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Draft REV. 0

Interim-Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

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DOE/RL-2015-49
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APPROVED
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Executive Summary

This document presents a revision to the Waste Management Area (WMA) A-AX 2006 groundwater monitoring plan[1]. This revised monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976*[2] (RCRA) and the implementing requirements in *Washington Administrative Code* (WAC) 173-303-400[3], which in turn, specifies groundwater monitoring regulations under 40 *Code of Federal Regulations* (CFR) 265[4]. Additionally, WMA A-AX is subject to the requirements of the Tri-Party Agreement[5], with the Washington State Department of Ecology (Ecology) identified as the lead regulatory agency for the WMA.

The U.S. Department of Energy (DOE) Richland Operations Office has undertaken revision of this RCRA groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford groundwater monitoring information for the WMA. This groundwater quality assessment monitoring plan is the principal controlling document for conducting groundwater monitoring at WMA A-AX.

WMA A-AX, which contains two tank farms (241-A and 241-AX) with 10 single-shell storage tanks, is within the 200-PO-1 Groundwater Operable Unit (OU). Other waste sites located within WMA A-AX include French drains, catch tanks, diversions boxes, valve pits, pipelines, and unplanned releases. WMA A-AX is located on the east side of the 200 East Area within the Hanford Site. The tank farms were designed to manage tank waste during operations at the Plutonium-Uranium Extraction Plant and, to a lesser extent, B Plant from 1956 to 1980. Two of the tanks are known or suspected to have leaked. In 1980, single-shell tanks (SSTs) at the 241-A and 241-AX Tank Farms were

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[1] PNNL-15315, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15315.pdf.

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

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

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

[5] Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

stabilized and isolated (pumped overlying liquid supernatant in the tanks and disconnected input pipes).

WMA A-AX was placed in groundwater quality assessment monitoring (40 CFR 265.93[d]) in 2005 because the indicator parameter specific conductance showed an exceedance relative to the statistical comparison value between upgradient and downgradient wells (40 CFR 265.93[b]). The elevated specific conductance is caused by elevated levels of groundwater constituents such as nitrate and sulfate, but these constituents are not classified as dangerous waste[6]. However, the dangerous waste constituent nickel has been found in samples from two downgradient wells (299-E25-40 and 299-E25-236) in the WMA A-AX network at higher concentrations than the corresponding upgradient wells. The elevated nickel was determined to be the result of stainless steel casing corrosion in Well 299-E25-236 and the well has been replaced. Currently, corrosion appears to also be affecting Well 299-E25-40.

This document presents an updated groundwater quality assessment plan to determine whether RCRA dangerous waste constituents associated with past releases from WMA A-AX have affected the underlying groundwater. It is a continuation of the first determination process of the previous plan (PNNL-15315) and includes a comprehensive list of dangerous waste constituents for assessment. The constituents include those potentially present single shell tank waste[7] in addition to dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407[8], which references 40 CFR 264, Appendix IX[9]. Results from the first and second semiannual sampling events of the dangerous waste constituents will be used to prepare a first determination report in accordance with 40 CFR 265.93(d)(4). If it is determined that dangerous waste from

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[6] WAC 173-303-040, "Dangerous Waste Regulations," "Definitions," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-040.

[7] RPP-23403, 2006, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

[8] Ecology Publication 97-407, 2014, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, Washington State Department of Ecology, Olympia, Washington. Available at: http://www.ecy.wa.gov/pubs/97407.pdf.

[9] 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-part264-applX.xml.

WMA A-AX has entered groundwater, then the migration rate and extent, as well as the concentration of the dangerous waste constituents, will be determined.

The previous plan (PNNL-15315) included sampling for technetium-99 as a supporting constituent. Technetium-99 is a radioactive constituent that is regulated under the *Atomic Energy Act of 1954*[10] and is not included for sampling in this RCRA monitoring plan. However, monitoring for technetium-99 at the 200-PO-1 OU will continue under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[11].

This revised RCRA groundwater monitoring plan presents a groundwater quality assessment program that addresses the following:

- Number, locations, and depths of wells in the WMA A-AX groundwater monitoring network
- Sampling and analysis methods for groundwater RCRA dangerous waste constituents in WMA A-AX
- Analysis for known or suspected dangerous waste constituents contained in SSTs
- Preparation of a first determination report for dangerous waste constituents
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at WMA A-AX

This revised plan uses the groundwater monitoring network identified in the previous monitoring plan (PNNL-15315), except that Well 299-E25-236 was decommissioned due to corrosion and has been replaced with a new well (299-E25-237). Groundwater flow direction determinations in 2013 showed a southeast flow direction, with flow to the south-southeast indicated in 2014 beneath WMA A-AX. Groundwater in the WMA A-AX monitoring wells will be sampled and analyzed semiannually for supporting constituents (anions and metals) used for determining water chemistry charge balance and corrosion of the stainless steel well casings and screens. Field parameters

[10] *Atomic Energy Act of 1954*, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: http://epw.senate.gov/atomic54.pdf.

[11] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

(pH, specific conductance, temperature, and turbidity) will be obtained each time a well is sampled, along with a water level measurement.

Sampling for potential dangerous waste constituents from SST waste will be conducted semiannually. After two sampling events, a first determination report will be prepared and will determine whether dangerous waste constituents from WMA A-AX have entered the groundwater. The report will identify 1) constituents attributable to previous releases from WMA A-AX, 2) constituents that are not detected in the groundwater monitoring network or that are not attributable to previous WMA A-AX releases, and 3) constituents that require additional sampling to allow this determination. Based on the first determination report, this groundwater quality assessment plan will then be revised. In the revised plan, 1) constituents attributable to releases from WMA A-AX will be included for routine sampling on a quarterly basis, 2) constituents that are not detected in the groundwater monitoring network, detected below background, or are not attributable to previous WMA A-AX releases will be eliminated from further sampling, and 3) constituents that require additional sampling to allow this determination will continue to be sampled semiannually.

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Terms

AEA	Atomic Energy Act of 1954
amsl	above mean sea level
bgs	below ground surface
BIX	221-B Plant cesium ion exchange waste
CAS	Chemical Abstracts Service
CCU	Cold Creek Unit
CCU_g	Cold Creek unconsolidated coarse-grained gravel unit
CCU_z	Cold Creek silt-dominated unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
CSM	conceptual site model
DOE	U.S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
K_d	distribution coefficient
N/A	not applicable
OU	operable unit
P1	PUREX high-level waste
PUREX	Plutonium-Uranium Extraction
PVC	polyvinyl chloride
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
TIC	tentatively identified compound
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

UPR	unplanned release
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System
WMA	waste management area

1 Introduction

This document presents the revised groundwater quality assessment plan for Waste Management Area (WMA) A-AX and supersedes the previous plan (PNNL-15315, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*). The U.S. Department of Energy (DOE) Richland Operations Office has undertaken revision of this *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford groundwater monitoring information for the WMA. This groundwater quality assessment monitoring plan is the principal controlling document for conducting groundwater monitoring at WMA A-AX.

The specific objective of this groundwater quality assessment plan is to fulfill the requirements specified in WAC 173-303-400(3) ("Dangerous Waste Regulations," "Interim Status Facility Standards"), incorporating by reference 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring." These regulations require that a groundwater quality assessment monitoring plan be implemented and allow for a determination (40 CFR 265.93[d][5], "Preparation, Evaluation, and Response") of whether dangerous waste constituents found in the underlying groundwater are associated with past releases at WMA A-AX. If dangerous waste constituents from WMA A-AX are detected, the migration rate and extent, as well as the concentration of the dangerous waste constituents in groundwater, must be determined (40 CFR 265.93[d][4]). To meet these objectives, this plan defines a network of groundwater monitoring wells; specifies the sampling frequency; identifies the potential dangerous waste constituents, contaminant indicators, and supporting constituents to be monitored in groundwater; and requires the preparation of a first determination report.

Closure of WMA A-AX will be coordinated with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as part of the single-shell tank (SST) system. Groundwater cleanup will be addressed under the 200-PO-1 Groundwater Operable Unit (OU).

WMA A-AX is located on the east side of the 200 East Area within the Hanford Site (Figure 1-1) and contains two tank farms (241-A and 241-AX) with 10 single-shell storage tanks. The tank farms were designed to manage tank waste during operations at the Plutonium-Uranium Extraction (PUREX) Plant, and, to a lesser extent, the B Plant, from 1956 to 1980. In 1980, SSTs at the 241-A and 241-AX Tank Farms were stabilized and isolated. Two SSTs in WMA A-AX are known, or are suspected, to have leaked. Other liquid handling structures associated with the tank farm operations and located within WMA A-AX include French drains, catch tanks, diversions boxes, valve pits, and process pipelines. Several unplanned release (UPR) waste sites are also within WMA A-AX.

Initial groundwater monitoring results for the WMA A-AX well network indicated that WMA A-AX constituents have entered the groundwater based on comparison between upgradient and downgradient wells (SGW-47538, *Groundwater Quality Assessment Report for Waste Management Area A-AX: First Determination*). Nitrate and other WMA A-AX constituents are more concentrated in one downgradient well (299-E25-93), and nickel is more concentrated in two downgradient wells (299-E25-40 and 299-E25-236) (Figure 1-2). With the exception of nickel, these are not dangerous wastes or dangerous waste constituents as defined by WAC 173-303-040, "Definitions," and listed in WAC 173-303-9905, "Dangerous Waste Constituents List." However, nickel is a potential product of corrosion of stainless steel well casings such as are found in the southern part of WMA A-AX where three wells (299-E24-19, 299-E25-46, and 299-E25-236) were decommissioned due to corrosion of their casings. Wells 299-E24-19, 299-E25-46, and 299-E25-236 (when they were still in service) showed elevated levels of nickel along with manganese, iron, and chromium. These constituents in groundwater monitored by stainless steel wells are indicators of well corrosion. Currently, Well 299-E25-40 shows

elevated levels of four metals indicative of stainless steel corrosion (nickel, chromium, iron, and manganese); however, the cause of the corrosion is currently unknown.

At the three corroded and decommissioned wells, the corrosion occurred above the water table at (or slightly above) a fine-grained geologic unit (the Cold Creek silt-dominated unit [CCU_z]). This unit either creates perching conditions for groundwater (percolating downward between the surface and the water table) or retains a higher percentage of moisture due to its fine-grained nature. It is unlikely that SSTs and other liquid waste facilities in WMA A-AX leaked or discharged a large enough volume that contained the corrosive constituents necessary to corrode the three wells. The most likely source of the corrosion is chloride-bearing effluent from the 200 East Area powerhouse (284-E Powerhouse) that was discharged to an unlined ditch (200-E-286 Ditch) that traversed the southwest end of what later became the 241-A Tank Farm (Figure 1-2). This ditch was active from 1946 to 1953.

The groundwater quality assessment will continue the determination as to whether there are dangerous wastes or dangerous waste constituents from WMA A-AX in groundwater beneath WMA A-AX. Samples will be analyzed for dangerous waste constituents identified as potentially present in SST waste (RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*) along with dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, which references 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List")[12]. In addition, sampling for anions, metals, and field parameters necessary to calculate charge balance[13], and metals indicative of corrosion of stainless steel wells[14] will be conducted. Although included as a supporting constituent in PNNL-15315, technetium-99 is a radioactive constituent that is regulated under the *Atomic Energy Act of 1954* and is not included for sampling in this RCRA monitoring plan.

This comprehensive sampling and analysis effort will complete the groundwater quality assessment necessary to determine if SST wastes have contaminated groundwater at WMA A-AX with dangerous waste constituents. A first determination report will be prepared and will evaluate the results of the dangerous waste constituents to determine if any dangerous waste constituents detected in groundwater samples are the result of previous WMA A-AX releases. Any constituents determined to originate from previous WMA A-AX releases will be included as constituents for routine monitoring on a quarterly basis in a revision to this monitoring plan.

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the site and incorporates knowledge about the potential for contamination originating from the WMA A-AX. Chapter 2 summarizes background information and describes WMA A-AX and the types of waste present, the regulatory basis and a brief history of the groundwater monitoring program, and a description of the geology and hydrogeology of the area. This information is incorporated into the CSM to aid in development of the groundwater monitoring program. Chapter 3 describes the RCRA groundwater monitoring program, the wells monitored, sampling frequency and protocols, and the constituents analyzed. Chapter 4 describes data evaluation and reporting. A list of the references cited in this document is provided in Chapter 5. Appendix A provides the quality assurance project plan (QAPjP). Sampling protocols are provided in Appendix B. Well construction information is provided in Appendix C.

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[12] Although 40 CFR 265 contains final status requirements, constituents listed in Appendix IX will be used to determine if dangerous waste from WMA A-AX have entered the groundwater.

[13] Includes alkalinity, anions (chloride, nitrate, and sulfate), and metals (calcium, magnesium, potassium, and sodium).

[14] Indicators of corrosion in stainless steel wells: nickel, chromium, manganese, and iron.

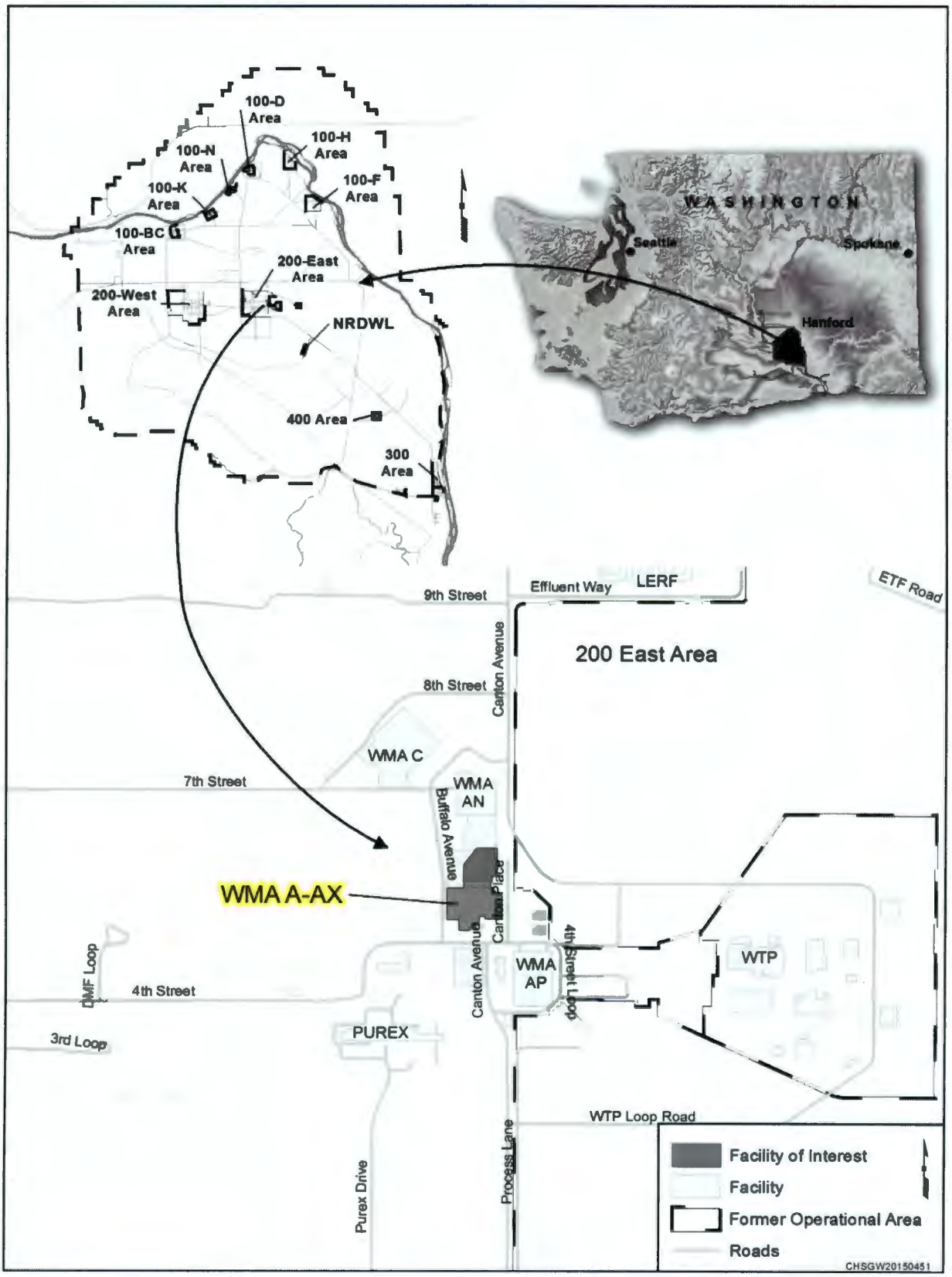


Figure 1-1. Location of WMA A-AX

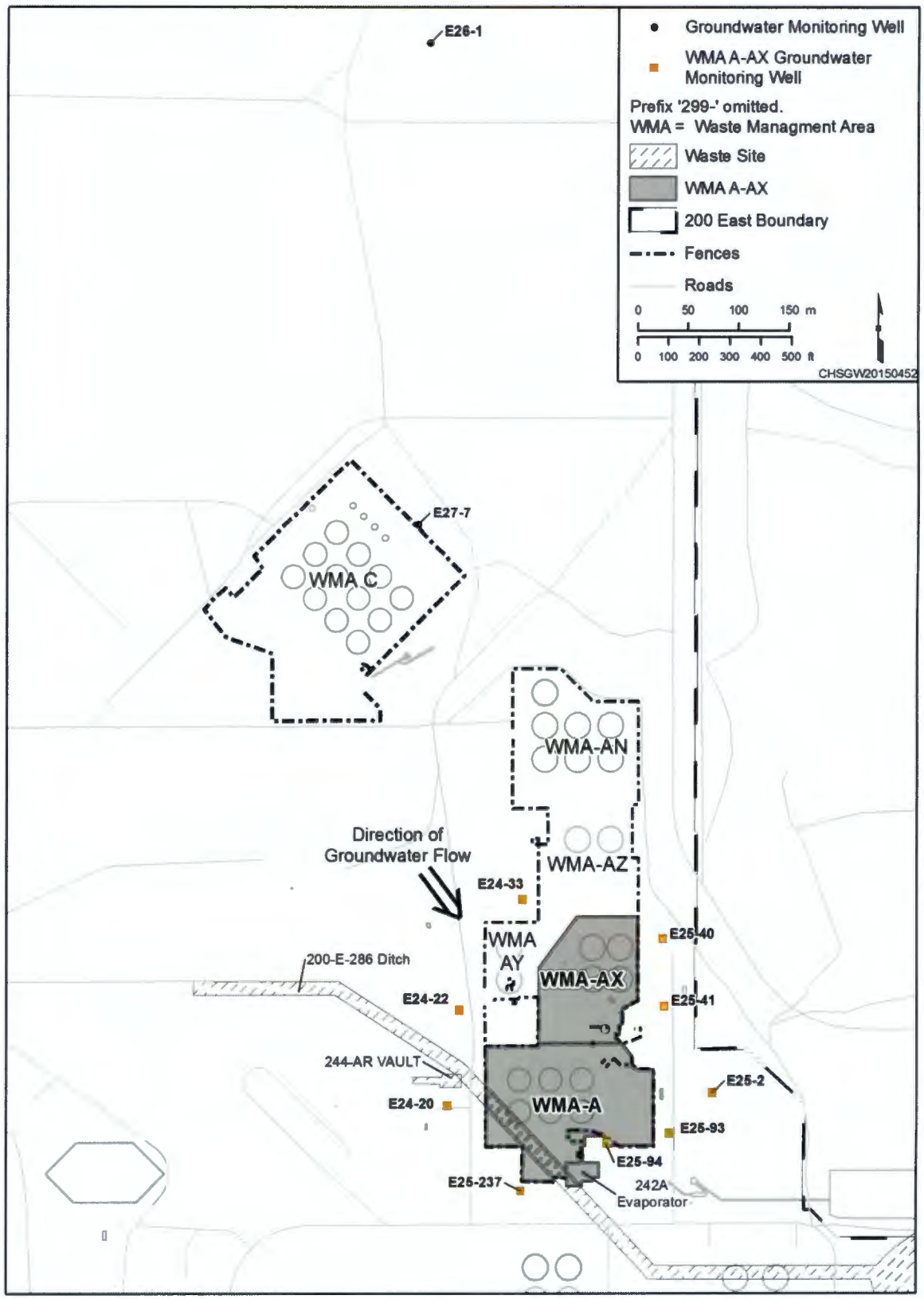


Figure 1-2. Location of WMA A-AX, A and AX Tank Farms, and Wells in the WMA A-AX Monitoring Network

2 Background

This chapter provides an overview of WMA A-AX, including a brief account of its operational history, regulatory basis, and a general description of the tank wastes. Local subsurface geology and hydrogeology is provided, along with a summary of the CSM of vadose zone contaminant migration. This chapter also summarizes previous groundwater monitoring and describes the monitoring objectives used to gather data of the appropriate quantity and quality for the groundwater quality assessment.

