

Interim Status Change Number 2: Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond

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



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Interim Status Change Number 2: Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond

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**RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN
 INTERIM CHANGE FORM**

Change Number: <i>(Obtain Change Number From Interim Change Custodian)</i> RCRA-CN-02_DOE-RL-2008-59_R2		Date: 04/30/2020
Document Number: DOE/RL-2008-59	Title: Interim Status Change Number 2: Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond	Rev: 2
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.

- Add site-specific metals to monitor for stainless steel corrosion (chromium, iron, manganese, molybdenum, and nickel) to the Executive Summary on pg. ix, Section 2.5 on pg. 2-31, Table 2-4, Section 3.1 on pg. 3-1, Table 3-1 (footnote d), and Table 3-4 (Constituents row).
- Change section reference from "A2.6" to "A2.5" in Table 2-3, page 2-36, in main file.
- In Table 3-1, add superscript "g" to "Phenols" with footnote "g. 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. 3-3a 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" 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.

- Additional site-specific constituents (chromium, iron, manganese, molybdenum, and nickel) added to monitor for stainless steel corrosion.
- Reference in Table 2-3 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:

K. M. Whitley	email approval attached - 06/08/2020	
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Change History of Interim Status Monitoring Plan DOE/RL-2008-59, Rev. 2, for the 216-B-3 Pond

Title	Document Number	Revision Number	Interim Change Number	Effective Date
Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond	DOE/RL-2008-59	2	N/A	9-27-2017
Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond	DOE/RL-2008-59	2	RCRA-CN-01_DOE/RL-2008-59_R2	4-24-2019
Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond	DOE/RL-2008-59	2	RCRA-CN-02_DOE/RL-2008-59_R2	4-30-2020

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Executive Summary

This document presents a revision to the 2017 groundwater monitoring plan (DOE/RL-2008-59¹) for the 216-B-3 Main Pond (hereafter referred to as Main Pond) and the 216-B-3-3 Ditch. These two sites comprise a single treatment, storage, and disposal (TSD) unit and are collectively referred to as B Pond. 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 to incorporate changes to the well network proposed in Rev. 1 of this groundwater monitoring plan, which included installation of one new network well (699-44-43C; installed in 2017) with subsequent removal of one existing well (699-45-42) from the network. Additionally, due to a failure of the well casing, one downgradient well (699-43-44) is being removed from the network and is scheduled for direct replacement (699-43-43B). This indicator evaluation program groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at B Pond.

B Pond is an inactive, interim status TSD unit comprising the Main Pond and the 216-B-3-3 Ditch. The Main Pond is located 1,600 m (5,200 ft) east of the 200 East Area fence. The Main Pond was a natural topographic depression, diked on the eastern margin, and covers 14.2 ha (35 ac).

Operation of the Main Pond began in 1945. During its operation, the Main Pond received effluent from several 200 East Area facilities including the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, 241-A Tank Farm, 242-A Evaporator, 244-AR Vault, and 284-E Power Plant. Dangerous waste was received from the 216-A-29 Ditch, which

¹ DOE/RL-2008-59, 2017, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/pdf.cfm?accession=0071410H>.

² *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: <https://elr.info/sites/default/files/docs/statutes/full/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=24aad4966ac52acbeba416c2c114889&mc=true&node=pt40.26.265&rgn=div5>.

discharged into the eastern portion of the 216-B-3-3 Ditch and then flowed eastward into the Main Pond. The 216-B-3-3 Ditch was an open, unlined earthen ditch, 6 m (20 ft) wide at ground level, 1.8 m (6 ft) deep and 1,130 m (3,700 ft) long, that was used to transport effluent from the B Plant and PUREX Facilities to the Main Pond. In 1994, all discharges ceased and the Main Pond and 216-B-3-3 Ditch underwent interim stabilization measures.

As B Pond received wastewater contaminated with dangerous waste or dangerous waste constituents, a groundwater monitoring program in accordance with 40 CFR 265 was implemented in 1988 and revised in 1989 (WHC-SD-EN-AP-013).⁵ Monitoring of the 216-B-3-3 Ditch portion of the TSD included only the eastern portion of the 216-B-3-3 Ditch from its juncture with the 216-A-29 Ditch to where the 216-B-3-3 Ditch enters the Main Pond. In 1990, statistical evaluation of total organic halogen (TOX) and total organic carbon (TOC) showed that concentrations in two downgradient wells (699-43-41E and 699-43-41F) were statistically greater than background levels (PNNL-11604).⁶ A required groundwater quality assessment plan for B Pond was prepared and initiated (WCH-SD-EN-AP-030).⁷ In 1997, the groundwater quality assessment results (PNNL-11604) concluded that the increased concentrations of TOX and TOC were isolated occurrences and not related to releases of dangerous waste constituents from B Pond. The TSD unit was returned to an indicator evaluation program in 1998 under Rev. 1 of WHC-SD-EN-AP-013.⁸

This revised groundwater monitoring plan presents an updated indicator evaluation program for detection monitoring of the uppermost aquifer beneath B Pond. This plan addresses the following:

- Number, locations, and depths of wells in the B Pond groundwater monitoring network

⁵ WHC-SD-EN-AP-013, 1989, *Interim-Status Groundwater Monitoring Plan for the 216-B-3 Pond*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195064799>.

⁶ PNNL-11604, 1997, *Results of RCRA Groundwater Quality Assessment at the 216-B-3 Pond Facility*, Pacific Northwest National Laboratory, Richland, Washington. Available at: <http://www.iaea.org/inis/collection/NCLCollectionStore/Public/29/036/29036425.pdf>.

⁷ WHC-SD-EN-AP-030, 1990, *Groundwater Quality Assessment Plan for the 216-B-3 Pond System*, Westinghouse Hanford Company, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0009533>.

⁸ WHC-SD-EN-AP-013, 1995, *Interim-Status Groundwater Monitoring Plan for the 216-B-3 Pond*, Rev. 1, Westinghouse Hanford Company, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196004500>.

- Sampling and analytical methods of parameters required for groundwater contamination detection monitoring
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at B Pond

The Rev. 1 plan used the groundwater monitoring well network as identified in the previous groundwater monitoring plan (DOE/RL-2008-59, Rev. 0) with the addition of a second existing upgradient well (699-45-42). Groundwater flow direction determinations indicate that west and southwest groundwater flow directions exist beneath B Pond. Groundwater in the B Pond monitoring wells will continue to be sampled and analyzed semiannually for the parameters used as indicators of groundwater contamination (pH, specific conductance, TOC, and TOX) 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). Field parameters (dissolved oxygen, temperature, and turbidity) will be sampled semiannually. Site-specific constituents for analysis of general water chemistry including alkalinity, metals (calcium, chromium, iron, magnesium, manganese, molybdenum, nickel, and potassium) will continue to be collected annually. Arsenic and nitrate have been identified as site-specific constituents that could be associated with B Pond operations and will continue to be monitored annually. Cadmium is associated with previous discharges to B Pond and will continue to be monitored annually. Water level measurements will be taken each time that a sample is collected to satisfy the requirements of 40 CFR 265.92(e).

The Rev. 1 plan added a second existing upgradient well (699-45-42) to the monitoring network that was proposed to be used until a new upgradient well (699-44-43C), positioned closer to B Pond, was drilled and ready for sampling. Well 699-44-43C is intended to provide better representation of the variability in upgradient hydrogeologic conditions and constituent concentrations affecting the site. Well 699-44-43C was installed in 2017 and is incorporated into this Rev. 2, replacing well 699-45-42 as discussed in Rev. 1 of this groundwater monitoring plan. Due to casing failure from corrosion, downgradient well 699-43-44 is being removed from the network and is scheduled for direct replacement with planned well (699-43-43B). Quarterly sampling for indicators of groundwater contamination, groundwater quality parameters, and drinking water suitability parameters included in Appendix III to 40 CFR 265 will be performed

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for 1 year at well 699-44-43C and replacement well 699-43-43B once installed.
Well 699-44-43C is scheduled to begin quarterly sampling in October 2017.

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Terms

AEA	<i>Atomic Energy Act of 1954</i>
bgs	below ground surface
CCU	Cold Creek unit
CSM	conceptual site model
DO	dissolved oxygen
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
ECN	Engineering Change Notice
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
FY	fiscal year
HSU	hydrostratigraphy unit
NAD83	<i>North American Datum of 1983</i>
PUREX	Plutonium-Uranium Extraction
QAPjP	quality assurance project plan
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
TOX	total organic halogen
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order (Ecology et al., 1989a)</i>
TSD	treatment, storage, and disposal

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1 Introduction

This document presents the revised groundwater monitoring plan for the 216-B-3 Main Pond (hereafter referred to as Main Pond) and the 216-B-3-3 Ditch and supersedes the previous plan (DOE/RL-2008-59, Rev. 1, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*). These two sites comprise a single treatment, storage, and disposal (TSD) unit and are collectively referred to as B Pond. The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) is revising this groundwater monitoring plan to incorporate a new well (699-44-43C) proposed in Rev. 1 of this groundwater monitoring plan and installed in 2017 with subsequent removal of one existing well (699-45-42) from the network. Additionally, due to well casing failure attributed to corrosion, well 699-43-44 is being removed from the network and is scheduled for direct replacement with 699-43-43B in fiscal year (FY) 2018. 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.

B Pond is an inactive, interim status 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), B Pond will continue to be considered an interim status unit until it is incorporated into Part III, V, or VI of the Hanford Facility RCRA Permit. For regulatory purposes, the TSD unit boundary of B Pond is identified on the current Hanford Facility RCRA Permit Part A Form. The TSD unit boundary includes the Main Pond and the 216-B-3-3 Ditch (Figure 1-1). However, groundwater monitoring of the 216-B-3-3 Ditch portion of the TSD includes only the eastern portion of the 216-B-3-3 Ditch from its juncture with the 216-A-29 Ditch to where the 216-B-3-3 Ditch enters the Main Pond (Figure 1-1).

The Main Pond is located 1,600 m (5,200 ft) east of the 200 East Area fence (Figure 1-1). The Main Pond occupies a natural topographic depression, diked on the eastern margin, and covers 14.2 ha (35 ac). The Main Pond had a maximum depth of 6.1 m (20 ft) during operational use and received effluent from several 200 East Area facilities, including the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, 241-A Tank Farm, 242-A Evaporator, 244-AR Vault, and 284-E Power Plant. Operating records indicate that the Main Pond began receiving wastewater in 1945. Multiple ditches were used to convey wastewater to the Main Pond during its operational period. The 216-B-3-3 Ditch began receiving effluent from the B Plant and PUREX Facilities in 1970 and was an open, unlined, earthen ditch, 6 m (20 ft) wide at ground level, 1.8 m (6 ft) deep, and 1,130 m (3,700 ft) long. In 1994, all discharges to the Main Pond and 216-B-3-3 Ditch ceased, and both the Main Pond and ditch underwent interim stabilization measures.

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 B Pond, commonly referred to as an indicator evaluation program under interim status. This plan is required by 40 CFR 265.90(a) and (b) and is intended 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 265.92, Subpart F. This monitoring plan is the principal controlling document for conducting groundwater monitoring at B Pond. The indicator evaluation program detailed in this plan requires

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semiannual sampling for parameters used as indicators of groundwater contamination, as well as annual sampling for parameters establishing groundwater quality at two upgradient and three downgradient wells. The Rev. 1 plan added a second existing upgradient well (699-45-42) to the monitoring network. A new well (699-44-43C) was proposed to be drilled near the Main Pond to provide more information on upgradient conditions closer to the site. Until the new well was ready for sampling, 699-45-42 was included in the B Pond network under Rev. 1. Well 699-44-43C was installed in 2017 and replaces well 699-45-42 under this Rev. 2. Quarterly sampling will be performed for 699-44-43C during the first year of monitoring for indicators of groundwater contamination and is scheduled to begin sampling in October 2017. All site-specific and supporting constituents are retained in this revision. Water level measurements are also required each time that a sample is collected in accordance with 40 CFR 265.92(e).

During routine monitoring activities in 2017, downgradient well 699-43-44 was identified as containing significant well corrosion and casing structural failure. Well 699-43-44 is scheduled for decommissioning and direct replacement with well 699-43-43B in FY 2018. Well 699-43-44 is removed from the network under this Rev. 2 plan.

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 B Pond 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 B Pond and the regulatory basis, types of waste present, the pertinent geology and hydrogeology beneath B Pond; 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.

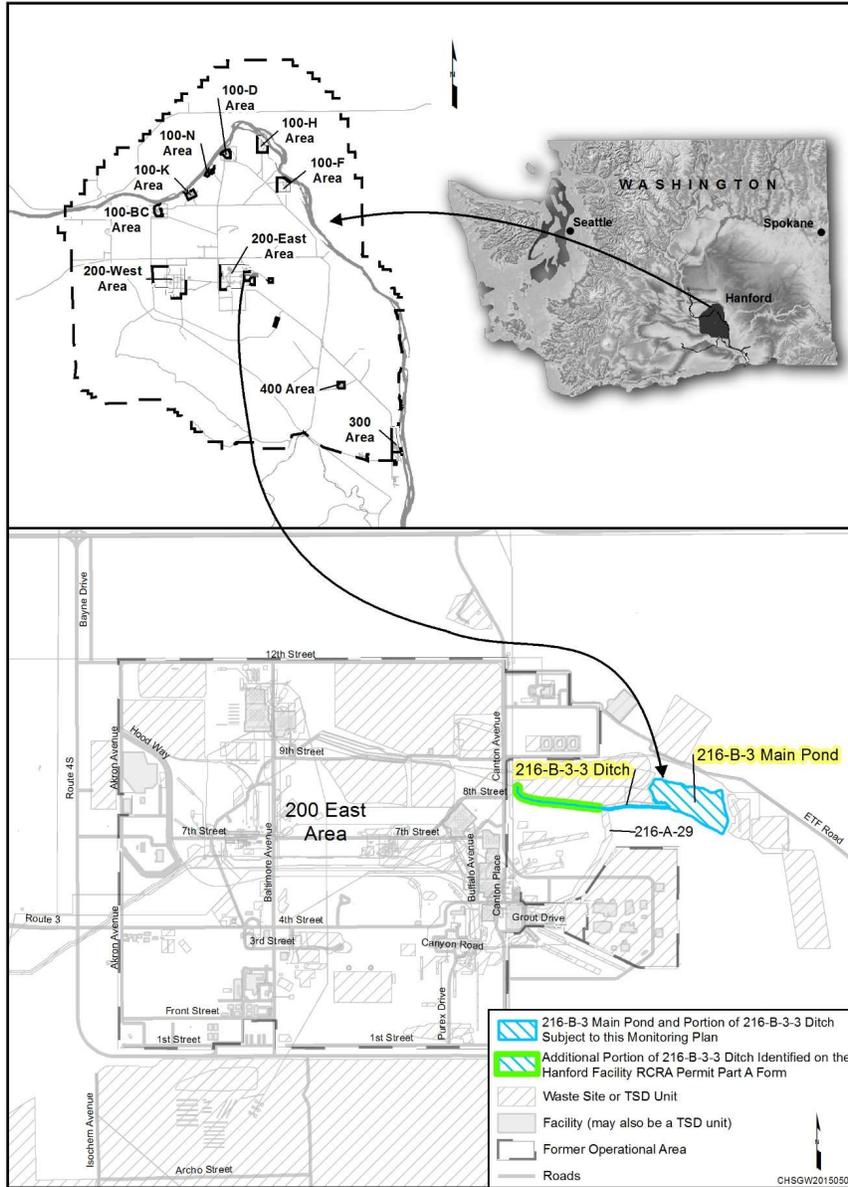


Figure 1-1. Location Map for B Pond

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2 Background

This chapter describes B Pond and its operating history, regulatory basis, wastes and waste characteristics associated with B Pond, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for B Pond. Other constituents, in addition to those collected to meet the requirements of 40 CFR 265.92, are included in this monitoring plan.

The information contained in this chapter was obtained from several sources, including the previous groundwater monitoring plans listed in Section 2.5 and the following documents:

- BHI-01367, *200-CW-1 Operable Unit Borehole/Test Pit Summary*
- DOE, 1987, *Preliminary Closure/Post-Closure Plan 216-B-3 Pond*
- DOE/RL-89-28, *216-B-3 Expansion Ponds Closure Plan*
- DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*
- DOE/RL-93-74, *200-BP-11 Operable Unit RFI/CMS and 216-B-3 Main Pond, 216-B-63 Trench, and 216-A-29 Ditch Work/Closure Plan Volume 1: Facility Investigation and Sampling Strategy*
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- PNNL-11604, *Results of RCRA Groundwater Quality Assessment at the 216-B-3 Pond Facility*
- WHC-SD-EN-AP-042, *Phase 1 Characterization of the 216-B-3 Pond System*

2.1 Facility Description and Operational History

The Main Pond began receiving effluent in 1945. The Main Pond was located in a natural topographic depression, diked on the eastern margin, covering approximately 14.2 ha (35 ac), with a maximum depth of approximately 6.1 m (20 ft) during its operational use. In the 1970s, a 1.7 ha (4.1 ac) area directly west of the Main Pond was diked to serve as an overflow area for the Main Pond. The overflow area was decommissioned and backfilled in 1985 (DOE/RL-92-05). Expansion ponds (216-B-3-A, referred to as 3A; 216-B-3-B, referred to as 3B; and 216-B-3-C, referred to as 3C) were placed in service in 1983, 1984, and 1985, respectively. The 3A and 3B expansion ponds are approximately 4.5 ha (11 ac), and the 3C expansion pond is approximately 17 ha (41 ac).

Four ditches were used to convey effluent from production facilities in the 200 East Area to the Main Pond, where the water then evaporated and infiltrated into the ground. The 216-B-3-1 Ditch operated from 1945 to 1964, the 216-B-3-2 Ditch operated from 1964 to 1970, and the 216-B-3-3 Ditch operated from 1970 to 1994. The 216-B-3-3 Ditch was 1.2 to 2.4 m (4 to 8 ft) deep and 0.9 m (3 ft) wide at the bottom. The 216-A-29 Ditch, which fed into the 216-B-3-3 Ditch approximately 305 m (1,000 ft) west of the Main Pond, operated from 1955 to 1991. The 216-B-3-1 and 216-B-3-2 Ditches were decommissioned (backfilled with soil) in 1964 and 1970, respectively (DOE/RL-89-28, Section 2.2). The 216-A-29 Ditch was removed from service in 1991 and interim stabilized (soil was placed over the radioactively contaminated ditch bottom) (DOE/RL-89-28, Section 2.2). DOE/RL-92-05 presents operational details for these ponds and ditches. The B Pond system (not to be confused with the B Pond TSD) consists of the Main Pond, three expansion ponds, and four ditches (Figure 2-1).

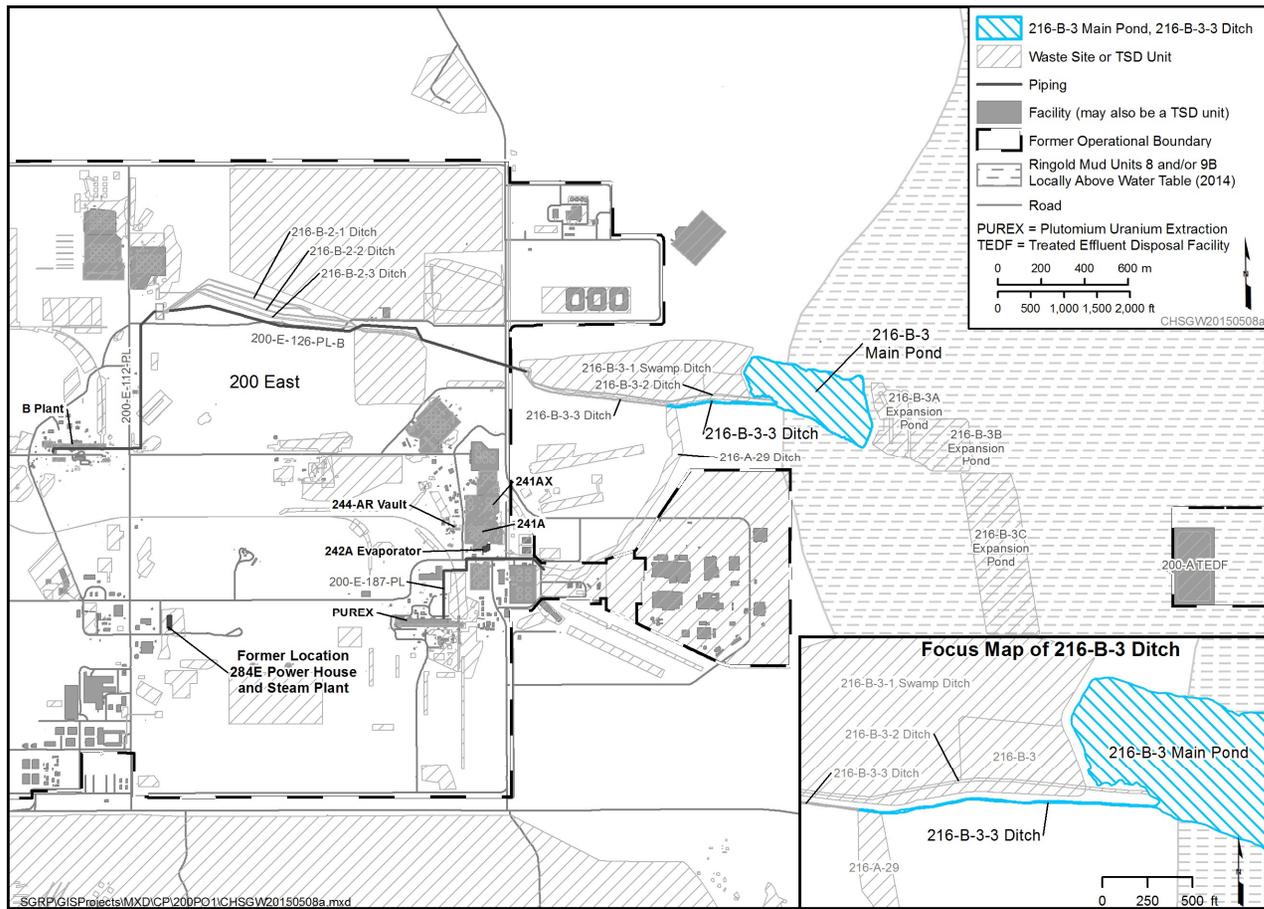


Figure 2-1. Map of the B Pond System

Discharge volumes to the B Pond system averaged 10 billion L/year (2.6 billion gal/year), except for a short period in the mid-1980s. From 1986 to 1991, discharges to the B Pond system totaled over 64 billion L (17 billion gal), with a maximum in 1988 of over 100 billion L/year (26 billion gal/year). Total discharge to the facility since 1945 is estimated to have exceeded 1 trillion L (260 billion gal).

