and for disposal facilities, during the post-closure care period as well.	Chapter 1
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 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
Sample Protocols Analytical Methods	40 CFR 265.92: (a) The owner or operator must obtain and analyze samples from the installed ground-water monitoring system. The owner or operator must develop and follow a ground-water sampling and analysis plan. He must keep this plan at the facility. The plan must include procedures and techniques for: (1) Sample collection; (2) Sample preservation and shipment; (3) Analytical procedures; and (4) Chain of custody control.	Appendix A, Section A3 and Appendix B, Sections B2 through B5

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

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
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. (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.	Section 3.1 and Appendix B, Section B2.2

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

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Groundwater Quality Assessment Program Plan Outline	40 CFR 265.93, "Preparation, Evaluation, and Response": (a) Within one year after the effective date of these regulations, the owner or operator must prepare an outline of a ground-water quality assessment program. The outline must describe a more comprehensive ground-water monitoring program (than that described in §§265.91 and 265.92) capable of determining: (1) Whether hazardous waste or hazardous waste constituents have entered the ground water; (2) The rate and extent of migration of hazardous waste or hazardous waste constituents in the ground water; and (3) The concentrations of hazardous waste or hazardous waste constituents in the ground water.	Chapter 5
Methods used to evaluate the collected data and responses	40 CFR 265.93 (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 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 265.93: (c)(1) If the comparisons for the upgradient wells made under paragraph (b) of this section show a significant increase or (pH decrease), the owner or operator must submit this information in accordance with §265.94(a)(2)(ii). 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(e), and the evaluation required in §265.93(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 §265.93(c)(1). (iii) No later than March 1 following each calendar year: Results of the evaluations of ground-water surface elevations under §265.93(f), and a description of the response to that evaluation, where applicable.	Section 4.5; Appendix A, Sections ~~A1.6 and A2.6~~ A2.5 and A3.9

Commented [CTJ5]: RCRA-CN-01_DOE/RL-2008-61_R1

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

In accordance with WAC 173-303-400(3)(b), "Dangerous Waste Regulations," "Interim Status Facility Standards", for the purposes of applying the interim status standards of 40 CFR 265, Subpart F, the federal terms "Regional Administrator" means the "Department" and "Hazardous" means "Dangerous."

In accordance with Section I.A of the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (Hanford Facility RCRA Permit), this unit will continue to be considered an interim status unit until is it incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit, or until interim status is terminated.. Therefore, groundwater monitoring continues under interim status requirements.

a. Regulatory requirements for interim status TSD units, where no impact to groundwater has been identified, are found in WAC 173-303-400(3) and 40 CFR 265.90, "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 conducted during the first year of monitoring in accordance with 40 CFR 265.92(c)(1), "Sampling and Analysis." If applicable to this TSD unit, the Appendix III parameters are included for monitoring at well(s) as specified in Section 3.1.

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. Chromium (total and hexavalent) and nitrate will continue to be monitored as part of the S-10 indicator evaluation program. 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, and molybdenum) to provide the data needed to assess corrosion in all of the network wells. These site-specific constituents are listed in Table 2-3.

Commented [CTJ6]: RCRA-CN-01_DOE/RL-2008-61_R1

Table 2-3. Additional Monitoring Objectives

Monitoring Objective	TSD Unit-Specific Constituent/ Field Measurements*
Track contaminants potentially from the S-10 unit	Chromium (total) Hexavalent chromium Nitrate
Track carbon tetrachloride concentrations (affects total organic halogen)	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 Molybdenum

* Sampling for TSD unit-specific constituents/field measurements is not required by WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards" nor 40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

TSD = treatment, storage, and disposal

Commented [CTJ7]: RCRA-CN-01_DOE/RL-2008-61_R1

3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for the S-10 unit consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, site-specific constituents, a monitoring well network, 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), and supersedes the monitoring program of the previous plan.

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, the parameters analyzed, and the sampling frequency for monitoring of the S-10 unit. Parameters used as indicators of groundwater contamination (pH, specific conductance, TOC, and TOX) 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 that a sample is obtained (40 CFR 265.92(e)).

Site-specific constituents will also be monitored (Section 2.7). Chromium (total), hexavalent 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 (chromium, iron, nickel, ~~and~~ manganese, and molybdenum) to assess corrosion in the network wells.

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3.1.1 Sample Schedule Impacts from Well Maintenance and Sampling Logistics

Well maintenance (e.g., pump repairs, periodic well cleaning and redevelopment) problems and sampling logistics resulting from multiple factors including environmental (i.e., inclement weather) and access restrictions (i.e., heightened fire danger, area access restriction due to work by other Hanford Site contractors such as in the tank farms) sometimes 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 will be 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, will consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the pre-sampling walkdown that one or more network wells cannot be sampled, then sampling of the well network will not begin and management will be notified. Depending on the situation, the network sampling will be rescheduled within a short time frame (such as 3 to 4 weeks). In some cases, it may not be obvious that sampling cannot be performed until a well is accessed (e.g., an issue with a pump).

Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE-RL and Ecology may agree to resampling wells. DOE-RL will provide informal notification to Ecology if sampling of the network is expected to be delayed for longer than 4 weeks. Ecology may provide input in a timely fashion to DOE-RL on how to proceed. Missed or cancelled sampling events are reported to DOE-RL and are documented in the in the annual Hanford Site RCRA groundwater monitoring report (e.g. DOE/RL-2016-12).

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

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]											Site-Specific Constituents					
				Contamination Indicator Parameters				Groundwater Quality Parameters											
			Water Level	pH[b]	Specific Conductance[b]	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[c]	Manganese (Filtered and Unfiltered)[c]	Phenols[c]	Sodium (Filtered and Unfiltered)[c]	Sulfate	Hexavalent Chromium[d]	Anions[e]	Metals (Filtered and Unfiltered)[c,f]	Alkalinity[g]	Carbon Tetrachloride[h]	Field Parameters[i]
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[j]	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

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

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]											Site-Specific Constituents					
				Contamination Indicator Parameters				Groundwater Quality Parameters											
			Water Level	pH[b]	Specific Conductance[b]	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[c]	Manganese (Filtered and Unfiltered)[c]	Phenols[k]	Sodium (Filtered and Unfiltered)[c]	Sulfate	Hexavalent Chromium[d]	Anions[e]	Metals (Filtered and Unfiltered)[c,f]	Alkalinity[g]	Carbon Tetrachloride[h]	Field Parameters[i]

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. Field measurement.

c. Unfiltered samples will be collected in conjunction with filtered samples for select analysis to determine if metal constituents being monitored occur as both suspended and dissolved phases, or in only one state. The evaluation of suspended and dissolved metals provide supporting information for groundwater geochemical characteristics, as well as indication of well integrity such as the presence of dislodged well encrustation, well corrosion products, or failure of the well screen filter pack.

d. Hexavalent chromium is sampled as a site-specific constituent due to previous discharge from the unit.

e. 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 can be a substantial contributor to specific conductance. Nitrate is also sampled as a site-specific constituent due to previous discharge from the unit.

f. For metals, analytes include (but are not limited to) calcium, chromium (total), iron, magnesium, manganese, nickel, potassium, and sodium. 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. Chromium (total) is sampled as a site-specific constituent due to previous discharge from the unit. Chromium (total), iron, manganese, molybdenum, and nickel are sampled to evaluate well corrosion.

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

h. Carbon tetrachloride is present in groundwater from the 200-ZP-1 operable unit and potentially from U Pond. It is monitored at the S-10 unit to provide a check on the indicator parameter total organic halogen.

i. Temperature and turbidity.

j. 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.

k. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-1a.

Commented [CTJ9]: RCRA-CN-01_DOE/RL-2008-61_R1

Commented [CTJ10]: RCRA-CN-01_DOE/RL-2008-61_R1

Commented [CTJ11]: RCRA-CN-01_DOE/RL-2008-61_R1

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

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]												Site-Specific Constituents					
				Contamination Indicator Parameters				Groundwater Quality Parameters												
			Water Level	pH[b]	Specific Conductance[b]	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[c]	Manganese (Filtered and Unfiltered)[c]	Phenols[c]	Sodium (Filtered and Unfiltered)[c]	Sulfate	Hexavalent Chromium[d]	Anions[e]	Metals (Filtered and Unfiltered)[c,f]	Alkalinity[g]	Carbon Tetrachloride[h]	Field Parameters[i]

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

Commented [CTJ9]: RCRA-CN-01_DOE/RL-2008-61_R1

Table 3-1a. Phenols Analyzed as Groundwater Quality Constituents

Constituent	CAS Number
2-Chlorophenol	95-57-8
2-Methylphenol (o-Cresol)	95-48-7
2-Nitrophenol (o-Nitrophenol)	88-75-5
2,3,4,6-Tetrachlorophenol	58-90-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol (2,4-Xylenol)	105-67-9
2,4-Dinitrophenol	51-28-5
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,6-Dichlorophenol	87-65-0
3-Methylphenol (m-Cresol)	108-39-4*
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7
4-Methylphenol (p-Cresol)	106-44-5*
4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1
Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
p-Nitrophenol (4-Nitrophenol)	100-02-7
Pentachlorophenol	87-86-5
Phenol	108-95-2

This table provides the specific phenols to be included for analysis as groundwater quality parameters under this monitoring plan.

*Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9)

CAS = Chemical Abstracts Service

Commented [CTJ1]: RCRA-CN-01_DOE/RL-2008-61_R1

3.1.2 Well Biofouling and TOC Results

Biofouling of wells can result in collection of non-representative groundwater samples and produce non-representative analytical results for TOC. In Hanford Site wells, biofouling is often associated with iron and manganese-oxidizing bacteria. The bacterial growths are physically manifested as slime or as filamentous or flocculent accumulations. The accumulations frequently occur in the screened interval and exhibit discrete coloration (e.g., rusty orange in the case of iron-oxidizing bacteria or black in the case of manganese-oxidizing bacteria).