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

- BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*
- Bjornstad, *On the Trail of the Ice Age Floods: A Geological Field Guide to the Mid-Columbia Basin*
- DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*
- DOE/RL-89-28, *216-B-3 Expansion Ponds Closure Plan*
- DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*
- DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*
- DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- HNF-EP-0182, Rev. 329, *Waste Tank Summary Report for Month Ending May 31, 2015*
- HW-28121, *Release of Radioactive Wastes to Ground*
- PNL-8337, *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System*
- PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*
- PNNL-13023, *RCRA Groundwater Monitoring Plan for Single Shell Tank Waste Management Area A AX at the Hanford Site*
- PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*
- PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*
- PNNL-14548, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*
- PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*
- PNNL-15141, *Investigation of Accelerated Casing Corrosion in Two Well at Waste Management Area A-AX*

- PNNL-15955, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*
- PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*
- RPP-7494, *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations*
- RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*
- RPP-16608, *Site-Specific Single-Shell Tank Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan Addendum for Waste Management Areas C, A-AX, and U*
- RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*
- RPP-23748, Geology, *Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*
- RPP-26744, *Hanford Soil Inventory Model*
- RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*
- RPP-ENV-37956, *Hanford A and AX-Farm Leak Assessments Report: 241-A-103, 241-A-104, 241-A-105, 241-AX-102, 241-AX-104 and Unplanned Waste Releases*
- SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*
- SGW-58828, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*
- WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*
- WHC-MR-0132, *A History of the 200 Area Tank Farms*
- WHC-SD-EN-AP-012, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*
- WHC-SD-EN-TI-019, *Hydrogeologic Model for the 200 East Groundwater Aggregate Area*

2.1 Facility Description and Operational History

Section 2.1.1 describes the overall tank farm facility. Section 2.1.2 describes the operational history and identifies releases from SSTs and related liquid handling structures, French drains, and other waste sites within WMA A-AX. Section 2.1.2.3 summarizes the 200-E-286 Ditch operations and the related potential impact to groundwater.

2.1.1 Facility Description

The fence line surrounding the 241-A and 241-AX Tank Farms constitutes the RCRA site boundary of WMA A-AX (Figure 1-2). The WMA includes ten 100-series SSTs (Figure 2-1). Five French drains used for liquid disposal and multiple liquid handling structures associated with the A and AX tank operations, including catch tanks, diversions boxes, process pipelines, and valve pits, are within WMA A-AX. The 241-A Tank Farm contains six SSTs constructed in 1954 to 1955. The 241-AX Tank Farm contains four SSTs constructed in 1963 to 1964. The SSTs were constructed in place with carbon steel lining the bottom and sides of a reinforced concrete shell (Figure 2-2). The tanks each had an operating capacity

of 3,785,000 L (1,000,000 gal). The tank dimensions are 23 m (75 ft) in diameter and 12 m (44 ft) tall. They were installed below ground with the tops of the tanks at least 1.8 m (6 ft) below grade to provide radiation shielding and protection for operating personnel. The 241-A tanks each have three horizontal lateral pipes that run approximately 3 m (10 ft) beneath the tank concrete foundation. These laterals were 10 cm (4 in.) outer diameter pipes that allowed probes to be inserted to monitor for gamma radiation as a means of indicating waste leakage from a tank. Tanks in the 241-AX Tank Farm, although essentially the same as the 241-A Tank Farm, had a grid of drain slots beneath the steel liner bottom to collect potential tank leakage. Any leaked liquid was then diverted to a leak detection well. The tanks within WMA A-AX were all stabilized and isolated in 1980 (pumped overlying liquid supernatant in the tanks and disconnected input pipes).

Drywells surround both tank farms. Drywells are open bottom, 15 cm (6 in.) or 20 cm (8 in.) steel casings placed vertically around the tank perimeters, and extending between 23 m (75 ft) and 61 m (200 ft) below grade. Historically, the drywells were monitored with gross gamma and other radiation logging tools as part of a secondary leak monitoring system.

2.1.2 Operational History

Waste sent to tanks in WMA A-AX came primarily from operations at the PUREX Plant and B Plant waste fractionation process. The majority of the waste was neutralized acid waste from PUREX operations starting in 1956 and continuing through 1972 (WHC-MR-0132). Another significant waste stream starting in 1965 and continuing until 1980 came from the preparation, temporary storage, volume reduction, and transfers of the various B Plant fractionation waste (RPP-7494).

Facilities and waste sites within WMA A-AX that potentially affected groundwater include SSTs, liquid handling structures associated with the tanks, UPRs, and French drains. These facilities and waste sites were evaluated to determine potential groundwater monitoring constituents for this plan. Furthermore, the 200-E-286 Ditch was evaluated to determine whether it had sufficient volume and corrosive content to have contributed to the corrosion of the casings in the three corroded and decommissioned wells (299-E24-19, 299-E25-46, and 299-E25-236) at the depth of the Cold Creek unit (CCU).

2.1.2.1 Single-Shell Tanks, French Drains, and Liquid Handling Structures within WMA A-AX

Of the 10 tanks located within WMA A-AX (Figure 2-1), two are currently confirmed or assumed leakers: 241-A-104 and 241-A-105 (HNF-EP-0182, Rev. 329). Leaks from Tanks 241-A-103, 241-A-104, 241-A-105, 241-AX-102, and 241-AX-104 were reassessed in the 2014 revision of RPP-ENV-37956. Although previously assumed to have leaked, Tanks 241-A-103, 241-AX-102, and 241-AX-104 are now classified as "Sound" based on the incorporation of recommendations from formal leak assessments as identified in Table 2-1.

Table 2-1. Tanks within Waste Management Area A-AX with Reclassification of Tank Integrity

Tank	Current Status	Leak Assessment Report	Waste Tank Summary Report Documenting Status Change
241-A-103	Sound	RPP-ASMT-42278, *Tank 241-A-103 Leak Assessment Report*	HNF-EP-0182, Rev. 306, *Waste Tank Summary Report for Month Ending September 30, 2013*
241-AX-102	Sound	RPP-ASMT-42628, *Tank 241-AX-102 Integrity Assessment Report*	HNF-EP-0182, Rev. 319, *Waste Tank Summary Report for Month Ending July 31, 2014*
241-AX-104	Sound	RPP-ASMT-57574, *Tank 241-AX-104 Integrity Assessment Report*	HNF-EP-0182, Rev. 321, *Waste Tank Summary Report for Month Ending September 30, 2014*

Leaks from Tanks 241-A-104 and 241-A-105 were reassessed in RPP-ENV-37956, however the revised leak volumes have not yet been formally adopted as of May 2015 (HNF-EP-0182, Rev. 329). The leak volumes provided below include estimates from both HNF EP-0182, Rev. 329 and RPP-ENV-37945. The reported leak inventory and composition for Tanks 241-A-104 and 241-A-105 is obtained from the revised (2014) leak inventory assessment report (RPP-ENV-37956). The following discussion refers to the radiation activity and radioactive constituents and components of released material; however, these constituents and components are not subject to RCRA regulations and are included here for the sole purpose of identifying releases from tanks. Dangerous waste constituents potentially present in SST waste are considered potential groundwater monitoring constituents for this plan.

Tank 241-A-104 was categorized as an assumed leaker in 1975 and has a total leak volume of 1,900 to 9,500 L (500 to 2,500 gal) (HNF-EP-0182, Rev. 329). During sluicing operations in 1975, increased radiation activity was detected in two laterals beneath the tank, although gross gamma scans of the drywells did not indicated activity above background (RPP-ENV-37956). Reassessment of the Tank 241-A-104 leak in RPP-ENV-37956 concludes that the estimated waste loss is approximately 7,600 L (2,000 gal) based on radioactivity in the laterals. The waste type released from tank 241-A-104 is PUREX sludge supernate, containing approximately 0.56 Ci/gal of cesium-137 (activity as of May 2008). The cesium-137 inventory for the release is approximately 1,100 Ci (RPP-ENV-37956). The solids inventory for Tank 241-A-104 is 106,000 L (28,000 gal) of sludge (HNF-EP-0182, Rev. 329).

Tank 241-A-105 was categorized as an assumed leaker in 1963 and has a total leak volume of 38,000 to 1,022,000 L (10,000 to 270,000 gal) (HNF-EP-0182, Rev. 329). RPP-ENV-37956 reports the tank was categorized as a confirmed leaker in 1975, based on increased radioactivity detected in laterals and information resulting from the 1965 sudden steam release incident (RPP-ENV-37956).
On January 28, 1965, tank 241-A-105 experienced a rapid pressurization event that resulted in the tank liner bulging upward. In 1977, a topographical map produced of the tank bottom clearly showed the bottom of the steel liner had ripped and separated from the sidewall along approximately three-fourths of the tank bottom (RPP-ENV-37956). Reassessment of Tank 241-A-105 leaks in RPP-ENV-37956 concludes that the lateral data obtained from 1963 to 1986 showing elevated gamma activity and high temperatures below tank 241-A-105 clearly indicates the presence of a tank liner leak. In-tank surface level changes and video observation of a bulge and ripped liner confirm that the tank leaked.

The leak inventory estimate for Tank 241-A-105 in RPP-ENV-37956 is based on the extent of the ripped liner, the dates when increased gamma activity was detected in the tank laterals, and the extent of contamination in the laterals. The estimated leak volume in RPP-ENV-37956 is 7,600 to 151,000 L (2,000 to 40,000 gal) depending on the waste type, based on an estimated 56,000 Ci of cesium-137 in the soil. At least three leak events occurred at Tank 241-A-105. PUREX high-level waste supernate (waste type P1) leaked from this tank in late 1963 and again in 1965. During sluicing operations in 1968 to 1970, 221-B Plant cesium ion exchange waste (waste type BIX) also leaked from this tank. In an effort to better quantify the inventory of waste leaked from tank 241-A-105, a new conceptual model was devised to describe the leak. Based on this conceptual model, the range of waste volume leaked from tank 241-A-105 was estimated to be between 7,600 L (2,000 gal) (if all P1waste) or 151,000 L (40,000 gal) (if all BIX waste).

In addition to the P1 and/or BIX supernate waste leaked, cooling water likely leaked from tank 241-A-105 (RPP-ENV-37956). An estimated 2,300,000 L (610,000 gal) of cooling water was added to tank 241-A-105 during November 1970 through December 1978 and 760,000 to 880,000 L (200,000 to 232,000 gal) of cooling water were unaccounted for by evaporation estimates and may have leaked to the soil. The solids inventory for Tank 241-A-105 is 140,000 L (37,000 gal) of sludge (HNF-EP-0182, Rev. 329).

Information on the French drains was obtained from WIDS. Five French drains located within WMA A-AX were used for liquid waste disposal (Figure 2-3). The 216-A-16 French drain is located in the southeast corner of the 241-A Tank Farm. It received approximately 60,000 L (15,850 gal) of floor drainage from the 241-A-431 Building and stack drainage from the 296-A-11 Stack. The 216-A-16 French drain also received overflow from the 216-A-17 French drain and was taken out of service in March 1969.

The 216-A-17 French drain, located in the southeast of the 241-A Tank Farm, received approximately 122,000 L (32,230 gal) of floor drainage from the 241-A-431 Building and stack drainage from the 296-A-11 Stack. The 216-A-17 French drain was taken out of service in 1969.

The 216-A-23A and 216-A-23B French drains, located in the southeast corner of the 241-A Tank Farm, received approximately 6,000 L (1,585 gal) of tank condensate and the backflush from the 241-A-431 Building from 1975 through 1969. The total amount discharged by this waste stream, 6,000 L (1,585 gal), applies to both 216-A-23A and 216-A-23B French drains. The French drains were connected to each other by an underground overflow pipe and were separated by 3 m (10 ft).

The 241-A-702-WS-1 French drain is located in the southern portion of the 241-AX Tank Farm and received steam condensate from the 241-A-702 Ventilation Building beginning in 1968. Process steam was used in the steam heaters to raise the temperature of vent gases from the 241-AY and 241-AZ tanks to prevent wetting of the filters. The 241-A-702-WS-1 French drain was used in conjunction with a steam trap for the system. The drain was permanently isolated in 1995.

Other liquid handling structures within WMA A-AX, including diversions boxes, valve pits, catch tanks, and process pipelines were used to transport or contain liquid waste associated with the tank farms. Information for these structures, which are identified as waste sites in WIDS, is provided below.

There are four diversion box waste sites in WMA A-AX. Diversion boxes are concrete structures containing transfer piping and were designed to contain leaks from transfers and drainage of effluent from operations within the unit. The diversion boxes drained to catch tanks or double-shell tanks.

There are five valve pits in WMA A-AX. The valve pits are underground concrete structures designed to contain leaks from transfers and drainage operations and then drain to catch tanks. Valve pits were equipped with a leak detection system, which was designed to shut down operations if a leak in the pit were detected.

There are three catch tanks in WMA A-AX. The catch tanks are underground structures designed to receive valve pit or diversion box leaks during transfers and drainage operations. Catch tanks are constructed of concrete and, in some cases, were lined with stainless steel. One catch tank (241-AX-152) was declared leaking in March 2001 (Figure 2-3). All liquid within the 241-AX-152 catch tank was removed and the tank isolated using administrative and engineering controls. The design capacity of the 241-AX-152 catch tank was 41,640 L (11,000 gal). In March 1980, a routine pressure test of the return pipeline from the 241-AX-501 valve pit to the 241-A-417 catch tank (Figure 2-3) indicated a flange connection leak. An excavation at the pipeline leak was performed and two barrels of contaminated soil, reading 10,000 counts per minute, were removed and a new gasket installed.

Fourteen pipeline structures in WMA A-AX transferred effluent or condensate waste from the tank farm to French drains and surface liquid waste facilities. The pipelines were constructed of either carbon steel, stainless steel, vitrified clay, or fiberglass reinforced epoxy. Pipelines were either direct buried or encased in concrete. The pipelines delivered process fluids or condensate and were either gravity or pressurized lines. There are no releases or losses of transfer fluids documented in WIDS from pipelines in WMA A-AX.

These liquid handling structures within WMA A-AX carried or contained waste effluent (e.g., mixed waste solutions and decontamination solutions) associated with the tanks. Therefore, any impacts to groundwater from these structures will be assessed using the constituents identified from the tank waste.

2.1.2.2 Unplanned Releases

The following information about UPRs within WMA A-AX is from WIDS and RPP-ENV-37956. With the information available about the volume of the releases and the corrosive nature of the liquids released, it is unlikely that these UPRs contributed to corrosion of groundwater monitoring wells or that they uniquely identify any potential dangerous waste constituents that would need to be added to this groundwater monitoring plan. Contaminants from the higher volume UPRs (UPR-200-E-125 and UPR-200-E-126) are associated with tank waste. Therefore, potential impacts to groundwater from these contaminants will be assessed as part of the identified potential dangerous waste contaminants from SSTs.

UPR-200-E-47 occurred south of the 241-A-702 Building at the southern border of the AX Tank Farm. This UPR was a 1974 surface contamination event consisting of white specks that covered a 30 m (98 ft) by 76 m (250 ft) area near the building. The specks were assumed to have been windblown from the 702-A Vessel Ventilation Building stack. The parking area and vehicles were cleaned and returned to normal operation the same day.

UPR-200-E-48 occurred adjacent to Tank 241-A-106. This UPR was a small liquid release during installation of a new pump at the 241-A-106 pump pit in January of 1974.

UPR-200-E-115 occurred adjacent to Tank 241-AX-103. This UPR consisted of a spray leak in the 241-AX-103 Pump Pit in February 1974 (RPP-7494). According to WIDS, during bleeding of air from a line, air flowed up (instead of down) causing contaminated liquid to spray onto two employees and the ground adjacent the 241-AX-103 Pump Pit.

UPR-200-E-119 occurred adjacent to Tank 241-AX-104. This UPR consisted of an employee mistakenly pulling a contaminated electrode cable out of Tank 241-AX-104 and setting it on the ground. The contamination was limited to a small area near the 241-AX-104 Tank.

UPR-200-E-125 is associated with a tank leak at 241-A-104 and occurred in the soil underneath the tank. According to WIDS, approximately 9,463 L (2,500 gallons), containing 18,000 curies of cesium-137 were released from the 241-A-104 tank.

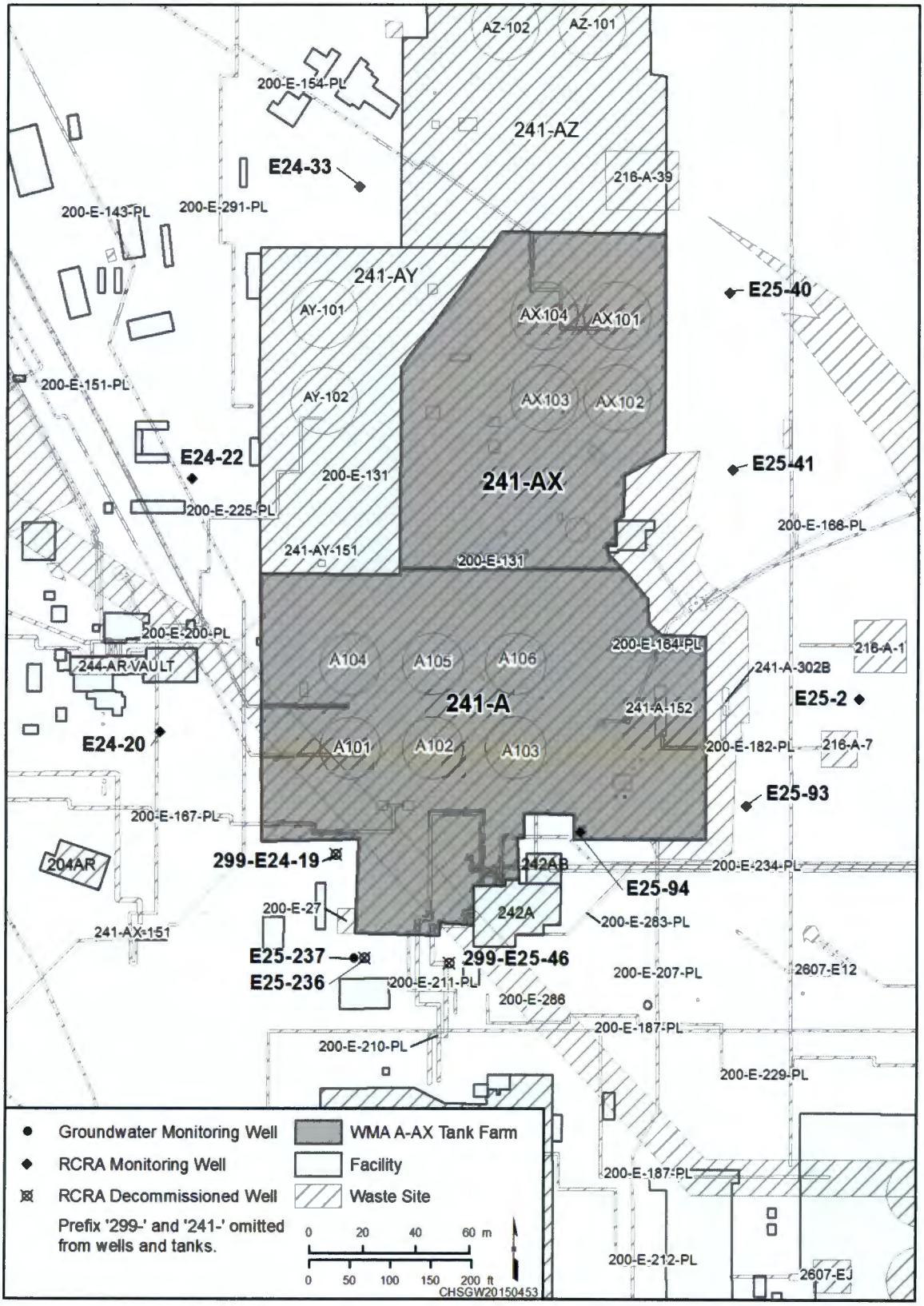


Figure 2-1. Map of Single-Shell Tank Waste Management Area A-AX Including Well Locations