In April 1994, discharges to the Main Pond and the 3A expansion pond ceased, and all effluents were rerouted to the 3C expansion pond via a pipeline. Also in 1994, the Main Pond and 216-B-3-3 Ditch were interim stabilized. Interim stabilization at Main Pond included draining the pond, backfilling, covering with 0.3 m (12 in.) of topsoil, and revegetating (BHI-00219, Section 4.2.1 and 4.3). Activities at the 216-B-3-3 Ditch included consolidating spoil piles into the ditch, removal of the flume, demolition of the concrete headwall, isolation of inflow pipes, and covering the contaminated soil with 0.5 to 0.6 m (18 to 24 in.) of clean soil (BHI-00219, Section 4.2.1). All vegetation was removed from the perimeter and incorporated with the fill soil (BHI-00219, Section 4.2.1). Prior to diversion of effluent from the Main Pond, the 3A, 3B, and 3C expansion ponds were clean closed under the Hanford Facility RCRA Permit (Wilson, 2005, "Acceptance of Closure Certification for the 216-B-3 Expansion Ponds"), though the 3C expansion pond continued to receive uncontaminated discharges until 1997 (DOE/RL-99-07, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan*, Table 2-1). Clean closure of the expansion ponds indicates that no identifiable waste remains in the closed facilities. Thus, the only portions of the original facilities that are addressed under this groundwater monitoring plan are the Main Pond and the segment of the 216-B-3-3 Ditch between the Main Pond and the 216-A-29 Ditch. The 216-A-29 Ditch is a separate TSD unit and the expansion ponds have been clean closed.

In June 1995, portions of the effluent stream were rerouted to the permitted 200 Areas Treated Effluent Disposal Facility (TEDF) (State Waste Discharge Permit #ST 4502). The remaining streams were diverted from the 3C expansion pond to TEDF by August 1997, thus ending all routine operation of the B Pond system (Figure 2-1).

During operations, B Pond received effluent from several 200 East Area facilities, including PUREX, B Plant, 241-A Tank Farm, 242-A Evaporator, 244-AR Vault, and 284-E Power Plant. Corrosive hazardous wastes, such as nitric and sulfuric acids, were routinely discharged to B Pond via the ditches, although attempts were made to neutralize these wastes before they were discharged. As described in WHC-SD-EN-AP-013, Section 2.1.3.1, the most frequent dangerous waste discharged to the 216-B-3 Pond occurred during the regeneration of the PUREX Plant demineralizers. During regeneration with sulfuric acid and sodium hydroxide, the pH of the effluents routinely alternately dropped below 2 or exceeded 12.5. These corrosive discharges continued frequently until coregeneration practices were instituted in February 1986. Coregeneration practices reduced, but did not eliminate, the potential for discharging corrosive effluents to the chemical sewer. Before coregeneration practices, the successive discharges of acidic and caustic waste would have somewhat neutralized the effluents before and upon reaching the pond. Residual acidic waste would have been neutralized by the calcareous nature of the soil.

Other dangerous waste discharged to B Pond included cadmium nitrate, ammonium fluoride, ammonium nitrate, hydrazine, and sodium and potassium hydroxide. Sulfuric acid and sodium hydroxide were the most frequently discharged dangerous waste. An unplanned release of cadmium nitrate (15 kg [33 lb]) from the PUREX chemical sewer was sent to B Pond in 1977 (DOE/RL-93-74). Records of dangerous waste discharges to B Pond are poor prior to 1983, and information concerning chemical (nonradioactive) releases is incomplete prior to 1987 (DOE/RL-89-28). The last known reportable discharge of chemical waste (sodium nitrate) occurred in 1987 (PNNL-15479, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*).

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 waste since August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989a, *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 B Pond. Groundwater monitoring is conducted at B Pond 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). AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by 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 B Pond was initiated in 1988, based on the interim status indicator evaluation program requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. The initial groundwater monitoring program is described in the preliminary closure plan (DOE, 1987).

In 1994, the Hanford Facility RCRA Permit Part A application (DOE/RL-89-28) was modified to distinguish the three expansion ponds (3A, 3B, and 3C) from the Main Pond and a segment of the 216-B-3-3 Ditch. This change allowed RCRA clean closure of the expansion ponds to meet Tri-Party Agreement (Ecology et al., 1989a) Milestone M-17-10. The portion of 216-B-3-3 Ditch, west of its junction with 216-A-29 Ditch, and the 216-B-3-1 and 216-B-3-2 Ditches are RCRA past-practice facilities. The 216-A-29 Ditch conveyed dangerous waste from the PUREX chemical sewer to the 216-B-3-3 Ditch. From the juncture of 216-A-29 and 216-B-3-3, waste from the PUREX chemical sewer flowed to the Main Pond (Figure 1-1). Therefore, only this eastern section of the 216-B-3-3 Ditch requires groundwater monitoring under the Hanford Facility RCRA Permit. Thus, the only portions of the original facilities that are addressed under this groundwater monitoring plan are the Main Pond and the segment of the 216-B-3-3 Ditch between the Main Pond and the 216-A-29 Ditch. The 216-A-29 Ditch is a separate TSD unit.

Activities conducted as part of the closure process for the expansion ponds included soil and sediment sampling, interim stabilization of the Main Pond and 216-B-3-3 Ditch, and decontamination and removal of structures and associated fixed equipment (DOE/RL-89-28). Soil and sediment sampling activities in support of closure were conducted in three phases. The first phases were completed from 1989 through 1992 and involved shallow soil sampling and analysis of sediments from the Main Pond, expansion ponds, and 216-B-3-3 Ditch (WHC-SD-EN-AP-042) and deep vadose zone sampling in the expansion ponds (DOE/RL-89-28). Additional characterization of the vadose zone at B Pond occurred during September 1999 when 1 deep borehole and 10 trenches were excavated in the Main Pond and 216-B-3-3 Ditch (BHI-01367).

Groundwater monitoring at B Pond has been conducted under interim status requirements since 1988. Interim status indicator parameter monitoring was performed from 1988 to 1990 when monitoring was changed to an assessment program (40 CFR 265.93(d), “Preparation, Evaluation, and Response”) due to elevated levels of total organic halogen (TOX) in a downgradient well (699-43-41E) (Izatt and Lerch, 1990, “Groundwater Quality Assessment Plan for the 216-B-3 Pond System”). In 1990, WHC-SD-EN-AP-030, Rev. 0, *Groundwater Quality Assessment Plan for the 216-B-3 Pond System*, was issued, and it was revised in 1992 with Engineering Change Notice (ECN) 166756. The assessment included the Main Pond and a portion of an inactive overflow area, the 216-B-3-3 Ditch, and the 3A, 3B, and 3C expansion ponds. The 1997 assessment report (PNNL-11604) identified that a second downgradient well (699-43-41F) had also exceeded TOX, and total organic carbon (TOC) levels were elevated in these downgradient wells. PNNL-11604 concluded that no dangerous waste or dangerous waste constituents associated with the assessment areas could be correlated to the elevated TOX or TOC results, and B Pond was returned to indicator parameter monitoring in 1998. Several updates to the monitoring plan have since occurred, and a new plan was issued in 2010 (DOE/RL-2008-59, Rev. 0). Due to the age of the plan and to ensure that the plan contained the most current Hanford Site groundwater monitoring information for the TSD unit including revision to the well network, DOE/RL-2008-59, Rev. 1 was issued on April 12, 2017. This Rev. 2 incorporates network changes proposed in Rev. 1 including the addition of upgradient well 699-44-43C (installed in 2017) and subsequent removal of 699-45-42. Downgradient well 699-43-44 is additionally being removed under this Rev. 2 and is scheduled to be replaced with 699-43-43B in FY 2018. Proposed sampling criteria for the replacement well (699-43-43B) are included within this revision.

To date, no dangerous waste or dangerous waste constituents subject to WAC 173-303 have contaminated groundwater beneath B Pond. Therefore, the site remains under an indicator evaluation program for groundwater contamination detection, as specified in 40 CFR 265.92(b).

2.3 Waste Characteristics

B Pond received effluent from several 200 East Area facilities, including the PUREX Plant, B Plant, 241-A Tank Farm, 242-A Evaporator, 244-AR Vault, and 284-E Power Plant (Figure 2-1). Dangerous waste associated with these operations came from three primary sources: (1) corrosive and dangerous waste resulting from regeneration of demineralizer columns at the PUREX Plant, (2) spills of dangerous or mixed waste from PUREX and other facilities, and (3) off-specification chemical makeups at the PUREX Plant. The dangerous waste consists of toxicity characteristic waste, acutely dangerous discarded chemical products, and state-only waste. The last dangerous waste discharge to the unit was hydrazine in July 1986 (DOE/RL-89-28, Table 4-3). The last known reportable discharge of chemical waste (sodium nitrate) occurred in 1987. The identity and quantity of dangerous waste disposed at B Pond are outlined in the Hanford Facility RCRA Permit Part A Form and presented in Table 2-1. The regulated wastes disposed included corrosive waste, cadmium, hydrazine, toxic dangerous waste criteria of extremely hazardous waste (WT01) and dangerous waste (WT02).

Table 2-1. Dangerous Waste Disposed to B Pond from Hanford Facility RCRA Permit Part A Form

Waste Constituent	Quantity kg (lb)*	Description
Nitric Acid, Sulfuric Acid, Sodium Hydroxide, Potassium Hydroxide	1,622,500 (3,577,000)	Corrosive and Toxic
Hydrazine	34,900 (77,000)	Listed

Table 2-1. Dangerous Waste Disposed to B Pond from Hanford Facility RCRA Permit Part A Form

Waste Constituent	Quantity kg (lb)*	Description
Cadmium Nitrate	76,700 (169,000)	Listed
Ammonium Fluoride/Ammonium Nitrate	8,600 (19,000)	Dangerous Waste/Toxic Dangerous Waste

* Quantity includes the water in which the chemicals were discharged.

Several sources of wastewater and effluent contributed to B Pond discharges during the operational life of the facility. The greatest volume consisted of raw Columbia River water. Discharges from these sources were routine scheduled releases and a few unplanned releases. Sources of effluent include the following:

- PUREX chemical sewer
- B Plant chemical sewer
- 242-A Evaporator steam condensate and cooling water
- 244-AR Vault cooling water
- 284-E Power Plant wastewater
- 241-A Tank Farm cooling water
- B Plant cooling water
- PUREX cooling water

Waste streams from these facilities were conveyed to the Main Pond through a system of ditches and pipelines. From the PUREX Plant, the Main Pond received mixed wastes via the 216-A-29 Ditch and PUREX cooling water line. B Plant facilities conveyed effluent via the 216-B-2-1, 216-B-2-2, and 216-B-2-3 Ditches to the 216-B-3-1, 216-B-3-2, and 216-B-3-3 Ditches, which, in turn, emptied into the Main Pond. During the final few years of operation, mostly uncontaminated water (essentially river water and condensate) from the B Plant and PUREX facilities was conveyed to the Main Pond and the 3A and 3C ponds via closed pipelines. Of the eight streams listed, the largest contributors of dangerous waste to B Pond are the PUREX and B Plant chemical sewers.

2.4 Geology and Hydrogeology

The geologic units present beneath B Pond and their orientation have a significant effect on groundwater flow and contaminant migration. The stratigraphy and groundwater hydrology of B Pond have been described in numerous previous studies:

- DOE/RL-93-74, *200-BP-11 Operable Unit RFI/CMS and 216-B-3 Main Pond, 216-B-3 Trench, and 216-A-29 Ditch Work/Closure Plan Volume 1: Facility Investigation and Sampling Strategy*
- DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*
- DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010* (Chapter 2, “Overview of Hanford Hydrogeology and Geochemistry”)
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- ECF-Hanford-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site Washington*

- PNL-10195, *Three Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System: FY 1994 Status Report*
- PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*
- SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*
- WHC-SD-EN-AP-030, *Groundwater Quality Assessment Plan for the 216-B-3 Pond System*
- WHC-SD-EN-AP-042, *Phase I Characterization of the 216-B-3 Pond System*
- WHC-SD-EN-EV-002, *Interim Hydrogeologic Characterization Report for the 216-B-3 Pond*
- WHC-SD-EN-TI-012, *Geologic Setting of the 200 East Area: An Update*

Detailed descriptions of stratigraphic relationships at B Pond are presented in DOE/RL-93-74. A description of groundwater hydrology and groundwater contamination in the region of the Hanford Site surrounding B Pond is presented in DOE/RL-2015-07. A reinterpretation of well logs and hydrostratigraphy in the 200 East Area and vicinity (PNNL-12261) has allowed a more accurate portrayal of groundwater movement beneath B Pond.

2.4.1 Stratigraphy

Figure 2-2 illustrates the general stratigraphy of the Hanford Site. Geologic cross sections that include selected wells near B Pond show the geologic units underlying the area (Figures 2-3, 2-4, and 2-5). The principal geologic units beneath B Pond include the Pleistocene Hanford formation, Miocene/Pliocene Ringold Formation, and Miocene Elephant Mountain Member of the Saddle Mountains Basalt. General characteristics of these lithostratigraphic units (from youngest to oldest) are summarized as follows:

- A discontinuous veneer of Holocene eolian silty sand or backfill mixtures of sand and gravel.
- Hanford formation – Cataclysmic flood deposits equivalent to hydrostratigraphy unit (HSU) 1. The Hanford formation consists of three facies subunits (silt dominated, sand dominated, and gravel dominated), which grade into one another both vertically and laterally (Figure 2-2). The majority of the vadose zone above the Ringold Formation units is the Hanford formation as shown on Figures 2-3, 2-4, and 2-5. The Hanford formation ranges in thickness from approximately 40 m (130 ft) beneath the 3C Pond to about 50 m (160 ft) at the northwestern corner of the Main Pond (Figure 2-5). On the Central Plateau, the Hanford formation is sometimes further delineated into H1, H2, and H3 lithostratigraphic sequences. H1 and H3 gravel sequences are not differentiated in those areas where the intervening sandy H2 sequence is absent. Units H1 and H3 consist of coarse-grained, basalt-rich, sandy gravels with varying amounts of silt/clay. These gravel units may also contain interbedded sand and or silt/clay lenses, and the units are notably rich in clay near the western portion of B Pond, as indicated in well logs from this area. The H2 sequence is dominated by sand to gravelly sand, with minor sandy gravel or silt/clay interbeds. Both the sand dominated and gravel dominated sequences are present near the Main Pond of the B Pond system (Figures 2-3, 2-4, and 2-5).
- Cold Creek unit (CCU) – equivalent to HSUs 2 and 3. The CCU is often undifferentiated but regionally has been subdivided into three subunits: CCU_z (Early Palouse Soil) and Unit C (caliche), both of which are primarily located in 200 West Area, and Unit G (pre-Missoula gravels), which is primarily located beneath the 200 East Area and vicinity. In much of the 200 East Area, the CCU is

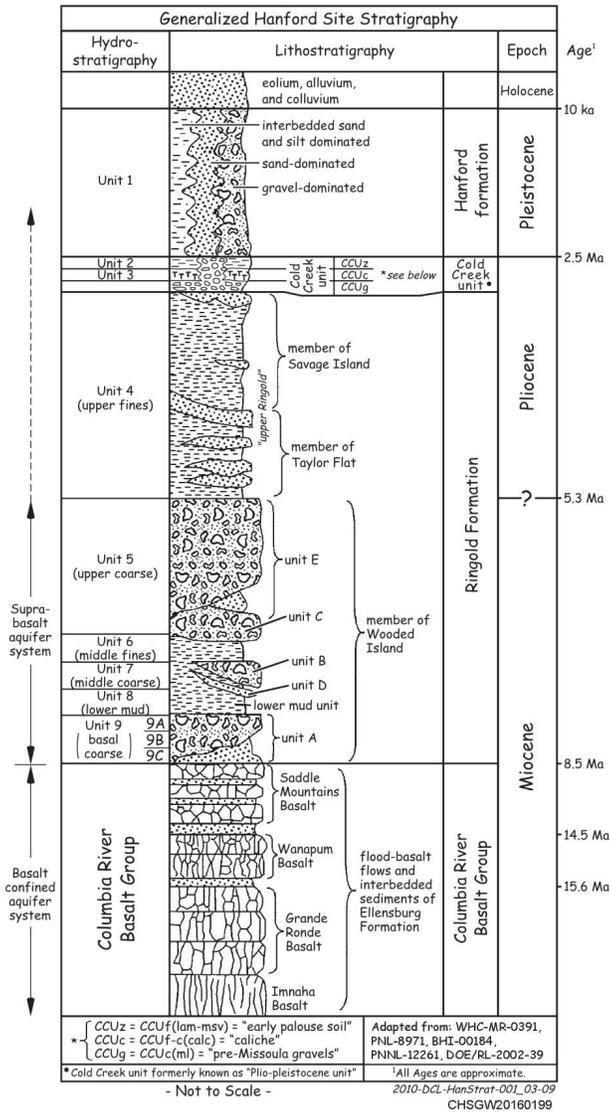
characterized as a quartzo-feldspathic sandy gravel (Unit G) above the Ringold Formation and below the more basaltic Hanford formation.

- Ringold Formation, Unit E – equivalent to HSU 5. Fluvial deposits with thick layers of silty sandy gravel (conglomerate), intercalated with thinner beds of overbank silts and fine-grained paleosols. In the 200 East Area, Unit E is present only in the southern quarter of the area because, in the northern three-quarters of the 200 East Area, the unit has been removed by erosion or was not deposited. Unit E has been removed through most of the far eastern portion of 200 East Area, including under the B Pond system, to approximately the May Junction Fault (located to the east of the B Pond area; Figures 2-6, 2-7, and 2-8), by the ancestral Columbia River and Missoula floods. Unit E was not removed from the downthrown side of the fault because of the structural displacement into the basin and distance from the highest forces of the floods (PNNL-12261).
- Ringold Formation, lower mud unit – equivalent to HSU 8. This unit is composed of a sequence of fluvial overbank, paleosol, and lacustrine silt and clay, with minor sand and gravel. This unit is an aquitard, creating confining conditions, and isolating the Ringold Formation Unit E from the underlying Ringold Formation Unit A when all units are present. The Ringold lower mud sequence is not present in the middle (Figure 2-4) and northwestern portion of B Pond (Figure 2-5), but is greater than 20 m (66 ft) thick east of TEDF, generally thickening south and southeast of B Pond (Figure 2-6). The Ringold lower mud unit consists mostly of various mixtures of silt and clay (DOE/RL-93-74). This unit is particularly important to effluent infiltration and groundwater flow patterns east and southeast of the Main Pond.
- Ringold Formation, Unit A – equivalent to HSU 9. Unit 9 can be further subdivided into three hydrostratigraphic subunits based on different lithologies and hydraulic properties (Figure 2-2). The middle subunit is characterized as a silt to clay-rich confining zone with lower permeability, defined as subunit 9B. Upper and lower subunits (9A and 9C) have much higher permeability and lower clay content and consist of consolidated silty sandy gravel deposits. Occurrence of these subunits in the B Pond area are shown in Figures 2-3, 2-4, 2-5, and 2-6.
- Bedrock consisting of Columbia River Basalt flows dip gently to the south toward the axis of the Cold Creek syncline. The two uppermost flows are within the Elephant Mountain Member of the Saddle Mountains Basalt.

2.4.2 Hydrogeology

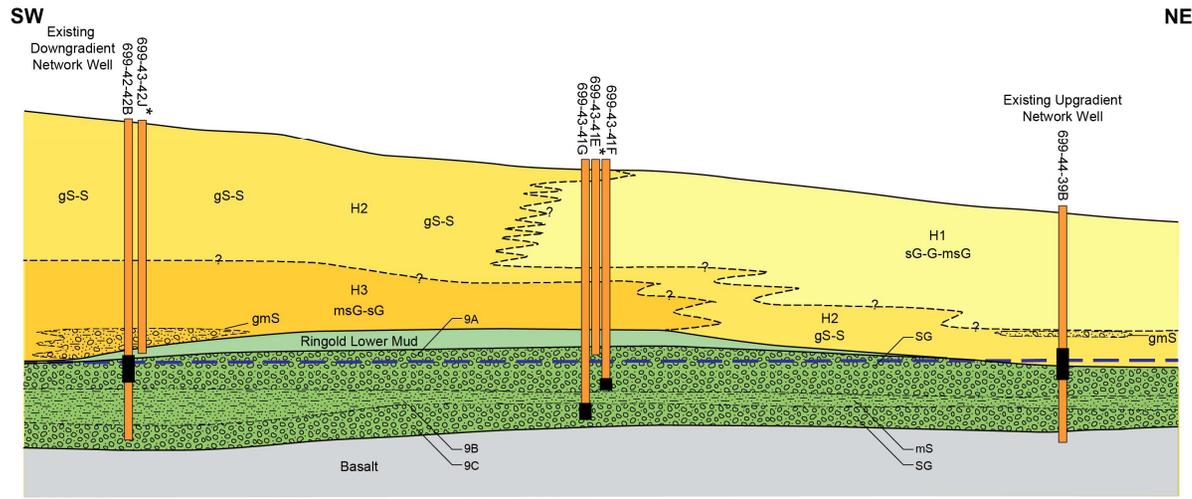
Figure 2-6 illustrates the hydrostratigraphic relationships in the B Pond/TEDF area, hydraulic elevation heads, and groundwater flow characteristics. Because of the dipping beds of the Ringold Formation in this area and the erosional unconformable contact with the overlying Hanford formation, groundwater beneath the B Pond System can occur in both confined and unconfined states, depending on the location (Figures 2-3, 2-4, 2-5, and 2-6). The uppermost aquifer is unconfined west, southwest, and northwest of the Main Pond where the Ringold Formation confining units (Unit 8 and Unit 9B) are absent (Figures 2-4, 2-5, 2-6, 2-7, and 2-8). The aquifer becomes progressively more confined to the east and southeast of the Main Pond (Figures 2-3 and 2-6).