TOC is a non-specific analysis that is used as an indicator of the presence of organic compounds in groundwater. TOC represents organic compounds in the sample; this includes dissolved organic compounds as well as suspended organic particles that may be present in an unfiltered sample. Suspended organic materials in groundwater samples can include microbial biomass associated with well biofouling. TOC is used in detection monitoring as an indicator of the possible presence of regulated organic compounds, but the TOC measurement is non-specific. Furthermore, the TOC measurement is subject to positive interference if suspended organic material (e.g., microbial biomass) or dissolved naturally-occurring organic compounds (e.g., humic and fulvic acids) are present in the sample.

If elevated concentrations of TOC are measured within a well (particularly, if a TOC concentration above the critical mean is encountered), then well maintenance activities to address accumulated microbiological growth in the well will be performed. Well maintenance activities are designed to reduce the impact of biomass transfer from the well and generation of a resultant high TOC value. Well maintenance will include cleaning/rehabilitation of the well to ensure that the groundwater samples collected are representative of ambient groundwater conditions and not the result of sampling of biomass material present within the well. Well cleaning will be completed per the contractor's standard operating procedures. A down-hole camera survey and well cleaning will be scheduled immediately following receipt of elevated TOC result where biofouling of the well is suspected. Subsequent to completing the cleaning activities, a well having an exceedance of the critical mean for TOC will be sampled for confirmational laboratory split samples as required under 40 CFR 265.93(c)(2).

3.2 Monitoring Well Network

The 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. Results from sampling from this well are not used for statistical comparisons with the upgradient well.

Additional monitoring needs at the S-10 unit may be identified. Future groundwater wells installed at the S-10 unit will be located so as to provide for integrated CERCLA and RCRA use.

As presented, well 299-W27-2 has indications of well corrosion, and the remaining S-10 unit wells are also likely to be subject to casing corrosion. Corrosion of stainless steel well casing may impact monitoring well integrity and groundwater sample results. Existing wells constructed with stainless steel casings are at potential risk for structural failure if corrosion occurs. Evidence of well corrosion typically includes groundwater sample results with elevated concentrations for nickel, iron, molybdenum, manganese and/or chromium and down-hole video inspection results showing casing with signs of degradation. If a well has attributes of casing corrosion, it will continue to be utilized until a new replacement well can be installed, provided its construction is still compliant and it produces data that can be used to assess surrounding groundwater conditions.

Commented [CTJ12]: RCRA-CN-01_DOE/RL-2008-61_R1

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	566621.21	133600.43	67.7 (222)	78.3 (257)	69.6 (228)	8.7 (29)	11/3/2014
299-W26-13	12/28/1999	566424.387	133293.598	61.6 (202)	72.3 (237)	64.9 (213)	7.4 (24)	11/4/2014
299-W26-14	4/3/2003	566682.69	133539.21	68.1 (223)	78.8 (259)	71.0 (233)	7.8 (26)	5/20/2014
299-W27-2	12/18/1992	566908.267	133670.351	123.8 (406)	127.0 (417)	73.2 (240)	53.8 (177)	5/20/2014
699-32-76	1/4/2008	566683.94	133137.73	69.2 (227)	79.9 (262)	70.8 (232)	9.1 (30)	11/3/2014
699-33-75	1/31/2008	566907.78	133662.48	71.6 (235)	82.3 (270)	73.5 (241)	8.8 (29)	11/3/2014

a. Coordinates are in NAD83, *North American Datum of 1983*.

b. Upgradient well.

bgs = below ground surface

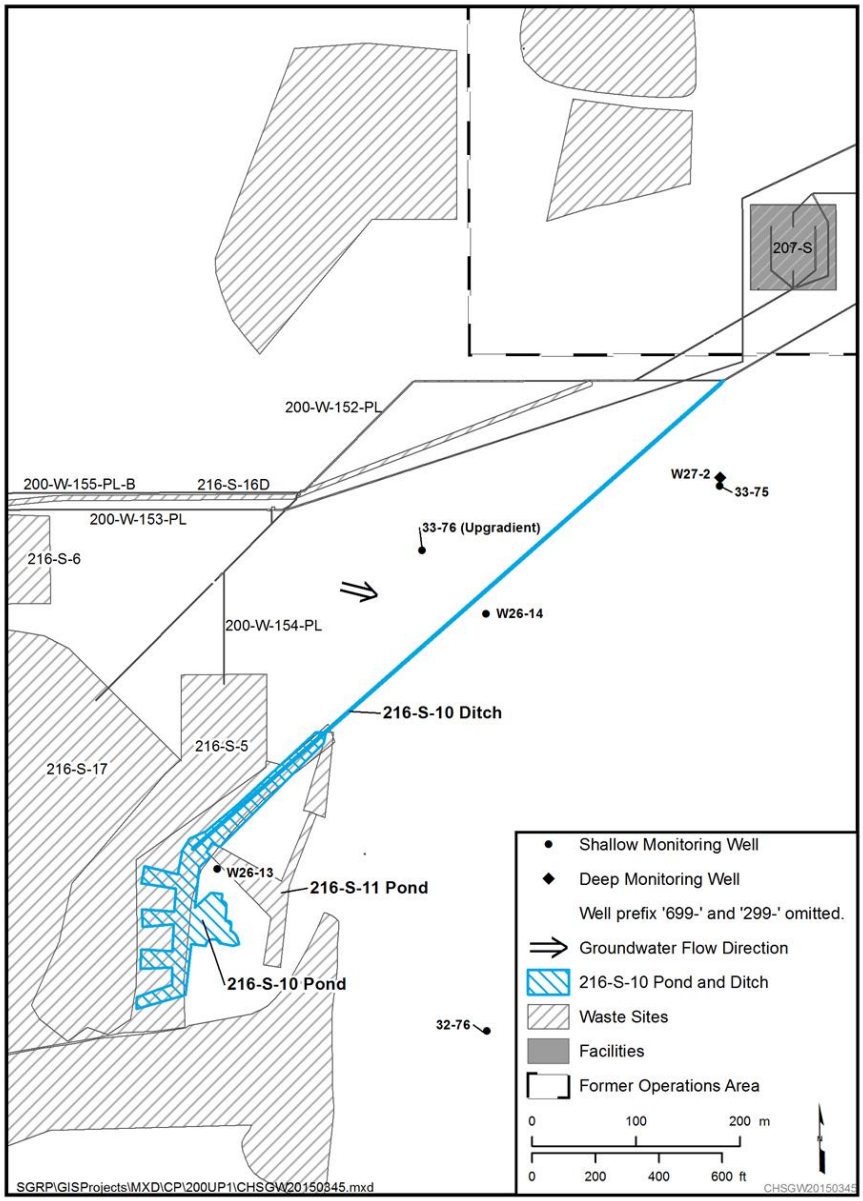

Figure 3-1. Monitoring Well Network for the 216-S-10 Pond and Ditch

If a well is within approximately 2 years of going dry, a replacement well will be proposed; such wells 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.

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).

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)).

The following changes were made to the site-specific constituents:

- Copper, mercury, zinc, and benzo(a)pyrene were removed from the monitoring program. These constituents were added to the indicator parameter 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 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).
- 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). The presence of carbon tetrachloride, which is an organic chlorinated (halogenated) compound, affects the results for the indicator parameter TOX. Carbon tetrachloride from upgradient sources represents a contributor to the TOX concentrations within groundwater samples collected from the S-10 unit wells.
- 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.
- Nickel~~, and~~ manganese, and molybdenum 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).

Commented [CTJ13]: RCRA-CN-01_DOE/RL-2008-61_R1

These changes are listed in Table 3-3.

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	Hexavalent chromium	Same.
	Copper	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway. A total of 141 samples for total copper[b] have been collected from downgradient wells beginning in 1986. A total of 30 detections for copper have been identified, ranging from 0.42 to 130 µg/L, and well below the DWS of 640 µg/L.
	Mercury	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway. A total of 97 samples for total mercury[b] have been collected from downgradient wells beginning in 1986. A total of 5 detections for mercury have been identified, ranging from 0.073 to 0.1 µg/L, and well below the DWS of 2 µg/L. Four of these five detections contain a laboratory data qualifier indicating detectable mercury concentrations present in the method blank.
	Zinc	—	Removed as a site-specific constituent; risk driver under CERCLA for direct-contact exposure scenarios but not for the groundwater pathway. A total of 137 samples for total zinc[b] have been collected from downgradient wells beginning in 1986. A total of 40 detections for zinc have been identified, ranging from 0.64 to 460 µg/L, and well below the DWS of 5,000 µg/L.

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

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
	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 (ECF-200W-15-0056).
	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.
	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. A total of 203 samples for fluoride have been collected from downgradient wells beginning in 1986. A total of 200 detections for fluoride have been identified, ranging from 200 to 1,200 µg/L, and well below the DWS of 4,000 µg/L. A total of 392 samples for nitrate have been collected from downgradient wells beginning in 1957. A total of 387 detections for nitrate have been identified, ranging from 100 to 110,000 µg/L. A total of 9 detections have been above the DWS of 45,000 µg/L; all occurring at well 699-32-77 between 1957 and 1961. Four additional detections in downgradient wells have been identified prior to 1986, but are excluded as data outliers.
	—	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.

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

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
	Additional metals (calcium, magnesium, and potassium)	Additional metals (calcium, magnesium, nickel, and potassium)	Nickel and molybdenum 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.
Background Arithmetic Mean Recalculated	Calculated annually using the single upgradient well	Calculated annually using the single upgradient well	Calculated annually using EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*.
Groundwater Quality Assessment Plan Outline	Was included in the first monitoring plan (WCH-SD-EN-AP-018[c])	Included	Update outline to current norms

Commented [CTJ14]: RCRA-CN-01_DOE/RL-2008-61_R1

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

Type of Change	Previous Plan[a]	Current Plan	Justification Summary

Reference: 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*

a. Previous plan was DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0.

b. Results of unfiltered samples.

c. 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*

DWS = drinking water standard

OU = operable unit

TOX = total organic halogen

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).