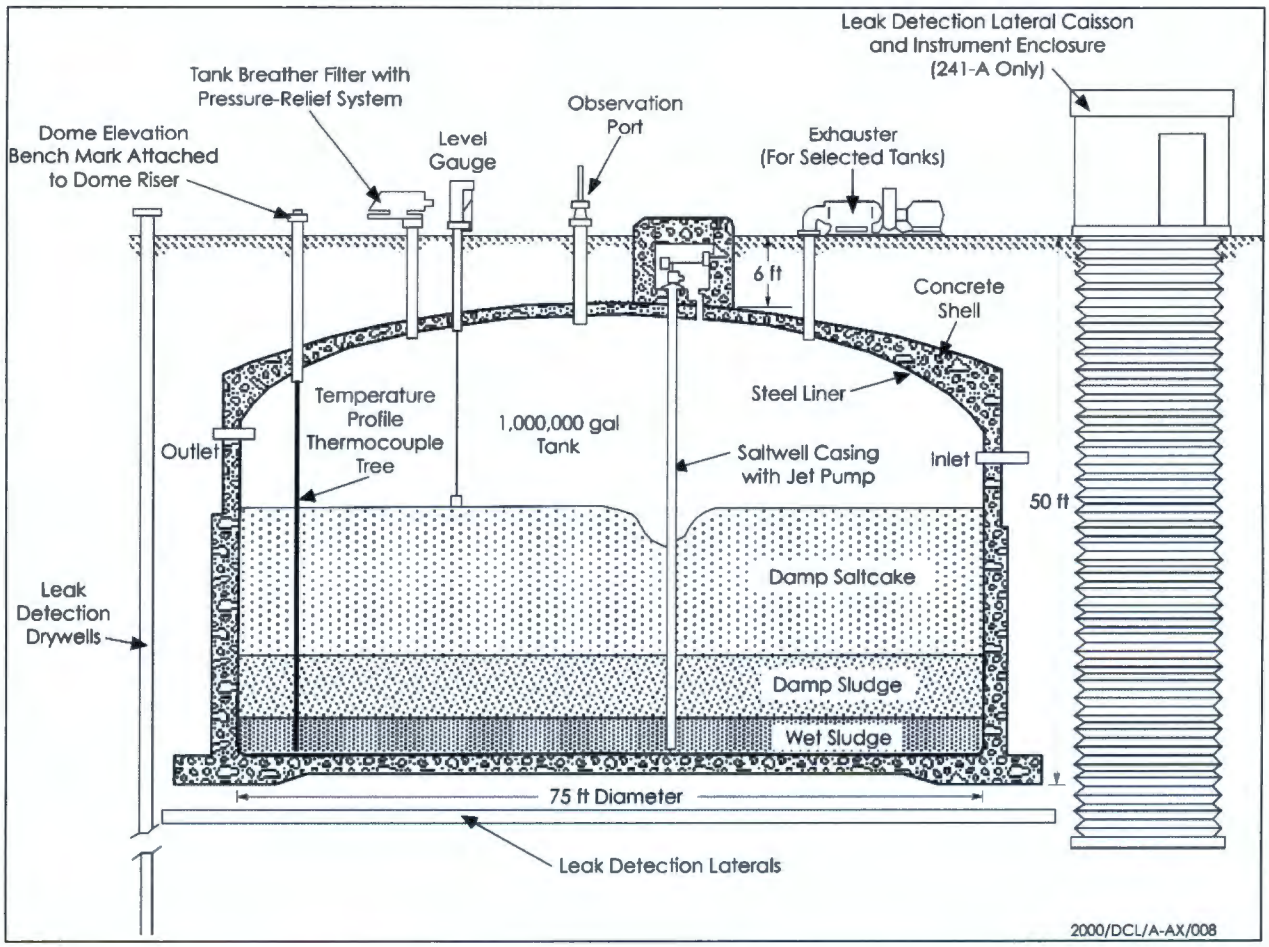


Figure 2-2. Schematic of Typical Single-Shell Tank with 1 Million Gallon Capacity

UPR-200-E-126 is associated with the rapid pressurization event at Tank 241-A-105 and occurred in the soil underneath the tank. A sudden steam release of severe intensity occurred in January 1965. Approximately 18,900 L (5,000 gal) of waste leaked from the deformed tank (this release amount does not include the cooling water added to the tank).

The preceding UPRs are located within the boundary of the 200-E-131 Contaminated Soil Associated with 241-A Tank Farm Complex waste site and have been consolidated within 200-E-131. The 200-E-131 waste site was created to consolidate and manage multiple, unrelated UPRs that had occurred in the 241-A, -AN, -AX, -AY, and -AZ Tank Farms complex and includes the entire area within the 241-A complex fence. Some of the releases, such as the preceding UPR waste sites, are identified in WIDS but not all UPRs that have occurred at the 241-A Tank Farm are identified waste sites. The 200-E-131 site is classified as Accepted in WIDS. Any remedial action for the consolidated UPR sites will be associated with 200-E-131.

Another category of UPRs includes leaking or ruptured water lines, leaking fire hydrants, or broken valves. One such break in a water line occurred in February of 1978 on the east side of 241-A Tank Farm (WHC-SD-EN-AP-012). Before the line could be turned off, 227,125 L (60,000 gal) of water were released to the soil column. This large volume of water caused soil collapse in the center of the farm between Tanks 241-A-102 and 241-A-105 (a known leaking tank), even though the ruptured line was on the east side of the tank farm.

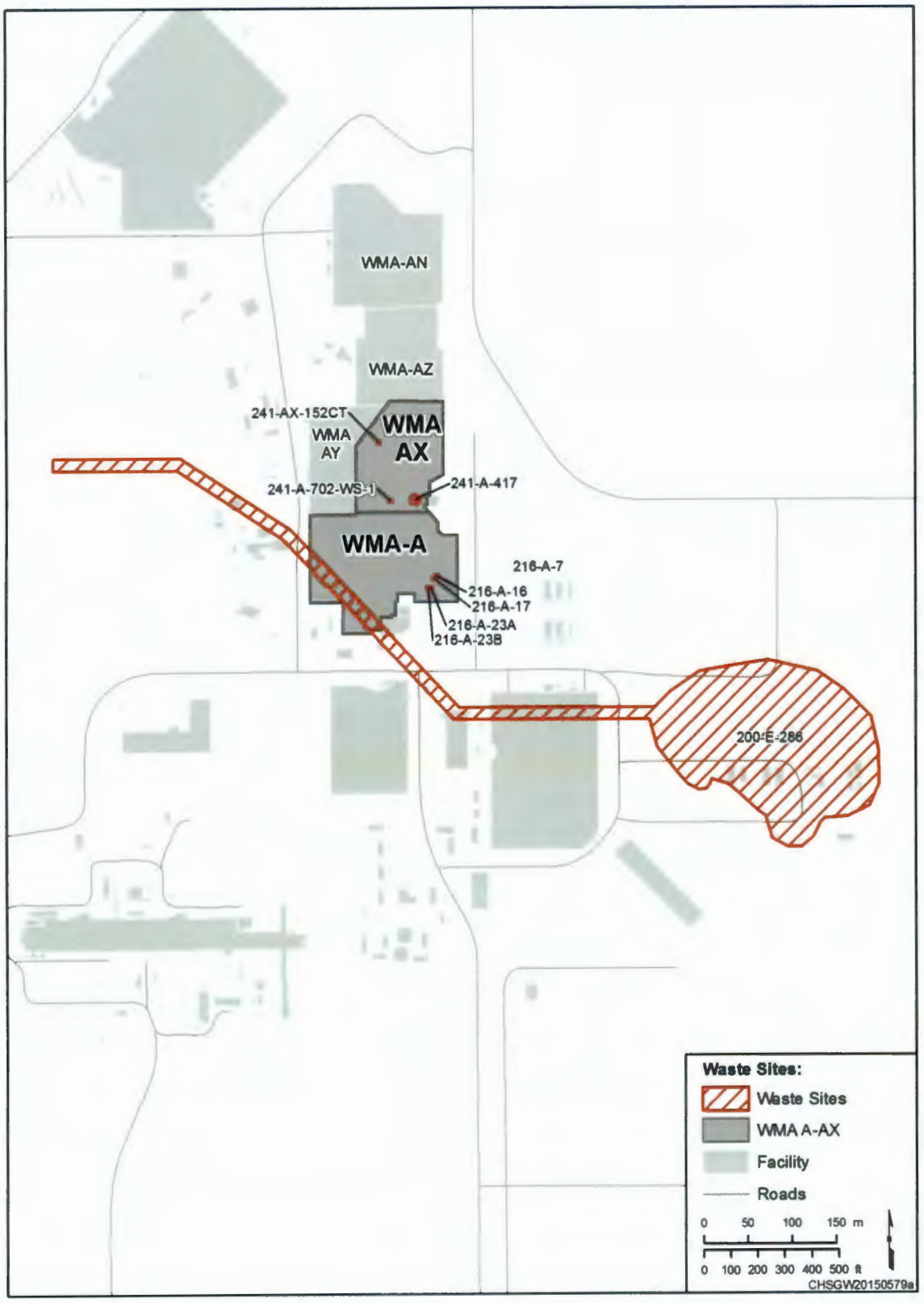


Figure 2-3. Location of French Drains and Selected Catch Tanks within WMA A-AX and the 200-E-286 Ditch and Swamp

2.1.2.3 200-E-286 Ditch and Swamp

The 200-E-286 Ditch (Figure 2-3) was evaluated to determine if the associated waste could have contributed corrosive liquids to the perched water horizon at the CCU_z associated with accelerated corrosion of Wells 299-E24-19, 299-E25-46, and 299-E25-236. From 1946 to 1953, the 200 East Area powerhouse (284-E Powerhouse) discharged effluent to a swamp (known as "A-Swamp") located east of the 200 East Area fence via a man-made ditch. In 1954, the ditch was redirected in a northeast direction to connect to 216-B-3 Pond and the eastern end of the ditch was abandoned. The abandoned portion of the ditch is known as the 200-E-286 Ditch while the portion of the ditch originating at the 284-E Powerhouse and rerouted to the 216-B-3 Pond is known as the 200-E PD Ditch. The liquid effluent stream from the powerhouse contained boiler blowdown, cooling water, floor drain water, and water softener regeneration solution (DOE/RL-89-28).

There is no longer any sign of the A-Swamp or the distal end of the ditch. The original ditch traversed the area southeast of the powerhouse, cut across what is now the southwest corner of the 241-A Tank Farm, and flowed into the A-Swamp, located at the east end of the ditch (Figure 2-3). The Grout Facility and Waste Treatment Plant have been built over the former A-Swamp. During the 7 years the ditch was in use, large volumes of effluent traveled down this unlined ditch. It is estimated that approximately 57,800 L/day (150,000 gal/day) was discharged to the swamp between 1945 and April 1953, with a total discharge volume estimated at 1.7×10^9 L (4.5×10^8 gal) (HW-28121). Because it was unlined, an unknown but large amount of effluent percolated into the ground along the extent of this ditch, which passed by the southwest corner of 241-A Tank Farm (and approximately at the location of the three corroded and decommissioned wells). Furthermore, the effluent contained a large amount of chloride ion as a part of the water softener regeneration solution. During the water softening process at the powerhouse, sanitary water passed through a water softener to remove calcium and magnesium prior to heading to the boiler in order to minimize scaling on the tube bundles. When the resin in the ion-exchange column became saturated with calcium and magnesium, ion exchange no longer occurred, and the resin had to be regenerated. This was accomplished by passing a concentrated solution of sodium chloride through the column. Sodium ions displaced the calcium and magnesium ions, which were flushed out of the softener along with the concentrated chloride solution and routed to the A-Swamp via the ditch.

The 200-E-286 Ditch likely contributed to casing corrosion in the southern part of WMA A-AX. The effluent conveyed via the ditch contained significant corrosive fluids (such as chloride content) that would have accelerated the corrosion of stainless steel casing in the three wells in the southern part of WMA A-AX at the depth of the CCU_z (perched horizon). Therefore, the 200-E-286 Ditch is considered the likely source of the corrosion.

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. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (Ecology) to regulate these hazardous waste components within the State of Washington (51 FR 24504, "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste"). In 1996, the Washington State Attorney General determined that the effective date for regulation of mixed waste in Washington State was August 19, 1987.

In May 1989, DOE, EPA, and Ecology signed the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which

includes WMA A-AX. Groundwater monitoring is conducted at WMA A-AX in accordance with WAC 173-303-400(3) and, by reference, 40 CFR 265, Subpart F, which requires monitoring to determine whether dangerous waste or dangerous waste constituents from the waste site have entered the groundwater.

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

Table 2-2 identifies the previous groundwater monitoring plans at WMA A-AX. In 1989, a RCRA interim status indicator evaluation program for the SSTs WMAs was issued (WHC-SD-EN-AP-012). In 1991, detection monitoring began at WMA A-AX. A site-specific WMA A-AX indicator evaluation plan was written and implemented in 2001 (PNNL-13023), and interim change notices were generated to make changes to interpretations in groundwater flow direction (PNNL-13023-ICN-1), to add additional wells to the network (PNNL-13023-ICN-2), and to change critical means (PNNL-13023-ICN-3). WMA A-AX was placed into assessment monitoring in 2005 because of elevated specific conductance in one downgradient monitoring well: 299-E25-93 (PNNL-15315). PNNL-15315 was written as a "first determination" plan, as allowed under 40 CFR 265.93(d)(5), to determine if dangerous waste constituents from the regulated unit have entered groundwater. The plan (PNNL-15315) was not fully implemented until 2008, when Well 299-E25-236 was installed to replace two wells (299-E24-19 and 299-E25-46) in the WMA A-AX network (Figure 1-2) that were damaged by corrosion and decommissioned.

Table 2-2. Previous Monitoring Plans

Document	Date Issued	Monitoring Program*
40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks (WHC-SD-EN-AP-012)	1989	Indicator Evaluation Program
RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area A-AX (PNNL-13023)	2001	Indicator Evaluation Program
PNNL-13023-ICN-1	2002	Indicator Evaluation Program
PNNL-13023-ICN-2	2004	Indicator Evaluation Program
PNNL-13023-ICN-3	2004	Indicator Evaluation Program
RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site (PNNL-15315)	2006	Groundwater Quality Assessment 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."

After 4 quarters of groundwater monitoring data were collected from Well 299-E25-236, the results along with data from the other existing wells for the previous 5 years were used to determine if dangerous wastes or dangerous waste constituents from WMA A-AX had entered groundwater. Results showed that nitrate was more concentrated at one downgradient well (299-E25-93) than at any other well at WMA A-AX, and nitrate concentrations exceeded the drinking water standard (DWS) (DOE/RL-2008-66). Nitrate is not a dangerous waste constituent as defined by WAC 173-303-040 and listed in WAC 173-303-9905. The assessment report (SGW-47538) concluded that concentrations of nickel, which is a dangerous waste, were higher at two downgradient wells (299-E25-40 and 299-E25-236) relative to concentrations at upgradient wells (299-E24-20, 299-E24-22, and 299-E24-33) and that WMA A-AX may have contaminated the unconfined aquifer with a dangerous waste constituent. However, the elevated levels of nickel in the wells are accompanied by corresponding increases in concentrations of iron, manganese, and chromium.

In 2012, a sharp short term increase in the nickel concentrations in Well 299-E25-236 was definitively associated with casing corrosion as supported by a visual inspection of the interior of the well using a downhole video survey that showed significant corrosion. A video survey was also completed in 2012 inside the casing of Well 299-E25-40, but did not show distinct corrosion characteristics. Elevated metal concentrations in these wells do not appear to be from waste associated with leaking SSTs. Similar corrosion of stainless steel casings has occurred elsewhere at the Hanford Site with a corresponding increase in nickel concentrations in groundwater. An example is the elevated concentrations of nickel, iron, manganese, and chromium due to corrosion at Wells 299-W27-2 and 299-W14-71 at the 216-S-10 Pond and Ditch in the 200-UP-1 OU (DOE/RL-2014-32).

This plan continues the groundwater quality assessment to determine if waste from WMA A-AX has entered the groundwater. This plan includes a comprehensive list of constituents including dangerous waste constituents identified as potentially present in SST waste along with constituents indicative of corrosion of stainless steel wells.

2.3 Waste Characteristics

During the period of Hanford Site operations, wastes routed to tanks in the A and AX Tank Farms were alkaline slurries of mixed waste, containing dangerous constituents and radioactive fission products. Appendix A of PNNL-13023 lists the chemical constituent inventories in each of the 241-A and 241-AX tanks.

WHC-MR-0132 provides the approximate chemical compositions for the major waste types sent to the SSTs and RPP-26744, includes detailed estimates for chemical and radioisotope concentrations for each tank leak in WMA A-AX. These sources were used to prepare the Dangerous Waste Permit Application Part A Form (WA7890008967) for the SST system (treatment, storage, and disposal unit number S-2-4) (Table 2-3). RPP-ENV-37956 provides a detailed waste history of SSTs in WMA A-AX that were known or assumed to have leaked, including Tanks 241-A-104 and 241-A-105 (Appendix B, Sections B2.1 and B3.1).Elevated concentrations of nickel and other metals related to stainless steel corrosion (iron, chromium, and manganese) have been measured in downgradient wells. Nickel is not identified as a dangerous waste associated with SSTs on the Dangerous Waste Permit Application Part A Form (WA7890008967). However, nickel is identified as an underlying hazardous constituent (as identified in 40 CFR 268.48, "Land Disposal Restrictions," "Universal Treatment Standards") for SSTs in RPP-23403, issued in 2013.

Table 2-3. Dangerous Wastes in the Single-Shell Tank System Dangerous Waste Permit Application Part A Form

Dangerous Waste Code[a]	Contaminant Description	Dangerous Waste Code[a]	Contaminant Description
D001	Ignitable waste	D034	Hexachloroethane
D002	Corrosive waste	D035	Methyl ethyl ketone
D003	Reactive waste	D036	Nitrobenzene
D004	Arsenic	D038	Pyridine
D005	Barium	D039	Tetrachloroethylene
D006	Cadmium	D040	Trichloroethylene
D007	Chromium	D041	2,4,5-trichlorophenol
D008	Lead	D043	Vinyl chloride
D009	Mercury	F001	Spent halogenated solvents
D010	Selenium	F002	Spent halogenated solvents
D011	Silver	F003	Spent non-halogenated solvents
D018	Benzene	F004	Spent non-halogenated solvents
D019	Carbon tetrachloride	F005	Spent non-halogenated solvents
D022	Chloroform	WP01	Extremely hazardous waste/ persistent dangerous waste
D028	1,2-dichloroethane	WP02	Dangerous waste/persistent dangerous waste
D029	1,1-dichloroethylene	WT01	Extremely hazardous waste/toxic dangerous waste
D030	2,4-dinitrotoluene	WT02	Dangerous waste/toxic dangerous waste
D033	Hexachlorobutadiene		

Source: WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit.*

Dangerous Waste Codes: WAC 173-303-090, "Dangerous Waste Regulations," "Dangerous Waste Characteristics;" WAC 173-303-104, "State-Specific Dangerous Waste Numbers;" and WAC 173-303-9904, "Dangerous Waste Sources List."

WAC = *Washington Administrative Code*

2.4 Geology and Hydrogeology

Section 2.4.1 describes the geology beneath and surrounding WMA A-AX and Section 2.4.2 describes the hydrogeology.

2.4.1 Geology

The relatively flat stratigraphy beneath WMA A-AX consists of unconsolidated to semi-consolidated sediments overlying basalt bedrock of the Columbia River Basalt Group (Figure 2-4). The sedimentary units present (in descending sequence) are as follows (RPP-23748, RPP-35484, RPP-14430, and PNNL-15955):

- Sand and gravel backfill, and scattered amounts of eolian silty sand
- Sand and gravel of the Hanford formation
- Silt to gravel deposits of the Cold Creek unit
- Sand and gravel of Ringold Formation unit A (which overlies the basalt)

The SSTs were placed in the upper portions of the Hanford formation. The vadose zone consists (in descending order) of the Hanford formation (gravel in the upper portions but predominantly the sand-dominated facies), CCU_z, and the Cold Creek unconsolidated coarse-grained gravel unit (CCU_g)/Ringold Formation unit A (RPP-14430) (Figure 2-5). Beneath the CCU_g is unit A of the Ringold Formation at approximately 94.5 m (310 ft) elevation (above mean sea level [amsl]), followed by Columbia River Basalt (PNNL-12261).