DOE/RL-2008-59, REV. 2
RCRA-CN-02_DOE/RL-2008-59_R2



Note: Complete reference citations are provided in Chapter 6.

Figure 2-2. General Stratigraphy at the Hanford Site



Legend

- Well
- Well Screen Interval
- Dry Well
- 2015 Water Table (122 m AMSL)
- Hanford Upper Gravel-Dominated Facies (H1) – Sandy Gravel to Gravel to Silty Sandy Gravel (G-sG-msG)
- Hanford Sand-Dominated Facies (H2) – Gravelly Sand to Sand (gS-S)
- Hanford Lower Gravel-Dominated Facies (H3) – Silty Sandy Gravel to Sandy Gravel (msG-sG)
- Ringold Lower Mud
- Ringold Unit A
- Basalt

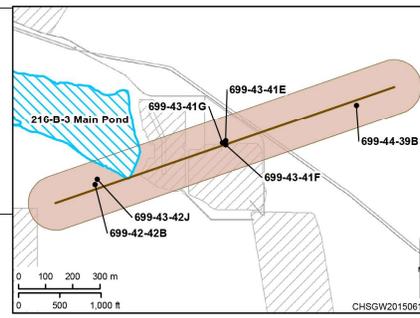
Localized Lithology

- Silty Sand (mS)
- Gravelly Sand (gS)
- Gravelly Silty Sand (gmS)
- Sandy Gravel (sG)
- Silty Sandy Gravel (msG)
- Gravel (G)

AMSL = Above Mean Sea Level
 Note: 5x vertical exaggeration.

Map Legend

- Well Location
- 216-B-3 Main Pond, 216-B-3-3 Ditch
- Waste Site or TSD Unit
- Facility (may also be a TSD unit)
- Cross Section Line
- Cross Section Line Buffer (75 m)
- Roads



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Figure 2-3. Southwest-Northeast Geologic Cross Section Showing the Stratigraphy below the Southeastern Portion of the B Pond (Main Pond)

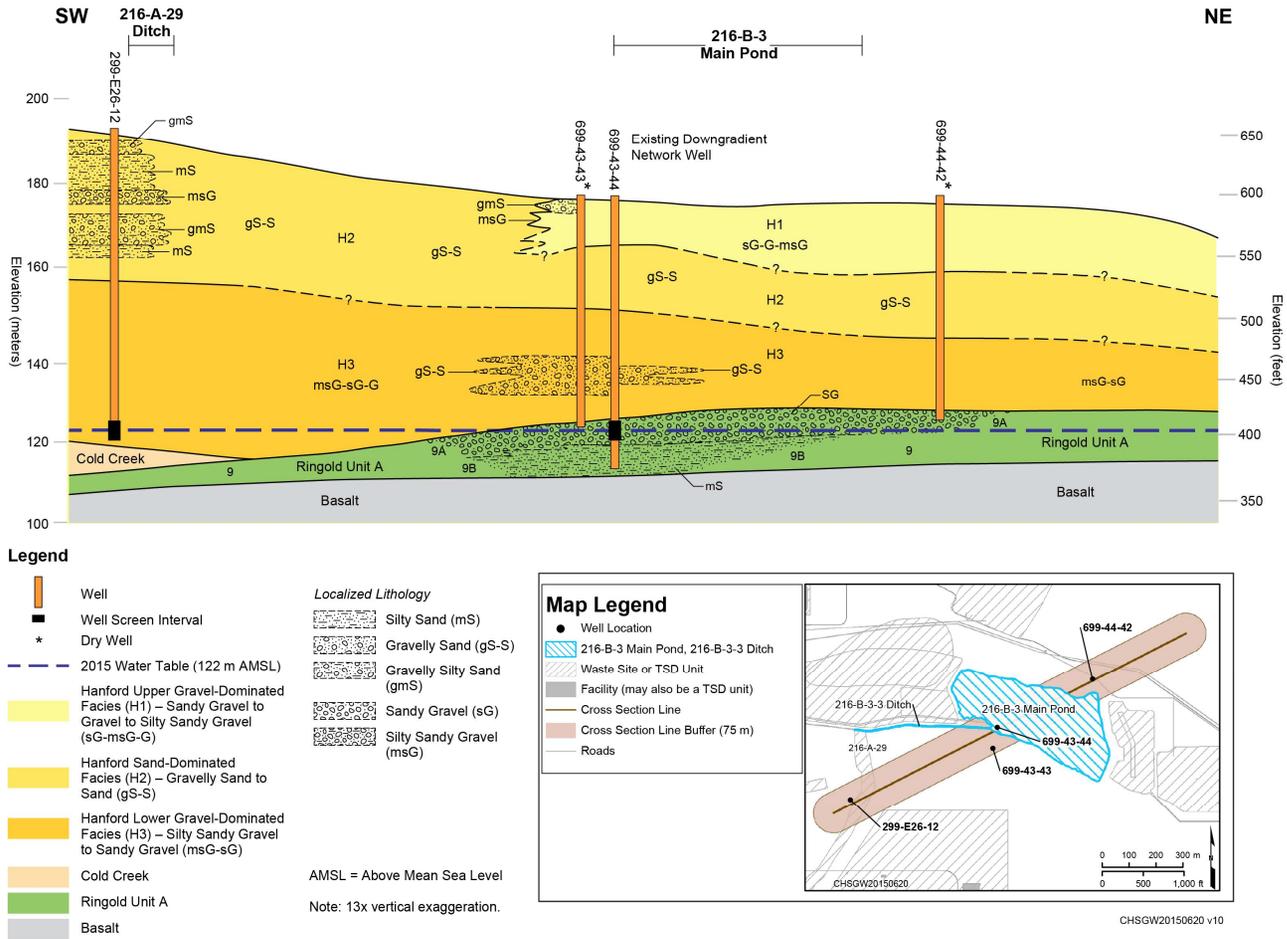


Figure 2-4. Southwest-Northeast Geologic Cross Section Showing the Stratigraphy below the Middle Portion of the B Pond

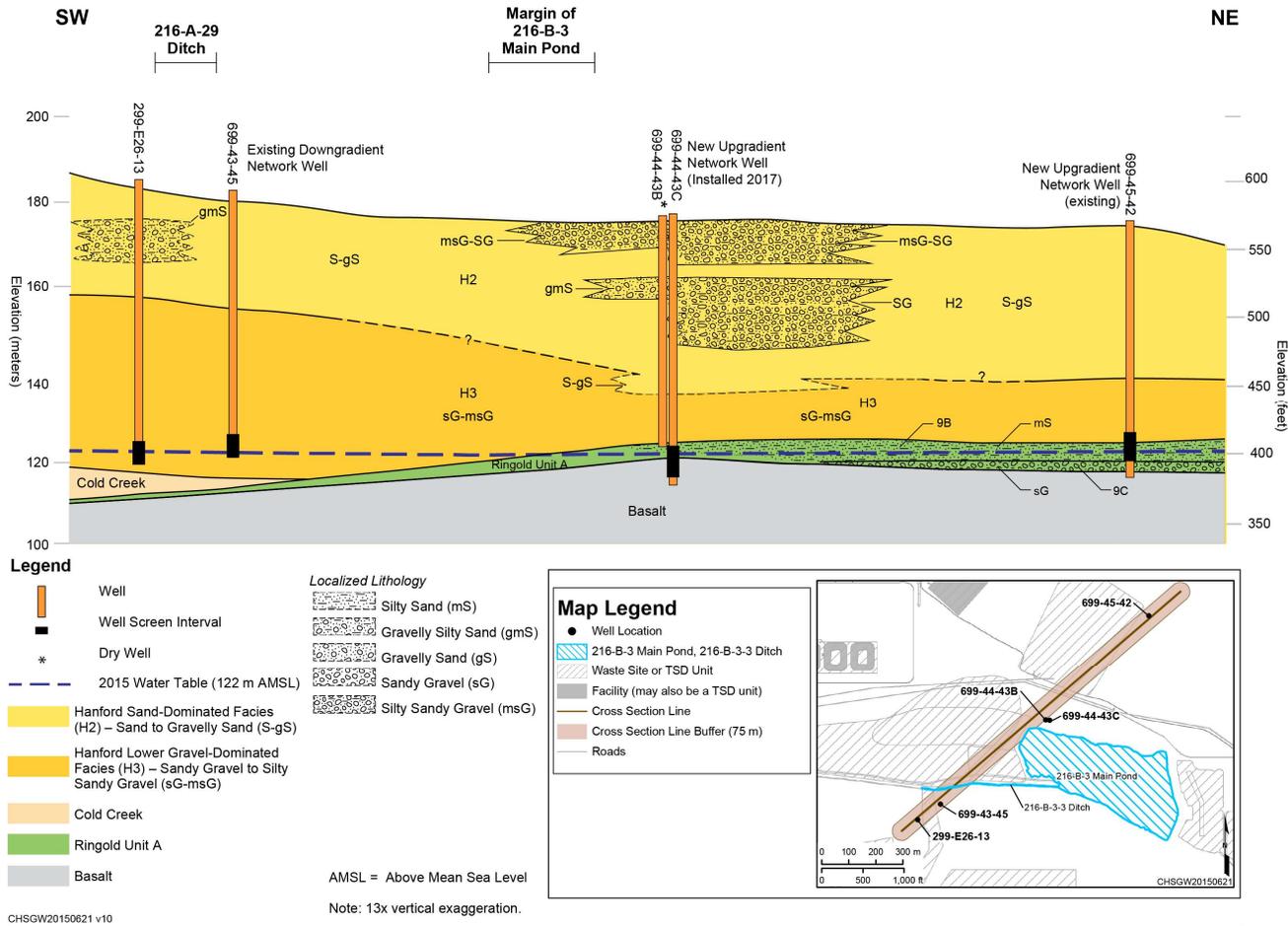


Figure 2-5. Southwest-Northeast Geologic Cross Section Showing the Stratigraphy below the Northwestern Portion of the B Pond

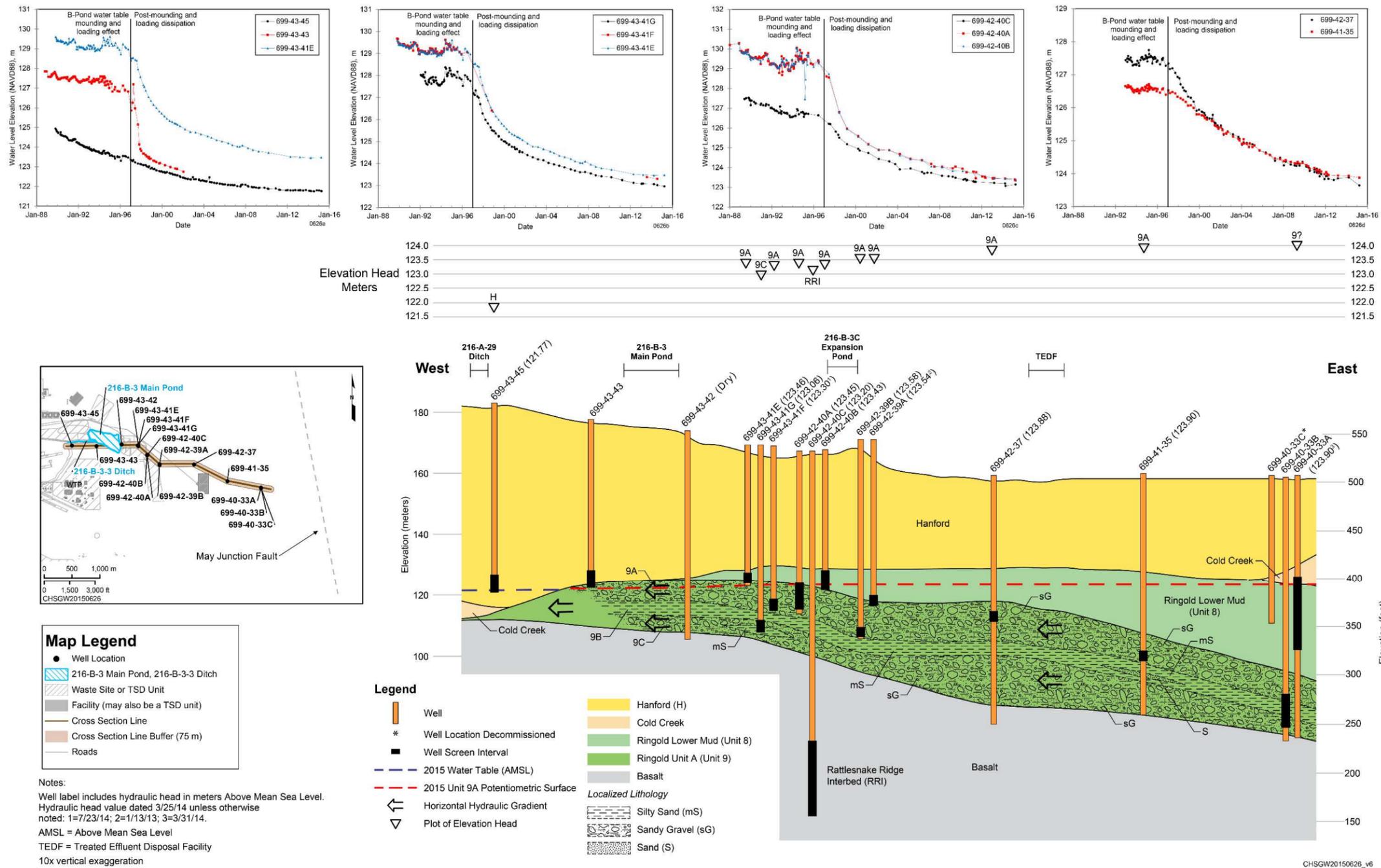
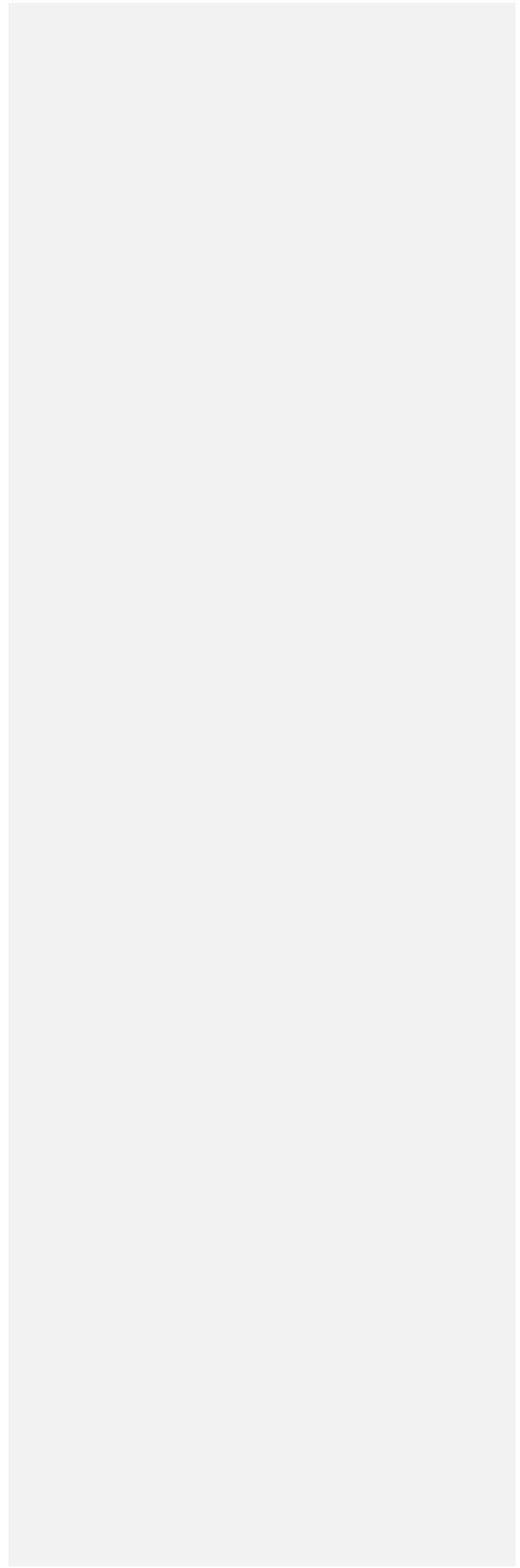


Figure 2-6. Hydrostratigraphy Extending from below B Pond Southeast toward Treated Effluent Disposal Facility

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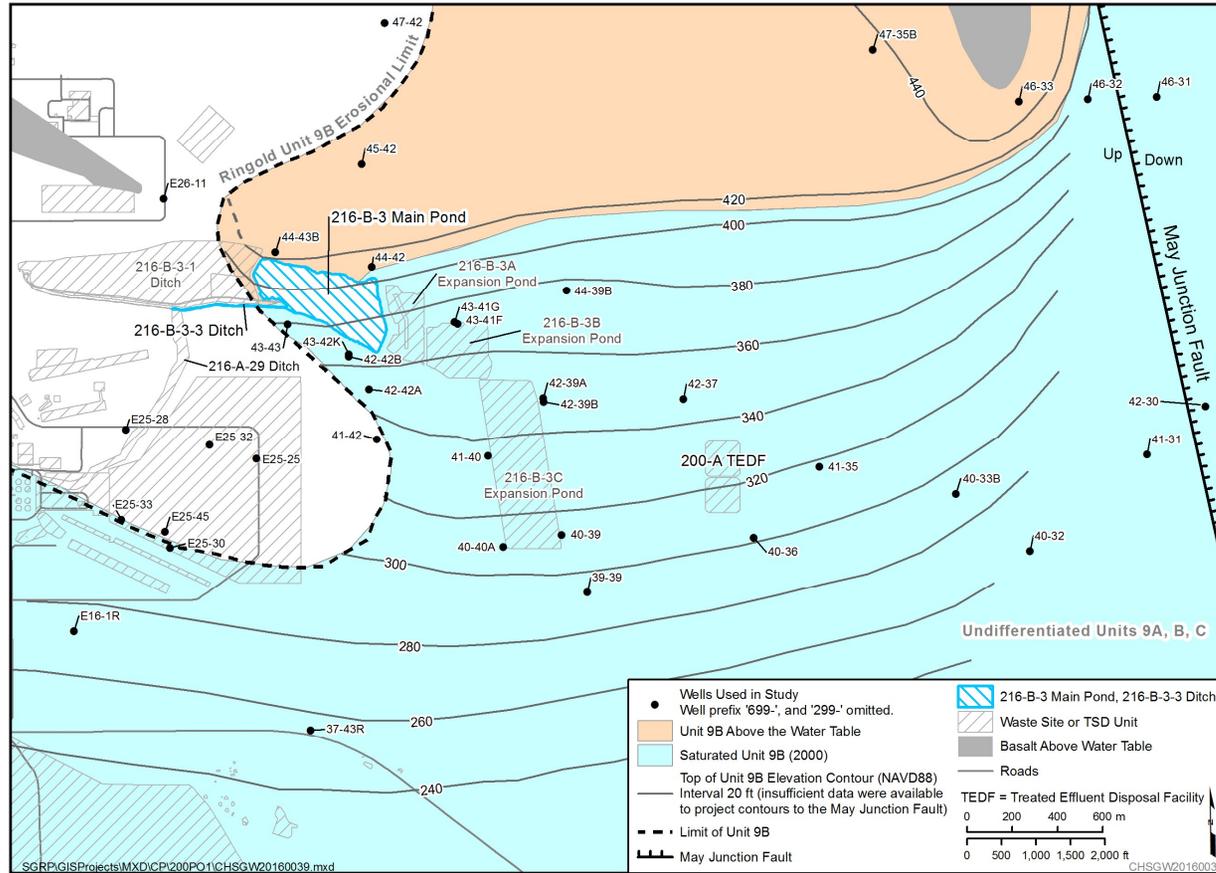


Figure 2-8. Elevation Contour Map of the Top of the Ringold Formation Unit 9B, Aquifer Confining Unit (After PNNL-12261)

The Ringold Formation gravels (Units 9A and 9C) comprise the bulk of the uppermost aquifer in the B Pond area. In the south-central and southwestern part of the site (south-central portion of the Main Pond and a portion of 216-B-3-3 Ditch), the unconfined aquifer occurs in Ringold Unit 9A (Figure 2-4), as well as the Hanford formation (Figures 2-4 and 2-5). Most of the Hanford formation aquifer near B Pond is coarse-grained and highly permeable. Estimates of the saturated thickness of the uppermost aquifer vary from west to east across B Pond (Figures, 2-3, 2-4, 2-5, and 2-6). On the west side, approximately 6 m (20 ft) of unconfined Hanford formation sandy gravels are present near the northern end of the 216-A-29 Ditch. Near the southeast side of the Main Pond (Figure 2-3), the uppermost aquifer is made up of approximately 7 m (23 ft) of Ringold Formation Unit 9A (unconfined) and 5 m (16 ft) of Ringold Formation Unit 9C (semi-confined). Farther east, the uppermost aquifer includes approximately 12 m (39 ft) of Unit 9A and 6 m (20 ft) of Unit 9C near the northern end of the 3C Pond. Where hydraulic conductivities have been measured in the B Pond area, values have been calculated ranging from 1.0 m/day (3.3 ft/day) for the Ringold Formation to 640 m/day (2,100 ft/day) for the Hanford formation (WHC-SD-EN-EV-002; PNL-10195).

2.4.3 Groundwater Flow Interpretation

During active operations, groundwater beneath the B Pond was interpreted to flow radially outward in the unconfined aquifer from the hydraulic mound that was generated as the result of the large artificial effluent recharge volume. The apex of the mound was located near 216-B-3B Pond (Figure 2-9). This mound remained a major influence on flow direction even after discharges to the 3C expansion pond ended in 1997.