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4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

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

4.2 Statistical Evaluation

The goal of the groundwater monitoring indicator evaluation program is to determine if the S-10 unit operations have affected groundwater quality beneath the TSD unit, 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, TOC, and TOX) to background levels to test for potential impact to groundwater. Each time that a monitoring well is sampled, four replicate samples for TOC and TOX 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 arithmetic mean and variance must be calculated based on at least four replicate measurements on each sample, for each well monitored, and then compared 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) and Appendix IV to 40 CFR 265). 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 upgradient concentrations and groundwater flow conditions. The statistical evaluation utilized is consistent with requirements under WAC 173-303-645(8)(h), "Releases from Regulated Units," "General Groundwater Monitoring Requirements."

If a downgradient well comparison 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 265.93(d)(1)

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 the equal potential lines 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:** Illustrate the relative abundances of contaminants from previously characterized Hanford Site-related processes and sources. Comparison of these ratios in groundwater can sometimes be used to distinguish among different sources of contamination (e.g., a specific process and its associated facility). Ratios may provide evidence of continuing source contamination, thereby linking contamination with a specific facility under monitoring. Evaluation of contaminant ratios in concentration trends may be used to demonstrate when facility-specific contamination no longer affects underlying groundwater.

4.4 Annual Determination of Monitoring Network

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 modifications required for the network.

Water-level measurements will continue to be collected during 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 Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

4.5 Reporting and Notification

Groundwater monitoring and evaluation of groundwater surface elevation results are reported annually in accordance with the requirements of 40 CFR 265.94(a)(2). Reporting will be made in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

If an upgradient well comparison shows a significant increase (or pH decrease) relative to the statistical comparison value, that information is also reported (40 CFR 265.93(c)(1)) in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

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 plan must be developed and placed in the facility operating record (40 CFR 265.93(d)(2)). This plan must be submitted to Ecology (WAC 173-303-400 (3) (c)(v)(D)).

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 groundwater quality 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 as required by 40 CFR 265.93(a). A crosswalk to information that is still pertinent (e.g., the facility description, geology and hydrogeology, or sampling protocols) within the indicator parameter program groundwater monitoring plan that precedes the groundwater quality assessment plan may be included. An outline for the assessment plan is presented in Table 5-1. Changes may be made to this outline based on the information identified on the crosswalk, if used. 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 results of the groundwater quality assessment program will then be reported annually as required by 40 CFR 265.94(b).

Table 5-1. Suggested 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
Data Evaluation
Interpretation
Annual Determination of Monitoring Network
Reporting and Notification
Implementation Schedule
References
Appendix A – Quality Assurance Project Plan
Appendix B – As-Built Drawings of Wells in Well Network

Note: A crosswalk to information that is still pertinent (e.g., the facility description, geology and hydrogeology, or sampling protocols) within the indicator parameter program groundwater monitoring plan that precedes the groundwater quality assessment plan may be included. Changes may be made to this outline based on the information identified on the crosswalk, if used.

6 References

10 CFR 962, "Byproduct Material," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=80b019e27927f1f64251c94caea42893&mc=true&node=pt10.4.962&rgn=div5.

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.ecfr.gov/cgi-bin/text-idx?SID=80b019e27927f1f64251c94caea42893&mc=true&node=pt40.26.265&rgn=div5.

40 CFR 265.90, "Applicability."

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

40 CFR 265.92, "Sampling and Analysis."

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

40 CFR 265.94, "Recordkeeping and Reporting."

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Appendix A

Quality Assurance Project Plan

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Figure A-1. Project Organization A-2

Terms

DOE	U.S. Department of Energy
DQI	data quality indicator
DUP	duplicate (laboratory)
DWMU	dangerous waste management unit
EB	equipment blank
ECO	Environmental Compliance Officer
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
VOC	volatile organic compound

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A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. This QAPjP includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection quality assurance (QA) elements for this groundwater monitoring plan. This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four chapters that describe the quality requirements and controls applicable to the dangerous waste management unit (DWMU) groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Data Review and Usability
- Chapter A5, References

A2 Project Management

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

A2.1 Project/Task Organization

Project organization (regarding groundwater monitoring) is described in the following sections and illustrated in Figure A-1. Titles used in the project organization are for the purposes of discussing the role of the individual in the performance of the work scope. Individuals with different titles but similar/equivalent positions may fulfill these roles.

A2.1.1 U.S. Department of Energy Manager

Hanford Site operation is the responsibility of the U.S. Department of Energy (DOE). The DOE Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976* (RCRA); *Atomic Energy Act of 1954*; and Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*.

A2.1.2 U.S. Department of Energy Project Lead

The DOE Project 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 DOE management.

A2.1.3 U.S. Department of Energy Primary Contractor Management for Groundwater Science

The DOE Primary Contractor Management for Groundwater Science provides oversight and coordinates with DOE in support of sampling and reporting activities. The DOE Primary Contractor Management for Groundwater Science also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

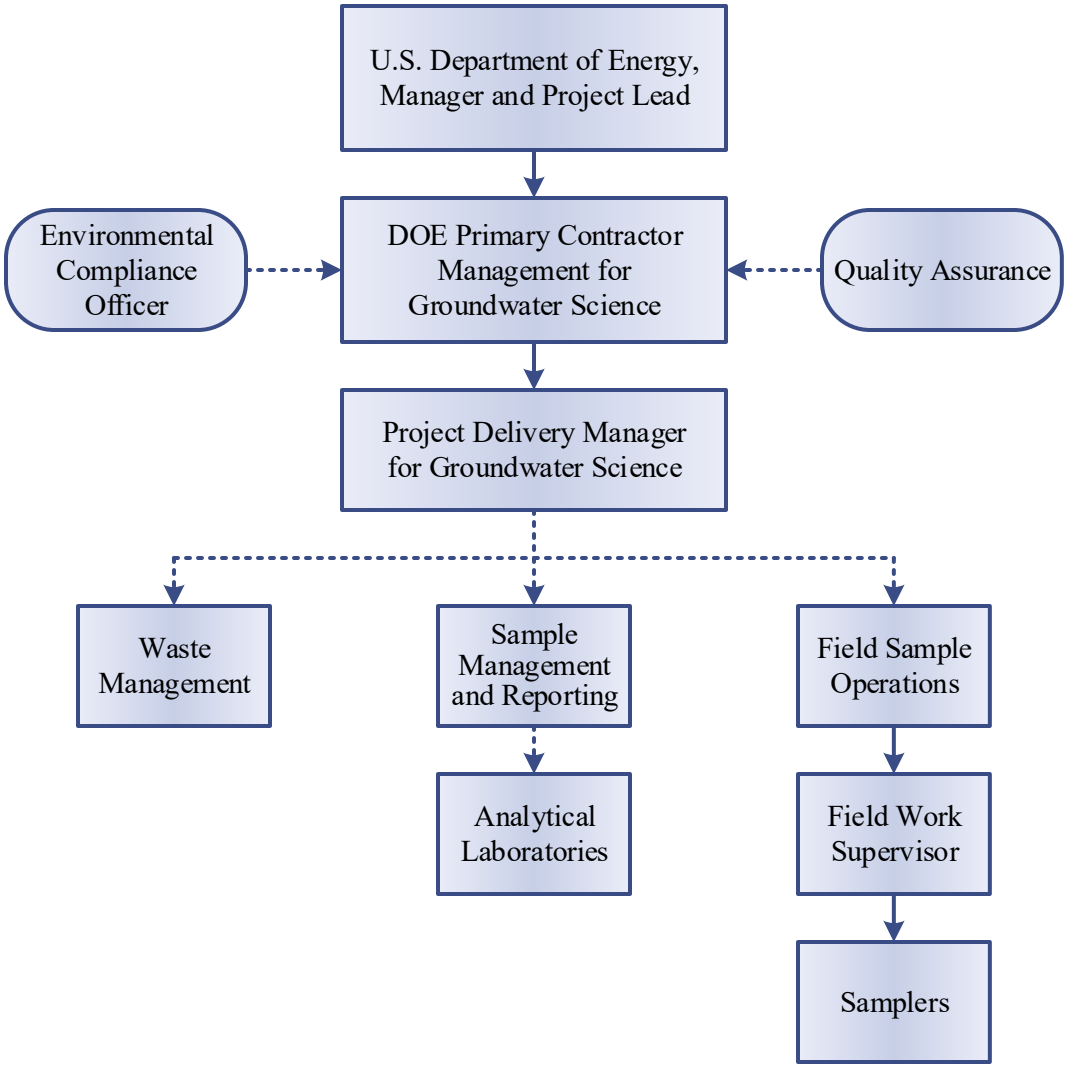

Figure A-1. Project Organization

A2.1.4 Project Delivery Manager for Groundwater Science

The Project Delivery Manager for Groundwater Science is responsible for direct management of activities performed to meet DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with, and reports to, DOE and DOE Primary Contractor Management for Groundwater Science regarding DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The Project Delivery Manager for Groundwater Science assigns staff to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work with this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. They generate field sampling documents, labels, and instructions for field sampling personnel and develop sample authorization forms, which provide information and instruction to the analytical laboratories. The SMR group revises field sampling documents to reflect approved changes. This group's

responsibilities include receiving analytical data from the laboratories, performing data entry into the Hanford Environmental Information System (HEIS) database, arranging for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. They are responsible for informing the Project Delivery Manager for Groundwater Science (or designee) of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

FSO 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 samplers who collect groundwater samples for this groundwater monitoring plan. Samplers collect samples, complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and assist sample delivery to the analytical laboratory.

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight, is responsible for addressing QA issues on the project, and overseeing implementation of the project QA program.

A2.1.8 Environmental Compliance Officer

ECOs provide technical oversight, direction, and acceptance of project and subcontracted environmental work, with the goal of minimizing adverse environmental impacts.

A2.1.9 Waste Management

Waste Management identifies waste management sampling/characterization activities for regulatory compliance and is responsible for data interpretation to determine waste designations and profiles. Waste Management communicates policies and practices for project compliance for waste storage, transportation, disposal, and tracking in a safe and cost-effective manner.