The Hanford formation is the informal name for the glacio-fluvial deposits from cataclysmic Ice Age floods. Sources for floodwaters included Glacial Lake Missoula, pluvial Lake Bonneville, and ice-margin lakes that formed around the margins of the Columbia Plateau (Baker et al., 1991, "Quaternary Geology of the Columbia Plateau"). The last Ice Age floods occurred about 15,000 years ago; the earliest may have been 1 to 2 million years ago (Bjornstad, 2006). The Hanford formation consists of mostly unconsolidated sediments that cover a wide range in grain size (from silt to boulders). Hanford formation sediments beneath and adjacent the 241-A and 241-AX Tank Farms range from gravel to silt. Gravel and sandy gravel (H1) generally occur in the upper 22.9 m (75 ft), while sand and gravelly sand (H2) predominate below this depth. The lower gravel-dominated facies (H3) found elsewhere in the 200 Areas is missing beneath WMA A-AX.

Hanford formation sand-dominated sequence (H2) overlies the CCU_z beneath the 241-A and 241-AX Tank Farms. This sequence is the dominate facies within the vadose zone as evidenced in geologist and driller descriptions provided in borehole summary logs. The summary logs for the wells drilled on the boundaries of the tank farms described sand of some variation extending from the CCU_z to within 6.1 m (20 ft) of ground surface. Drywells within the tank farm and adjacent to the tanks described gravels to 22.9 m (75 ft) below ground surface (bgs) and then sand. Most of the descriptions for this facies are sand or sand with some associated variation of silt. Most of the silt percentages were between 1 to 3 percent; however, there were silt lens and beds of 15 to 30 percent silt in a couple wells within this facies.

The Cold Creek unit is important to the understanding of the geology at WMA A-AX because its upper portion, the CCU_z, is the aquitard responsible for groundwater that is perched (or retained in the fine-grained sediments) above the water table. Corrosive liquid (containing elevated chloride ion concentration) in this perched zone appears to be responsible for corrosion of the three decommissioned wells. At WMA A-AX, the CCU_z is approximately 1 to 6 m (3 to 20 ft) thick and ranges from slightly muddy sand to clay. The CCU_z is associated with fluvial overbank to eolian deposits, which can have variable thickness (PNNL-19277).

Underlying the CCU_z is the CCU_g, an unconsolidated coarse-grained gravel that varies from a sandy gravel with cobbles to a silty gravelly sand. It overlies the Ringold Formation unit A or basalt and contains the water table beneath WMA A-AX. The unit thickness, which is interpreted at approximately 27.4 m (90 ft), constitutes the majority of the unconfined aquifer saturated thickness.

Ringold Formation unit A lies beneath the CCU. In the vicinity of WMA A-AX, it ranges from zero to 10 m (33 ft) thick, although the contact between the CCU_g and Ringold Formation unit A is difficult to determine because of the similarities in lithology and compaction. Where not eroded away, it consists of multilithic, clast-supported to matrix-supported, variably cemented sandy gravel. The gravel sequences are occasionally separated by thinner sequences of horizontally laminated sand or silt. Sands are generally well sorted and predominantly quartzofeldspathic (light in color). The gravels represent fluvial channel fill and braided stream deposits while intervening, fine-grained deposits are interpreted as lacustrine and/or fluvial overbank-paleosol deposits (BHI-00184).

2.4.2 Hydrogeology

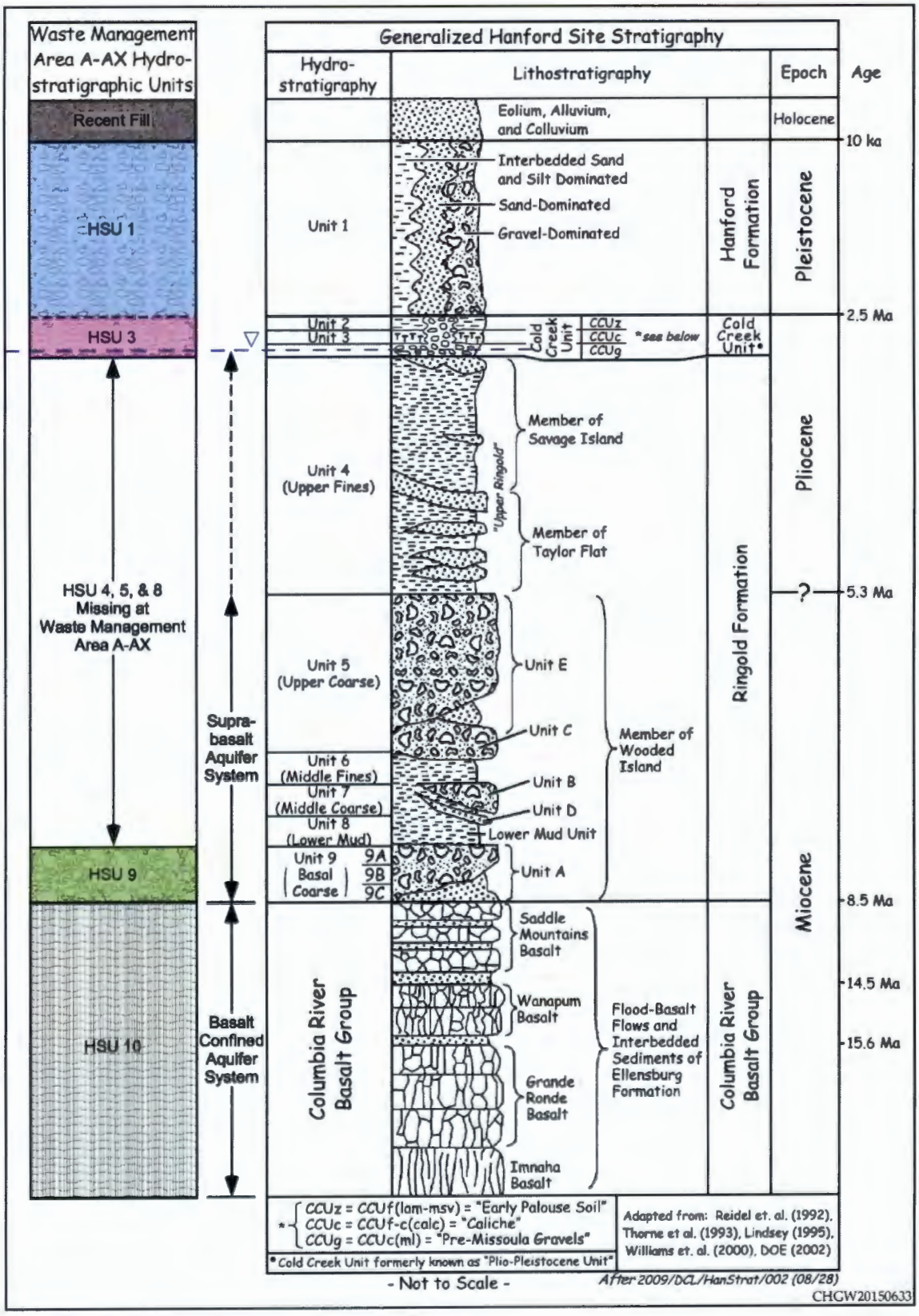
The vadose zone beneath WMA A-AX is approximately 82 to 88 m (270 to 290 ft) thick (PNNL-15955). The water table occurs within the CCU_g at approximately 122 m (400 ft) amsl. The uppermost aquifer beneath WMA A-AX is unconfined and occurs mainly within the CCU_g and Ringold Formation unit A, where present. The base of the unconfined aquifer is defined as the top of the Elephant Mountain Member of the Saddle Mountains Basalt (Columbia River Basalt Group). The top of the basalt ranges between 91.4 and 97.5 m (300 and 320 ft) amsl. The unconfined aquifer thickness ranges from 24.4 to 30.5 m (80 to 100 ft) with the thickest toward the south. The well screen intervals across the aquifer for WMA A-AX are presented in Section 3.2 (Table 3-3).

The CCU_z lies above the water table across the entire WMA A-AX. It varies in thickness from over 6 m (20 ft) beneath the 241-A Tank Farm and pinches out to the northwest, west, and southwest and thins in all other directions (Figure 2-6). It is a partial obstruction to vertical flow of groundwater due to its high content of silt and clay. The finer grain size also causes it to retain more moisture, thereby having higher moisture content than the coarser sediments above and immediately below. Throughout its extent in the 200 East Area, it may actually cause perching of groundwater in places where the amount of vertically percolating fluids exceeds the unit's ability to transmit groundwater. However, it is more likely that the CCU_z is more of an aquitard rather than an aquiclude, thereby vertically transmitting groundwater but at a reduced rate compared to the more coarse Hanford formation sediments above. In either case, the increased residual moisture of the CCU_z provided the retaining stratum for the corrosive fluids that corroded the three decommissioned wells.

During the defense operational efforts at Hanford (1943 to 1995), the groundwater flow direction in most of the 200 East Area was influenced by the hydraulic mounding associated with discharges to the 216-B-3 Pond system, which is located to the northeast of WMA A-AX. This groundwater mound is evident in water table maps through the 1990s and generated a hydraulic gradient to the southwest beneath WMA A-AX.

Water table elevations at WMA A-AX were at their maximum during peak operation years (1960s through the early 1980s). Figure 2-7 shows the effect of these large discharges at 216-B-3 Pond on the water table near WMA A-AX in Wells 299-E25-2, 299-E26-1, and 299-E27-7 (Figure 1-2). Based on correlations between Wells 299-E26-1 and 299-E25-2, the maximum groundwater elevation beneath WMA A-AX was in December of 1985, when the estimated peak groundwater elevation was 124.7 m (409 ft) amsl. At this elevation, groundwater would have reached the bottom of the CCU_z facies beneath the 241-A Tank Farm. This may have contributed to the increased moisture levels observed in CCU_z sediments. However, to reach the upper portion of the CCU_z, the moisture would have had to migrate up several meters. The more probable contributor to the moisture in the CCU_z facies is the unlined 200-E-286 ditch from the 284-E Powerhouse.

The termination of discharges to the 216-B-3 ponds resulted in the groundwater mound dissipation with time. As groundwater elevation continued to decline, determining groundwater flow directions from the water table gradient beneath WMA A-AX became difficult because of the extremely flat water table. By 2001, a determination was made that the flow direction was southeast, based on local hydrographs and "colloidal borescope" measurements (PNNL-13788).



Note: Complete reference citations are provided in Chapter 5.

Figure 2-4. Comparison of WMA A-AX Hydrostratigraphy to Hanford Site Stratigraphy

Recently, efforts have been made to obtain more accurate well elevation surveys and measurements of well deviation from vertical on 56 wells in the 200 East Area. These 56 wells constitute the "low gradient evaluation network." The water level measurements of the low gradient evaluation network were analyzed by generating digital grids of the water table and performing trend surface analyses. To minimize error, data were averaged for each well over yearly periods. Results of site-specific trend surface analyses were described in SGW-54165, and this included an estimate of the residual error remaining in the water level measurements. Water table contours representing the average water table in 2013 and 2014 across the low gradient evaluation network are shown in Figure 2-8 (SGW-58828). The map generally indicates flow across the 200 East Area and WMA A-AX toward the southeast in 2013 and to the south-southeast in 2014. The southeastern flow direction is more consistent with historical plume movement in the area (DOE/RL-2015-07). The contours are more distantly spaced in the south, indicating the magnitude of the hydraulic gradient is lower in the south part of the 200 East Area compared to the northwest part. The aquifer thickness is largest in the southeast causing the transmissivity to be higher, and higher transmissivities equate to lower hydraulic gradient magnitudes (when all other factors are equal).

Estimates of average groundwater flow rate using hydraulic gradient from Figure 2-7 and the Darcy equation.

$$V = KI/n_e$$

are 0.03 to 0.10 m/d, where:

V = average flow velocity (m/d),

K = Hydraulic conductivity (m/d) = 1,981 m/d (1,981 m/d from PNL-8337; WHC-SD-EN-TI-019),

I = Hydraulic gradient (m/m) = 0.000005 (from 2014 in Figure 2-8), and

n_e = Effective porosity = ranges from 0.1 to 0.3 (an estimated range for the unconfined aquifer)

2.5 Summary of Previous Groundwater Monitoring and Results

This section discusses the general groundwater monitoring results at WMA A-AX, as well as groundwater and vadose zone conditions that are believed to have caused well casing corrosion.

2.5.1 Groundwater Contamination

Site-specific (or primary) groundwater constituents required by the previous groundwater monitoring plan (PNNL-15315) included nitrate, sulfate, sodium, chromium, lead, and total organic carbon (TOC). The results showed that only nitrate exceeded its DWS (45 mg/L). Chromium and lead were detected, but chromium was detected only at low levels with a maximum result of 14.3 µg/L, as reported in SGW-47538. The detections for lead were all below Hanford Site background levels at the 95th percentile (DOE/RL-96-61). Sodium and sulfate, naturally occurring constituents in Hanford Site groundwater, were detected in all WMA A-AX samples. Detected sodium was at or below background levels. Sulfate concentrations were well above Hanford Site background levels, but upgradient wells had concentrations similar to downgradient wells. Concentrations of TOC were detected as high as 1,400 µg/L in Well 299-E24-22, but this is an upgradient well.

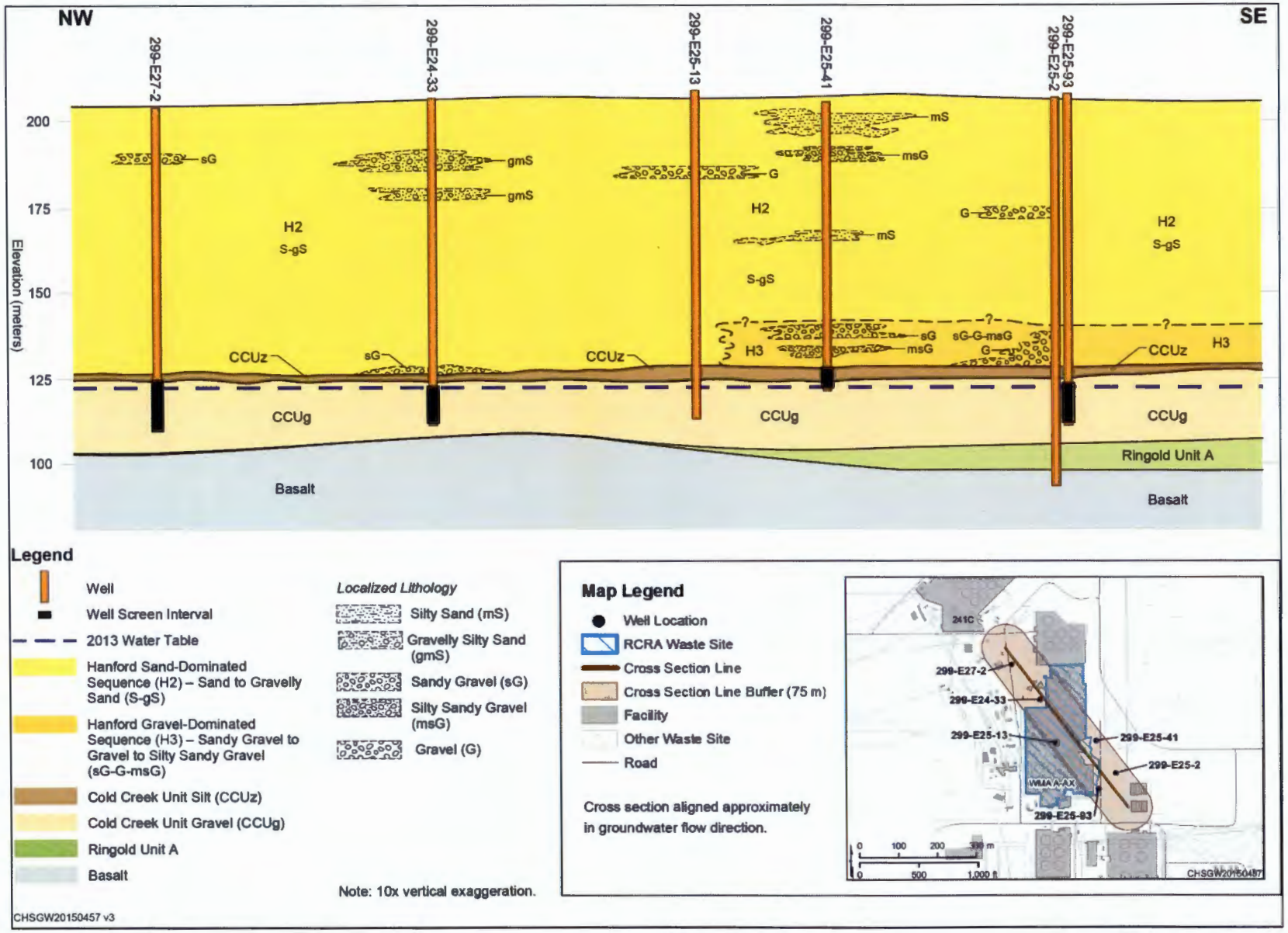


Figure 2-5. Stratigraphy Beneath WMA A-AX

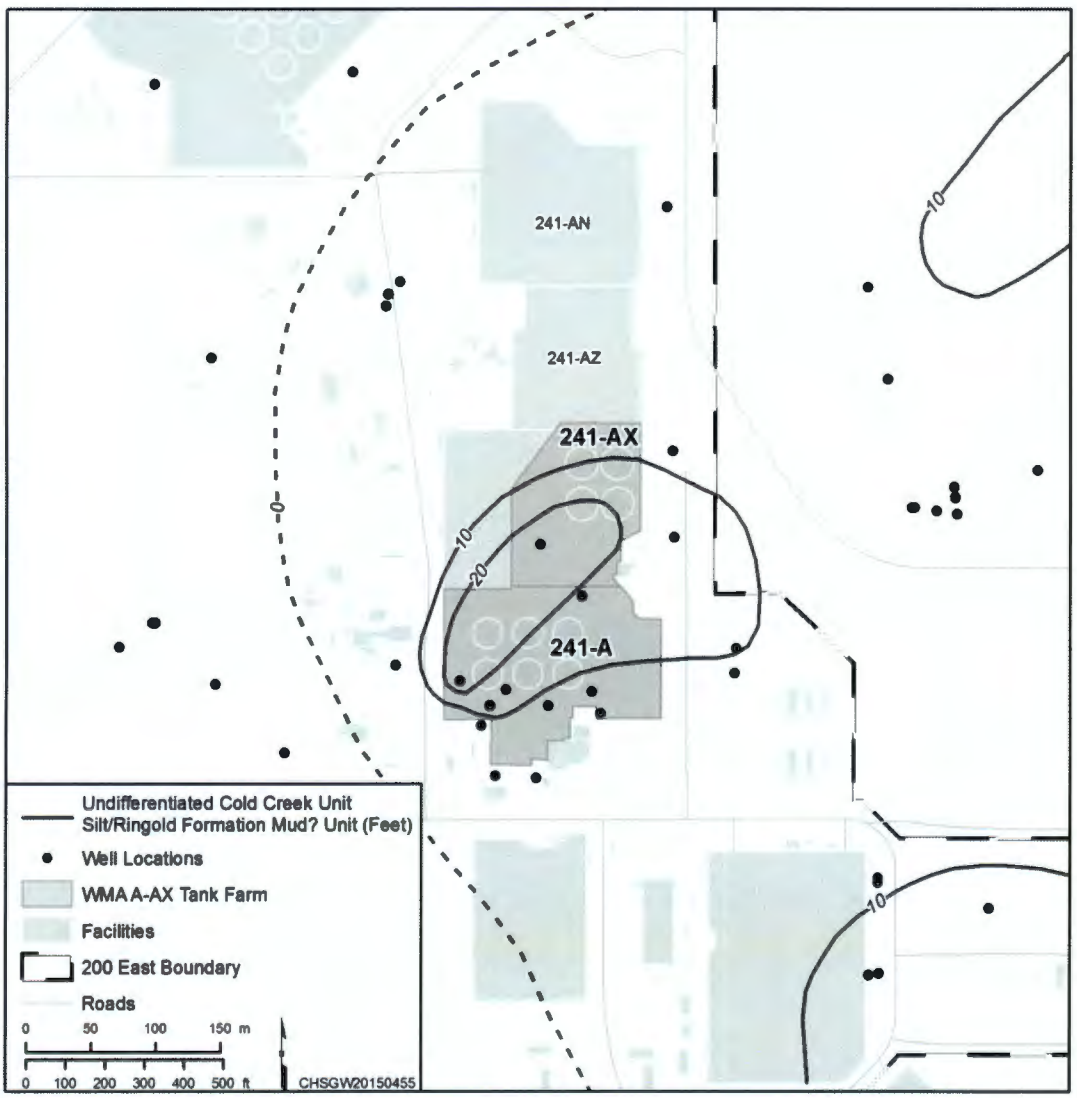


Figure 2-6. Isopach Map of the Cold Creek Unit Fine-Grained Facies (CCU_z)

Nitrate was detected in upgradient wells and in wells monitoring other waste sites that are upgradient, indicating that WMA A-AX is within a larger 200 East Area nitrate plume. Downgradient Well 299-E25-93 had nitrate concentrations exceeding the DWS, with an average of 46 mg/L since early 2013. The higher concentrations at downgradient Well 299-E25-93 compared with upgradient well concentrations (Figure 2-9), potentially indicates a source of nitrate within WMA A-AX.