The confined aquifers of Ringold Unit 9 (subunits 9A and 9C) southeast of the B Pond area appear to have been mostly isolated from a significant part of the B Pond effluent discharges (Figure 2-6). The B Pond effluent was mostly intercepted by the intervening Ringold lower mud unit (Unit 8) and diverted along the upper surface of this fine-grained unit, which is structurally dipping to the south (Figure 2-7). When groundwater mounding was occurring, where the Ringold lower mud unit (Unit 8) isolates Ringold Unit 9 aquifers 9A and 9C (Figure 2-6), B Pond effluent entered the overlying more permeable Hanford formation and spread laterally (Section 2.2, Section 2.3, and Figure 2-2 in PNNL-15479). Migration appears to have occurred preferentially to the south and west of the Main Pond when saturated flow occurred in the permeable Hanford formation (Figure 2-9). Confinement of the Ringold Unit 9 aquifers to the east is supported by the fact that no hydrologic response to TEDF discharges to the vadose zone has been observed in the TEDF wells completed in Unit 9A since the facility began operating in 1995. Wells in the area, including those near the 3C expansion pond and TEDF, have shown a regional decline in head since late 1996 or early 1997 (Figure 2-6).

Some of the B Pond effluent apparently did enter Units 9A and 9C where the overlying confining layers (Ringold lower mud Unit 8 and Unit 9B) are absent. This occurred primarily in the northern portion the Main Pond (Figure 2-4) and to the east and southeast of the B Pond where Ringold Units 8 and 9B pinch out or have been eroded and are in contact with the Hanford formation (Figures 2-7 and 2-8). How B Pond effluent may have penetrated into Units 9A and 9C in these areas is illustrated in DOE/RL-2008-59, Rev. 0 on Figure 2-3 and in PNNL-12261 on Figure 4.10. Groundwater sampling data indicate that any constituents associated with this effluent may not have migrated very far to the east, even though there was a hydraulic gradient in this direction due to groundwater mounding and increased hydrostatic load beneath the B Pond. A stratigraphic “trap” could exist east of the B Pond System (i.e., east of 3C Pond and the TEDF) where the May Junction Fault has been identified (Figures 2-7 and 2-8). The stratigraphic and hydrologic lateral discontinuities forming the potential “stratigraphic trap” at the May Junction Fault east of B Pond are discussed in Section 4.1.2.4 and illustrated on Figure 4-4 of PNNL-12261. The north-south trending May Junction Fault appears to represent a barrier to groundwater

flow in Units 9A and 9C, preventing any appreciable flow to the east. An extensive discussion of historical groundwater flow conditions in the 200 East Area in general and in the vicinity of B Pond more specifically, is presented in Section 4.2 of PNNL-12261. In the analysis provided in Section 4.2.3 of PNNL-12261, it was found that a comparison of hydrochemistry data did not support easterly movement of groundwater in the confined Ringold aquifer to the east of B Pond on the upthrown side of the fault. Calculations of hydraulic conductivity, stratigraphic relationships noted to the south and southeast of B Pond (Figures 2-6, 2-7 and 2-8), and groundwater geochemistry (Figure 4.3 in PNNL-13367, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*) suggest that the movement of groundwater in an east and southeast direction was more limited than depicted by some historical interpretations of the water table around B Pond (Figure 2-9 A and C). Interpretations of flow directions in 1991 (Figure 2-9 B) and 2004 (Figure 2-9 D) indicate an interpreted predominant flow direction to the west and southwest. Thus, the relatively uniform radial flow pattern envisioned in earlier reports (e.g., PNNL-11604) was likely oversimplified.

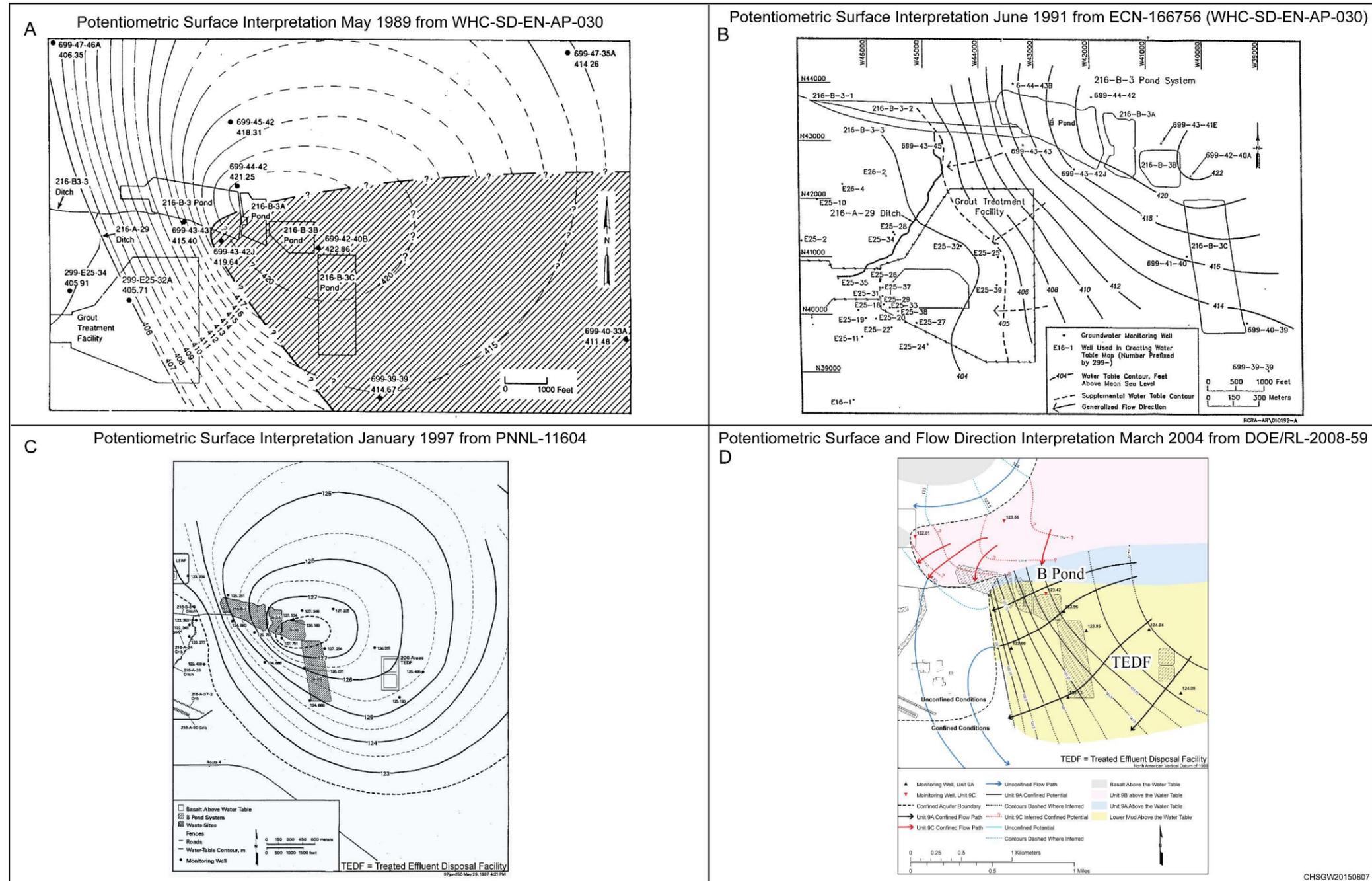
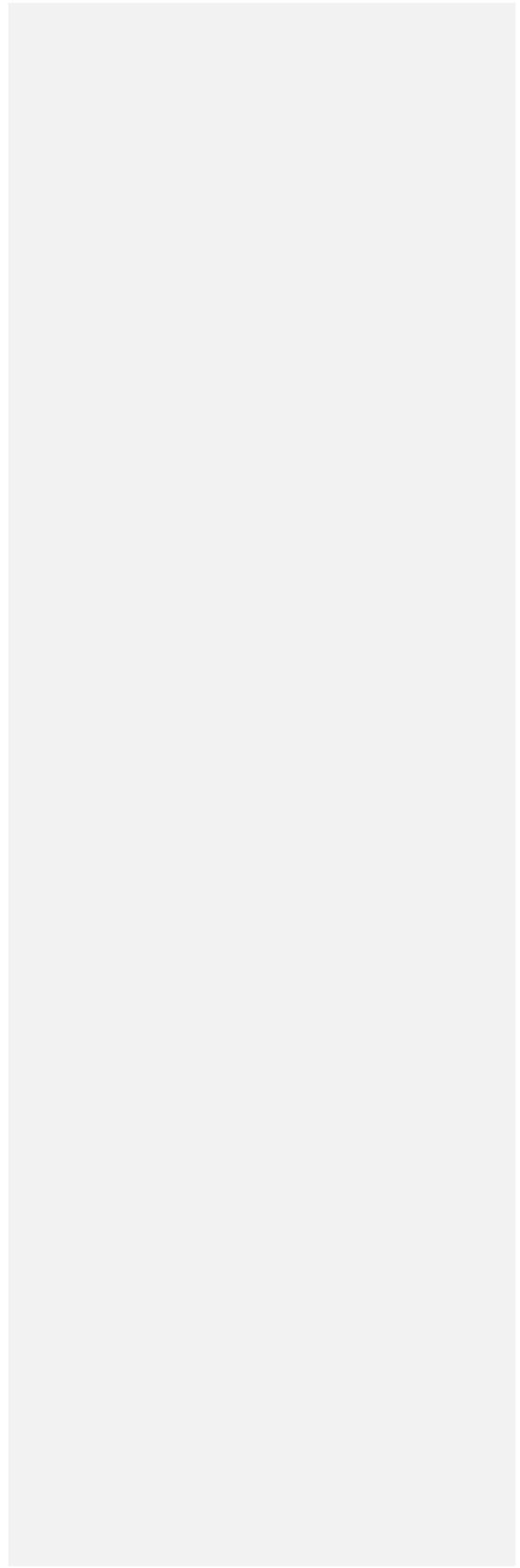


Figure 2-9. Historic Potentiometric Surface and Groundwater Flow Pattern Interpretations in the B Pond Area 1989, 1991, 1997, and 2004

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For the saturated Ringold units underlying the B Pond System and TEDF, groundwater currently flows to the west and southwest and discharges to the unconfined aquifer along the erosional boundary of confining Units 8 and 9B (Figures 2-3, 2-4, 2-5, 2-6, 2-7, and 2-8). Aquifer tests of Units 9A and 9C show that hydraulic conductivities and calculated average flow rates are low. Using a hydraulic conductivity of 1.0 m/d (3.3 ft/d) (WHC-SD-EN-EV-002 and PNL-10195), effective porosity of 0.25, hydraulic gradients of 0.0015 and 0.0013 for units 9A and 9C (respectively, derived from Figure 2-10), and the Darcy equation, the calculated average linear flow rates are 0.006 m/d (0.020 ft/d) and 0.005 m/d (0.016 ft/d) for Units 9A and 9C (respectively) for the area near B Pond. Based on recent groundwater flow and transport modeling iterations, the average hydraulic conductivity for the Hanford formation gravel-dominated sequence (H3) and CCU, where channelized flow occurs, is estimated to be approximately 17,000 m/day (55,777 ft/day) and 2.27 m/day (7.45 ft/day) in those areas without channelized flow where older sediment occurs (CP-57037, Table 3-1). A synopsis of hydraulic properties for Hanford Site stratigraphic units is provided in Section 2.5 of PNL-10886. Hydraulic conductivity of the sand and gravel dominated sequence in Hanford formation and the pre-Missoula gravel deposits (i.e. CCU) generally ranges from 1 to 1,000,000 m/d and is much higher than any of the other units that compose the unconfined aquifer. The estimated flow velocity of the Hanford formation and Cold Creek Unit comprising the unconfined aquifer to the southwest of B Pond is estimated to range from 0.0036 m/day to 0.6 m/day (0.012 ft/day to 1.97 ft/day) (Table B-1 in DOE/RL-2015-07).

Head differences between wells completed in Units 9A versus 9C that are indicative of aquifer separation are most notable in reviewing the historical hydrographs at the top of Figure 2-6 for wells 699-43-41G completed in Unit 9C versus wells 699-43-41E and 699-43-41F, completed in Unit 9A. As noted in the head data for the period shown when B Pond water table mounding was prevalent and a hydraulic loading effect on the confined aquifers was occurring (from January 1988 to approximately April 1996), there is marked separation in heads in the wells completed in Units 9A versus 9C. Wells 699-43-41E and 699-43-41F that are both completed in Unit 9A show similar head values, both during the mounding and loading effect and, subsequently, as the groundwater mounding and hydraulic loading dissipated. Whereas well 699-43-41G, completed in Unit 9C, shows different head values both pre- and post-mounding because of aquifer separation.

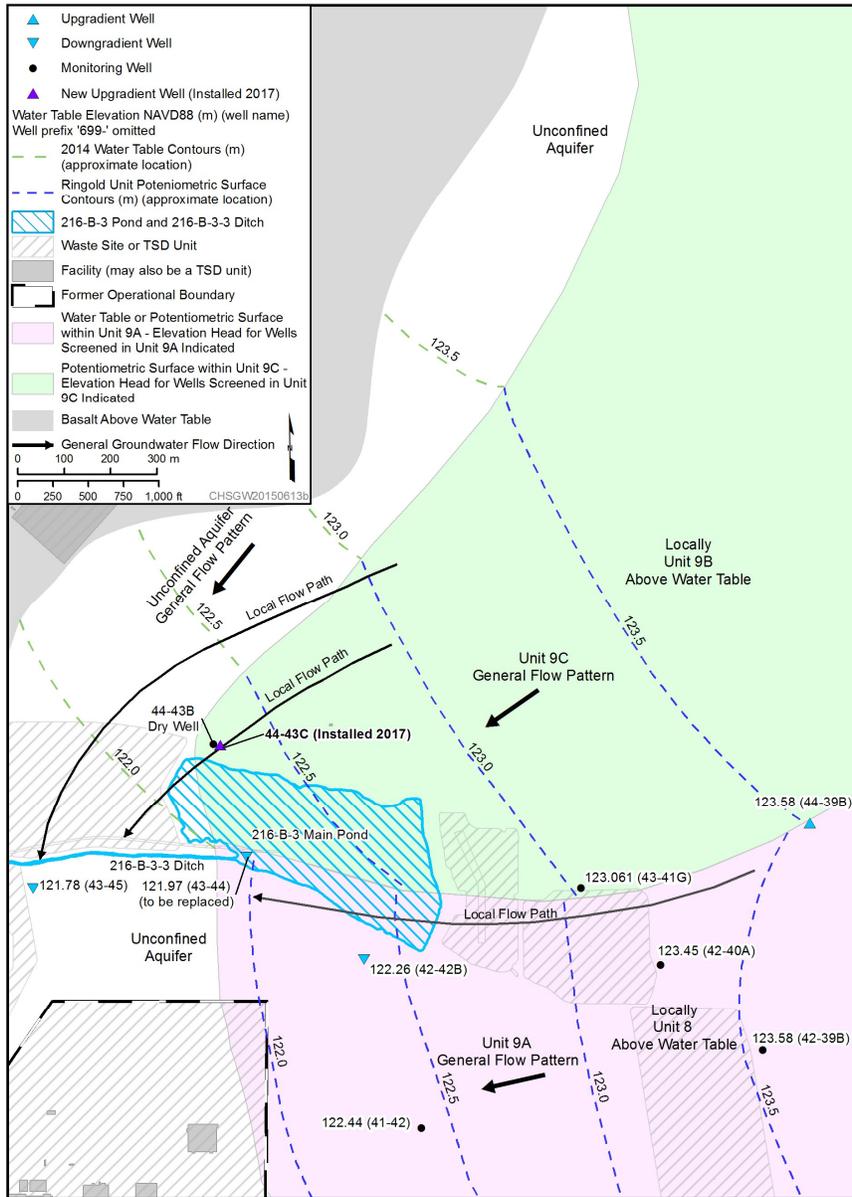


Figure 2-10. Groundwater Flow near B Pond in 2014

2.5 Summary of Previous Groundwater Monitoring

Table 2-2 lists the previous groundwater monitoring plans implemented at B Pond.

Table 2-2. Previous Monitoring Plans

Document	Date Issued	Monitoring Program*
DOE, 1987, <i>Preliminary Closure/Post-Closure Plan 216-B-3 Pond</i>	1987	Indicator Evaluation Program
WHC-SD-EN-AP-013, <i>Interim-Status Groundwater Monitoring Plan for the 216-B-3 Pond, Rev. 0</i>	1989	Indicator Evaluation Program
WHC-SD-EN-AP-030, <i>Groundwater Quality Assessment Plan for the 216-B-3 Pond System, Rev. 0</i>	1990	Groundwater Quality Assessment Plan
WHC-SD-EN-AP-030 (ECN 166756)	1992	Groundwater Quality Assessment Plan
WHC-SD-EN-AP-013, Rev. 1	1995	Indicator Evaluation Program
PNNL-13367, <i>Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility</i>	2000	Indicator Evaluation Program
PNNL-13367-ICN-1	2002	Indicator Evaluation Program
PNNL-15479, <i>Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility</i>	2005	Indicator Evaluation Program
DOE/RL-2008-59, <i>Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond, Rev. 0</i>	2010	Indicator Evaluation Program
DOE/RL-2008-59, <i>Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond, Rev. 1</i>	2017	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 quality assessment program's first determination satisfies the requirements of 40 CFR 265.93(d)(4) and (d)(6), "Preparation, Evaluation, and Response."

Groundwater monitoring was initiated at B Pond in 1988 in accordance with the preliminary closure plan (DOE, 1987). Under this interim status indicator evaluation plan, samples were to be collected quarterly for the first year at six planned wells and analyzed for contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b). In 1989, the interim status indicator evaluation program was issued as a separate monitoring plan (WHC-SD-EN-AP-013, Rev. 0); it included one existing (699-42-40A), four new (699-42-42B, 699-43-43, 699-43-42J, and 699-44-42), and six planned (699-40-39, 699-41-40, 699-43-41E, 699-43-41F, 699-43-45, and 699-44-43B) downgradient wells and two existing (299-E18-1 and 299-E32-4) upgradient wells (Figure 2-11). Wells 299-E18-1 and 299-E32-4 were located as close to B Pond as possible while located outside the influence of the B Pond mound (WHC-SD-EN-AP-013 Rev. 0, Section 3.0). Analysis for volatile organic constituents, hydrazine, and ammonia was also included. After the first year of sampling, the frequency changed to semiannual.

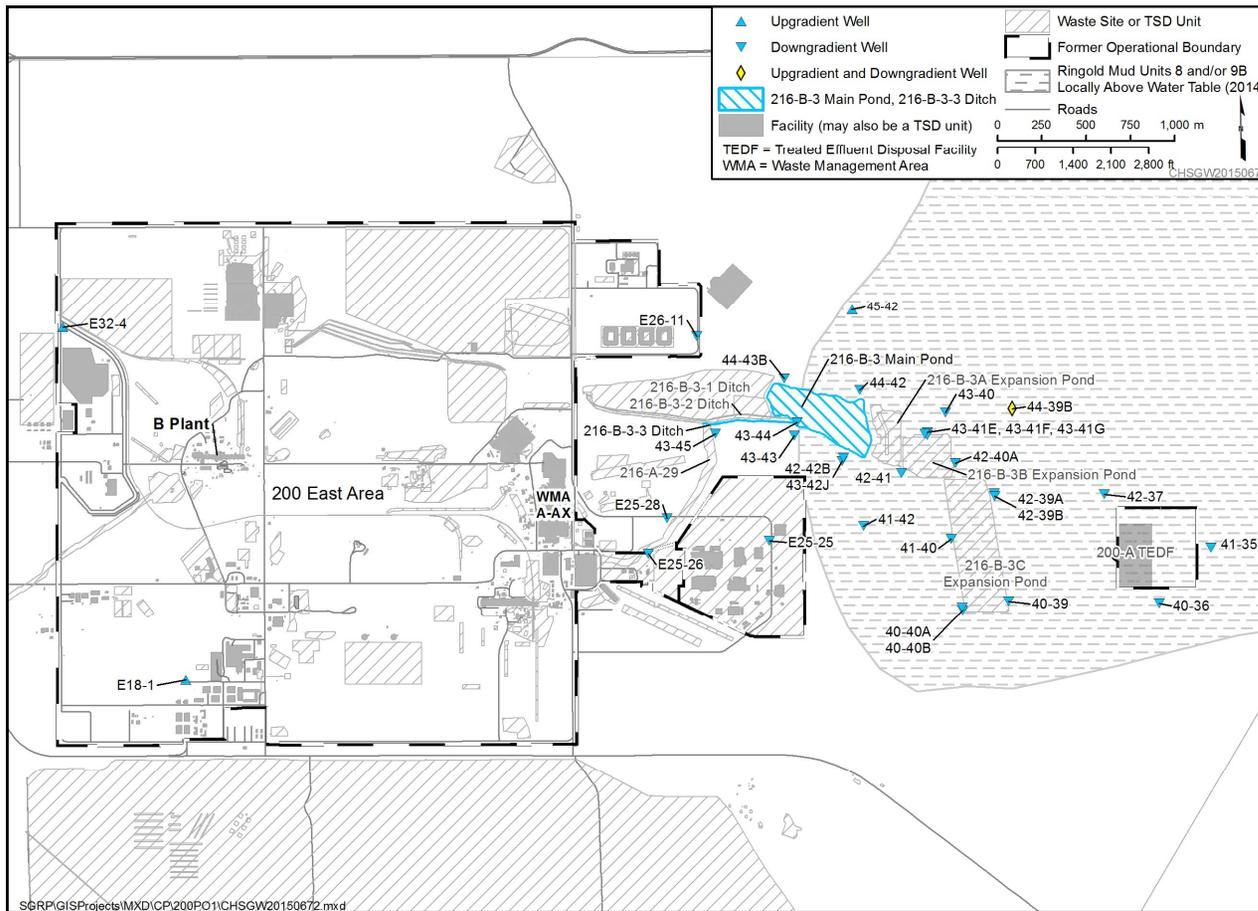


Figure 2-11. Historical RCRA Groundwater Network Wells Used to Monitor the B Pond System

Groundwater monitoring was changed from an indicator evaluation program to an assessment program in 1990 because levels of TOC and TOX in two downgradient wells (699-43-41E and 699-43-41F) exceeded the critical mean (PNNL-11604). A groundwater quality assessment plan (WHC-SD-EN-AP-030, Rev. 0) was prepared in 1990 and revised in 1992, to include two additional monitoring wells (ECN 166756, Section 12). The plan included 11 downgradient wells (699-40-39, 699-41-40, 699-42-40A, 699-42-42B, 699-43-41E, 699-43-41F, 699-43-42J, 699-43-43, 699-43-45, 699-44-42, and 699-44-43B) and two upgradient wells (299-E18-1 and 299-E32-4). Seven downgradient wells (699-40-40A, 699-40-40B, 699-42-39A, 699-42-39B, 699-42-41, 699-43-40, and 699-43-41G), installed in 1991 and two downgradient wells (699-41-42 and 699-44-39B) installed in 1992 were also included (Figure 2-11). Constituents included 40 CFR 265.92(b) required parameters, site-specific parameters (ammonium, hydrazine, and total organics), and assessment parameters (herbicides, pesticides, enhanced volatiles, acid/base/neutrals, and polychlorinated biphenyls).