A2.1.10 Analytical Laboratories

The laboratories maintain custody and analyze samples in accordance with established quality systems and provide data packages containing sample and quality control (QC) results. Laboratories provide explanations of results to support data review and resolve analytical issues.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy *Washington Administrative Code* and *Code of Federal Regulations* requirements (WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” and 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring”) for indicator parameter evaluation. Additional information on the activities to satisfy these requirements and background information on monitoring is provided in the main text of this monitoring plan.

A2.3 Project/Task Description

The focus of this plan is to monitor the parameters used as indicators of groundwater contamination and for parameters establishing groundwater quality in accordance with 40 CFR 265.92, “Sampling and Analysis;” evaluate the well network; and interpret analytical results. The indicator parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main text (Chapter 3). Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is the generation of analytical data of known and appropriate quality. In support of this objective, the process to assess data usability may include data verification, data validation, or a data quality indicator (DQI) evaluation. 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.

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. The process to assess data usability is further discussed in Section A4.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	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 remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, and surrogates)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include 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 remeasurement. • Determine if follow-up evaluation is needed. • Evaluate instrumentation and re-calibrate, if necessary
Representativeness (field duplicates)	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 that 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 results 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

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one dataset 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 quality assurance protocols.	If data are not comparable to other datasets: • 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 (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered 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 dataset does not meet the 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.
Bias (equipment blanks, field transfer blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	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 (matrix spike).	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling processes to limit preferential selection or loss of sample media. • Use sample handling processes, 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

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
			their methods to remove the bias as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	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[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Based on SW-846, *Compendium* (July 2014). Available at: https://www.epa.gov/hw-sw846/sw-846-compendium.

a. Acceptance criteria for QC elements are provided in Table A-5.

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

QC = quality control

A2.5 Documents and Records

The Project Delivery Manager for Groundwater Science (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Elements of the monitoring plan that are required by 40 CFR 265 Subpart F cannot be changed.

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Unintentional impact to groundwater monitoring plan that impacts the groundwater quality assessment program requirements of 40 CFR 265, Subpart F, including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of groundwater constituents or parameters, or loss of samples in transit.	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL. DOE-RL provides informal notification to Ecology as appropriate.	Copy of informal notification to Ecology is placed in the facility operating record. Annual Hanford Site RCRA groundwater monitoring report.
Planned change to groundwater monitoring activities, including addition or deletion of constituents analyzed for, change of sampling frequency, or changes to well network.	Project Delivery Manager for Groundwater Science obtains DOE-RL approval; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report and revised groundwater monitoring plan as appropriate.

40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

DOE-RL = U.S. Department of Energy, Richland Operations Office

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

Logbooks and data forms are used to document field activities. The logbooks are identified with a unique project name and number. Individuals responsible for the logbooks are identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled documents. Data forms are also identified with a unique project name and number, may be used to record the same field information as logbooks, and are referenced in the logbooks.

The FWS, SMR group, and field crew supervisors are responsible for alignment of field instructions with the groundwater monitoring plan.

Convenience copies of laboratory analytical results are maintained 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 hardcopy format (e.g., DOE Records Holding Area). Records of analyses required by 40 CFR 265.94, "Recordkeeping and Reporting," are to be maintained throughout the active life of a facility and post-closure care period (if any).

By March 1, groundwater monitoring results are reported in the Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*).

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition so that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Instrument calibration and maintenance, supply inspections, and data management are also discussed.

A3.1 Analytical Method Requirements

Sample analytical methods are presented in Table A-3. Equivalent (e.g., U.S. Environmental Protection Agency [EPA] Method 300 and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* Method 9056) or updated (e.g., updates to SW-846 methods) Washington State Department of Ecology-accredited methods may be substituted for the methods identified in Table A-3.

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
General Chemistry			
ALKALINITY	Alkalinity, total as CaCO3	310.1, Standard Method 2320, Standard Method 4500	5250
18540-29-9	Hexavalent chromium	7196	10.5
TOC	Total organic carbon	415.1, 9060	1050
59473-04-0	Total organic halogen	9020	31.5
Anions[b]			
16887-00-6	Chloride	300, 9056	400
14797-55-8	Nitrate, as NO3	300, 9056	250
14808-79-8	Sulfate	300, 9056	1050
Field Measurements			
--	pH	150.1, 9040, Standard Method 4500 H+	N/A
--	Specific conductance	120.1, 9050, Standard Method 2520 B-97	N/A
--	Temperature	170.1	N/A
--	Turbidity	180.1, Standard Method 2130 B	N/A
Metals			
7440-70-2	Calcium	6010	1050
7440-47-3	Chromium	6020	10.5
7439-89-6	Iron	6010	105

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
7439-95-4	Magnesium	6010	1050
7439-96-5	Manganese	6020	5.25
7439-98-7	Molybdenum	6020	5.25
7440-02-0	Nickel	6020	21
7440-09-7	Potassium	6010	5250
7440-23-5	Sodium	6010	1050
Volatile Organic Compounds			
56-23-5	Carbon tetrachloride	8260	3
Semivolatile Organic Compounds			
95-57-8	2-Chlorophenol	8270	10.5
95-48-7	2-Methylphenol (o-Cresol)	8270	10.5
88-75-5	2-Nitrophenol (o-Nitrophenol)	8270	10.5
58-90-2	2,3,4,6-Tetrachlorophenol	8270	52.5
120-83-2	2,4-Dichlorophenol	8270	10.5
105-67-9	2,4-Dimethylphenol (2,4-Xylenol)	8270	10.5
51-28-5	2,4-Dinitrophenol	8270	50
95-95-4	2,4,5-Trichlorophenol	8270	10.5
88-06-2	2,4,6-Trichlorophenol	8270	10.5
87-65-0	2,6-Dichlorophenol	8270	10.5
108-39-4[c]	3-Methylphenol (m-Cresol)	8270	--
59-50-7	4-Chloro-3-methylphenol (p-Chloro-m-cresol)	8270	10.5
106-44-5[c]	4-Methylphenol (p-Cresol)	8270	--
534-52-1	4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	8270	52.5
88-85-7	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	8270	21
100-02-7	p-Nitrophenol (4-Nitrophenol)	8270	21
87-86-5	Pentachlorophenol	8270	52.5
108-95-2	Phenol	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)

Note: Analytical methods and practical quantitation limits provided in this table do not represent EPA nor Washington State Department of Ecology requirements but are intended solely as guidance.

a. For EPA Methods 180.1 and 300, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples.* For EPA Methods 120.1, 150.1, 170.1, 310.1, 360.1, 376.1 and 415.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*. For Standard Methods, see APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*.

b. Dilutions for certain ion chromatography constituents may be necessary, potentially raising the practical quantitation limit above the limits provided.

c. Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9). The PQL for 3 & 4 Methylphenol is 20 µg/L.

CAS = Chemical Abstracts Service
DWMU = dangerous waste management unit
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
N/A = not applicable
PQL = practical quantitation limit

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with applicable work practices. Field analytical methods may also be performed in accordance with manufacturer manuals. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects on the analytical data. Field and laboratory QC samples, and their typical frequencies, are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in the HEIS database, as appropriate.

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Equipment blanks	1 in 20 samples when nondedicated equipment is used[a]	Contamination from nondedicated sampling equipment
Field duplicates	1 in 20 well trips[b]	Reproducibility/sampling precision
Field splits	As needed	Interlaboratory comparability
Field transfer blanks	One each day VOCs are sampled; additional field transfer blanks are collected if VOC samples are acquired on the same day for multiple laboratories	Contamination from sampling site

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Full trip blanks	1 in 20 well trips[b]	Contamination from containers preservative reagents, storage, or transportation
Analytical QC[c]		
Laboratory control samples	One per analytical batch[d]	Method accuracy
Laboratory sample duplicates	One per analytical batch[d]	Laboratory reproducibility and precision
Matrix spikes	One per analytical batch[d]	Matrix effect/laboratory accuracy
Matrix spike duplicates	One per analytical batch[d]	Laboratory reproducibility, and method accuracy and precision
Method blanks	One per analytical batch[d]	Laboratory contamination
Surrogates	Added to each sample and QC sample	Recovery/yield for organic compounds

Note: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

a. For portable pumps, equipment blanks are collected (1 for every 20 well trips). Whenever a new type of nondedicated equipment is used, an equipment blank will be collected each 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. For groundwater, a sample is collected any time a well is accessed for sampling; this is also known as a well trip. Field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month and drilling campaign (for all groundwater monitoring programs).

c. A batch is a group of up to 20 samples that behave similarly with respect to the sampling or testing procedures being employed and which are processed as a unit. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

d. Unless not required by, or different frequency is called out, in laboratory analysis method.

QC = quality control

VOC = volatile organic compound

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemistry			
Alkalinity	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o”[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
	Field duplicate[c]	≤20% RPD	Review data[e]
Hexavalent chromium	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Total organic carbon	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Total organic halogen	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Anions			
Anions by ion chromatography	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Metals			

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
Metals by inductively coupled plasma/atomic emission spectrometry	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Metals by inductively coupled plasma/mass spectrometry	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Volatile Organic Compounds			
Volatile organics by gas chromatography/mass spectrometry	MB	<MDL[f] <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[g]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	70% to 130% recovery	Flag with "T"
	SUR	70% to 130% recovery	Review data[e]
	EB, FTB, FXR	<MDL[f] <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Semivolatile Organic Compounds			
Phenols gas chromatography/mass spectrometry	MB	<MDL <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[g]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	% recovery statistically derived[g]	Flag with "T"
	SUR	% recovery statistically derived[g]	Review data[e]

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]

Notes: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, pH, temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.
b. The reporting laboratory will apply the "o" flag with SMR group concurrence.
c. Applies when at least one result is greater than the laboratory PQL.
d. Either a DUP or an MS/MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, a laboratory control sample duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria).
e. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.
f. For the common laboratory contaminants acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criterion is less than five times the MDL.
g. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
FXR = field transfer blank
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference
SMR = Sample Management and Reporting
SUR = surrogate

Data Flags

B, C = possible laboratory contamination: analyte was detected in the associated method blank – laboratory applied. The B flag is used for organic analytes. The C flag is used for general chemical and inorganic analytes.
N = result may be biased: associated matrix spike result was outside the acceptance limits (except gas chromatograph/mass spectrometry) – laboratory applied.
o = result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied.
Q = problem with associated field QC blank: results were out of limits – SMR review.
T = result may be biased: associated matrix spike result was outside the acceptance limits (gas chromatograph/mass spectrometry only) – laboratory applied.