Other results for the last 5 years revealed several other metals and anions that are detected in groundwater at WMA A-AX, although at concentrations lower than DWSs (SGW-47538). Two metal constituents (barium and nickel) are dangerous waste constituents (as defined by WAC 173-303-040 and listed in WAC 173-303-9905 that appeared to be in higher concentrations in at least one downgradient well versus the concentrations in upgradient wells. Concentrations of barium are lower than Hanford Site background (105 µg/L at the 90th percentile), but nickel concentrations were detected above Hanford Site background (1.56 µg/L at the 90th percentile) in two downgradient wells (299-E25-40 and 299-E25-236). Statistical testing using T-test of means, paired T-test, and signed-rank tests all indicate a statistically significant increase in nickel concentrations in a downgradient well (299-E25-40) relative to concentrations in an upgradient well (299-E24-33) (SGW-47538).

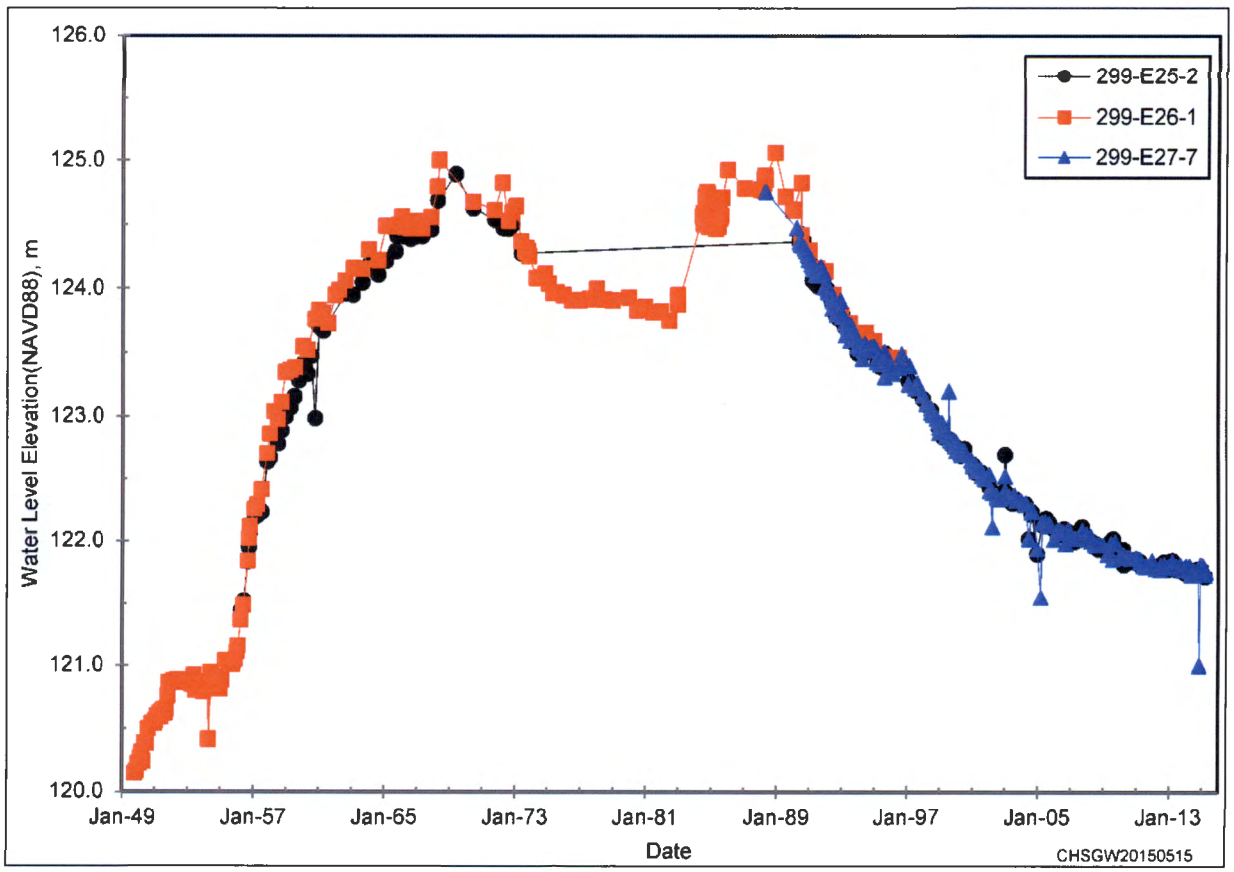


Figure 2-7. Historical Groundwater Elevations at Wells 299-E25-2, 299-E26-1, and 299-E27-7

Figure 2-10 shows nickel concentrations at two downgradient wells (299-E25-40 and 299-E25-236) and the corresponding upgradient well (299-E24-33). The highest nickel concentration at Well 299-E25-236 during this period was 186 µg/L for a sample collected in December 2012. The cause for the elevated nickel is associated with corrosion of the stainless steel screens and casings. This corrosion is discussed further in Section 2.5.2.

The elevated nickel at Well 299-E25-40 is also most likely due to corrosion of the well casing, but the reason for the corrosion there is unknown. A downhole camera survey was conducted in November of 2012 to evaluate the condition of the inner casing. Definitive signs of casing corrosion, as noted in Well 299-E25-236 were not identified, but portions of the well screen above the water table had attributes of breakdown. Nickel concentrations in this well continue to be elevated with respect to upgradient Well 299-E24-33, but have been showing a stable trend since mid-2007. Nickel has low mobility under conditions observed in Hanford Site groundwater, making it unlikely that nickel detected at Wells 299-E25-236 and 299-E25-40 is from SSTs or any liquid waste facility within WMA A-AX. Nickel (nickel II, the most soluble state for Ni) has a retardation factor (distribution coefficient [K_d]) in the range of 300 to over 4,000 mL/g (PNNL-13895). In contrast, the highly mobile nitrate and technetium-99 have K_d values near zero. The higher K_d values for nickel are associated with pH values greater than 7. With the high alkalinity and ubiquitous carbonates typical of Hanford Site groundwater, groundwater pH remains above 7. In a groundwater environment with pH greater than 7, it is unlikely that nickel would be transported through the vadose zone beneath WMA A-AX and encounter the water table.

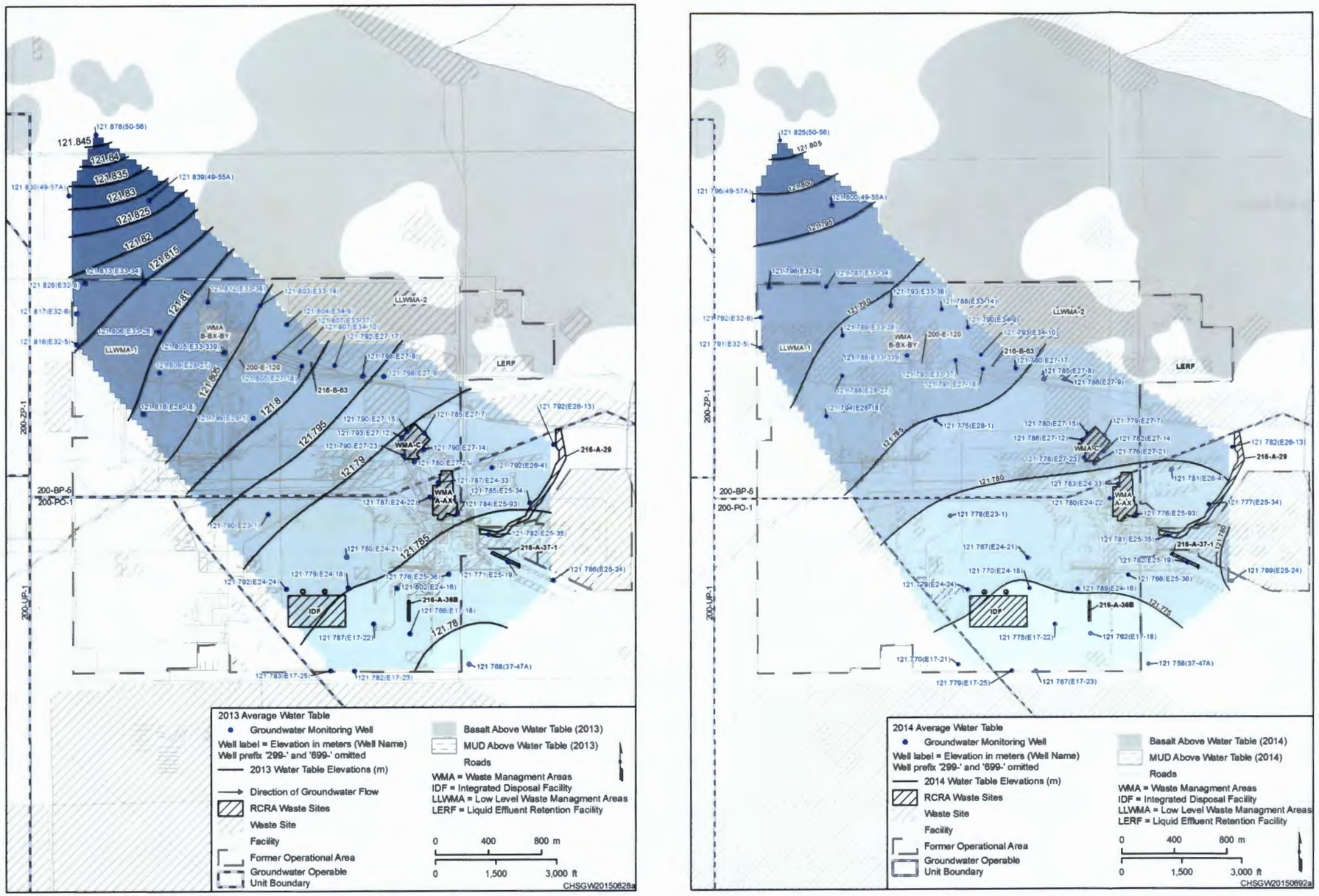


Figure 2-8. Averaged Water Table Surface Maps of the 200 East Area Including WMA A-AX During 2013 and 2014

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2.5.2 Vadose Zone Contamination

The threat to groundwater posed by SSTs themselves has been significantly reduced for two reasons:

- All SSTs at the Hanford Site have been interim stabilized (i.e., most of the liquid has been removed).
- Interim measures have been implemented to reduce the forces driving contamination downward to the groundwater (e.g., constructing berms around the tank farms to divert surface water runoff away from the facility, testing all nearby water lines and removing leaking water lines from service, and capping all vadose zone monitoring boreholes in the tank farms).

However, past tank releases have left portions of the vadose zone contaminated. This contamination has the potential to move downward into the groundwater, especially if a driving force is present.

Three wells (299-E24-19, 299-E25-46, and 299-E25-236 [Figure 2-1]) became corroded in the vadose zone portion of their casings at or just above the level of the CCU_z. The first two wells to show the effects of this corrosion were 299-E24-19 and 299-E25-46, and they were decommissioned in 2004 after corrosion was confirmed by a borehole video survey (PNNL-15070). Both these wells suffered extensive casing corrosion at the level of the CCU_z that was discovered to have high moisture content. The groundwater at both well locations displayed high levels of dissolved chromium, nickel, and manganese (PNNL-13788; PNNL-14548). These dissolved metals most likely came from corrosion of the stainless steel casing.

In November 2012, a borehole video survey completed within Well 299-E25-236 also revealed accelerated corrosion (Figure 2-11). The corrosion was identified between 80.2 and 81.4 m (263 and 267 ft) bgs, which corresponds to the depth of CCU_z. Black staining from the corroded casing extended downward approximately 8.5 to 9.8 m (28 to 32 ft) to groundwater at 89.9 m (295 ft) bgs. The surface of the groundwater inside the well was covered with various particles.

Figure 2-9. Nitrate Concentrations in Groundwater at Wells 299-E24-22 (Upgradient) and 299-E25-93 (Downgradient) at WMA A-AX

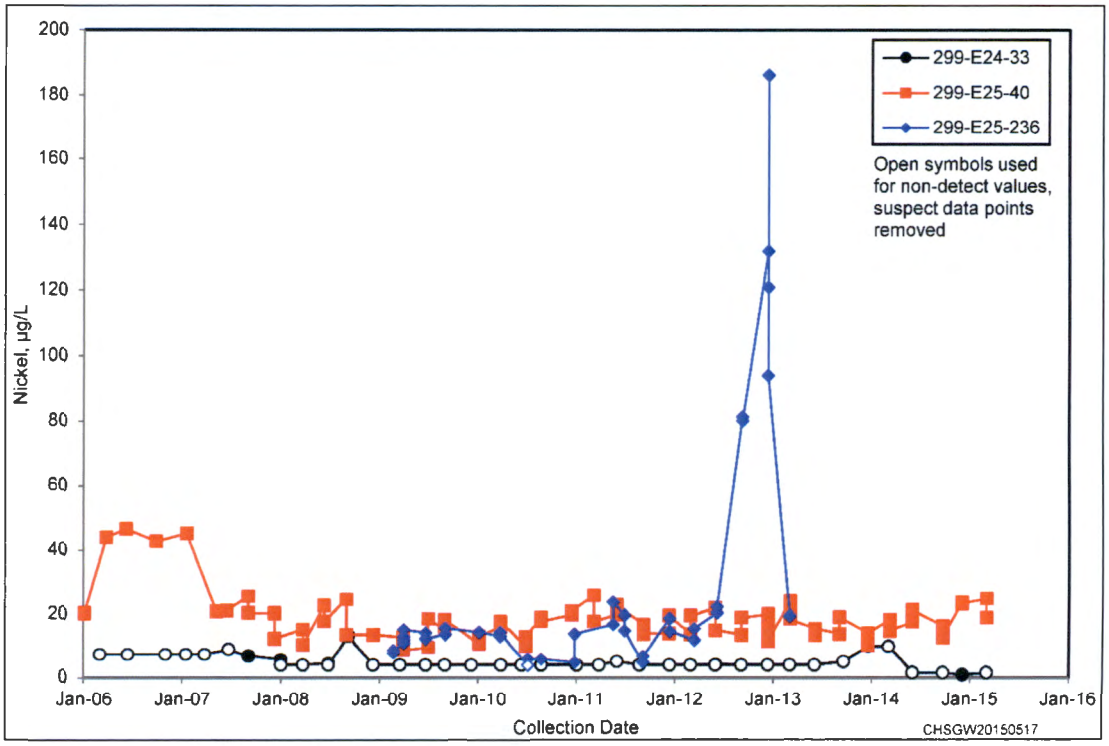

Figure 2-10. Nickel Concentrations at Downgradient Wells 299-E25-40 and 299-E25-236 Compared to Upgradient Well 299-E24-33 at WMA A-AX

Groundwater samples from 2011 and 2012 at Well 299-E25-236 revealed elevated levels of chromium, iron, manganese, and nickel. Between May and June of 2011, the unfiltered chromium increased from non-detect to 23 µg/L (Figure 2-12). In December 2011, filtered chromium levels began to be detected. Filtered manganese detections lagged behind the chromium results, but made a significant increase in September 2012. Nickel increased significantly in September 2012 (Figure 2-13), even though it had been present since the well was installed, suggesting that the elevated nickel is related to casing corrosion rather than leaking tanks as suggested in SGW-47538. Concentrations of manganese and iron also increased in 2012 (Figure 2-14).

Well 299-E25-236 is not the first well in this area to experience casing degradation. Prior to entering into assessment monitoring in 2005, two WMA A-AX RCRA monitoring wells (299-E24-19 and 299-E25-46) failed due to rapid corrosion of the stainless steel casing. Well 299-E24-19 failed between 84.3 and 84.6 m (276.6 and 277.7 ft) bgs, and Well 299-E25-46 failed between 83.6 and 84.9 m (274.4 and 278.6 ft) bgs. The depths of failure in these other wells were at the same horizon as Well 299-E25-236 was near the level of the CCU_z. Well 299-E25-236 was decommissioned in 2013 and replaced by Well 299-E25-237 in 2015. New Well 299-E25-237 was constructed using polyvinyl chloride (PVC) to address corrosion of stainless steel casing experienced by wells in this area. During drilling, vadose zone soil porewater vertical profile characterization samples were collected through the vadose zone interval where Well 299-E25-236 had shown casing corrosion. These characterization sampling results will be included with other data collected as part of this plan and presented in the first determination report.

An investigation of the accelerated well corrosion at Wells 299-E24-19 and 299-E25-46 analyzed sidewall core samples collected from those wells and bentonite material typically used to provide annular seals for Hanford Site wells (PNNL-15141). Special emphasis was placed in determining the chloride content because of the rapid casing corrosion.