Samples for the groundwater assessment were collected from 1994 to 1996. Results of the groundwater quality assessment were issued in 1997 (PNNL-11604) and found that only one compound, tris(2-chloroethyl) phosphate, may have contributed to the elevated TOX results. No compounds were identified as a contributor to elevated TOC. Due to the low concentrations of TOX and TOC, no further investigation was performed and monitoring returned to an indicator evaluation program under WHC-SD-EN-AP-013, Rev. 1. The revised plan included 16 downgradient wells (699-40-36, 699-40-39, 699-40-40A, 699-41-35, 699-41-40, 699-41-42, 699-42-37, 699-42-39B, 699-42-41, 699-42-42B, 699-43-40, 699-43-41E, 699-43-41G, 699-43-45, 699-44-39B, and 699-44-43B) and two upgradient wells (299-E18-1 and 299-E32-4) (Figure 2-11). Samples were collected quarterly and analyzed for 40 CFR 265.92(b) contamination indicator parameters and site-specific parameters (gross alpha, gross beta, alkalinity, turbidity, anions, semivolatile organic compounds, and metals).

The number of wells in the B Pond monitoring network was reduced in 1995 after clean closure of the 3A, 3B, and 3C expansion ponds to eliminate redundancy and focus resources on additional hydrochemical analyses in the remaining wells. Three of the wells no longer in the B Pond network were part of the TEDF groundwater monitoring network. These three wells were monitored for informational purposes only and were not part of the B Pond network. In 1996, an upgradient well (299-E18-1) was removed from the network following closure of the 2101-M Pond. The other upgradient well (299-E32-4) was shared with the low-level burial grounds facility in the 200 East Area (Figure 2-11).

Hydrazine was last included as a B Pond constituent in the 1995 monitoring plan revision (WHC-SD-EN-AP-013, Rev. 1). PNNL-11604 reports that hydrazine was only detected in three samples, with a maximum of 5 µg/L at well 699-40-36. Because hydrazine was discharged as an off-specification chemical, it is considered a listed waste (U133). During the investigation of the Main Pond and 216-B-3-3 Ditch, a “contained-in” determination for hydrazine was approved by Ecology for soils associated with investigation derived waste and any future contaminated soil designations for the Main Pond and 216-B-3-3 Ditch (Hedges, 2000, “Approval of the Contained-In Determination Request for Hydrazine”). Based on results from the sampling effort, hydrazine is not considered a contaminant of interest at B Pond due to rapid oxidation in the environment to nitrogen and water.

In 1998, a revision to the interim status indicator evaluation groundwater monitoring plan was proposed in PNNL-11903, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*, which incorporated final status sampling requirements under WAC 173-303-645, “Releases from Regulated Units,” in anticipation of approval of an updated closure plan. Statistical methods for intrawell groundwater data evaluation were included. Although PNNL-11903 was never implemented, it was used as a basis for the subsequent monitoring plan revision. Groundwater monitoring continued under WHC-SD-EN-AP-013, Rev. 1.

From late 1998 through early 2000, the network was restructured (existing wells were dropped or added) to adjust for changes in the groundwater flow direction following cessation of effluent disposal to the facility, compensate for the drying of some wells, and reduce redundancy in monitoring locations. In September 1999, a new downgradient well (699-43-44) was installed to fill a gap in coverage left by drying of a well (699-43-43) and compensate for changes in groundwater flow directions beneath B Pond.

In 2000, a revised monitoring plan (PNNL-13367) was issued based on PNNL-11903. PNNL-13367 incorporated final status requirements elements under WAC 173-303-645 but also included the constituents and indicator parameters required for an interim status program under 40 CFR 265.92(b). An intrawell statistical evaluation approach was included for a two-year trial. The plan included three downgradient wells (699-42-42B, 699-43-44, and 699-43-45) and one upgradient well (699-44-39B) (Figure 2-11). Sampling was included for the 40 CFR 265.92(b) required parameters, field parameters (alkalinity, dissolved oxygen [DO], turbidity, and temperature), and site-specific parameters (gross alpha and gross beta). Arsenic was identified as a previously detected groundwater contaminant but was not known to be associated B Pond. Therefore, arsenic and nitrate (which may have originated from B Pond) were included for sampling as part of a sitewide surveillance effort.

In 2002, PNNL-13367 was revised (PNNL-13367-ICN-1) to update the constituents and well network and incorporate certain criteria required for obtaining a variance from interim status regulations based on Ecology guidance concerning monitoring network, constituent list, statistical analysis, and reporting procedures (PNNL-13367-ICN-1, Section 1.0). Well 699-43-43 (Figure 2-11) was added back to the network in 2002 per agreement with Ecology to serve as a historical surrogate for well 699-43-44 to establish the degree of data comparability between wells (PNNL-13367-ICN-1). Well 699-43-43 was considered part of the network and was to be sampled as long as it remained serviceable, which was estimated to be less than one year. Well 699-43-43 was later decommissioned in 2004. Revised constituents were included for semiannual sampling of site-specific indicator parameters (specific conductance, gross alpha, and gross beta), field parameters (alkalinity, DO, pH, turbidity, and temperature), and additional chemical parameters (arsenic and nitrate as part of sitewide surveillance efforts and cadmium, lead, mercury, and silver for a four-year evaluation period based on previous soil investigation results). Annual sampling for 40 CFR 265.92(b) groundwater quality parameters was also included.

In 2005, a revised monitoring plan (PNNL-15479) was issued to reestablish the sampling frequency and evaluation requirements under an interim status indicator evaluation program, while results of the alternate statistical approach from PNNL-13367-ICN-1 were evaluated. The anticipated closure plan had not been approved, and final status monitoring elements from the previous plan were removed in PNNL-15479. The statistical analysis method returned to that for interim status indicator parameter evaluation under 40 CFR 265. Semiannual sampling was included for indicator parameters required under 40 CFR 265.92(b) and field parameters (alkalinity, DO, turbidity, and temperature). Annual sampling for 40 CFR 265.92(b) groundwater quality parameters, anions (chloride, sulfate, and nitrate) and metals (calcium, magnesium, potassium, and sodium) was included. Cadmium, lead, mercury, and silver were not included for further monitoring because no anomalous concentrations or trends were identified during the four-year evaluation (PNNL-15479 Section 1.2.1). The network included three downgradient wells (699-42-42B, 699-43-44, and 699-43-45) and one upgradient well (699-44-39B) (Figure 2-11).

In 2010, a revised monitoring plan DOE/RL-2008-59 (Rev. 0) was issued. The plan retained the same well network (699-42-42B, 699-43-44, 699-43-45, and 699-44-39B). Samples were analyzed for 40 CFR 265.92(b) required parameters, supporting constituents (temperature and turbidity), metals (calcium, magnesium, potassium, and sodium), and contaminants of interest (arsenic, cadmium, and nitrate).

Monitoring results from one upgradient well (699-44-39B) and two downgradient wells (699-42-42B and 699-43-44) for pH, specific conductance, nitrate, and sulfate since 1990 and recent (2012 to early 2015) TOC and TOX values are shown in Figure 2-12. This group of network wells monitors flow and constituent concentrations within Ringold Unit 9A (Figure 2-12). Since 1990, pH and specific conductance values for all three wells have generally been stable. Over this time period, pH values have been slightly higher in an upgradient well (699-44-39B). Specific conductance has generally shown lower values in this upgradient well than the two downgradient wells. Both sulfate and nitrate, which contribute to specific conductance, have most often had level or increasing concentrations in all three wells over time. Downgradient well 699-43-44 has shown the lowest sulfate and nitrate values, potentially resulting from its proximity to a transitional mixing zone, where levels may be impacted by flow within the Hanford unconfined aquifer (Figures 2-4 and 2-10). Recent semiannual monitoring results for TOC since 2012 indicate an increasing concentration trend for both upgradient and downgradient wells. Both the upgradient and downgradient wells show similar concentrations. Other than an anomalous value in 2012, TOX concentrations have generally been stable, with concentrations at or near the laboratory reporting limit (5 µg/L) in all three wells (Figure 2-12).

Monitoring results for pH, specific conductance, nitrate, and sulfate since 1990 and recent (2012 to early 2015) TOC and TOX values from upgradient well 699-45-42 (Figure 2-10) and downgradient well 699-43-45 (Figure 2-10) are shown in Figure 2-13. These two network wells are utilized to monitor flow and constituent concentrations upgradient of the site, where well 699-45-42 is completed in the Ringold Unit 9C and downgradient of the site, and where well 699-43-45 is screened in the Hanford formation (Figures 2-5 and 2-10). Well 699-45-42 was temporarily included in the updated B Pond monitoring network presented in DOE/RL-2008-59, Rev. 1 until a new upgradient well (699-44-43C) sited closer to B Pond adjacent to the location of 699-44-43B (previously used for B Pond monitoring but is now dry), was installed and ready for sampling. Well 699-44-43C was installed in 2017 and replaces 699-45-42 in this revision (Rev. 2).

Because of the geology and local flow patterns in the area, groundwater moves from Unit 9C near well 699-45-42, enters the Hanford formation, and is then directed toward well 699-43-45, which is located downgradient of the Main Pond and the 216-B-3-3 Ditch (Figure 2-10). New well 699-44-43C, which is located closer to the Main Pond, is positioned along a similar though shorter flow path moving toward well 699-43-45 (Figure 2-10). With the addition of 699-44-43C, some of the differences in water chemistry noted between upgradient well 699-45-42 and downgradient well 699-43-45 are expected to be minimized. Because of the groundwater flow path and mixing of Ringold Unit 9C groundwater with Hanford groundwater, constituent concentrations measured at well 699-43-45 display some differences in concentration trending in comparison to well 699-45-42. Since 1990, pH and specific conductance values for wells 699-45-42 and 699-43-45 have both generally displayed a level trend (Figure 2-13). Over this time, pH values have been slightly lower in upgradient well 699-45-42 (Figure 2-13). Specific conductance values measured in the upgradient well have tended to be higher than in downgradient well 699-43-45 (Figure 2-13). Sulfate concentrations have trended upward in both wells with higher concentrations consistently occurring in upgradient well 699-45-42 (Figure 2-13). Nitrate levels in downgradient well 699-43-45 had been lower than the upgradient well until late 2008 when a sharp increase in concentrations began (Figure 2-13). As with the analytical results for wells monitoring Ringold Unit 9A, TOC values for downgradient well 699-43-45 (completed in the Hanford formation) have shown an upward trend since 2012. Two TOC sampling events are available for upgradient well 699-45-42 during the period from 2012 to 2015 (Figure 2-13). One data point is slightly higher than the downgradient value, and the other is anomalously high and currently under data quality review. TOX values for downgradient well 699-43-45 have been variable since 2012 but have recently shown levels at or near the laboratory detection limit (5 µg/L) (Figure 2-13). Two TOX values from upgradient well 699-45-42 obtained in 2015 were low

DOE/RL-2008-59, REV. 2
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level, consistent with the concentration trend measured in downgradient well 699-43-45 for the same period (Figure 2-13).

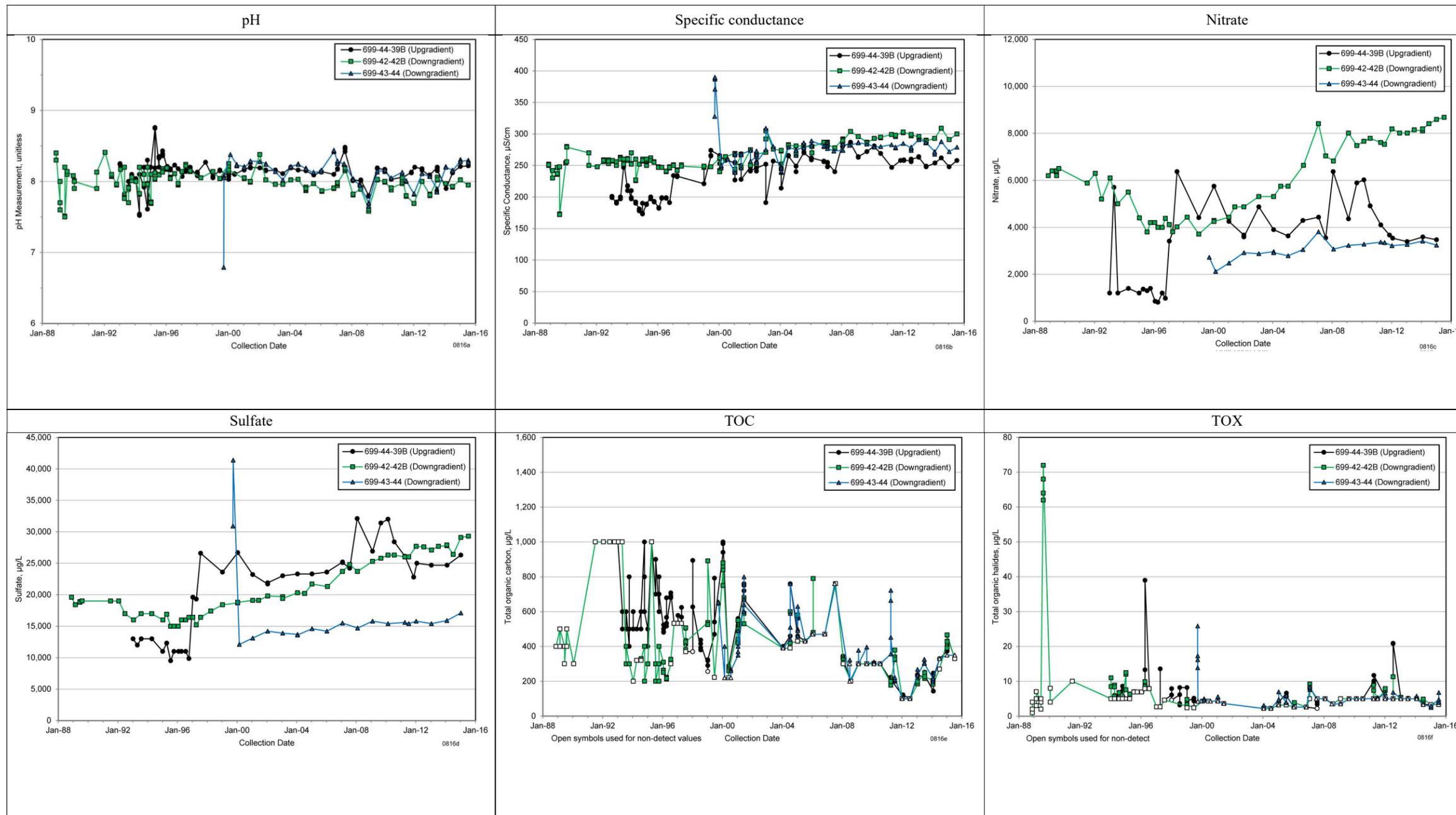


Figure 2-12. pH, Specific Conductance, Nitrate, Sulfate, TOC, and TOX Time Series Trend Plots Showing Concentrations for Upgradient Well 699-44-39B versus Downgradient Wells 699-42-42B and 699-43-44

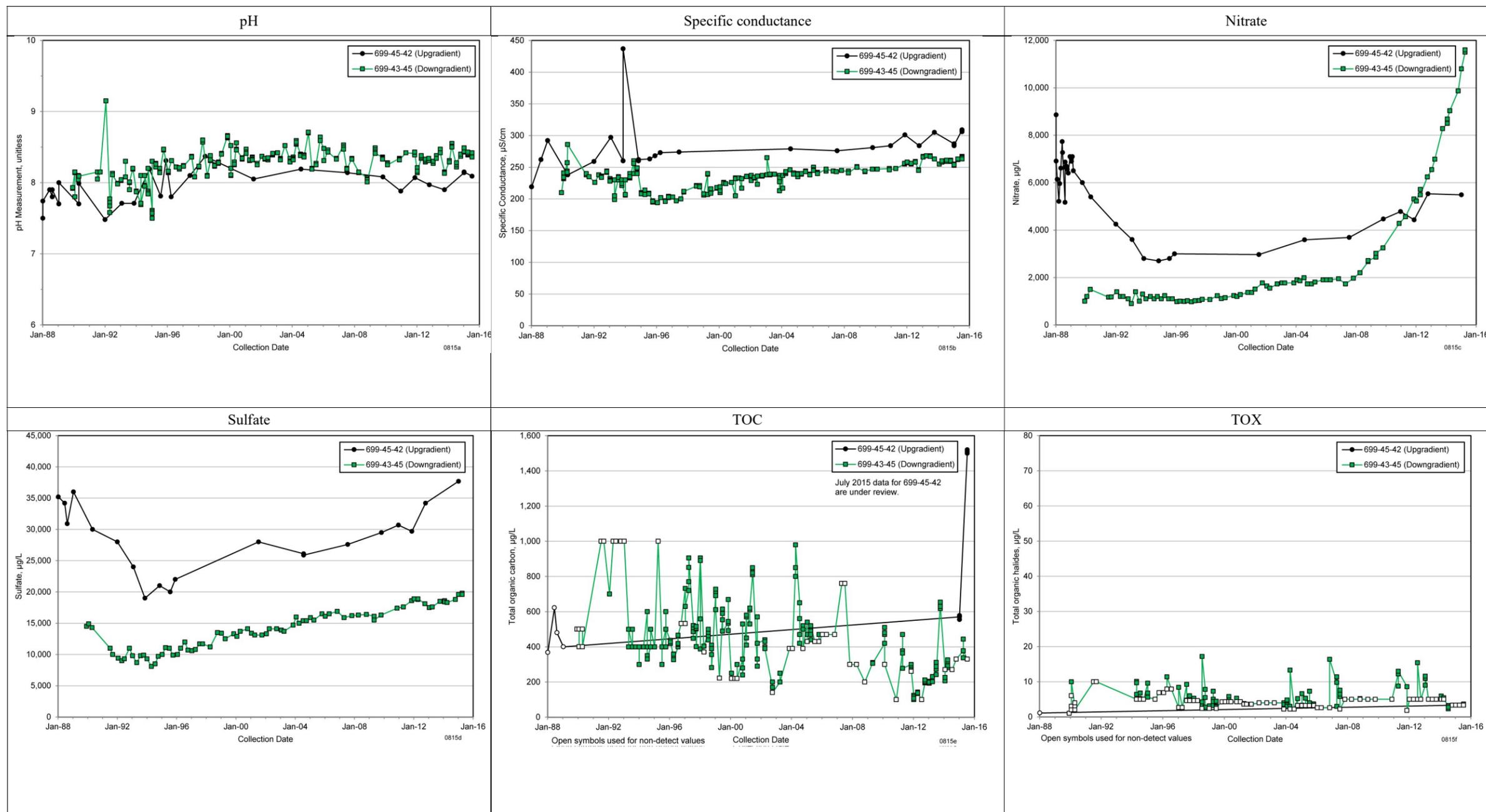


Figure 2-13. pH, Specific Conductance, Nitrate, Sulfate, TOC, and TOX Time Series Trend Plots Showing Concentrations for Upgradient Well 699-45-42 versus Downgradient Well 699-43-45

The groundwater monitoring activities at B Pond under this groundwater monitoring plan currently sample from a network of five wells; however, sampling from well 699-43-44 has been suspended due to well casing corrosion. This well is scheduled for decommissioning and will be directly replaced with well 699-43-43B in FY 2018. Samples are analyzed semiannually for parameters used as indicators of groundwater contamination and annually for parameters establishing groundwater quality, supporting constituents (temperature and turbidity), metals (calcium, [chromium](#), [iron](#), [magnesium](#), [manganese](#), [molybdenum](#), [nickel](#)), potassium, and sodium), and site-specific constituents (arsenic, cadmium, and nitrate). Water level measurements are collected each time a sample was 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*). Since 1988, groundwater monitoring results for B Pond have been summarized annually in RCRA groundwater monitoring annual reports (1989 to 1995, and beginning in 2015 with DOE/RL-2016-12) and as part of the sitewide annual Hanford Site groundwater monitoring reports (1996 to present) (e.g., DOE/RL-2015-07).