A3.3.1 Field Quality Control Samples

Field QC samples are used to monitor the integrity of field samples during sample collection, transportation, storage, and laboratory analysis. Field QC samples are submitted to the analyzing laboratories as field samples. Field QC samples are analyzed for the same set of analytes as their corresponding field samples. Field QC samples include field duplicates, field split (SPLIT) samples, and field blanks (equipment blanks [EBs], field transfer blanks [FXRs], and full trip blanks [FTBs]). Field

blanks are typically prepared to match the sample matrix as closely as possible using high-purity water[1]. The following describe the QC samples in more detail:

- **Equipment blanks:** EBs are used to monitor the effectiveness of the decontamination process for reusable sampling equipment. They are samples of high-purity water contacted with the sampling surfaces of equipment used to collect samples prior to using that equipment for field sampling. EBs are collected from each type of reusable sampling equipment to ensure that the decontamination procedures are effective for the specific equipment types. EBs will be analyzed for the same analytes as samples collected using that equipment. EB samples are not required for disposable sampling equipment.
- **Field duplicates:** Field duplicates provide information regarding the homogeneity of the sample matrix and the precision of the sampling and analysis processes. Field duplicates are two samples that are intended to be identical and are collected as close as possible in time and location. Each sample in the sample-duplicate pair receives its own unique sample number.
- **Field splits:** SPLITs are two samples that are intended to be identical and are collected as close as possible in time and location. 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.
- **Field transfer blanks:** FXRs are used to document possible contamination during field acquisition of volatile organic compound (VOC) samples. FXRs are sample bottles (already containing any required sample preservative) filled at the sample collection site with high-purity water. The blank is sealed at the sampling site and becomes part of the sample set sent to the laboratory. FXRs are prepared daily for sites sampling for VOC analysis. Typically, one set of FXRs is prepared each day that VOC field samples are collected. If VOC samples are collected on the same day and shipped to multiple laboratories, a set of FXRs is collected for each analyzing laboratory.
- **Full trip blanks:** FTBs are used to monitor for potential sample contamination from the sampling container, preservation reagents, or storage conditions. FTBs are prepared high-purity water and sealed prior to traveling to the sampling site, transported to the sampling site (not opened in the field), and then shipped as part of the sample set to the laboratory. The bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project and include the use of laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), and surrogates (SURs). These QC analyses follow EPA methods (e.g., those in the SW-846 Compendium). QC checks outside of control limits are documented in analytical laboratory reports and during a DQI evaluation. Descriptions of the various types of laboratory QC samples are as follows:

[1] High-purity water is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques.

- **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.
- **Laboratory sample duplicate:** A second aliquot of a sample that is taken through the entire sample preparation and analytical process. DUPs are 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) that is then taken through the entire sample preparation and analytical process. An MS is used to assess the bias of a method in a given sample matrix. Thus, MS results are an indicator of the effect the sample matrix has on the accuracy of measurement of the target analytes.
- **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.
- **Method blank:** An analyte-free matrix to which the same 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 process. The MB is used to quantify contamination resulting from the sample preparation and analysis.
- **Surrogate:** Used only in organic analyses, a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and analytical process in a manner similar to the analytes of interest. Because SURs are added to every sample and QC sample, they are used to evaluate overall method performance in a given matrix.

Samples are analyzed within the holding time guidelines provided in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an "H."

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

Constituent[a]	Preservation[b]	Holding Time
General Chemistry		
Alkalinity	Store ≤6°C	14 days
Hexavalent chromium	Store ≤6°C	24 hours
Total organic carbon	Store <6°C, adjust pH to <2 with sulfuric acid or hydrochloric acid	28 days
Total organic halogen	Store <6°C, adjust pH to <2 with sulfuric acid	28 days
Anions		
Chloride, Sulfate	Store ≤6°C	28 days
Nitrate, Nitrite	Store ≤6°C	48 hours

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

Constituent[a]	Preservation[b]	Holding Time
Metals		
Metals by inductively coupled plasma-atomic emission spectrometry	Adjust pH to <2 with nitric acid	6 months
Metals by inductively coupled plasma/mass spectrometry	Adjust pH to <2 with nitric acid	6 months
Volatile Organic Compounds		
Volatile organics by gas chromatography/mass spectrometry	Store ≤6°C, Adjust pH to <2 with sulfuric acid or hydrochloric acid	7 days unpreserved 14 days maximum preserved
Semivolatile Organic Compounds		
Phenols by gas chromatography/mass spectrometry	Store ≤6°C	7 days before extraction 40 days after extraction

Notes: Holding times and preservation methods are dependent on the constituent and are consistent with EPA guidance and approved analytical methods. Information in this table does not create EPA or Washington State Department of Ecology requirements but is intended solely as guidance.

The container type for a sample is available on the chain-of-custody documentation.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, pH, temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.

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

A3.4 Measurement Equipment

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

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

Collection, measurement, and testing equipment will meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or have been evaluated as acceptable and valid according to instrument-specific methods and specifications. Software applications will be acceptance tested prior to use in the field. Measurement and testing equipment used in the field will be subject to preventive maintenance measures to minimize downtime.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed per test methods in the SW-846 Compendium and EPA/600 Method series (e.g., EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*)

and will be appropriate for their use. Supplies and consumables used in sampling and analysis activities are procured under internal work processes. 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 records will be evaluated by the staff member assigned by the Project Delivery Manager for Groundwater Science. Data used in evaluations will be identified by source. Historical data obtained from the HEIS database are usable for comparison to data collected by this groundwater monitoring plan.

A3.9 Data Management

Records of data analyses and groundwater surface elevations are maintained as required by 40 CFR 265.94.

Electronic data access will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided.

A4 Data Review and Usability

This chapter addresses 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.

A4.1 Data Review and Verification

Data review and verification are performed to confirm that field and field QC sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to determine if holding times were met.

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, and the correct application of conversion factors. Data verification is typically conducted on a portion of multi-media samples collected across projects.

The staff member, assigned by the Project Delivery Manager for Groundwater Science, will also perform a data review to determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in a request for data review on questionable data. The laboratory may be asked to check calculations, reanalyze samples, or the well may be resampled. Results of the request for data review process are used to flag data in the HEIS database and to add comments.

A4.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science, under the direction of the SMR group. The decision to perform validation is based on the results of QC samples for individual well networks and discussions with the staff member assigned by the Project Delivery Manager for Groundwater Science. If conducted, data validation (third-party) will be performed at a minimum frequency of 5% per method. Data validation evaluates the analytical quality of data from samples specifically collected for this plan.

A4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. For routine groundwater monitoring undertaken by projects, DQIs such as precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity for the specific datasets (individual data packages) will typically be evaluated on an annual basis. A DQI evaluation specific to data quality requirements specified in this plan may be performed at the discretion of the Project Delivery Manager for Groundwater Science. Results of the DQI evaluation(s) will be used by the Project Delivery Manager for Groundwater Science to interpret the data and determine if the data quality objectives for this activity have been met.

A5 References

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Appendix B

Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
gpm	gallons per minute
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
NTU	nephelometric turbidity unit
QA	quality assurance
QC	quality control
SMR	Sample Management and Reporting

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B1 Introduction

*G*roundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* and implemented in WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," has been conducted since the mid-1980s. 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. Together, Appendices A and B provide the sampling and analysis essentials necessary for the groundwater monitoring plan: sample collection, sample preservation and holding times, chain-of-custody control, analytical procedures, and field and laboratory quality assurance (QA)/quality control (QC).

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

B2 Sampling Methods

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

- Field screening measurements
- Groundwater sampling
- Water level measurements

Groundwater samples will be collected in accordance with 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. (32.3°F)
- **Conductivity:** Two consecutive measurements agree within 10% of each other.
- **Turbidity:** Less than 5 nephelometric turbidity units prior to sampling (or project scientist's recommendation).

Unless special requirements are requested from project scientists, wells are typically purged using the equivalent volume as that of three borehole diameters multiplied by the length of the saturated portion of the well screen. Stable field readings are also required (as specified above). The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gallons per minute [gpm]) depending on the pump, although this is not practical at every well. On occasions where the purge volume is extraordinarily large, wells are purged for a minimum of 1 hour and are then sampled once stable field readings are obtained.

Field measurements (except for turbidity) are obtained using a flow-through cell. Groundwater is pumped directly from the well 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, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, and conductivity. 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 the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. Filtered and unfiltered sample containers are designated separately by unique sample container identification labeling and are tracked via the chain-of-custody documentation. For some constituents (e.g., metals), both filtered and unfiltered samples are collected. If additional samples requiring filtration (e.g., at turbidity greater than 5 nephelometric turbidity unit [NTU]s), an inline disposable 0.45 µm filter is used.

Typically, three traditional types (i.e., Grundfos[1], Hydrostar[2], and submersible electrical pumps) of environmental-grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support pumping of samples because of low yield or the physical characteristics of the well. In these cases, a grab sample may be obtained (note that S-10 network wells have sufficient yield and grab sampling does not apply). In cases where there is not sufficient yield, purgewater activities are not performed.

Low-purge-volume sampling methodology for the collection of groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically on the order of 0.1 to 0.5 L/min (0.026 to 0.13 gpm). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low-purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

For certain types of samples, preservatives are required. Preservatives, based on the analytical methods used, are added to the collection bottles before their use in the field. Samples may require filtering in the field, as noted on the chain-of-custody form.