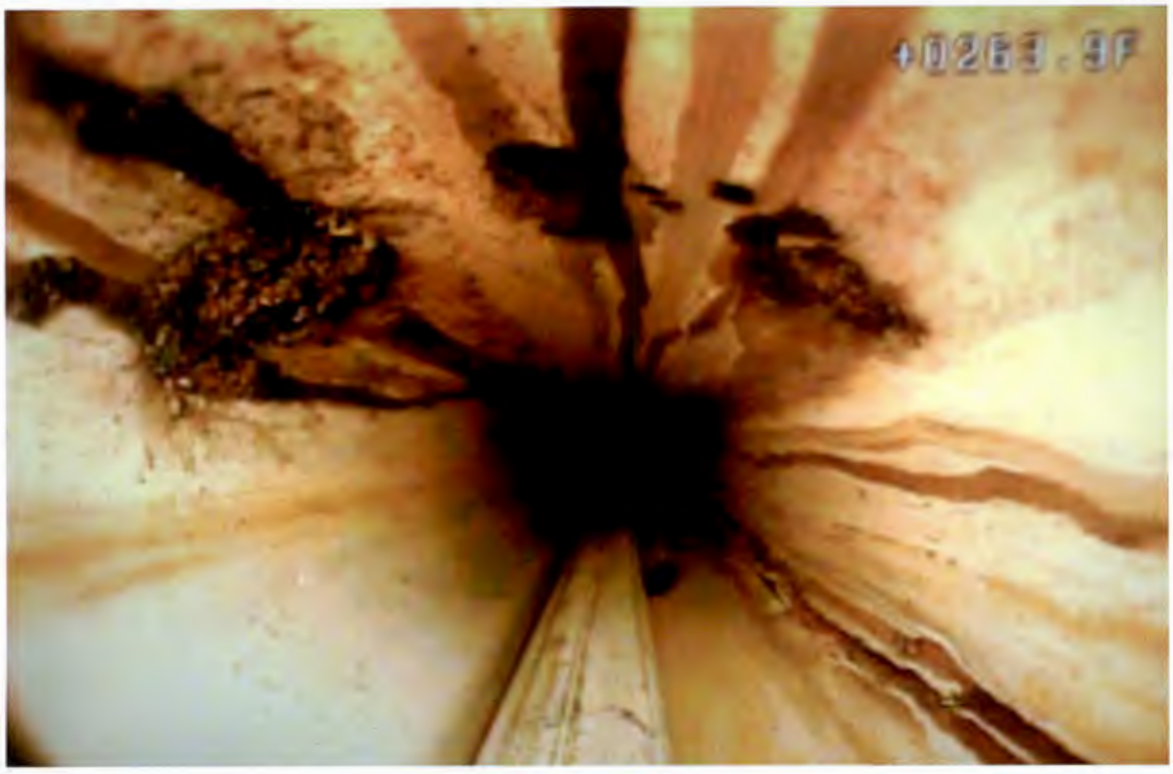

Figure 2-11. Casing Corrosion in Well 299-E25-236

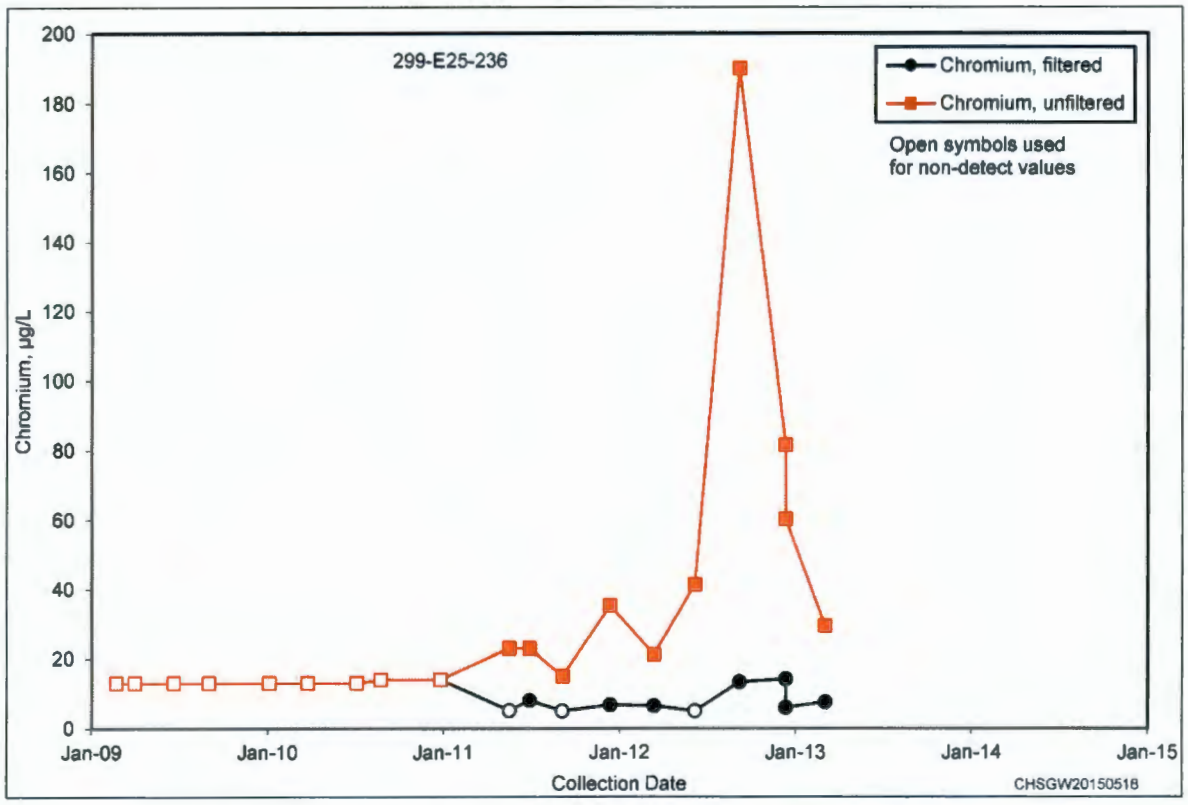

Figure 2-12. Filtered and Unfiltered Chromium Concentrations at Well 299-E25-236

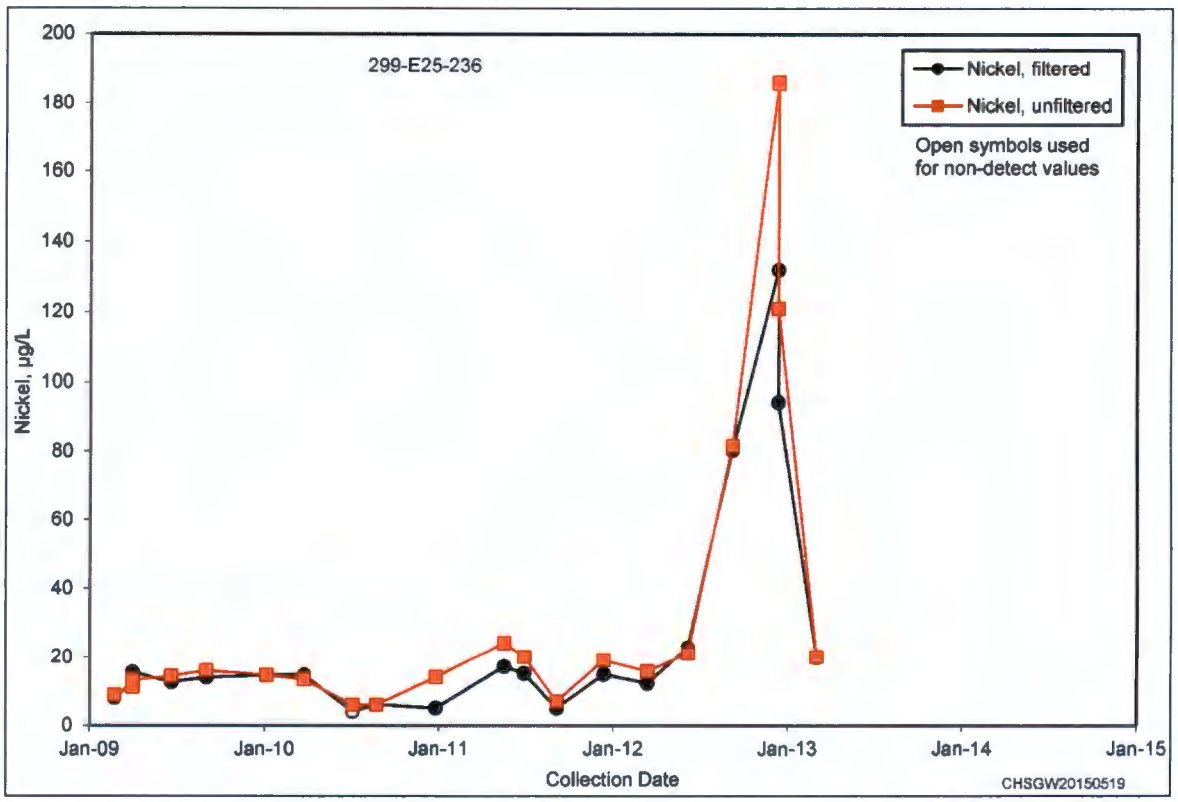

Figure 2-13. Filtered and Unfiltered Nickel Concentrations at Well 299-E25-236

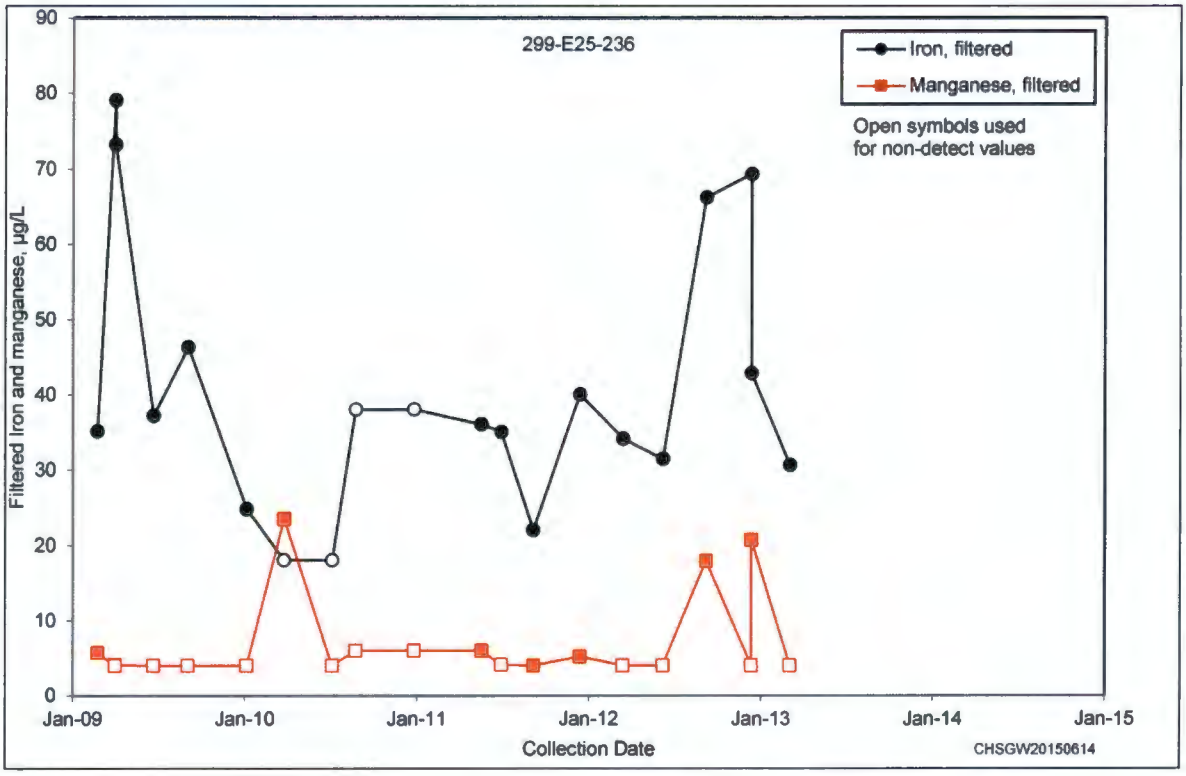

Figure 2-14. Manganese and Iron Concentrations at Well 299-E25-236

It was found that chloride pore water concentrations in the sidewall cores ranged considerably depending on the location sampled. Results from the casing corrosion zone at Well 299-E25-46 indicated decreasing chloride concentration with distance from the casing (PNNL-15141, Table 3-11). The sample result closest to the degraded casing had a dissolved chloride concentration in excess of 10,000 mg/L, while the farthest from the casing was 1,221 mg/L. Sidewall cores also showed the presence of technetium-99 and nitrate.

Results of the bentonite study showed that the bentonite had high water extractable concentrations of chloride and would be capable of generating localized vadose zone pore water with chloride concentrations in excess of 700 mg/L. The study concluded that the vadose zone near 299-E24-19 and 299-E25-46 had soils capable of generating pore water with sufficient chloride concentrations to cause corrosion of the stainless steel well casing, and showed a clear relationship between the chloride concentration and well casing corrosion. The study recommended using Portland cement as an annulus sealing agent for groundwater monitoring wells in zones with high moisture content or that have the potential to accumulate perched water.

In response to the recommendation in PNNL-15141, the well annulus of the replacement well (299-E25-236) was sealed with Portland cement through the CCU_z horizon. However, the well was decommissioned due to corrosion in 2013 after only five years of active service. Clearly, the replacement of bentonite with Portland cement in the well through the CCU_z zone did not provide a remedy for well corrosion. The corrosive fluids remaining in the CCU_z zone appear to have had sufficient chloride to corrode the well casing without the presence of bentonite.

2.5.3 Resulting Dangerous Waste Contaminants

The groundwater assessment results to date do not indicate that there are dangerous wastes attributable to WMA A-AX impacting groundwater. The strategy of this plan is to monitor for a comprehensive list of dangerous waste constituents, including those that may be present in SST waste, and determine which, if any, are impacting groundwater and are attributable to WMA A-AX. To identify these analytes, the list of dangerous waste constituents identified as potentially present in SST waste (RPP-23403) was combined with those constituents listed in Appendix 5 of Ecology Publication No. 97-407 (which references 40 CFR 264, Appendix IX). The resulting combined dangerous waste constituent list is provided in Section 3.1, Table 3-1.

Groundwater monitoring has shown that facilities within WMA A-AX have discharged effluent (intentionally or not) that has affected groundwater. Comparisons of upgradient and downgradient wells indicate that levels of specific conductance, nitrate, nickel, and technetium-99 are higher in concentration in downgradient wells. However, nitrate is not a dangerous waste constituent listed in Appendix 5 of Ecology Publication No. 97-407, which references 40 CFR 264, Appendix IX, but it is an indicator of groundwater impact from WMA A-AX. Technetium-99 is detected above the DWS in wells that are upgradient and downgradient of WMA A-AX (DOE/RL-2015-07). Technetium-99 is a radioactive constituent regulated under AEA and is not a dangerous waste. Nickel is a dangerous waste constituent listed in Appendix 5 of Ecology Publication No. 97-407, but its occurrence in groundwater at WMA A-AX can be correlated with other metals (e.g., chromium, iron, and manganese) typically associated with corrosion of stainless steel casings. Therefore, nickel is not a good indicator of groundwater impact from WMA A-AX.

Three wells have been decommissioned due to corrosion since 2004. In all three wells, the corrosion occurred approximately at the elevation of CCU_z, which either can cause groundwater perching or simply has a higher moisture content than overlying or underlying strata. As a result, the CCU_z either supports or contains corrosive fluids locally that are responsible for causing rapid casing corrosion and well loss.

An evaluation of the 200-E-286 Ditch that carried 284-E-Powerhouse effluent indicates that this site could supply sufficient volume of chloride-bearing solution through the vadose zone and eventually to the CCU_z that, in turn, could cause the corrosion at the three corroded and decommissioned wells. Therefore, groundwater constituents such as chromium, iron, and manganese, as well as nickel, remain as constituents of interest to identify well corrosion that may be caused by corrosive effluent.

2.6 Conceptual Site Model

A CSM of tank leak pathways to the groundwater is summarized in DOE/ORP-2008-01, and Appendix A of that document presents the CSM in detail. The following summary is from DOE/ORP-2008-01, PNNL-13023, PNNL-15315, and interpretation of more recently collected groundwater monitoring data at WMA A-AX.

2.6.1 Contaminant Sources

The contaminant sources at WMA A-AX are the SSTs, associated liquid handling structures, and French drains (Section 2.1.2.1), UPRs associated with SST waste (Section 2.1.2.2), and the 200-E-286 Ditch (Section 2.1.2.3). Contaminants from the SST and related structures, French drains, and UPRs are related to SST waste. Contaminants associated with the unlined, 200-E-286 Ditch are corrosive liquids (high ionic strength chloride solution from the water softener regeneration process at the 284-E Powerhouse) that percolated into the soil during discharge to the A-Swamp from 1945 to 1953.

Of the 10 SSTs within WMA A-AX, 2 are confirmed or assumed to have leaked. A maximum leak volume of approximately 1,032,000 L (272,500 gal) has been reported for WMA A-AX SSTs. Based on the findings presented in Chapters 1.0 and 2.0, a CSM (Figure 2-15) suggests the most probable sources associated with significant concentrations of nitrate and technetium-99 at Well 299-E25-93 are the leaking tanks. The source of elevated nickel concentrations at Wells 299-E25-40 and 299-E25-236 are most likely from corrosion of stainless steel well casings.

A potential source of groundwater contamination from outside WMA A-AX is effluent discharges from the 284-E Powerhouse through the 200-E-286 Ditch (Figure 2-3). This ditch ran across the southwestern end of the 241-A Tank Farm and conveyed concentrated chloride solutions to the A-Swamp (a predecessor to the 216-B-3 Pond system). The wastewater was of sufficient volume to migrate down through the vadose zone to the CCU_z where it was retained by the fine-grained sediments. This concentrated chloride held in the CCU_z appears to have caused rapid corrosion of the three wells at the WMA A-AX well network that were corroded and decommissioned (299-E24-19, 299-E25-46, and 299-E25-236). This corrosion, in turn, released metals such as nickel, chromium, iron, and manganese from the casing into the groundwater being sampled within the wells. Elevated levels of nickel and the other metals (chromium, iron, and manganese) also indicate corrosion in a downgradient well (299-E25-40).

2.6.2 Driving Forces

Downward migration of groundwater contaminants through the vadose zone may also have been aided by leaking waste transfer piping systems, dust suppression water, UPRs, spills, ruptured fresh water lines, and nearby cribs and ditches. Potential tank leak events and releases from transfer piping systems may have discharged waste fluid volume into the subsurface from a point of entry likely having a small spatial extent (on the order of a few meters). Such a discharge would temporarily increase the moisture content of the unsaturated soil, particularly at the point of entry, and increase the unsaturated hydraulic conductivity and downward migration. As waste fluids are migrating within the vadose zone, numerous contaminants are potentially react chemically with the vadose zone soil/water system to varying degrees. Water extracts of contaminants from sediments collected from sidewall core samples (Wells 299-E24-29

and 299-E25-46) suggest that wastewater from Hanford Site waste streams (contaminated with nitrate and technetium-99) have entered the vadose zone and migrated to depths nearly as deep as the water table at WMA A-AX. The detected groundwater contamination beneath WMA A-AX thus far includes only the nondangerous waste constituent nitrate and well casing corrosion products such as nickel and chromium. The possibility of other contaminants (including dangerous waste constituents) remaining in the vadose zone will be evaluated in this revised assessment plan.

2.6.3 Migration

Upon reaching the groundwater, the contaminants generally migrate toward the southeast with the groundwater flow. The groundwater flow velocity has been estimated at 0.03 to 0.10 m/d (0.10 to 0.33 ft/d) (Section 2.4.2).

2.7 Monitoring Objectives

The objective of groundwater monitoring at WMA A-AX is to determine whether dangerous waste or dangerous waste constituents associated with past releases at WMA A-AX have reached groundwater, and if so, to determine the migration rate, extent, and concentration of the dangerous waste constituents. The regulatory requirements applicable to this groundwater monitoring plan are found in 40 CFR 265.90, "Applicability," through 265.94, "Recordkeeping and Reporting" and promulgated in WAC 173-303-400(3). Table 2-4 identifies where each groundwater quality assessment monitoring element of the pertinent applicable regulations is addressed within this plan.

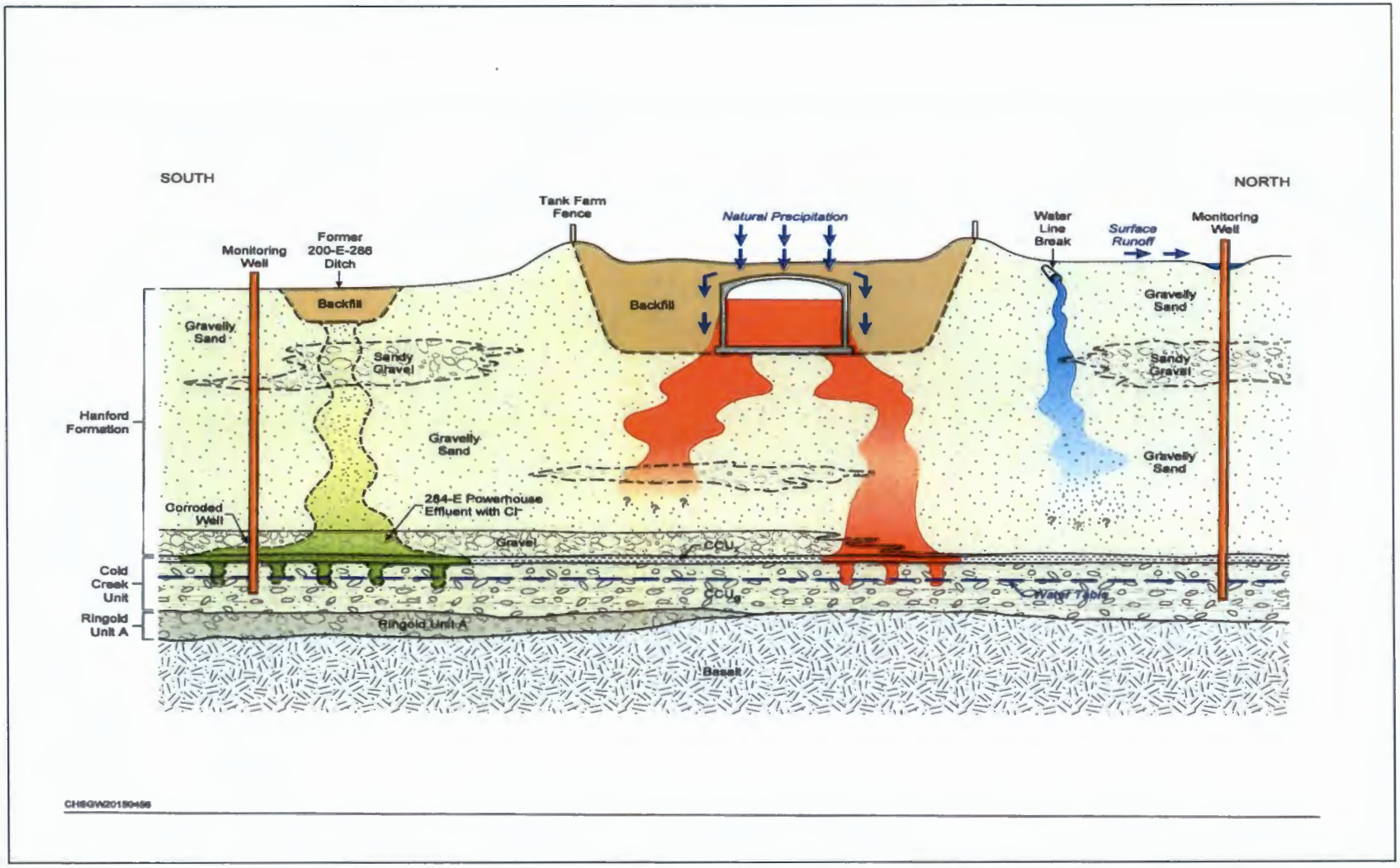

Figure 2-15. Conceptual Model for WMA A-AX

Table 2-4. Monitoring Elements and Associated Regulatory Requirements for WMA A-AX