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2.6 Conceptual Site Model

This section describes the B Pond CSM for potential contaminant transport to guide groundwater monitoring. The CSM describes the current understanding of the contaminant release and transport and includes the following observations and assumptions:

- B Pond received effluent from several 200 East Area facilities, including the PUREX Plant, B Plant, 241-A Tank Farm, 242-A Evaporator, 244-AR Vault, and 284-E Power Plant. Several sources of wastewater and effluent contributed to B Pond discharges during the operational life of the facility. The greatest volume consisted of raw Columbia River water. Discharge volumes to the Main Pond averaged around 10 billion L/year (2.6 billion gal/year), except for a short period in the mid-1980s. From 1986 to 1991, discharges to the B Pond totaled over 64 billion L (17 billion gal), with a maximum in 1988 of over 100 billion L/year (26 billion gal/year). Total discharge to the facility since 1945 is estimated to have exceeded 1 trillion L (260 billion gal). The large volume liquid discharges resulted in raising the water table surface and development of groundwater mound centered near the 216-B-3B expansion pond with an outward radial flow pattern (Figure 2-9). The effluent discharges to B Pond locally raised the water table more than 9.1 m (30 ft) from pre-operation levels. The groundwater mound and resulting induced gradients in the area have now essentially dissipated.
- Discharges over the lifetime of the B Pond system were sufficient for wastewater to reach groundwater.
- Conceptual models for vadose zone contaminant fate (DOE/RL-93-74; DOE/RL-99-07) and subsequent soil chemistry testing suggest that most of the contaminated effluent directed to the B Pond infiltrated into the ditches leading to the Main Pond, with only a portion of the effluent reaching the Main Pond. The possible pathways for contamination reaching groundwater would include remobilization of existing contamination in the vadose zone beneath the Main Pond. Some effluent could have been intercepted in the vadose zone by the Ringold lower mud unit (Unit 8), potentially moving laterally along this perching layer toward the Hanford unconfined aquifer to the west, south, and east.
- The potential for continued migration of residual contamination from the vadose zone to groundwater is unlikely due to the cessation of liquid effluent discharges and lack of any water pipelines or other direct sources of recharge. Infiltration of natural precipitation is the only potential force capable of moving a significant portion of the remaining contaminants to the groundwater. Based on records

from the Hanford Meteorological Station, the average annual precipitation at the Hanford Site between 1950 and 2015 has been 172 mm (6.78 in.). Recharge in the B Pond area has been estimated to be between 26 and 52 mm (1.02 and 2.05 in.) annually based on Table 4.15 in PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*. The range of recharge rates depends on a variety of factors, such as soil texture and vegetation cover. The risk of infiltration and the potential for vertical migration of contaminants in the B Pond area is considered low because of low annual precipitation.

- Historical groundwater analyses in the B Pond area have not revealed any contamination by dangerous waste or dangerous waste constituents. Extensive sampling of vadose zone soil across the B Pond area has indicated low levels of cadmium, lead, mercury, and arsenic (DOE/RL-89-28; WHC-SD-EN-AP-042; BHI-01367). Distribution coefficients for cadmium (6.7 mL/g), lead (80 mL/g), mercury (10 mL/g), and arsenic (29 mL/g) (DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection* and ECF-Hanford-12-0023, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological Analytes in the 100 Areas and 300 Area*) suggest very low potential migration rates to the water table. Analyses for total and dissolved concentrations of these metals in groundwater in the B Pond area from 2010 to 2015 revealed no anomalous concentrations or trends for these constituents. Based on soil characterization and groundwater monitoring results, the impact to groundwater from constituents detected in the vadose zone is minor.
- The uppermost aquifers in the B Pond area consisting of Ringold Units 9A and 9C, appear to have been mostly isolated from a significant part of the B Pond effluent discharges. The intervening, fine-grained units (Ringold lower mud Units 8 and 9B) intercepted infiltrating effluent in some areas around B Pond diverting the wastewater down along the surface of the stratigraphic units, predominantly to the south (Figures 2-7 and 2-8; and Figure 2.3 in PNNL-13367). Where these fine-grained confining units are thin or absent, generally near the western end of the Main Pond (Figures 2-7 and 2-8), under an induced gradient caused by groundwater mounding, some effluent migrated to the east into Units 9A and 9C. The historical distribution of radiological constituents in the effluent such as iodine-129 and tritium (equivalent to a radiologic tracers) within Units 9A and 9C (Figures 10-7 and 10-12 in DOE/RL-2015-07) shows that constituents were driven, primarily laterally, into these units (Figures 2-3 and 2-6 in DOE/RL-2008-59, Rev. 0). Groundwater sampling data indicate that constituents associated with the B Pond effluent apparently did not migrate very far to the east or south (Figure 4.3 in PNNL-13367; Sections 10.4 and 10.5 in DOE/RL-2015-07; also see the web-based interactive historical plume tool found with the online version of DOE/RL-2015-07), even though there was a hydraulic gradient in these directions due to groundwater mounding beneath B Pond.
- Artificial recharge, groundwater mounding, and the resultant loading effect caused an increase in confined aquifer hydrostatic pressure in stratigraphic units both below the point of infiltration and to the east and southeast of the B Pond. Declining hydraulic head has been occurring since cessation of surface discharges to B Pond circa 1997 (Figure 2-6). Aquifer head losses in the confined portions of the Ringold 9A and 9C Units are expected to continue but at a lower rate as groundwater returns to pre-Hanford conditions. The rate of decline over the last several years has averaged approximately 0.2 m (0.7 ft)/year.
- Local flow directions in the B Pond area are now predominantly influenced by changes in hydraulic head driving flow in confined units 9A and 9C (Figure 2-6) or the small gradient changes locally influencing the direction of flow in the high conductivity Hanford and Cold Creek sediments (DOE/RL-2015-07, Section 10.2).

2.7 Monitoring Objectives

The groundwater monitoring program at B Pond 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, "Applicability," through 265.94, "Recordkeeping and Reporting." Table 2-3 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan. Site-specific constituents (Table 2-4) will also be collected for general groundwater chemistry, which will support the evaluation of upgradient and downgradient water chemistry variations. Field parameters will be collected to provide information on water properties at the time of sampling.

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	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 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
Well Configuration	<p>40 CFR 265.91:</p> <p>(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.</p> <p>Additional requirements from WAC 173-303-400(3)(c)(v)(C), "Dangerous Waste Regulations," "Interim Status Facility Standards":</p> <p>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.</p>	Section 3.2 and Appendix C
Sample Protocols Analytical Methods	<p>40 CFR 265.92:</p> <p>(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:</p> <p>(1) Sample collection;</p> <p>(2) Sample preservation and shipment;</p> <p>(3) Analytical procedures; and</p> <p>(4) Chain of custody control.</p>	Appendix A, Section A3 and Appendix B, Sections B2 through B5
Parameters to be Sampled Frequency of Sampling Water-Level Measurements	<p>40 CFR 265.92, "Sampling and Analysis":</p> <p>(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:</p> <p>(1) Parameters characterizing the suitability of the ground water as a drinking water supply, as specified in Appendix III</p> <p>(2) Parameters establishing ground-water quality:</p> <p>(i) Chloride</p> <p>(ii) Iron</p> <p>(iii) Manganese</p> <p>(iv) Phenols</p> <p>(v) Sodium</p> <p>(vi) Sulfate</p> <p>[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).]</p>	Section 3.1 and Appendix B, Section B2.2

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
	<p>(3) Parameters used as indicators of ground-water contamination:</p> <ul style="list-style-type: none"> (i) pH (ii) Specific conductance (iii) Total organic carbon (iv) Total organic halogen <p>(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.</p> <p>(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.</p>	
	<p>(d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies:</p> <ul style="list-style-type: none"> (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. <p>(e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.</p>	
<p>Groundwater Quality Assessment Program Plan Outline</p>	<p>40 CFR 265.93, "Preparation, Evaluation, and Response":</p> <ul style="list-style-type: none"> (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: <ul style="list-style-type: none"> (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. 	<p>Chapter 5</p>
<p>Methods Used to Evaluate the Collected Data and Responses</p>	<p>40 CFR 265.93</p> <ul style="list-style-type: none"> (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 	<p>Section 4.1, 4.2, 4.3 and Appendix A</p>

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
	<p>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.</p> <p>(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.</p> <p>(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.</p> <p>(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.</p>	
Recordkeeping and Reporting	<p>40 CFR 265.93:</p> <p>(c)(1) If the comparisons for the <i>upgradient</i> 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).</p> <p>40 CFR 265.94, "Recordkeeping and Reporting":</p> <p>(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.</p> <p>(a)(2) Report the following ground-water monitoring information to the department:</p> <p>(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 §265.93(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(e)(1).</p> <p>(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.</p>	<p>Section 4.5 Appendix A, Sections A2.6 A2.5 and A3.9</p>

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Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
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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.

* 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.

RCRA = *Resource Conservation and Recovery Act of 1976*

TSD = treatment, storage, and disposal

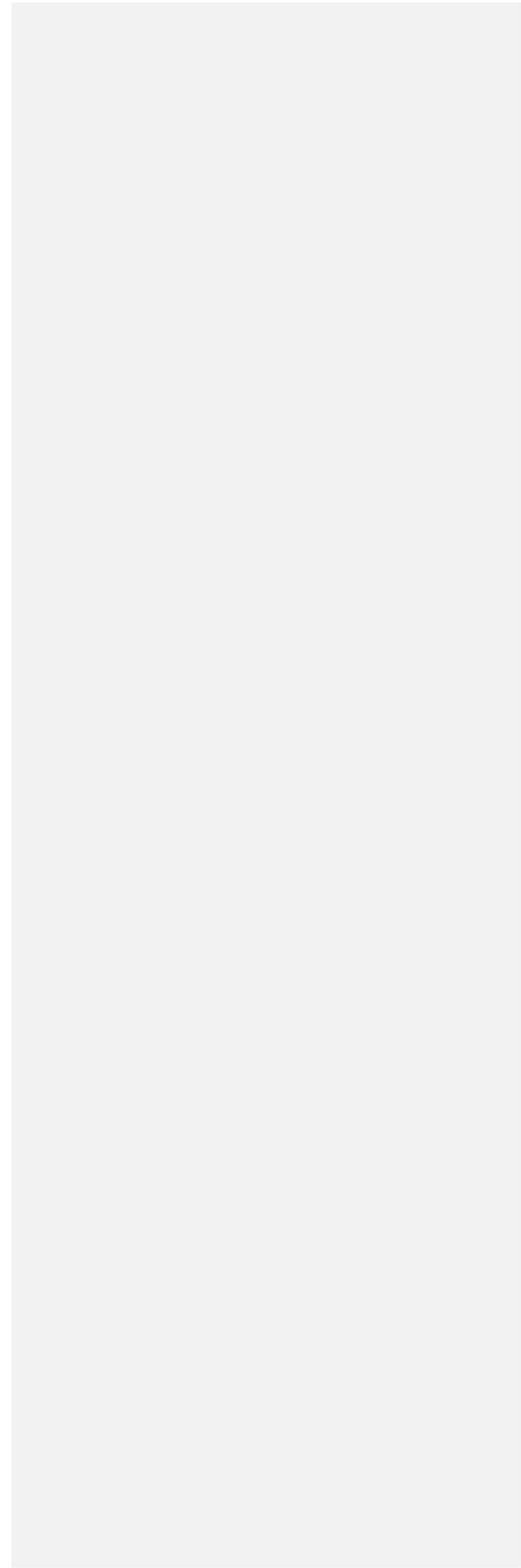
Table 2-4. Additional Monitoring Objectives

Monitoring Objective	TSD Unit-Specific Constituent/ Field Measurements
<p>Metals – additional metals (calcium, magnesium, and potassium) used in ion balance and to support water chemistry analysis.</p> <p>Metals – additional metals used to determine corrosion of stainless steel</p> <p>Arsenic has been identified as a site-specific contaminant in the groundwater that could be associated with B Pond operations. Current concentrations appear to be more regionally influenced, but levels are near the drinking water standard. Continued monitoring for continuity from previous plan.</p> <p>Cadmium was previously discharged to B Pond as cadmium nitrate and is retained in this plan.</p>	<p>Arsenic, cadmium, calcium, chromium, iron, magnesium, manganese, molybdenum, nickel, and potassium</p>
<p>Nitrate has been identified as a site-specific contaminant in the groundwater that could be associated with B Pond operations.</p>	<p>Nitrate</p>
<p>Alkalinity – used in ion balance and to support water chemistry analysis.</p>	<p>Alkalinity</p>
<p>Field parameters provide information on water properties at the time of sampling.</p>	<p>Dissolved oxygen, temperature, and turbidity</p>

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3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for B Pond consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, a monitoring well network, and sampling and analysis protocols. The monitoring program presented herein has not been revised from that presented in the previous plan (DOE/RL-2008-59, Rev. 1), which proposed the changes incorporated in this revision. This revision incorporates the new upgradient well (699-44-43C) and removes upgradient well (699-45-42) upon installation of 699-44-43C. Additionally, downgradient well 699-43-44 is being removed from the network due to casing failure and is scheduled for direct replacement with 699-43-43B in FY 2018. This revision 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, parameters analyzed, and sampling frequency for monitoring of B Pond. 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 a sample is obtained (40 CFR 265.92(e)).

New well 699-44-43C and planned replacement well 699-43-43B will be sampled quarterly for 1 year for contamination indicator parameters and groundwater quality parameters (Table 3-1). In addition to the monitoring in Table 3-1, well 699-44-43C and planned replacement well 699-43-43B will be sampled quarterly for 1 year for the drinking water suitability parameters included in Appendix III to 40 CFR 265 (Table 3-2). Monitoring for the Appendix III parameters in Table 3-2 will be performed concurrently with the monitoring required in Table 3-1. Quarterly sampling of well 699-44-43C is scheduled to begin in October 2017.

Although not required by regulation, additional constituents will be monitored and are identified in Table 3-1. Arsenic and nitrate have been identified as site-specific contaminants in groundwater that could be associated with B Pond operations. Nitrate is widely disseminated in the 200 East Area at elevated levels that have a significant impact on specific conductance values. Differentiation of regional from potential local contributions is needed. Arsenic was detected at low levels in characterization soil samples collected in the 216-B-3-3 Ditch, but it has only been detected in the site groundwater at levels below the drinking water standard. It is included in this plan for continuity with previous monitoring conducted at B Pond. Cadmium was previously discharged to B Pond as cadmium nitrate and is retained in this plan.

Additional metal constituents support calculations of water chemistry ion charge balance and include calcium, chromium, iron, magnesium, manganese, molybdenum, nickel, and potassium. Site-specific and additional metal constituents will be sampled annually. Field parameters (DO, temperature, and turbidity) will be sampled semiannually and used as indicators of sample quality and general aquifer/well environment conditions.

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Table 3-1. Monitoring Well Network for B Pond

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters ^a											Site-Specific Constituents				
			Water Level	Contamination Indicator Parameters			Groundwater Quality Parameters											
				pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered) ^b	Manganese (Filtered and Unfiltered) ^b	Phenols ^d	Sodium	Sulfate	Arsenic (Filtered and Unfiltered) ^b	Cadmium (Filtered and Unfiltered) ^b	Nitrate	Field Parameters ^c	Alkalinity
699-42-42B	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S	A	A
699-43-45	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S	A	A
699-44-39B	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S	A	A
699-44-43C ^e	Upgradient	Y	Q	Q4	Q4	Q4	Q4	Q	Q	Q	Q	Q	Q	A	A	Q	A	A
699-44-43C ^f	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S	A	A
699-43-43B ^e	Downgradient	Y	Q	Q4	Q4	Q4	Q4	Q	Q	Q	Q	Q	Q	A	A	Q	A	A
699-43-43B ^f	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S	A	A

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

b. 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.

c. Field parameters include dissolved oxygen, temperature, and turbidity.

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Table 3-1. Monitoring Well Network for B Pond

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters ^a										Site-Specific Constituents					
			Contamination Indicator Parameters				Groundwater Quality Parameters											
			Water Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered) ^b	Manganese (Filtered and Unfiltered) ^b	Phenols ^d	Sodium	Sulfate	Arsenic (Filtered and Unfiltered) ^b	Cadmium (Filtered and Unfiltered) ^b	Nitrate	Field Parameters ^e	Alkalinity

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DOE/RL-2008-59, REV. 2
RCRA-CN-02_DOE/RL-2008-59_R2

d. Metals; analytes include the following common soil minerals for charge-balance computations: calcium, magnesium, and potassium. Includes analysis of calcium, magnesium, and potassium for water chemistry analysis and chromium, iron, manganese, molybdenum, and nickel to monitor for stainless steel corrosion.

e. Constituents and sampling frequency for new well 699-44-43C and planned replacement well 699-43-43B only for first year of monitoring. Quarterly sampling of well 699-44-43C is scheduled to begin in October 2017.

f. Constituents and sampling frequency for well 699-44-43C and planned replacement well 699-43-43B after first year of monitoring.

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

- A = to be sampled annually
- Q = to be sampled quarterly
- Q4 = to be sampled quarterly, with quadruplicate samples collected during each event
- RCRA = *Resource Conservation and Recovery Act of 1976*
- S = to be sampled semiannually
- S4 = to be sampled semiannually, with quadruplicate samples collected during each event
- WAC = *Washington Administrative Code*
- Y = well is constructed as a resource protection well (WAC 173-160)

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

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

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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

Table 3-2. Constituents and Sampling Frequency for 1 Year of Monitoring at Wells Added to the B Pond Network

Well Name	Water Level	40 CFR 265 Appendix III Parameters ^a																				
		Arsenic (Filtered and Unfiltered) ^b	Barium (Filtered and Unfiltered) ^b	Cadmium (Filtered and Unfiltered) ^b	Chromium (Filtered and Unfiltered) ^b	Fluoride	Lead (Filtered and Unfiltered) ^b	Mercury	Nitrate (as N)	Selenium (Filtered and Unfiltered) ^b	Silver (Filtered and Unfiltered) ^b	Endrin	Lindane	Methoxychlor	Toxaphene	2,4,-D	2,4,5,-TP Silvex	Radium	Gross Alpha	Gross Beta	Coliform Bacteria	Turbidity
699-44-43C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
699-43-43B	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

Reference: 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix III, "EPA Interim Primary Drinking Water Standards."

a. Monitoring for the Appendix III parameters will be performed for 1 year and will be performed concurrently with monitoring required in Table 3-1. Quarterly sampling of 699-44-43C is scheduled to begin October 2017. Quarterly sampling of replacement well 699-44-43B will begin after installation.

b. 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.

Q = to be sampled quarterly

3.1.1 Sample Schedule Impacts from Well Maintenance and Sampling Logistics

Well maintenance (e.g., pump repairs, periodic well cleaning and redevelopment) 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 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 the DOE-RL and are documented in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

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 B Pond monitoring network consists of one existing upgradient well (699-44-39B), one new upgradient well (699-44-43C), and three downgradient wells (699-43-45, 699-43-43B [direct replacement of 699-43-44], and 699-42-42B).

During routine monitoring activities in 2017, downgradient well 699-43-44 was identified as containing significant well corrosion and casing structural failure. Well 699-43-44 is scheduled for decommissioning and direct replacement with well 699-43-43B in FY 2018. Well 699-43-44 is being removed from the monitoring network under this revised plan.

Rev. 1 of this plan added a second upgradient well to the B Pond network. Well 699-45-42 was utilized as the second upgradient monitoring well pending installation of new well 699-44-43C. Well 699-44-43C is scheduled to begin quarterly sampling October 2017. Well 699-45-42 will no longer be used for B Pond monitoring, but will continue sampling according to DOE/RL-2003-04. Figure 3-1 shows the configuration of the groundwater monitoring network, and information for the wells is summarized in Table 3-3.

Based on the orientation of geologic strata and hydrology beneath B Pond, well 699-44-39B, completed in Ringold Unit 9A, and well 699-44-43C, completed in Ringold Unit 9C and underlying fractured basalt, are appropriately located for upgradient monitoring. These wells occur along upgradient flow paths that cross the site. Groundwater locally flows beneath the Ringold Unit 8 mud and/or Ringold 9B confining layers near these wells and discharges to downgradient portions of the Hanford formation and unconfined Ringold Unit 9A aquifers (Figures 2-10 and 3-1).