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

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

Holding time is the maximum allowable 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/AWWA/WEF, 2012, *Standard Methods for the*

[1] Grundfos® is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.
[2] Hydrostar® is a registered trademark of KYB Corporation, Tokyo, Japan.

Examination of Water and Wastewater, and SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition; Final Update V*. Recommended holding times are also provided in HASQARD (DOE/RL-96-68) and in applicable laboratory contracts.

B2.1 Decontamination of Sampling Equipment

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

Decontamination of sampling equipment and pumps is performed using high-purity water[3] in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the equipment is washed in a phosphate-free detergent solution, followed by rinsing with water in three sequential containers. After the third water rinse, equipment that is stainless-steel or glass is rinsed in a 1M nitric acid solution (pH less than 2). Equipment is then rinsed with water in three sequential containers (the water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at 50°C (122°F) for items that are not metal or glass or at 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is enclosed in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. The pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with water. The pump is submerged in water and 30.3 L (8 gal) of water is pumped through the unit and disposed. The pump is removed from the water and the intake and housing are covered with plastic sleeving. The cleaning is documented on a tag that is affixed to the pump, and the tag will include the following information:

- Date pump cleaned
- Pump identification
- Comments
- Signature of person performing decontamination

[3] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

B2.2 Water Levels

Each time a sample is obtained, measurement of the ground water surface elevation at each monitoring well is required by 40 CFR 265.92(e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." Using a calibrated depth measurement tape, the depth to water is recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.); the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks or data forms are required for field activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. 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, 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 or on data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of 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). Also, details of any field tests that were conducted; reference to any forms that were used, other data records, and 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 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, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook 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 Project Delivery Manager for Groundwater Science, FWS, appropriate field crew supervisors, and Sample Management and Reporting (SMR) personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The Project Delivery Manager for Groundwater Science, 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

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with the HASQARD requirements (DOE/RL-96-68).

Field instrumentation, calibration, and QA 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 QC 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.
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturer's recommendations for storage and handling of standards (if any) will be followed.

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 database is used to track 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 that minimizes the possibility of sample container contamination. 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 on the chain-of-custody form.

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to 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 pre-printed or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained 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, new and previous custodians will sign the record and note the date and time. ~~The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.~~

Commented [CTJ1]: RCRA-CN-01_DOE/RL-2008-60_R1

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 each individual involved in the transfer of sample custody and storage locations, and dates/times 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 special direction for analysis can be provided to the laboratory if deemed necessary.

B5.4 Sample Transportation

Packaging and transportation instructions shall comply 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, "Transportation," "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway."[4] Carrier-specific requirements, defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*) 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. 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, wells listed in Table 3-1 in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required.

Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater and decontamination fluids will be collected and managed in accordance with DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*; and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*. Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements.

Packaging and labeling during waste storage and transportation will meet WAC 173-303 and DOT requirements, as appropriate. Packaging exceptions to DOT requirements may be used for onsite waste shipments if documented as such and if the packaging provides an equivalent degree of safety during transportation.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities.

[4] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

B7 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, "Worker Safety and Health Program," which incorporates the standards of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response"; 10 CFR 830, "Nuclear Safety Management"; and 10 CFR 835, "Occupational Radiation Protection." 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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Appendix C

Well Construction

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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 [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])
299-W26-13	TU	137.4 (450.8)	126.7 (415.7)	10.7 (35)
299-W26-14	TU	136.6 (448.2)	125.9 (413.1)	10.7 (35)
299-W27-2	LU	82.7 (271.3)	79.5 (260.8)	3.2 (10)
699-32-76	TU	134.8 (442.3)	124.1 (407.2)	10.7 (35)
699-33-75	TU	135.0 (442.9)	124.3 (407.8)	10.7 (35)
699-33-76	TU	135.5 (444.6)	124.9 (409.8)	10.7 (35)

NAVD88, *North American Vertical Datum of 1988.*

Note: See Table 3-2 in main text for depth of remaining water column.

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

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

0515345

Page 1 of 1

WELL SUMMARY SHEET

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 Dec99	Reviewed By: D.C. 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'
8⅜" 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 Dec99, 0800 hrs

SS 304 Screen, 4½" OD, 4" ID, 0.010" slot, from 2022 to 237.3 ft bgs.

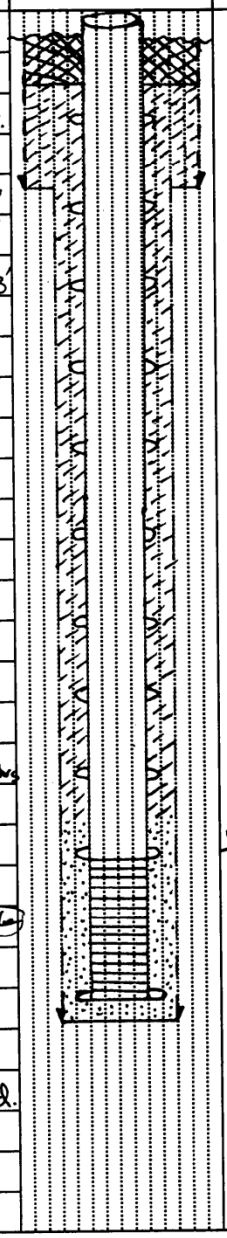
SLOUGH 237.3 to 240.7 ft

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'-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

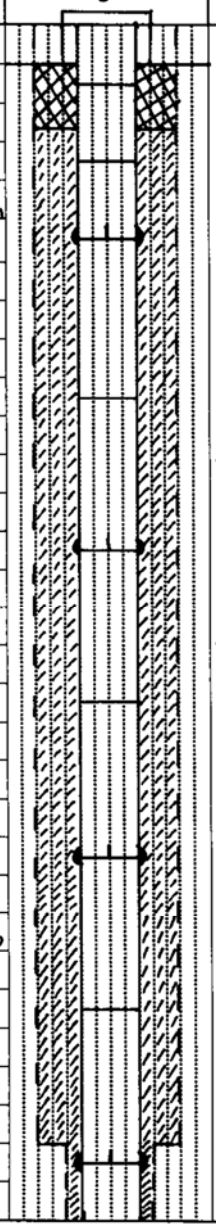
Start Date: 3/6/03
Finish Date: 4/3/03
Page: 1 of 2

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: Jess Hocking	Signature: LD Walker

CONSTRUCTION DATA

Description
4" TP-304/304L sch 05s Riser +2.00' → 223.37'
4" TP-304/304L sch 05s Wire Wrap screen 0.020" Cont. 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, 10 3/4" OD 0' → 143'
NOTE: ALL DEPTHS REPORTED IN FT. BELOW GROUND SURFACE.

Diagram



GEOLOGIC/HYDROLOGIC DATA

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

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

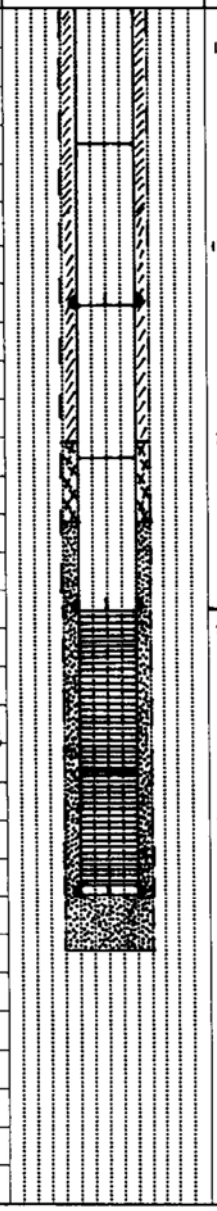
Description

Temporary Casing, 8 5/8" OD, to 267'

NOTE: ALL TEMP. CASING REMOVED FROM GROUND.

NOT TO SCALE

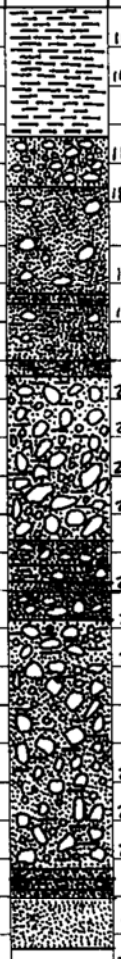
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 150, 175, 200, 225, 250, 275

Graphic Log



Lithologic Description

163 - 168' Sandy Gravel sG
168 - 182' Gravelly Sand gS
182 - 183' Slightly Silt Gravelly Sand (m) gS
183 - 190' Gravelly Silty Sand gmS
190 - 192' Silty Sand mS
192 - 214' Silty Sandy Gravel msG
214 - 217' Sandy Gravel sG
217 - 219' Silty Sandy Gravel msG
219 - 220' Sand S
220 - 224' Sandy Gravel sG
224 - 257' Silty Sandy Gravel msG
257 - 258' Sand S
258 - 259' Silty Sandy Gravel msG
259 - 260' Sandy Gravel sG
260 - 267' Sand S
267 - Silty Sandy Gravel msG
TD = 267.0' bgs
DTW = 223' bgs (3/31/03)

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 3

Location South of S tank farm

Project WMTM / S-10 Ditch

Elevation

Drilling Contractor K.E.H.