Groundwater Monitoring Element	Pertinent Requirements	Section Where Requirement is Addressed in Monitoring Plan
Scope	**40 CFR 265.93, "Preparation, Evaluation, and Response," as promulgated by WAC 173-303-400(3)(b) and modified by -400(3)(c)(v) when indicated.** (d)(3) The plan to be submitted under 40 CFR 265.90(d)(1) or paragraph (d)(2) of this section must specify: (i) The number, location, and depth of the wells; (iii) Sampling and analytical methods for those hazardous wastes or hazardous waste constituents in the facility; (iii) Evaluation procedures, including any use of previously gathered groundwater quality information; and (iv) A schedule of implementation. (d)(4) The owner or operator must implement the ground-water quality assessment plan which satisfies the requirements of paragraph (d)(3) of this section, and, at a minimum, determine: (i) The rate and extent of migration of the hazardous waste or hazardous waste constituents in the groundwater; and (ii) The concentrations of the hazardous waste or hazardous waste constituents in the groundwater. (d)(5) The owner or operator must make his first determination under paragraph (d)(4) of this section, as soon as technically feasible, and prepare a report containing an assessment of ground-water quality. This report must be placed in the facility operating record and be maintained until closure of the facility. (d)(7) If the owner or operator determines that hazardous waste or hazardous waste constituents from the facility have entered the ground-water, then the owner or operator: (i) Must continue to make the determinations required under paragraph (d)(4) of this section.	Sections 3.1 and 3.2, Table 3-3, Chapter 4, and Appendix A and B
Number and Location of Wells	**40 CFR 265.91, "Ground-water Monitoring System," as promulgated by WAC 173-303-400(3)(b) and modified by -400(3)(c)(v) when indicated.** (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 number, locations, and depths must ensure that they immediately detect any statistically significant amounts of hazardous waste or hazardous waste constituents that migrate from the waste management area to the uppermost aquifer. **40 CFR 265.93, "Preparation, Evaluation, and Response," as promulgated by WAC 173-303-400(3)(b) and modified by -400(3)(c)(v) when indicated.**	Section 3.2 and Table 3-3

Table 2-4. Monitoring Elements and Associated Regulatory Requirements for WMA A-AX

Groundwater Monitoring Element	Pertinent Requirements	Section Where Requirement is Addressed in Monitoring Plan
	(3) The plan to be submitted under §265.90(d)(1) or paragraph (d)(2) of this section must specify: (i) The number, location, and depth of wells	
Well Configuration (Depth and Length of Screened Interval; Well Construction)	**40 CFR 265.91, "Ground-water Monitoring System."** (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. 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 borehole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground-water. **Additional Requirements from WAC 173-303-400(3)(c)(v)(c)** Ground-water monitoring wells must be designed, constructed, and operated so as to prevent ground-water contamination. Chapter 173-160 WAC may be used as guidance in the installation of wells	Section 3.2 and Appendix C
Frequency of Sampling Types of Analysis or Measurement Methods Used to Evaluate the Collected Data	**40 CFR 265.93, Preparation, Evaluation, and Response; as promulgated by WAC 173-303-400(3)(b) and modified by -400(3)(c)(v) when indicated.** (d)(4) The owner or operator must implement the ground-water quality assessment plan which satisfies the requirements of paragraph (d)(3) of this section, and, at a minimum, determine: (i) The rate and extent of migration of the hazardous waste or hazardous waste constituents in the ground-water; and (ii) The concentrations of the hazardous waste or hazardous waste constituents in the ground-water. (d)(7) If the owner or operator determines, based on the first determination under paragraph (d)(4) of this section, that hazardous waste or hazardous waste constituents from the facility have entered the ground-water, then he: (i) Must continue to make the determinations required under paragraph (d)(4) of this section on a quarterly basis until final closure of the facility, if the ground-water quality assessment plan was implemented prior to final closure of the facility;	Section 3.1, Tables 3-1 and 3-2, Chapter 4, and Appendix A

Note: The references cited in this table are listed in the reference section (Chapter 5) of this plan.
CFR = *Code of Federal Regulations*
WAC = *Washington Administrative Code*

3 Groundwater Monitoring

This chapter describes the groundwater quality assessment program for WMA A-AX, including the constituents analyzed, sampling frequency, monitoring well network, and sampling and analysis protocols, and summarizes the differences between this plan and the previous groundwater monitoring plan (PNNL-15315).

3.1 Constituent List and Sampling Frequency

Constituents that are to be sampled for this assessment are discussed in Section 2.5.3 and listed in Tables 3-1 and 3-2. An analysis of a combination of the dangerous waste constituents identified as potentially present in SST waste (RPP-23403) and dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, which in turn references 40 CFR 264, Appendix IX, is used to determine if dangerous waste constituents from WMA A-AX have impacted the groundwater (Section 2.5.3). The combined list of dangerous waste constituents is provided in Table 3-1.

The constituents listed in Table 3-1 will be sampled semiannually for at least two sampling events. Following the second sampling event, an evaluation of the data results will be performed and a first determination report will be prepared as described in Section 4.2. The first determination report will identify detected constituents listed in Table 3-1 that have affected groundwater quality and are determined to be attributable to previous releases from WMA A-AX. These constituents will be retained for routine monitoring on a quarterly sampling frequency.

As described in Section 4.2, constituents from Table 3-1 that are not detected (designated with a "U" qualifier), detected below background concentrations, or attributed to contamination from another facility (e.g., detected at comparable concentrations in upgradient wells) will be eliminated from future sampling.

For some constituents in Table 3-1, the first two sampling results may be insufficient to determine if they are attributable to previous WMA A-AX releases. Such constituents will continue to be sampled at a semiannual frequency until sufficient results are available to support a determination. Furthermore, the ten most prominent tentatively identified compounds (TICs) will also be evaluated to determine if they are attributable to WMA A-AX.

Changes to the constituent list and sample frequency based on the first determination report will be implemented through a revision of this plan. For those constituents requiring additional sampling as described above, the first determination report will be revised on an annual basis, as necessary, as determinations for such constituents are established. Subsequent changes to the constituent list and sampling frequency based on revisions to the first determination report will be implemented through revisions to this monitoring plan.

In addition to the Table 3-1 constituents, other supporting constituents (major cations [metals], major anions), alkalinity, and field measured parameters will be monitored on a semiannual basis in the network monitoring wells (Table 3-2). These supporting constituents and field parameters provide information on general water chemistry and allow charge-balance computations to assess laboratory performance. The supporting constituents nickel, chromium, manganese, and iron provide information about corrosion of the stainless steel well screens and casings. If constituents from Table 3-1 are determined to be attributable to previous releases from WMA A-AX, monitoring of supporting constituents and field parameters will be increased to a quarterly basis through a revision of this plan.

Maintenance problems and sampling logistics sometime delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well is sampled. If a well cannot be sampled at the times determined by the FWS, then

the FWS and Sampling Management and Reporting group, along with the project scientist, consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling in the following month. Missed or cancelled sampling events are reported to DOE-RL, at the appropriate Unit Managers Meeting, and in the annual groundwater monitoring report.

Table 3-1. RCRA-Regulated Constituents Included in WMA A-AX Groundwater Quality Assessment

Constituent	CAS Number	Constituent	CAS Number
Inorganic Constituents (Nonradiological)			
Antimony	7440-36-0	Mercury	7439-97-6
Arsenic	7440-38-2	Nickel	7440-02-0
Barium	7440-39-3	Selenium	7782-49-2
Beryllium	7440-41-7	Silver	7440-22-4
Cadmium	7440-43-9	Sulfide	18496-25-8
Chromium	7440-47-3	Thallium	7440-28-0
Cobalt	7440-48-4	Tin	7440-31-5
Copper	7440-50-8	Vanadium	7440-62-2
Cyanide	57-12-5	Zinc	7440-66-6
Lead	7439-92-1		
Volatile Organic Compounds			
1,1-Dichloroethane	75-34-3	Carbon tetrachloride	56-23-5
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	Chlorobenzene	108-90-7
1,1,1-Trichloroethane	71-55-6	Chloroethane	75-00-3
1,1,1,2-Tetrachloroethane	630-20-6	Chloroform	67-66-3
1,1,2-Trichloroethane	79-00-5	Chloroprene	126-99-8
1,1,2,2-Tetrachloroethane	79-34-5	Dibromochloromethane	124-48-1
1,2-Dibromo-3-chloropropane	96-12-8	p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7
1,2-Dibromoethane	106-93-4	Dichlorodifluoromethane	75-71-8
1,2-Dichloroethane	107-06-2	Ethylbenzene	100-41-4
1,2-Dichloropropane	78-87-5	Ethyl methacrylate	97-63-2
trans-1,2-Dichloroethylene	156-60-5	Isobutanol (Isobutyl alcohol)	78-83-1
1,2,3-Trichloropropane	96-18-4	Methacrylonitrile	126-98-7

Table 3-1. RCRA-Regulated Constituents Included in WMA A-AX Groundwater Quality Assessment

Constituent	CAS Number	Constituent	CAS Number
cis-1,3-Dichloropropene	10061-01-5	Methyl bromide (Bromomethane)	74-83-9
trans-1,3-Dichloropropene	10061-02-6	Methyl chloride (Chloromethane)	74-87-3
trans-1,4-Dichloro-2-butene	110-57-6	Methyl iodide (Iodomethane)	74-88-4
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	Methyl methacrylate	80-62-6
2-Propanone (acetone)	67-64-1	Methylene bromide (Dibromomethane)	74-95-3
2-Hexanone	591-78-6	Methylene chloride	75-09-2
4-Methyl-2-pentanone (MIBK)	108-10-1	Propionitrile (Ethyl cyanide)	107-12-0
Acetonitrile; Methyl cyanide	75-05-8	Styrene	100-42-5
Acrolein	107-02-8	Tetrachloroethene	127-18-4
Acrylonitrile	107-13-1	Toluene	108-88-3
Allyl chloride	107-05-1	Trichloroethene (TCE)	79-01-6
Benzene	71-43-2	Trichlorofluoromethane	75-69-4
Bromodichloromethane	75-27-4	Vinyl acetate	108-05-4
Bromoform	75-25-2	Vinyl chloride (Chloroethene)	75-01-4
Carbon disulfide	75-15-0	Xylenes (total)	1330-20-7
Semivolatile Organic Compounds			
1-Naphthylamine	134-32-7	Dimethyl phthalate	131-11-3
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	Di-n-butylphthalate	84-74-2
1,2,4-Trichlorobenzene	120-82-1	m-Dinitrobenzene	99-65-0
1,2,4,5-Tetrachlorobenzene	95-94-3	Di-n-octylphthalate	117-84-0
1,4-Dioxane	123-91-1	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
1,4-Naphthoquinone	130-15-4	Diphenylamine	122-39-4
2-Acetylaminofluorene	53-96-3	Disulfoton	298-04-4
2-Chloronaphthalene	91-58-7	Ethyl methanesulfonate	62-50-0
2-Chlorophenol	95-57-8	Famphur	52-85-7
2-Methylphenol (o-cresol)	95-48-7	Fluoranthene	206-44-0

Table 3-1. RCRA-Regulated Constituents Included in WMA A-AX Groundwater Quality Assessment

Constituent	CAS Number	Constituent	CAS Number
2-Methylnaphthalene	91-57-6	9H-Fluorene (Fluorene)	86-73-7
2-Naphthylamine	91-59-8	Hexachlorobenzene	118-74-1
2-Nitrophenol (o-Nitrophenol)	88-75-5	Hexachlorobutadiene	87-68-3
2-Picoline	109-06-8	Hexachlorocyclopentadiene	77-47-4
2,3,4,6-Tetrachlorophenol	58-90-2	Hexachloroethane	67-72-1
2,4-Dichlorophenol	120-83-2	Hexachlorophene	70-30-4
2,4-Dimethylphenol	105-67-9	Hexachloropropene	1888-71-7
2,4-Dinitrophenol	51-28-5	Indeno(1,2,3-cd)pyrene	193-39-5
2,4-Dinitrotoluene	121-14-2	Isodrin	465-73-6
2,4,5-Trichlorophenol	95-95-4	Isophorone	78-59-1
2,4,6-Trichlorophenol	88-06-2	Isosafrole	120-58-1
2,6-Dichlorophenol	87-65-0	Kepone	143-50-0
2,6-Dinitrotoluene	606-20-2	Methapyrilene	91-80-5
3-Methylcholanthrene	56-49-5	Methyl methanesulfonate	66-27-3
3-Methylphenol (m-Cresol)	108-39-4	Methyl parathion	298-00-0
4-Methylphenol (p-cresol)	106-44-5	Naphthalene	91-20-3
3,3′-Dichlorobenzidine	91-94-1	Nitrobenzene	98-95-3
3,3′-Dimethylbenzidine	119-93-7	o-Nitroaniline (2-Nitroaniline)	88-74-4
4-Aminobiphenyl	92-67-1	m-Nitroaniline (3-Nitroaniline)	99-09-2
4-Bromophenyl phenyl ether	101-55-3	p-Nitroaniline (4-Nitroaniline)	100-01-6
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7	p-Nitrophenol (2-Nitrophenol)	88-75-5
4-Chlorophenyl phenyl ether	7005-72-3	N-Nitrosodi-n-butylamine	924-16-3
4-Nitroquinoline 1-oxide	56-57-5	N-Nitrosodiethylamine	55-18-5
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1	N-Nitrosodimethylamine	62-75-9
5-Nitro-o-toluidine	99-55-8	N-Nitrosodiphenylamine	86-30-6
7,12-Dimethylbenz[a]anthracene	57-97-6	n-Nitroso-di-n-dipropylamine (N-Nitrosodipropylamine; Di-n-propylnitrosamine)	621-64-7

Table 3-1. RCRA-Regulated Constituents Included in WMA A-AX Groundwater Quality Assessment

Constituent	CAS Number	Constituent	CAS Number
Acenaphthene	83-32-9	N-Nitrosomethylethalamine	10595-95-6
Acenaphthylene	208-96-8	n-Nitrosomorpholine	59-89-2
Acetophenone	98-86-2	N-Nitrosopiperidine	100-75-4
Aniline	62-53-3	N-Nitrosopyrrolidine	930-55-2
Anthracene	120-12-7	Parathion	56-38-2
Aramite	140-57-8	Pentachlorobenzene	608-93-5
Benz[a]anthracene (Benzo[a]anthracene)	56-55-3	Pentachloroethane	76-01-7
Benz[e]acephenanthrylene (Benzo[b]fluoranthene)	205-99-2	Pentachloronitrobenzene	82-68-8
Benzo[k]fluoranthene	207-08-9	Pentachlorophenol	87-86-5
Benzo[ghi]perylene	191-24-2	Phenacetin	62-44-2
Benzo[a]pyrene	50-32-8	Phenanthrene	85-01-8
Benzyl alcohol	100-51-6	Phenol	108-95-2
Bis(2-chloroethoxy)methane	111-91-1	p-Phenylenediamine	106-50-3
Bis(2-chloroethyl)ether	111-44-4	Phorate	298-02-2
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1	Pronamide	23950-58-5
Bis(2-ethylhexyl) phthalate	117-81-7	Pyrene	129-00-0
Butylbenzylphthalate	85-68-7	Pyridine	110-86-1
p-Chloroaniline (4-Chloroaniline)	106-47-8	Safrole	94-59-7
Chlorobenzilate	510-15-6	Tetraethyl dithiopyrophosphate	3689-24-5
Chrysene	218-01-9	o-Toluidine	95-53-4
Diallate	2303-16-4	O,O,O-Triethyl phosphorothioate	126-68-1
Dibenz[a,h]anthracene	53-70-3	sym-Trinitrobenzene	99-35-4
Dibenzofuran	132-64-9	Aroclor 1016	12674-11-2
m-Dichlorobenzene (1,3-Dichlorobenzene)	541-73-1	Aroclor 1221	11104-28-2
Diethyl phthalate	84-66-2	Aroclor 1232	11141-16-5

Table 3-1. RCRA-Regulated Constituents Included in WMA A-AX Groundwater Quality Assessment

Constituent	CAS Number	Constituent	CAS Number
O,O-Diethyl O-2-pyrazinyl phosphorothioate	297-97-2	Aroclor 1242	53469-21-9
Dimethoate	60-51-5	Aroclor 1248	12672-29-6
p-(Dimethylamino)azobenzene	60-11-7	Aroclor 1254	11097-69-1
alpha, alpha-Dimethylphenethylamine	122-09-8	Aroclor 1260	11096-82-5
Pesticides			
4,4′-DDD	72-54-8	Endosulfan I	959-98-8
4,4′-DDE	72-55-9	Endosulfan II	33213-65-9
4,4′-DDT	50-29-3	Endosulfan sulfate	1031-07-8
Aldrin	309-00-2	Endrin	72-20-8
alpha-BHC	319-84-6	Endrin aldehyde	7421-93-4
beta-BHC	319-85-7	Heptachlor	76-44-8
delta-BHC	319-86-8	Heptachlor epoxide	1024-57-3
gamma-BHC	58-89-9	Methoxychlor	72-43-5
Chlordane	57-74-9	Toxaphene	8001-35-2
Dieldrin	60-57-1		
Herbicides			
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Silvex; 2,4,5-TP	93-72-1
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5		
Dioxins			
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	Polychlorinated dibenzofurans	N/A
Polychlorinated dibenzo-p-dioxins	N/A		

Note: This table identifies the combined dangerous waste constituents provided in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100.*

The ten most prominent tentatively identified compounds will also be reported.

CAS = Chemical Abstracts Service
N/A = not applicable
RCRA = Resource Conservation and Recovery Act of 1976

Table 3-2. Monitoring Network, Constituent List, and Sampling Frequency for WMA A-AX

Well	WAC Compliant	Supporting Constituents			Field Parameters					Dangerous Waste Constituents
		Alkalinity	Anions[a]	Metals (Filtered and Unfiltered)[b]	pH	Specific Conductance	Temperature	Turbidity	Water Level	Table 3-1[c]
299-E24-20	Y	S	S	S	S	S	S	S	S	S
299-E24-22	Y	S	S	S	S	S	S	S	S	S
299-E24-33	Y	S	S	S	S	S	S	S	S	S
299-E25-40	Y	S	S	S	S	S	S	S	S	S
299-E25-41	Y	S	S	S	S	S	S	S	S	S
299-E25-2	N[d]	S	S	S	S	S	S	S	S	S
299-E25-93	Y	S	S	S	S	S	S	S	S	S
299-E25-94	Y	S	S	S	S	S	S	S	S	S
299-E25-237	Y	S	S	S	S	S	S	S	S	S

Table 3-2. Monitoring Network, Constituent List, and Sampling Frequency for WMA A-AX

Well	WAC Compliant	Supporting Constituents			Field Parameters					Dangerous Waste Constituents
		Alkalinity	Anions[a]	Metals (Filtered and Unfiltered)[b]	pH	Specific Conductance	Temperature	Turbidity	Water Level	Table 3-1[c]

Note: Wells completed at the top of the unconfined aquifer.
Bold/italic print indicates an upgradient well.

a. Anions include, as a minimum, chloride, nitrate, and sulfate.
b. Metals (filtered and unfiltered) include, as a minimum, calcium, magnesium, potassium, sodium, chromium, manganese, nickel, and iron.
c. Metals identified in Table 3-1 include filtered and unfiltered. They includes antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, tin, vanadium, and zinc.
d. Well is not compliant with WAC 173-160 "Minimum Standards for Construction and Maintenance of Wells" construction standards.

N = Well is not constructed as a resource protection well under WAC 173-160
S = semiannually
WAC = *Washington Administrative Code*
Y = Well is constructed as a resource protection well under WAC 173-160

3.2 Well Network

Table 3-2 includes the list of monitoring wells for WMA A-AX, and Figure 2-1 shows the well locations. Wells were selected based on the following criteria:

- Location – A sufficient number of wells are needed to sample groundwater upgradient and unaffected by potential waste emplaced at the site. Other wells are needed to sample groundwater on the downgradient side of the site. Wells need to be spaced around the downgradient site to reasonably sample contaminated groundwater coming from anywhere in the site. Three upgradient (northwest) and six downgradient (south) wells are identified for the monitoring network.

- Level or stratigraphic interval open to the well screen – Wells intended for RCRA compliance need to be screened in the hydrostratigraphic unit(s), which have been identified as the earliest potential contaminant flow path. At WMA A-AX, that is the unconfined aquifer at and below the water table in the CCU_g.