Only a few groundwater wells are present close to B Pond, and most often, they vary in completion depth. Not every well meets WAC 173-160 "Minimum Standards for Construction and Maintenance of Wells." The following criteria were used in selecting wells for RCRA monitoring of B Pond:

- Locations of the upgradient and downgradient wells with respect to the TSD unit boundary and groundwater flow path (wells closest to the TSD unit boundary were prioritized for use because they would provide the most immediate indication of a release)
- Well screen position with respect to the water table (wells constructed with screens positioned closest to the vadose zone/water table interface were preferred for detecting contaminant presence, within the uppermost aquifer, resulting from a nearby waste site/TSD unit release)
- Suitable well construction such that the sampling data provided are comparable with other network wells
- Compliance with WAC 173-160

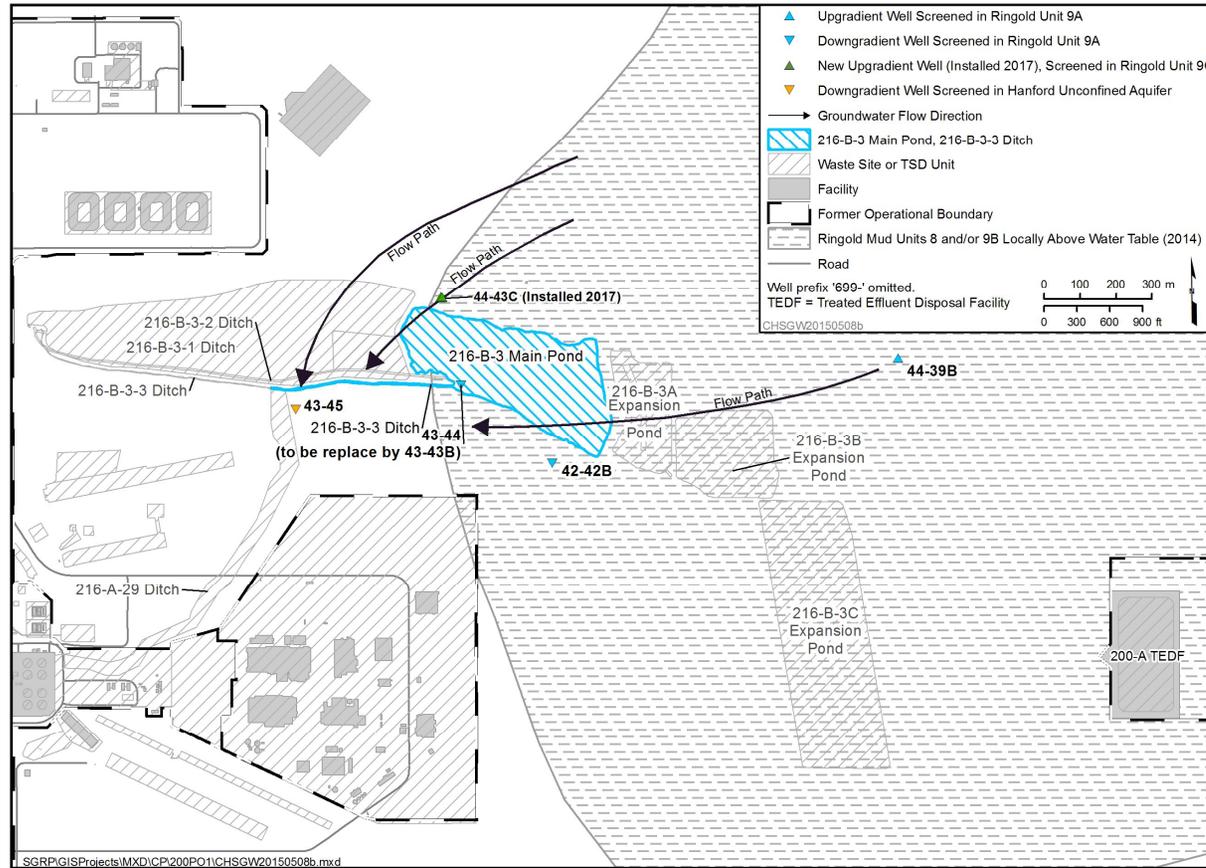


Figure 3-1. 216-B-3 Pond Monitoring Network

Table 3-3. Attributes for Wells in the B Pond Groundwater Monitoring Network

Well Name	Completion Date	Easting ^a (m)	Northing ^a (m)	Screened Unit	Screen Top (m [ft] bgs)	Screen Bottom (m [ft] bgs)	Depth to Water (m [ft] bgs)	Remaining Water Column (m [ft])	Water Level Date
699-42-42B	1988	576998.10	136433.92	Ringold 9A	55.9 (183.5)	62.0 (203.5)	55.3 (181.5)	6.7 (22.1)	7/14/2015
699-43-43B ^b	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
699-43-45	1989	576283.82	136585.73	Hanford	55.8 (183.0)	62.0 (203.3)	60.5 (198.4)	1.5 (5.0)	7/14/2015
699-44-39B	1992	577960.62	136727.39	Hanford/ Ringold 9A	30.1 (98.9)	36.2 (118.9)	32.9 (107.9)	4.1 (13.5)	7/14/2015
699-44-43C ^c	2017	576688.38	136896.72	Ringold 9C/ Basalt	53.1 (174.3)	60.7 (199.3)	54.3 (178.1)	6.5 (21.2)	6/21/2017

a. Coordinates are in Washington Coordinate System of NAD83, *North American Datum of 1983*, South Zone/1991 Adjustment.

b. Well 699-43-43B is a planned direct replacement for well 699-43-44 and is scheduled for installation in fiscal year 2018.

c. Coordinates and well screen elevation data derived from pre-drilling land survey information. No post-drilling survey information available at the time of this groundwater monitoring plan revision.

bgs = below ground surface

TBD = to be determined

While the rate of decline in water levels has slowed in B Pond wells, sometimes a well can go dry. The rate of decline over the last several years has averaged approximately 0.2 m (0.7 ft)/year. If a well is within approximately 2 years of going dry, such wells are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement (Ecology et al., 1989a) Milestone M-24-00.

Construction details and pertinent information for the wells are provided in Appendix C.

3.3 Differences between This Plan and Previous Plan

Table 3-4 identifies the main differences between this plan and the previous groundwater monitoring plan.

In Rev. 1, a second upgradient well (699-45-42) was added to the monitoring network to provide better representation of aquifer variability upgradient of B Pond until New Well #1 (699-44-43C) could be drilled upgradient near the northwest corner of the Main Pond. Well 699-45-42 is now removed from the B Pond network. Quarterly monitoring for contamination indicator parameters and groundwater quality parameters are required for wells 699-44-43C and 699-43-43B (once installed) for 1 year.

Table 3-4. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Constituents	Indicator parameters, groundwater quality parameters, and water chemistry	Same	No change
	Supporting constituents	Same <u>Stainless steel corrosion constituents (chromium, iron, manganese, molybdenum, and nickel) added</u>	<u>No change</u> <u>Stainless steel constituents are sampled to monitor for well corrosion</u>
	Site-specific constituents – arsenic, cadmium, and nitrate	Same	No change
Sampling Frequency	Indicator parameters – semiannual	Indicator parameters – same	No change
	Groundwater quality parameters – annual	Groundwater quality parameters – same	No change
	Supporting constituents – semiannual/annual	Supporting constituents – same	No change
	Site-specific constituents – annual	Site-specific constituents – same	No change

Commented [CTJ10]: RCRA-CN-02_DOE/RL-2008-59_R2

Table 3-4. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
	40 CFR 265, Appendix III parameters at New Well #1 and well 699-45-42 – quarterly for the first year.	40 CFR 265, Appendix III parameters at 699-44-43C (New Well #1) and replacement well 699-43-43B (once installed) – quarterly for the first year.	Well 699-45-42 is removed as well 699-44-43C has been installed. Well 699-44-43C requires quarterly first-year monitoring frequency. Replacement well 699-43-43B (once installed) requires quarterly first-year monitoring frequency.
	Water level measurements – every sampling event	Water level measurements – same	No change
Well Network	Two upgradient: 699-44-39B 699-45-42 (to be removed after New Well #1 installation) Three downgradient: 699-43-42B 699-43-44 699-43-45	Two upgradient: 699-44-39B 699-44-43C (New Well #1) Three downgradient: 699-43-42B 699-43-43B (planned replacement for 699-43-44) 699-43-45	Well 699-44-43C (New Well #1) was installed in 2017 and replaces well 699-45-42. Well 699-45-42 is no longer included in the 216-B-3 monitoring network. Well 699-43-44 is removed from the network due to well casing failure and is scheduled for direct replacement (699-43-43B) in fiscal year 2018.
Groundwater Flow Direction	West to southwest	Same	No change
Type of Groundwater Monitoring Program	Interim status indicator evaluation program	Same	No change
Background Arithmetic Mean Recalculated	Calculated annually using two upgradient wells	Same	The wells utilized to calculate the background arithmetic mean will transition from the 699-44-39B/699-45-42 well pair to the new 699-44-39B/699-44-43C well pair. Calculated annually using EPA 530/R-09-007, <i>Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance</i> .
Groundwater Quality Assessment Plan Outline	Chapter 5	Same	No change

Table 3-4. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
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Reference: 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix III, "EPA Interim Primary Drinking Water Standards."

* DOE/RL-2008-59, Rev. 1, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*.

3.4 Sampling and Analysis Protocol

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

4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification 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 B Pond 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 B Pond, 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 practice of annually updating the background values is consistent with statistical evaluation methods for TSD units in final status 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 B Pond. 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 B Pond 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 reports (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 reports (e.g., DOE/RL-2016-12) [by March 1](#).

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) [by March 1](#).

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)).

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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 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
- An 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
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 – Sampling and Analysis Protocol
Appendix C – 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

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Appendix A
Quality Assurance Project Plan

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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
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	<i>Resource Conservation and Recovery Act of 1976</i>
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate

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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.

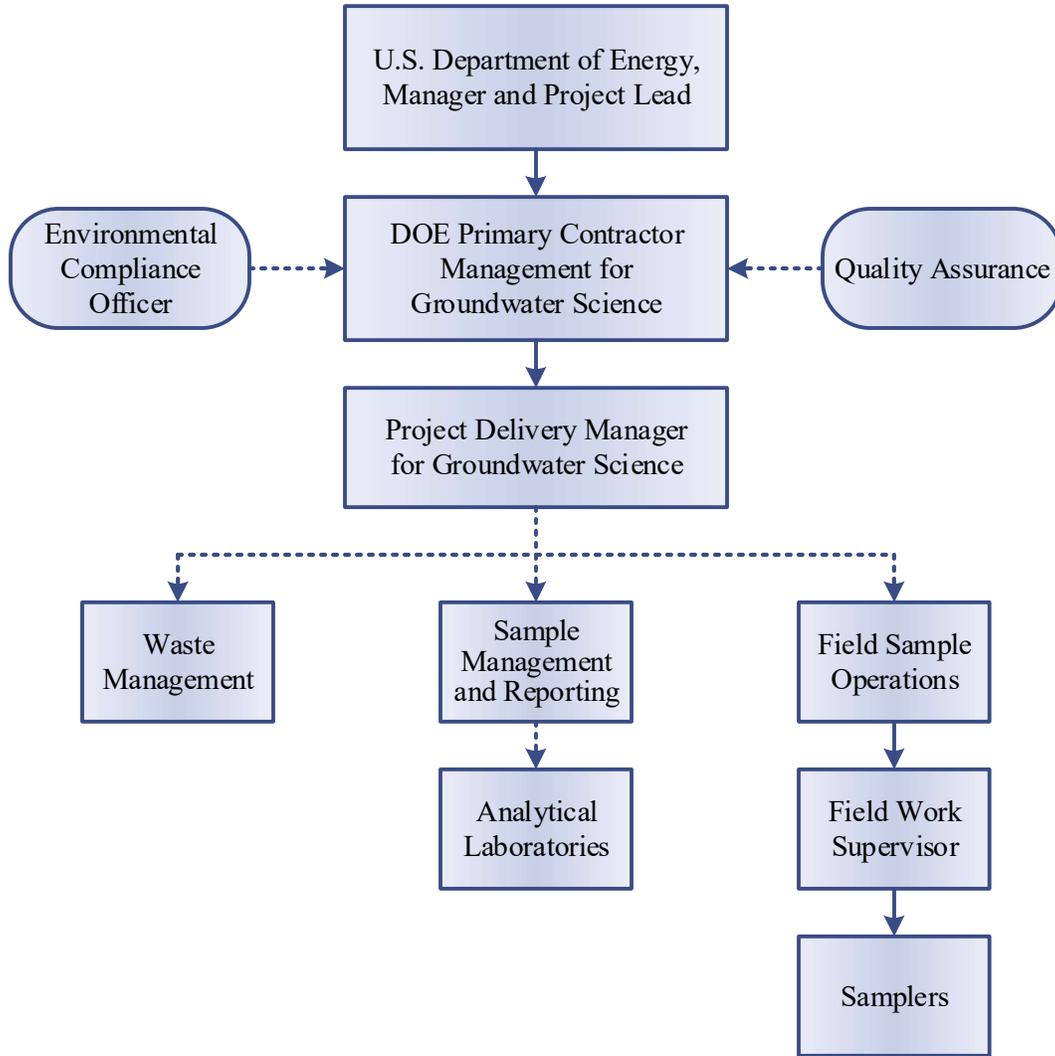


Figure A-1. Project Organization

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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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, 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 CaCO ₃	310.1, Standard Method 2320, Standard Method 4500	5250
18496-25-8	Sulfide (total)	376.1, Standard Method 4500S	2100
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
16984-48-8	Fluoride	300, 9056	525
14797-55-8	Nitrate, as NO ₃	300, 9056	250
14808-79-8	Sulfate	300, 9056	1050
Field Measurements			
--	pH	150.1, 9040, Standard Method 4500 H ⁺	N/A
--	Dissolved oxygen	360.1, Standard Method 4500 O	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

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
Metals			
7440-38-2	Arsenic	6020	10.5
7440-43-9	Cadmium	6020	2.1
7440-70-2	Calcium	6010	1050
7440-47-3	Chromium	6020	10.5
7439-89-6	Iron	6010	105
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
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

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method^a	Practical Quantitation Limit (µg/L)
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
Drinking Water Suitability Parameters^d			
7440-38-2	Arsenic	6020	10.5
7440-39-3	Barium	6020	5.25
7440-43-9	Cadmium	6020	2.1
7440-47-3	Chromium	6020	10.5
16984-48-8 ^b	Fluoride	300, 9056	525
7439-92-1	Lead	6020	3.15
7439-97-6	Mercury	7470	0.5
14797-55-8 ^b	Nitrate, as NO ₃	300, 9056	250
7782-49-2	Selenium	6020	10.5
7440-22-4	Silver	6020	5.25
72-20-8	Endrin	8081	0.1
58-89-9	gamma-BHC (Lindane; hexachlorocyclohexane)	8081	0.0525
72-43-5	Methoxychlor	8081	0.5
8001-35-2	Toxaphene	8081	2.625
94-75-7	2,4-D (2,4-Dichlorophenoxy acetic acid)	8151	20
93-72-1	Silvex (2,4,5-TP)	8151	1.05
ALPHA-RA	Radium (total alpha)	Gas Flow Proportional Counting	1 pCi/L
12587-46-1	Gross Alpha	Gas Proportional Counting	3 pCi/L
12587-47-2	Gross Beta	Gas Proportional Counting	4 pCi/L
--	Coliform Bacteria	Standard Method 9223	N/A

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
--	Turbidity	180.1, Standard Method 2130 B	N/A

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.
- d. Parameters characterizing the suitability of groundwater as a drinking water supply as presented in 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix III, "EPA Interim Primary Drinking Water Standards," were monitored for 1 year at the wells identified in Table 3-2 of the main text.

- 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

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field duplicates	1 in 20 well trips ^b	Reproducibility/sampling precision
Field splits	As needed	Interlaboratory comparability
Full trip blanks	1 in 20 well trips ^b	Contamination from containers preservative reagents, storage, or transportation
Analytical QC ^c		
Carrier	Added to each sample and quality control	Recovery/yield
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

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

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

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
	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
Sulfide	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”

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 ^c
Metals			
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 ^c
	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 ^c
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 ^c
	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 ^c
Mercury by cold-vapor atomic absorption	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 ^c
	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 ^c
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 ^c
	MS/MSD ^d	% recovery statistically derived ^g	Flag with "T"
	SUR	% recovery statistically derived ^g	Review data ^c

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 ^c
Herbicides			
Herbicides by gas chromatography	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 ^c
	MS/MSD ^d	% recovery statistically derived ^g	Flag with “N”
	SUR	% recovery statistically derived ^g	Review data ^c
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^c
Pesticides			
Pesticides by gas chromatography	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 ^c
	MS/MSD ^d	% recovery statistically derived ^g	Flag with “N”
	SUR	% recovery statistically derived ^g	Review data ^c
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^c
Other Drinking Water Suitability Parameters			
Coliform	MB	Pass/Fail ^g	Review Data ^c
	LCS	Pass/Fail ^g	Review Data ^c
	DUP	Pass/Fail ^g	Review Data ^c
	EB, FTB	Pass/Fail ^h	Flage with “Q”
	Field Duplicate ^c	Pass/Fail ^h	Review Data ^c
Gross alpha	MB	<MDC <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits ^f	Flag with “o” ^b
	DUP ^c	≤20% RPD	Review data ^c

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

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
	EB, FTB	< MDC < 5% sample activity concentration	Flag with “Q”
	Field Duplicate ^c	≤20% RPD	Review data ^c
Gross beta	MB	<MDC <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits ^f	Flag with “o” ^b
	DUP ^c	≤20% RPD	Review data ^c
	EB, FTB	< MDC < 5% sample activity concentration	Flag with “Q”
	Field Duplicate ^c	≤20% RPD	Review data ^c
Total Alpha Radium by Gas Flow Proportional Counting	MB	<MDC <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits ^f	Flag with “o” ^b
	DUP ^c	≤20% RPD	Review data ^c
	Carrier	40%-110% recovery	Review data ^c
	EB, FTB	< MDC < 5% sample activity concentration	Flag with “Q”
	Field Duplicate ^c	≤20% RPD	Review data ^c

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. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

g. Passing QC; MB = no colonies detected, LCS = appropriate colonies detected, DUP = colonies detected/undetected are consistent with sample.

DUP = laboratory sample duplicate

EB = equipment blank

FTB = full trip blank

LCS = laboratory control sample

MS = matrix spike

MSD = matrix spike duplicate

PQL = practical quantitation limit

QC = quality control

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

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
MB = method blank		RPD = relative percent difference	
MDC = minimum detectable activity		SMR = Sample Management and Reporting	
MDL = method detection limit		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], and full trip blanks [FTBs]). Field blanks are typically prepared to match the sample matrix as closely as possible using high-purity water¹. 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.
- **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

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.

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), and carriers (for radionuclide analyses). 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:

- **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.
- **Carrier:** Used only in radioanalytical analyses. Carriers are a known quantity of non-radioactive isotope that is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on carrier recovery.

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
Sulfide	Store ≤6°C, adjust pH to > 9 with zinc acetate and sodium hydroxide	7 days
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, Fluoride, Sulfate	Store ≤6°C	28 days
Nitrate, Nitrite	Store ≤6°C	48 hours
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
Mercury by cold-vapor atomic absorption	Adjust pH to <2 with nitric acid	28 days
Semivolatile Organic Compounds		
Phenols by gas chromatography/mass spectrometry	Store ≤6°C	7 days before extraction 40 days after extraction
Herbicides		
Herbicides	Store <6°C	7 days before extraction 40 days after extraction
Pesticides		
Pesticides	Store <6°C	7 days before extraction 40 days after extraction
Other Drinking Water Suitability Parameters		
Coliform	Store ≤6°C	6 hours
Gross alpha/Gross beta	Adjust pH to <2 with nitric acid	6 months
Total alpha radium by gas flow proportional counting	Adjust pH to <2 with nitric acid	6 months

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, dissolved oxygen [if applicable], temperature, and turbidity) are not listed because they are measured in the field.

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

Constituent ^a	Preservation ^b	Holding Time
--------------------------	---------------------------	--------------

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

b. For preservation identified as stored at $\leq 6^{\circ}\text{C}$, 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

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=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5>.

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265.93, "Preparation, Evaluation, and Response."

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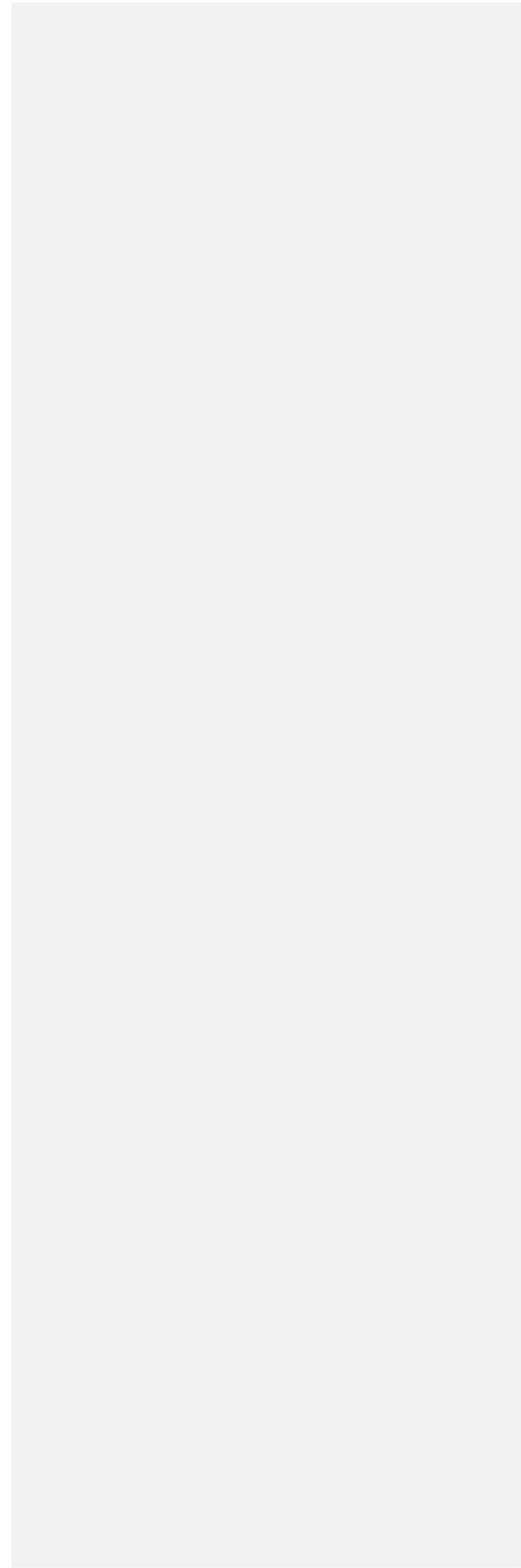
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Appendix B
Sampling Protocol



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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	<i>Hanford Analytical Services Quality Assurance Requirements Document</i> (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

Groundwater 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-1980's. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken; equipment and its use; cleaning and decontamination; records and documentation; and sample collection, management, and control activities. 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 the sampling frequency for the groundwater monitoring at B Pond.

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

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (32.3°F)
- **Conductivity** – two consecutive measurements agree within 10% of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist's recommendation)

Dissolved oxygen will also be measured in the field in this groundwater monitoring plan. Dissolved oxygen is not an indicator parameter nor groundwater quality parameter and is not required to be stable prior to sample collection.

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 when 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, conductivity, and dissolved oxygen. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

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

Typically, three traditional types (i.e., Grundfos¹, Hydrostar², 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. 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 (0.26 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, preservatives, 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

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.

listed in analytical method compilations such as APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater*, and SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition; Final Update 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 water³ 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

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).

- Comments
- Signature of person performing decontamination

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater 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. 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 used 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 on the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either 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.~~

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

- Project name
- Collectors' names
- Unique sample number

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- Date and time of collection
- Matrix
- Preservatives
- Chain of possession information (i.e., signatures and printed names of each individuals 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-2004-18, *Waste Control Plan for the 200-PO-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.

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.

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.

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.