Driller G. Howell, G. Lydin

Drilling Method and Equipment Cable tool S.E. 22 in

Prepared By Brett Thompson (Sign/Print Name) Date 10-8-92

Reviewed By Edward E. Rafuse (Sign/Print Name) Date 12/10/92

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
		0		Silty Sand with occasional pebble.
		5		"
16" ϕ C.S Casing set at 9.85'		10		"
		15		"
12" ϕ C.S casing set at 179.88		20		
10" ϕ CS CASING SET @ 202.82		25		Pebble or Gravell lense
		30		Silty Sand
9" ϕ CS CASING SET @ 416.56		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 Pipe 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 Gary Lydon
Drilling Method and Equipment Cable tool BE. 22W
Prepared By (Sign/Print Name) Date 11/13/92
Reviewed By (Sign/Print Name) Date 12/30/92

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
		165		Silt clay
12" ⌀ CS CASING SETTO 179.88'		170		Silty Sandy Gravel
		175		" " "
10" ⌀ CS CASING SETTO 303.92'		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		" " "
		260		GRAVELLY SAND
		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. MALONE

Drilling Method and Equipment CME 850/AIR ROTARY

Prepared By MOS WEENEY (Sign/Print Name) Date 12/19/92

Reviewed By Edward C. Rafuse (Sign/Print Name) Date 12/30/92

CONSTRUCTION DATA

Description	Diagram
8" Ø CS CASING SET @ 426.36	
SCREEN SET @ 416.56 TO 406.14	
PORTLAND CEMENT 9.7'-20'	
BENTONITE CHIPS (3/4") 221.8-9.7'	
BENTONITE SLURRY 374.5-221.8	
PORTLAND CEMENT 389.4-374.5	
BEHIND HOLE & CAL. 399.4-399.4	
10/20 SAND 420-~~399.4~~ 420 = 399.4	
BENTONITE PLUG 428.2-420.0	
HOLE COLLAPSED TO 428.2.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
330		SANDY GRAVEL.
335		" "
340		" "
345		" "
350		" "
355		GRAVEL.
360		
365		SANDY GRAVEL.
370		" "
375		GRAVEL.
380		SANDY GRAVEL.
385		" "
390		GRAVELLY SAND.
395		" "
400		SAND
405		SANDY GRAVEL.
410		GRAVEL
415		"
420		SANDY GRAVEL.
425		" "
430		CLAY/SILT.
435		
440		TD = 435.0' 11/20/92
		REDRILLED FROM 376' TO 414.5
		12/4/92 - 12/9/92 W/BE22W
		RIG # U-12.

4-6000-384 (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: Erika R	Signature:	

CONSTRUCTION DATA

Description

6-in Concrete Pad

6-in I.D. Type 304/304L Stainless Steel Protective Casing: +2.42 ft above Ground Surface

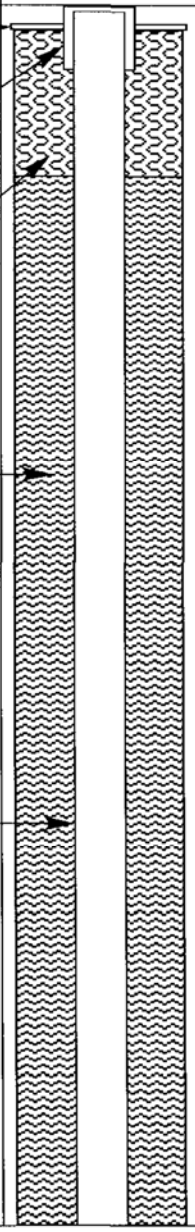
Portland Cement Type I/II: 0 - 10.8 ft

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.

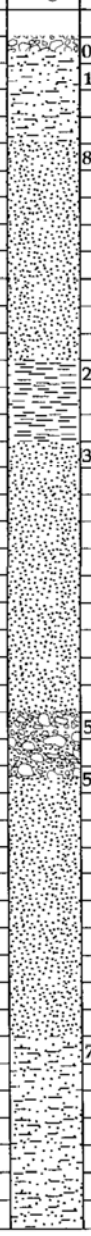
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 10, 20, 30, 40, 50, 60, 70, 80

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

0-1 Gravel, G (Fill)
1-8 Sandy Silt, sM
8-24 Sand, S
24-30 Silt, M
30-50 Sand, S
50-55 Sandy Gravel, sG
55-74 Sand, S
74-130 Silty Sand, mS

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

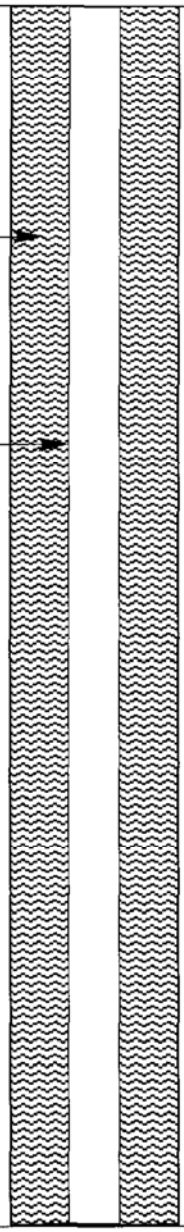
Description

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

All depths are in feet below ground surface.

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 90, 100, 110, 120, 130, 140, 150, 160, 170

Graphic Log

Lithologic Description/Groundwater Sample Depths (ft bgs)

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

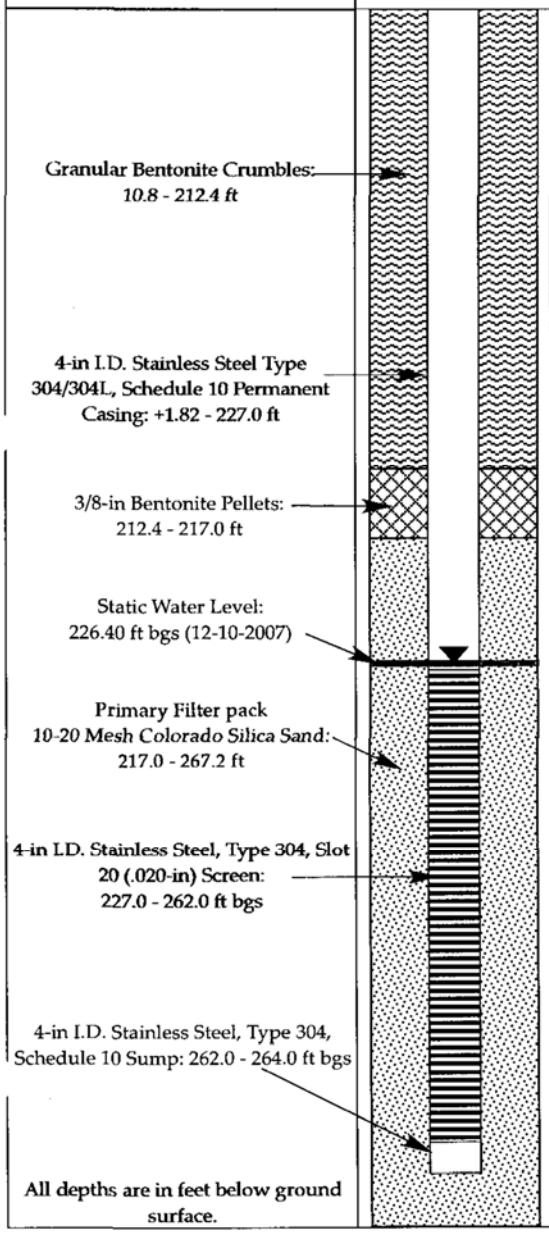
Figure C-4. Well 699-32-76 Well Summary Sheet (sheet 2 of 4)

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 3 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

Description	Diagram
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.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
180		
190		
200		200.5-210 Gravely Sand, gS
210		210-215 Sandy Gravel, sG
		215-230 Gravely Sand, gS
220		
230		230-236 Silty Sandy Gravel, msG
		236-237 Grab Sample for Sieve Analysis
		236-255 Sandy Gravel, sG
240		
		244 Water Sample HEIS: B1PM57 & B1PM85
250		
		255-257 Gravelly Silty Sand, gmS
		257-280 Silt Sandy Gravel, msG
		257 Grab Sample for Sieve Analysis
260		

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

WELL SUMMARY SHEET		Start Date: 11/8/07 Finish Date: 01/4/08	Page 4 of 4
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.S. Walker	Date: 4/17/08
Signature: Erika R		Signature:	

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	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
270		
		273 Water Sample HEIS: B1PM54, B1PM58 & B1PM86
280		280-300 Sandy Gravel, sG
290		
300		299 Water Sample HEIS: B1PM59 & B1PM87 300-304 Silty Gravely Sand, mgS
		304-344 Sandy Gravel, sG
310		
320		
330		
340		342 Water Sample HEIS: B1PM60 & B1PM88 344 Total Depth (12/13/2007)
350		

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 Rincon		Signature: LD Walker	

CONSTRUCTION DATA

Description

6-in Concrete Pad

6-in I.D. Stainless Steel Type 304/304L Protective Casing: +2.48 ft above Ground Surface

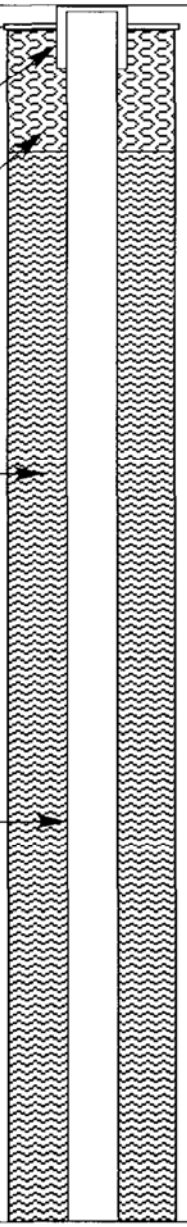
Portland Cement Type I/II: 0 - 9.0 ft

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.

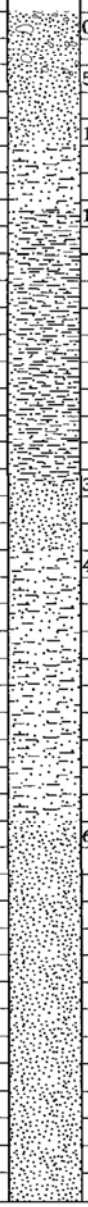
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 10, 20, 30, 40, 50, 60, 70, 80

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

0-5 Gravely Sand, gS

5-10 Sand, S

10-15 Silty Sand, mS

15-35 Sandy Silt, sM

35-40 Sand, S

40-60 Silty Sand, mS

60-140 Sand, S

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:	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
Granular Bentonite Crumbles: 9.0 - 220.9 ft		90		
		100		
		110		
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft		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
All depths are in feet below ground surface.				

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: Erika R	Signature: LD Walker	

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

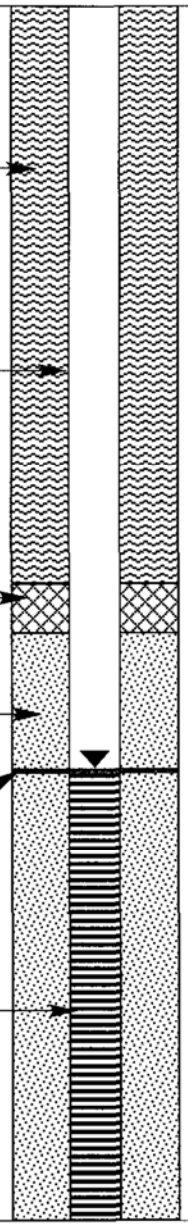
Primary Filter pack 10-20 Mesh Colorado Silica Sand: 224.5 - 274.0 ft

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.

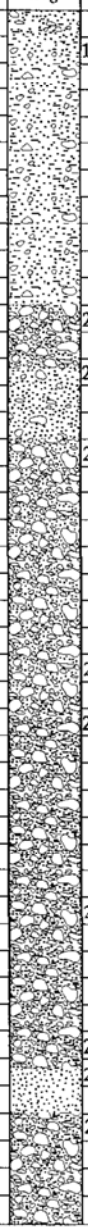
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

180-200 Gravely Silty Sand, gmS

200-205 Sandy Gravel, sG

205-210 Gravely Sand, gS

210-230 Sandy Gravel, sG

227-229 Split-Spoon Sample for Sieve Analysis

230-257 Silty Sandy Gravel, msG

244 Water Sample HEIS: B1PM53 & B1PM81

257-260 Sand, S

257-259 Split-Spoon Sample for Sieve Analysis

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

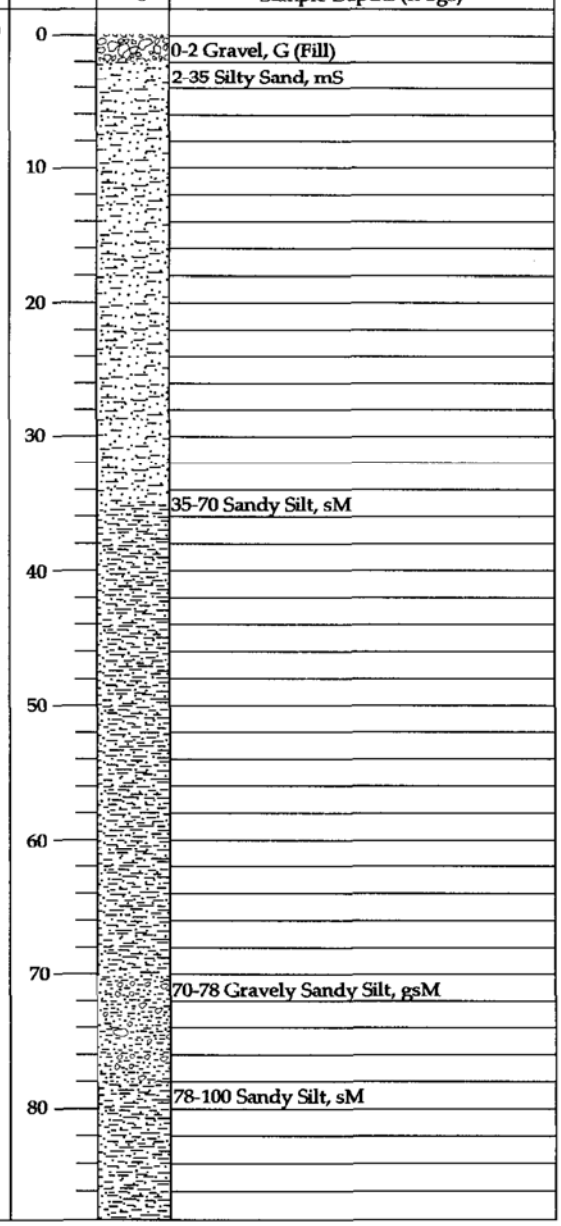
Depth in Feet	Lithologic Description/Groundwater Sample Depths (ft bgs)
270	
	277 Water Sample HEIS: B1PM54, B1PM82
280	
290	
300	
	307 Water Sample HEIS: B1PM55 & B1PM83
310	310-335 Sandy Gravel, sG
320	
330	
	335-340 Gravel, G
340	340-346 Sandy Gravel, sG
	346 Water Sample HEIS: B1PM56 & B1PM84
	346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

Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
	0-2 Gravel, G (Fill)
	2-35 Silty Sand, mS
	35-70 Sandy Silt, sM
	70-78 Gravely Sandy Silt, gsM
	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 Finish Date: 03/27/08	Page 3 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:	

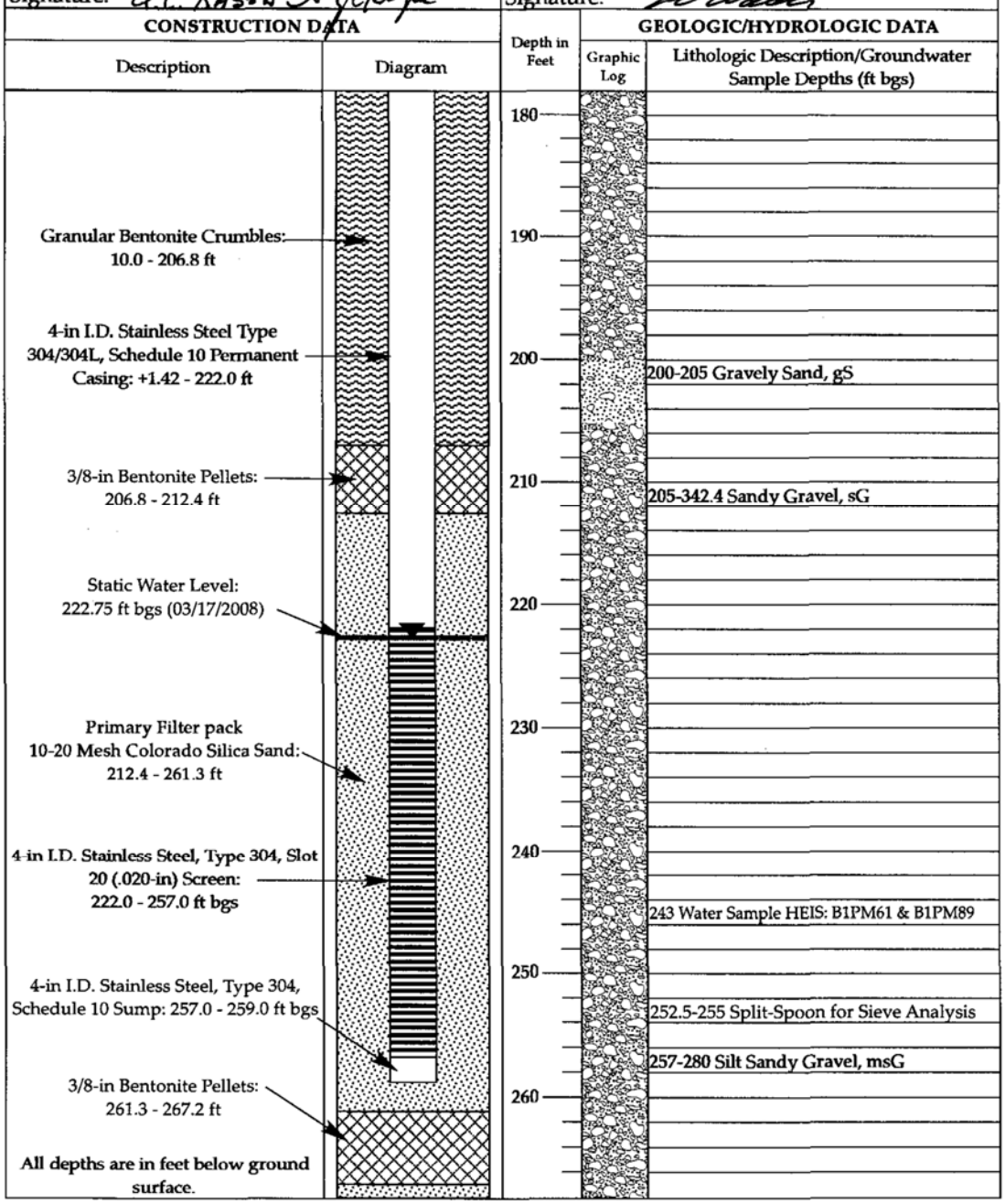


Figure C-6. Well 699-33-76 Well Summary Sheet (sheet 3 of 4)

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:	

CONSTRUCTION DATA

Description

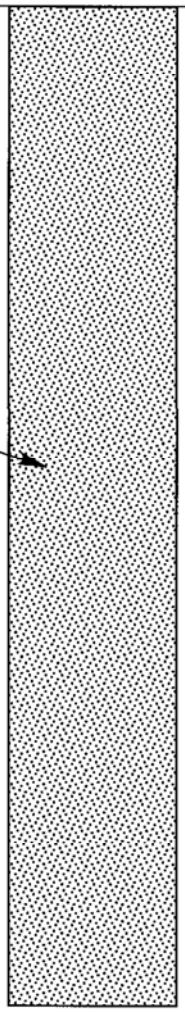
10-20 Mesh Colorado Silica Sand (Backfill): 267.2 - 342.4 ft

All depths are in feet below ground surface.

Borehole drilled with 11¾-in threaded casing 0-205 ft and 9⅝-in threaded casing 198-344 ft

All temporary drill casing was removed from the ground.

Diagram



GEOLOGIC/HYDROLOGIC DATA

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		
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		

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

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/.