B8 References

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Appendix C

Well Construction

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C1 Introduction

This appendix provides the following information for the B Pond groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be 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-4 provide the well construction and completion summaries for the B Pond monitoring wells.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
CR	Confined Ringold. Wells for which the open interval does not extend more than approximately 3 m (10 ft) below the top of basalt. Typically open to the lower mud (unit 8) and basal gravel (unit 9) of the Ringold Formation. This classification is not used for wells completed in the Ringold Formation upper mud.
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 B Pond 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])
699-42-42B	CR	121.6 (399.0)	115.5 (379.0)	6.1 (20.0)
699-43-43B ^a	TBD	TBD	TBD	TBD
699-43-45	TU	126.5 (415.0)	120.3 (394.7)	6.2 (20.3)
699-44-39B	TU	126.2 (414.0)	120.1 (394.0)	6.1 (20.0)
699-44-43C ^b	TU	123.9 (406.4)	116.3 (381.4)	7.6 (25.0)

Table C-2. Sampling Interval Information for Wells within the B Pond 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])
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Reference: NAVD88, *North American Vertical Datum of 1988*.

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

a. Well 699-43-43B is a direct replacement for downgradient well 699-43-44, which has been removed from the network due to well casing failure. Well 699-43-43B is scheduled to be installed in fiscal year 2018.

b. Screen elevation data derived from pre-drilling land survey information. No post-drilling survey information available at the time of this groundwater monitoring plan revision.

CR = Confined Ringold, as described in Table C-1

TBD = to be determined

TU = Top of Unconfined, as described in Table C-1

DOE/RL-2008-59, REV. 2
RCRA-CN-02_DOE/RL-2008-59_R2

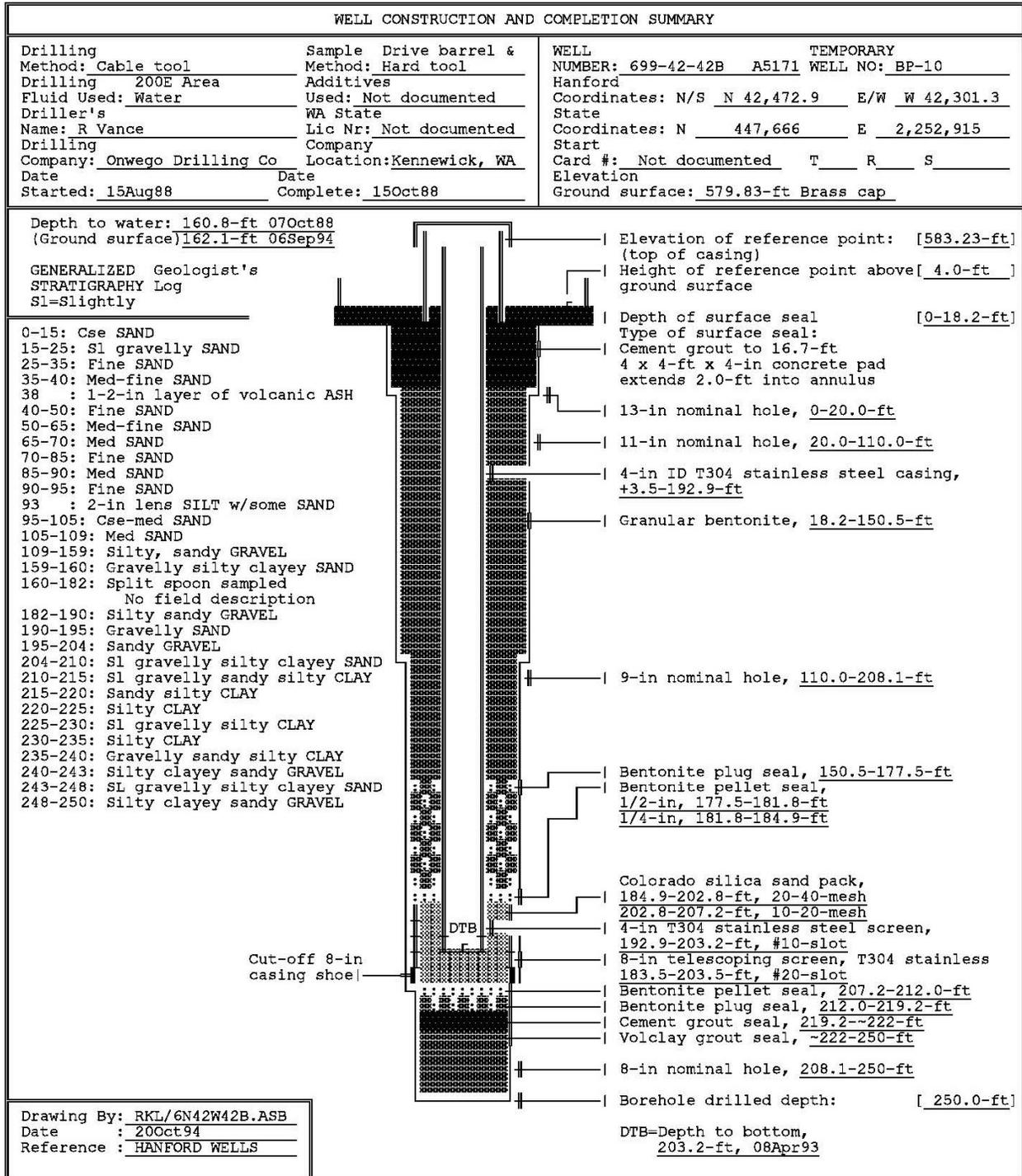


Figure C-1. Well 699-42-42B Construction and Completion Summary

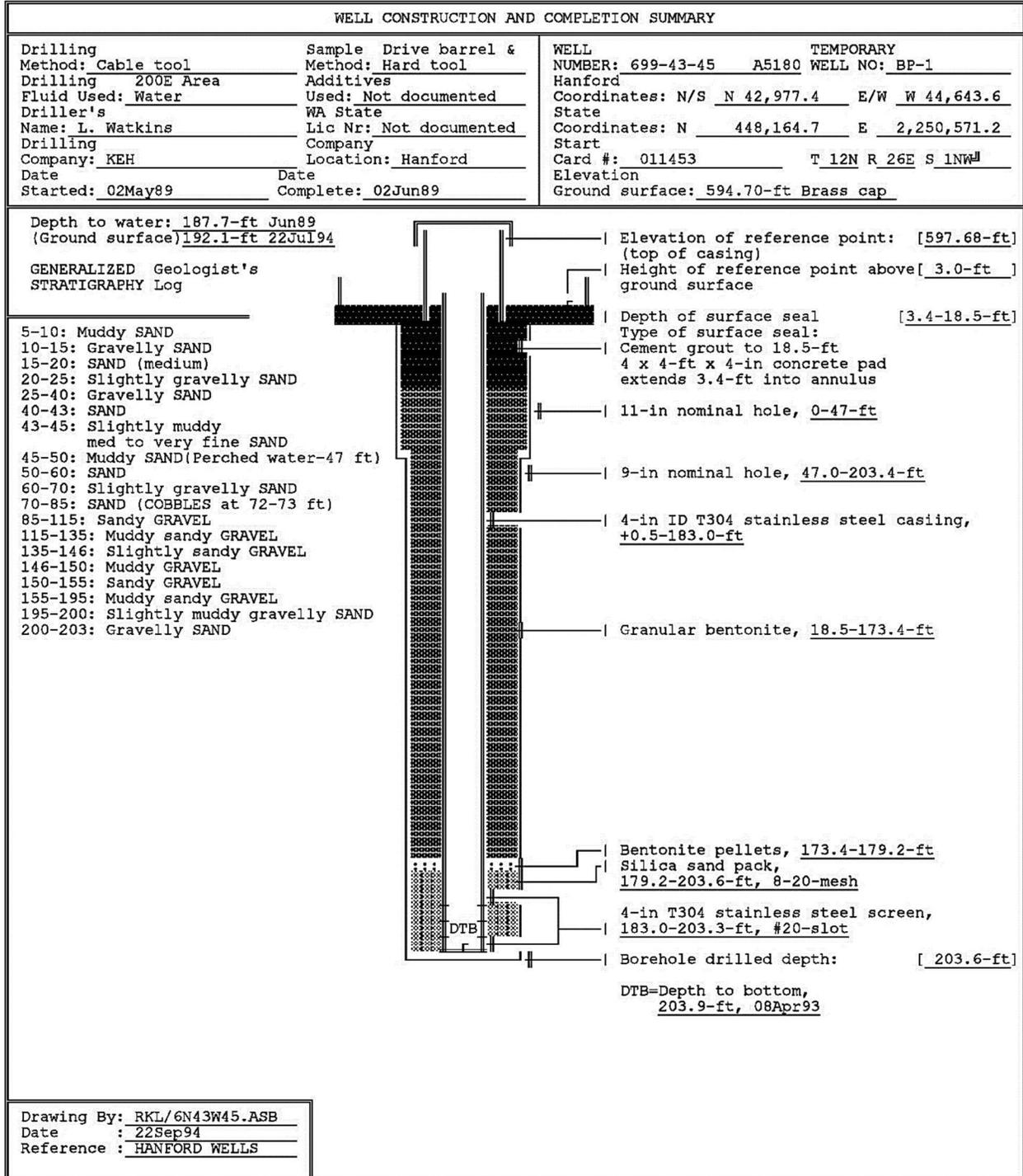


Figure C-2. Well 699-43-45 Construction and Completion Summary

DOE/RL-2008-59, REV. 2
RCRA-CN-02_DOE/RL-2008-59_R2

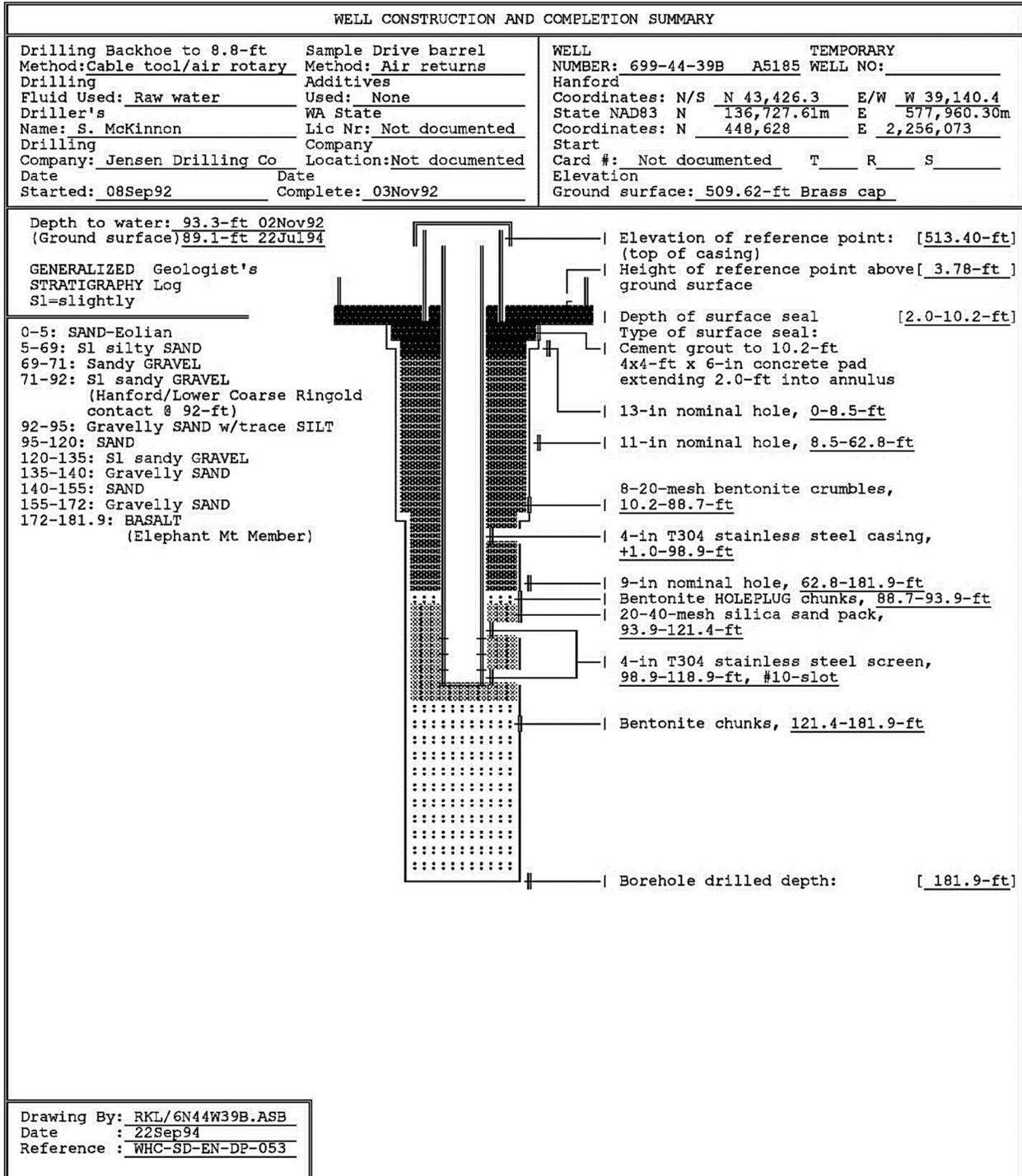


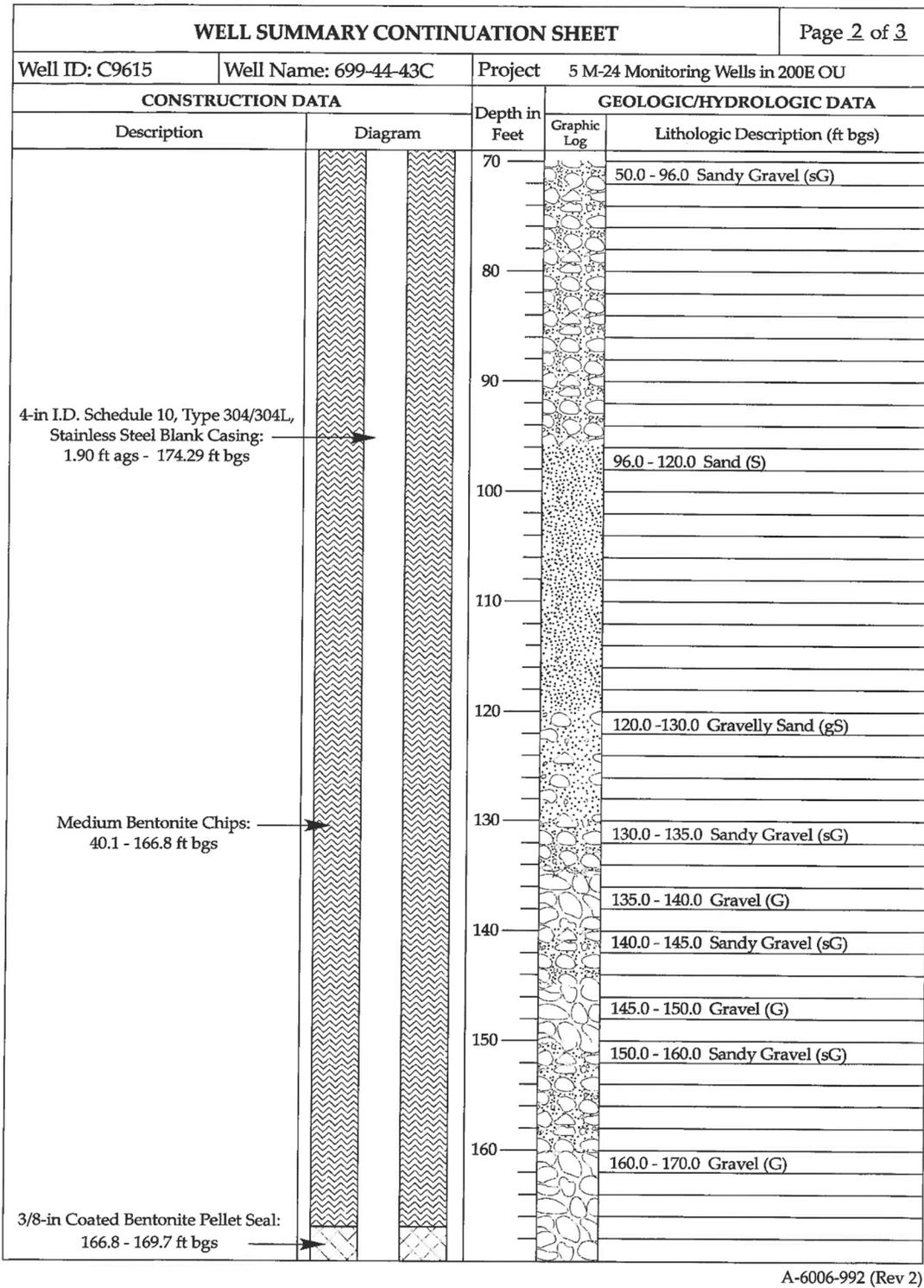
Figure C-3. Well 699-44-39B Construction and Completion Summary

WELL SUMMARY SHEET				Page 1 of 3	
Well ID : C9615		Well Name: 699-44-43C		Start Date: 06/19/2017	
Project: 5 M-24 Monitoring Wells in 200E OU		Location: 50 ft south of 699-44-43B		Finish Date: 07/26/2017	
CONSTRUCTION DATA			Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Graphic Log		Lithologic Description (ft bgs)	
Concrete Pad: 0.50 ft above ground surface (ags)			0	0.0 - 20.0 Sandy Gravel (sG)	
6-in Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs)			10		
Type I/II Portland Cement Grout: 0.0 - 40.1 ft bgs			20	20.0 - 25.0 Gravel (G)	
			30	25.0 - 35.0 Sandy Gravel (sG)	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 1.90 ft ags - 174.29 ft bgs			40	35.0 - 50.0 Sand (S)	
			50	50.0 - 96.0 Sandy Gravel (sG)	
Medium Bentonite Chips: 40.1 - 166.8 ft bgs			60		

Reported By:			
Kat Robertson	Geologist		08/11/17
<i>Print Name</i>	<i>Title</i>	<i>Signature</i>	<i>Date</i>
Reviewed By:			
	Well Coordinator		8/21/17
<i>Print Name</i>	<i>Title</i>	<i>Signature</i>	<i>Date</i>
For Office Use Only			
OR Doc Type:	WMU Code(s):		

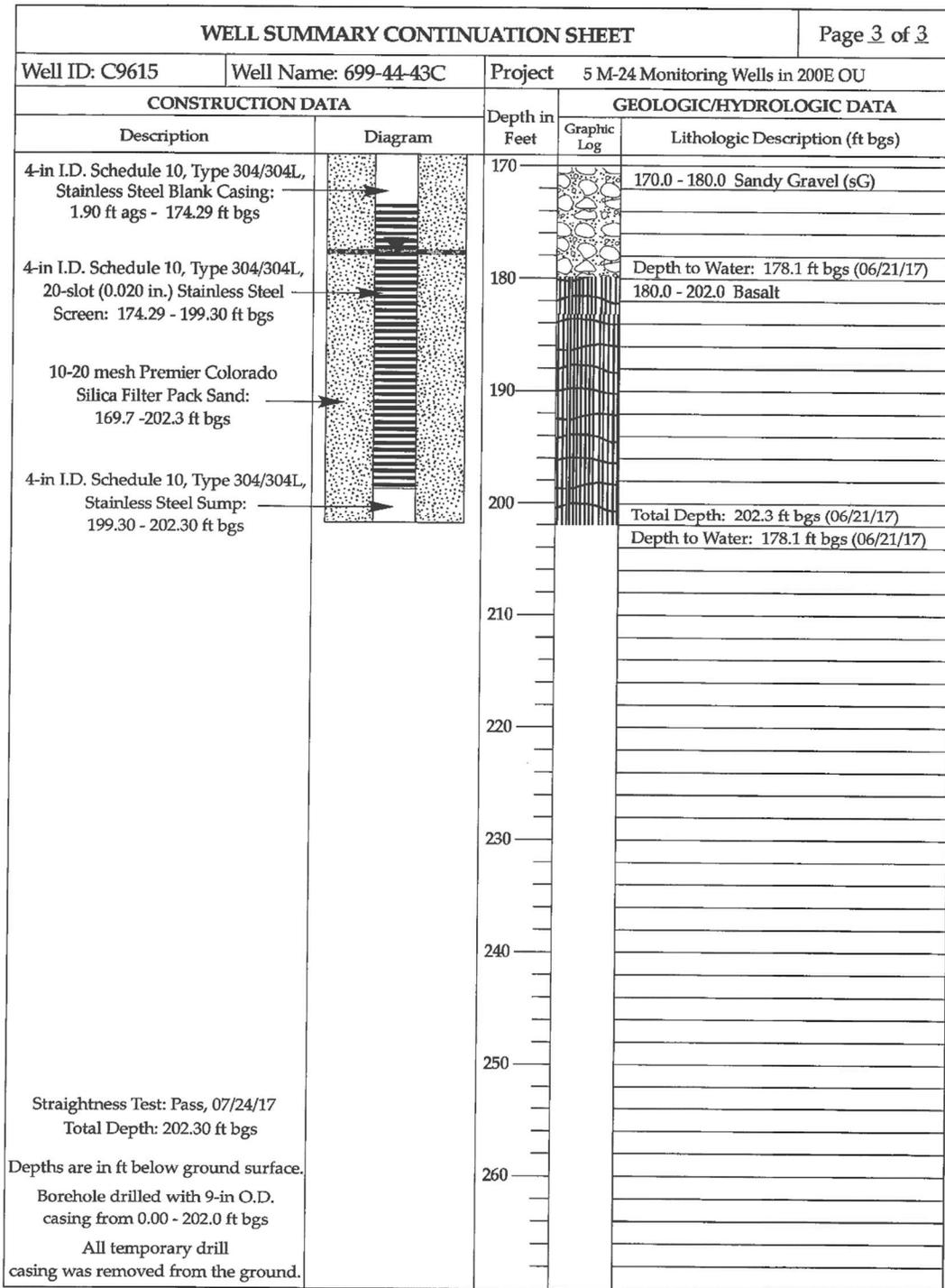
A-6003-643 (REV 2)

Figure C-4. Well 699-44-43C Construction and Completion Summary (page 1 of 3)



A-6006-992 (Rev 2)

Figure C-4. Well 699-44-43C Construction and Completion Summary (page 2 of 3)



A-6006-992 (Rev 2)

Figure C-4. Well 699-44-43C Construction and Completion Summary (page 3 of 3)

C2 Reference

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

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