- Well construction – It is preferable for wells to be compliant with 40 CFR 265.91 (implemented as WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," groundwater monitoring element "well configuration" of Table 3-3 of this document). Eight of the nine wells chosen for WMA A-AX meet the construction requirements of WAC 173-160; Well 299-E25-2 does not meet the requirements of WAC 173-160. Per agreement between DOE and Ecology, non-compliant wells are identified and placed on the prioritized drilling schedule for replacement consistent with sitewide cleanup priorities as described in Milestone M-024-58, which is contained in the Tri-Party Agreement Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*), as revised. This well has been included in this milestone for future replacement.

If a well is within approximately 2 years of going dry, a replacement well will be proposed. As indicated by previous evaluations, WMA A-AX wells are subject to casing corrosion. Wells with definitive indications of well casing corrosion, based on both visual downhole surveys and analytical results, will also be candidates for replacement. To address corrosion of stainless steel casing, Well 299-E25-237 was constructed using PVC. Utilization of PVC may be appropriate for well construction of other WMA A-AX wells that are identified for replacement as the result of casing corrosion. All new RCRA wells proposed for installation at the Hanford Site are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement Action Plan (Ecology et al., 1989b) Milestone M-24-00.

The network wells are co-sampled for the 200-PO-1 OU under CERCLA monitoring, although the CERCLA sampling is performed at a lower frequency (annually). Sampling is coordinated to avoid duplication of analyses and additional well trips.

Table 3-3 summarizes well information, including the elevation of the water table in each monitoring well. Well 299-E25-237 was constructed with a polyvinyl chloride casing to prevent corrosion. All wells are equipped with dedicated sampling pumps. As-built diagrams showing details of construction for each well are provided in Appendix C.

Table 3-3. Well Depths and Water Table Elevation at WMA A-AX

Well Name	Completion Date	Easting[a] m	Northing[a] m	Screen Top m (ft) bgs	Screen Bottom m (ft) bgs	Water Depth m (ft) bgs	Water Remaining m (ft)	Water Level Date
299-E24-20	1991	575251.1	136049.4	85.13 (279.23)	91.27 (299.35)	88.36 (289.81)	2.91 (9.54)	3/3/2015
299-E24-22	2003	575262.7	136142.8	87.26 (286.21)	97.95 (321.26)	86.89 (285.01)	11.06 (36.26)	3/6/2015
299-E24-33	2004	575325.4	136251.5	84.79 (278.10)	94.54 (310.10)	84.34 (276.65)	10.20 (33.45)	3/3/2015
299-E25-40	1989	575464.7	136212.3	76.83 (252.00)	83.23 (273.00)	81.42 (267.06)	1.81 (5.94)	3/3/2015
299-E25-41	1989	575466.1	136145.9	77.84 (255.30)	84.24 (276.30)	82.93 (271.99)	1.31 (4.31)	3/6/2015
299-E25-2	1955	575513.8	136061.9	84.15 (276.0)	96.34 (316.0)	84.51 (277.2)	11.83 (38.8)	3/3/2015
299-E25-93	2003	575471.5	136022.1	84.83 (278.23)	95.51 (313.26)	85.52 (280.50)	9.99 (32.76)	3/6/2015
299-E25-94	2004	575409.2	136012.4	89.97 (295.09)	100.64 (330.09)	89.84 (294.68)	10.80 (35.41)	3/25/2015
299-E25-237	2014	575323.8	135965.3	88.72 (291.00)	99.39 (326.00)	90.05 (295.36)	9.34 (30.64)	12/17/2015

Note: Bold/italic print indicates an upgradient well.

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

bgs = below ground surface

3.3 Difference between This Plan and Previous Plan

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

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

Type of Change	Previous Plan	Current Plan	Justification
Constituents	Anions, inductively coupled plasma metals, field parameters, lead, TOC, and technetium-99 analyzed in groundwater samples.	Eliminates lead, TOC, and technetium-99 as site-specific constituents. Includes supporting constituents (to provide information on water chemistry and well corrosion) and field parameters. Added analyses for dangerous waste constituents listed in Table 3-1. A first determination report will be prepared after the first two semiannual samples are collected. Annual revisions to the first determination report will be prepared, as necessary, as determinations are completed for the constituents. In addition to the constituents in Table 3-1, the 10 most prominent TICs will also be evaluated. Changes to the constituents that require monitoring will be based on the first determination report (and revisions). These changes will be included in a revision to this monitoring plan.	Lead was detected in concentrations below background. Lead is eliminated as a site-specific constituent but will be evaluated as a constituent in Table 3-1. TOC was detected in concentrations below upgradient wells. Due to the comprehensive list of organic constituents to be evaluated, TOC is no longer required. Technetium-99 is a radioactive constituent regulated under the *Atomic Energy Act of 1954*. Analyses for constituents in Table 3-1 continue the determination as to whether dangerous waste constituents from WMA A-AX have entered groundwater.
Sampling Frequency	Quarterly	Semiannual Monitoring frequency for Table 3-1 constituents may increase to quarterly based on the first determination report for dangerous waste constituents attributed to WMA A-AX. Constituents requiring additional results to support a first determination will continue at a semiannual frequency. Constituents not detected or not attributed to WMA	No dangerous wastes attributable to WMA A-AX have been identified. Well corrosion has led to elevated concentrations of nickel in some downgradient wells. This assessment continues the first determination with a comprehensive list of dangerous waste constituents.

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

Type of Change	Previous Plan	Current Plan	Justification
		A-AX will not require further monitoring. Changes to the sampling frequency will be included in a revision to this plan.	
Well Network	3 upgradient wells and 5 downgradient wells	Same wells, except Well 299-E25-236 is replaced with 299-E25-237	Well 299-E25-236 had corroded casing and was decommissioned
Groundwater Flow Direction	Southeast	Same	No change
Type of Groundwater Monitoring Program	Interim status, groundwater quality assessment plan, first determination	Same	No change

TIC = tentatively identified compound
TOC = total organic carbon
WMA= waste management area

3.4 Sampling and Analysis Protocols

The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

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

4.2 Evaluation of Dangerous Waste Constituents and First Determination Report

The sampling results of the dangerous waste constituents listed in Table 3-1 (including the 10 most prominent TICs) will be used to prepare a first determination report in accordance with 40 CFR 265.93(d). The report will include an assessment of groundwater quality and determine if dangerous waste or dangerous waste constituents from WMA A-AX have entered the groundwater. Sample results from all the wells in Table 3-3 will be used for the determination.

Results from the first sampling event will be confirmed with results from the second sampling event. The results from these two events will be used to prepare the first determination report. Constituents from Table 3-1 will be placed into one of three categories described as follows:

1. **Constituent is attributable to previous WMA A-AX releases.** Constituents that are detected in both the first and second sample results, quantified above Hanford Site background values (inorganics only), and are not attributed to contamination from another facility (e.g., detected in comparable concentrations in upgradient wells) will be considered attributable to WMA A-AX. Due to known occurrences of well corrosion, results of elevated metals that are associated with stainless steel (e.g., nickel, chromium, manganese, and iron in Table 3-2) will be evaluated to determine if results are the due to corrosion within the well. Constituents determined to be attributable to previous WMA A-AX releases will be monitored on a quarterly basis under a revision of this plan.

2. **Constituent is not detected in groundwater, or is detected below background or upgradient concentrations, with no further monitoring required.** Constituents that are not detected (designated with a "U" qualifier) in the first two semiannual results will be eliminated from future sampling. Constituents that are detected below background or below upgradient well concentrations will be eliminated from future sampling.

3. **Results are inconclusive and additional monitoring is required to make a determination.** The sampling results may include data qualifiers or have inconsistent detections. These constituents will continue to be sampled at a semiannual frequency until sufficient data are available to make a determination placing them into either category 1 or category 2.

As discussed above, some of the inorganic constituents included in Table 3-1 occur naturally in groundwater at concentrations above the laboratory method detection limit (e.g., barium, selenium, vanadium, and zinc). Detections of inorganic constituents will be evaluated to determine if the constituents are present naturally by comparison to sample results from the upgradient well and comparisons to the Hanford Site background values (DOE/RL-96-61). If it is determined that the inorganic constituent is present naturally or is not attributable to WMA A-AX, then no further monitoring is required.

This groundwater assessment plan will be revised to update the constituents and sampling frequency in accordance with the findings of the first determination report. Any dangerous waste constituent(s) determined to be attributed to previous WMA A-AX releases (category 1) will be included for routine

monitoring at a quarterly frequency. If dangerous waste constituents are determined to be attributable to WMA A-AX, then the sampling frequency for supporting constituents and field parameters identified in Table 3-2 will also change to quarterly. Dangerous waste constituents that are not detected or not attributable to WMA A-AX (category 2) will be removed from the monitoring plan. Dangerous waste constituents requiring additional sampling (category 3) will be included for semiannual sampling. The first determination report will continue to be revised on an annual basis, as necessary, as determinations for constituents in category 3 are completed.

If it is determined that dangerous waste or dangerous waste constituents have entered the groundwater from WMA A-AX, the rate and extent of contaminant migration and concentration of the constituents in groundwater will be determined. Further determinations will be made on a quarterly basis until facility closure. The results will be discussed in annual reports that will provide the basis for the extent of contamination.

If the first determination results find that no dangerous waste or dangerous waste constituents in Table 3-1 attributable to WMA A-AX have contaminated the groundwater, then WMA A-AX monitoring will return to an indicator evaluation program under WAC 173-303-400 and 40 CFR 265.92, "Sampling and Analysis."

4.3 Interpretation

After sampling and water level data are validated and verified, acceptable data are used to interpret groundwater conditions at WMA A-AX. Interpretive techniques include the following:

- **Hydrographs**: Graph water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- **Water table maps**: Use water table elevations from multiple wells to construct contour maps and to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.
- **Trend plots**: Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps**: Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.
- **Contaminant ratios**: Can sometimes be used to distinguish among different sources of contamination.

4.4 Annual Determination of Monitoring Network

The RCRA groundwater monitoring requirements include an annual evaluation of the monitoring well network to determine if it remains adequate to monitor the WMA. The network must include upgradient and downgradient wells in the uppermost aquifer (40 CFR 265.91(a)(1) and (2)). The current well network (as shown in Figure 1-2) is considered adequate to monitor for dangerous waste constituents originating from WMA A-AX.

The current groundwater monitoring network will continue to be re-evaluated annually to ensure that it is adequate to monitor any changing hydrogeologic conditions beneath the site. If flow changes are

observed, the WMA A-AX CSM and groundwater constituents will be re-evaluated to determine network efficiency and any necessary modification requirements for the network.

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

4.5 Reporting

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

Based on the results of the rate and extent of migration and concentrations of dangerous waste, as determined by this plan (40 CFR 265.93(d)(5)), a report will be prepared containing an assessment of groundwater quality.

Assessment monitoring results are reported annually, in accordance with the requirements of 40 CFR 265.94(b), in annual Hanford Site groundwater monitoring reports.

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Appendix A

Quality Assurance Project Plan

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Terms

CFR	*Code of Regulations*
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEAD	format for electronic analytical data
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
GC/MS	gas chromatography/mass spectrometry
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MDL	method detection limit
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
PQL	practical quantitation limit
PS	post-digestion spike
PSD	post-digestion spike duplicate
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control

RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	request for data review
RPD	relative percent difference
SAF	Sampling Authorization Form
S&GRP	Soil and Groundwater Remediation Project
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*
WMA	waste management area

A1 Introduction

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

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Waste Management Area (WMA) A-AX groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Review and Usability.

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A2 Project Management

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

A2.1 Project/Task Organization

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

A2.1.1 DOE-RL Project Manager

Hanford Site cleanup is the responsibility of the DOE-RL. The DOE-RL project manager is responsible for authorizing a contractor to perform activities 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 Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) for the Hanford Site.

A2.1.2 DOE-RL Technical Lead

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

A2.1.3 Soil and Groundwater Remediation Project Manager

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

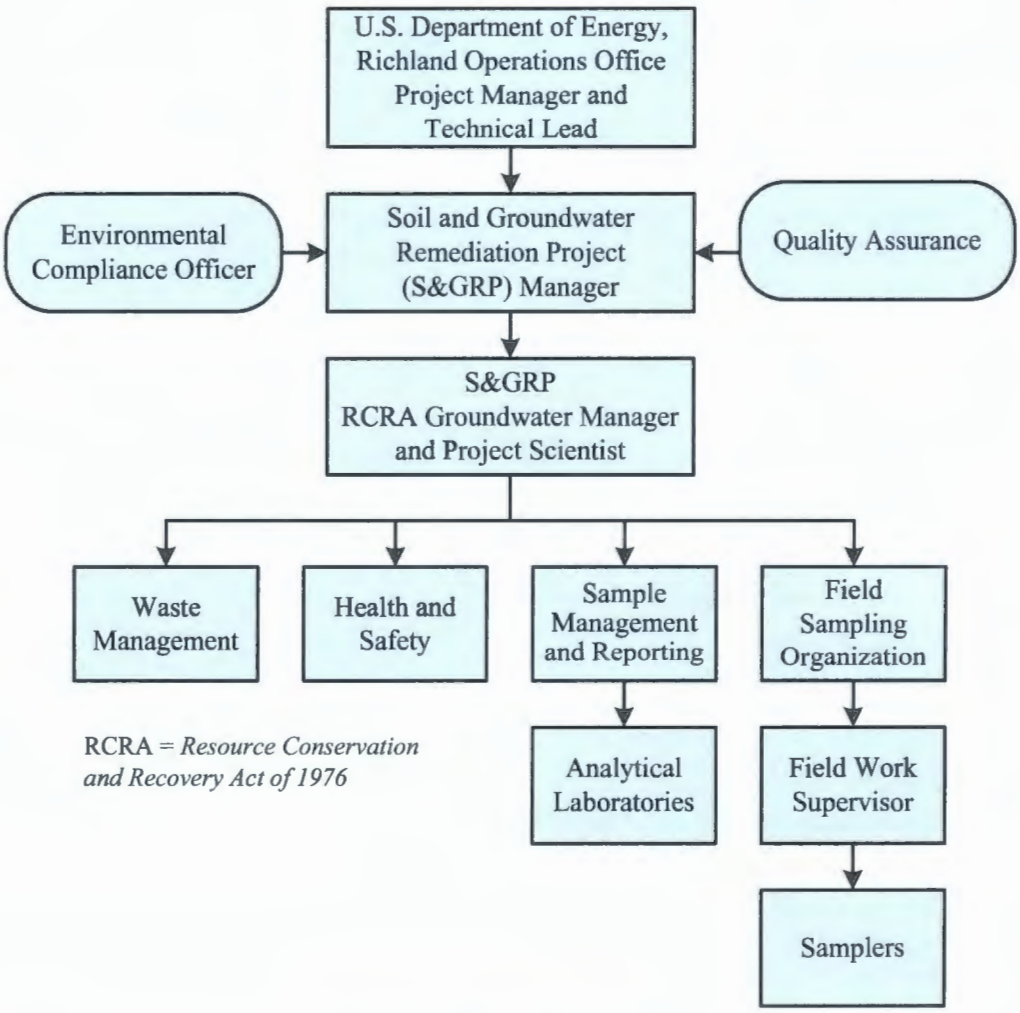

Figure A-1. Project Organization

A2.1.4 S&GRP RCRA Groundwater Manager

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

A2.1.5 Sample Management and Reporting Group

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

other entities. The SMR group is responsible for informing the S&GRP RCRA groundwater manager of any issues reported by the analytical laboratories.

A2.1.6 Field Sampling Organization

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

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

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

A2.1.7 Quality Assurance

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

A2.1.8 Environmental Compliance Officer

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

A2.1.9 Health and Safety

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

A2.1.10 Waste Management

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

A2.1.11 Analytical Laboratories

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

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy the requirements of *Washington Administrative Code* (WAC) 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," and Title 40 *Code of Federal Regulations* (CFR) 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring." Specifics on the activities to satisfy the requirements are provided in the main text of the monitoring plan in Chapter 1.0 and Sections 2.7, 3.1, 3.2, and 4.2. Background information on monitoring is also provided in the main text of this plan in Sections 2.2, 2.5, and 3.3.

A2.3 Project/Task Description

The project description is provided in Chapters 2, 3, and 4 of this monitoring plan and includes the groundwater constituents or parameters representing the dangerous wastes or dangerous waste constituents that may have entered the groundwater at WMA A-AX, the groundwater constituents or parameters to be monitored, the monitoring wells, and the frequency of sampling. Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

The following tasks are required by 40 CFR 265.93, "Preparation, Evaluation, and Response," as promulgated by WAC 173-303-400(3)(b) and modified by (3)(c)(v) when indicated:

- Determination whether dangerous wastes or dangerous waste constituents have entered groundwater, and if so, the rate and extent of migration and concentration of the dangerous wastes or dangerous waste constituents
- Evaluation of the monitoring network
- Interpretation of analytical results
- Reporting

A2.4 Quality Assurance Objectives and Criteria

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

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

Table A-1. Data Quality Indicators

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

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future completeness
Bias	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (MS).	For sampling bias: • Properly select and use sampling tools • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias.

Table A-1. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
			• Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other labs for analysis.
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[a] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation • Qualify/reject the data before use

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

a. For the purposes of this groundwater monitoring plan the lower limit of quantitation is equivalent to the practical quantitation limit

DQI = data quality indicator

MS = matrix spike

QA = quality assurance

A2.5 Special Training/Certification

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

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

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

A2.6 Documents and Records

The S&GRP RCRA groundwater manager (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Version control is maintained by an administrative document control process. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Changes to elements of the monitoring plan that are required by 40 CFR 265.93 are not allowed, except as unintentional changes as described in Table A-2.

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

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

Table A-2. Change Control for Monitoring Plans

Type of Change*	Action	Documentation
Temporary addition of wells or constituents analyzed for, or increased sampling frequency that do not impact the requirements of 40 CFR 265.93, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response."	S&GRP RCRA groundwater manager approves temporary change; provides informal notice to Ecology.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of groundwater constituents or parameters, and loss of samples in transit.	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL.	Annual groundwater monitoring report
Planned change to groundwater monitoring activities, including addition or deletion of constituents analyzed for, change of sampling frequency, or changes to well network.	S&GRP RCRA groundwater manager obtains DOE-RL approval; revise monitoring plan.	Revised RCRA groundwater monitoring plan
Anticipated unavoidable changes (e.g., dry wells).	S&GRP RCRA groundwater manager provides electronic notification to DOE-RL; revise monitoring plan.	Annual groundwater monitoring report and revised RCRA groundwater monitoring plan

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

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

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

The following records are managed and maintained by SMR personnel:

- Field sampling logbooks
- Groundwater sample reports and field sample reports
- Chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories
- Sample issue resolution forms

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

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

Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party

Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein. Convenience copies of laboratory analytical results are kept in the HEIS database.

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

A3 Data Generation and Acquisition

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

A3.1 Analytical Method Requirements

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

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
General Chemistry Analyses		
Alkalinity	EPA/600 Method 310.1 or Standard Method 2320	5,000
Cyanide	SW-846 Method 4012	20
Sulfide	SW-846 Method 9034	500
pH	Field Measurement Instrument/meter	N/A
Specific Conductance		N/A
Temperature		N/A
Turbidity		N/A
Anions		
Chloride	EPA/600 Method 300.0	400
Nitrate		250
Sulfate		550
Metals		
Antimony	SW-846 Method 6010B/C	60
Arsenic		10
Barium		20
Beryllium		4
Cadmium		5
Calcium		1,000
Chromium		10
Cobalt		20

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Copper		8
Iron		50
Lead		15
Magnesium		750
Manganese		5
Nickel		40
Potassium		4,000
Selenium		50
Silver		10
Sodium		500
Thallium		50
Tin		100
Vanadium		25
Zinc		10
Mercury	SW-846 Method 7470	0.5
Volatile Organic Compounds		
1,1-Dichloroethane		10
1,1-Dichloroethene (1,1-Dichloroethylene)		10
1,1,1-Trichloroethane		5
1,1,1,2-Tetrachloroethane		1.7
1,1,2-Trichloroethane		5
1,1,2,2-Tetrachloroethane		5
1,2-Dibromo-3-chloropropane	SW-846 Method 8260	5
1,2-Dibromoethane		5
1,2-Dichloroethane		5
1,2-Dichloropropane		5
trans-1,2-Dichloroethylene		5
1,2,3-Trichloropropane		5
cis-1,3-Dichloropropene		5

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
trans-1,4-Dichloro-2-butene		50
2-Butanone (methyl ethyl ketone; MEK)		10
2-Propanone (acetone)		20
2-Hexanone		20
4-Methyl-2-pentanone (MIBK)		10
Acetonitrile; Methyl cyanide		100
Acrolein		100
Acrylonitrile		100
Allyl chloride		10
Benzene		5
Bromodichloromethane		5
Bromoform		5
Carbon disulfide		5
Carbon Tetrachloride		3.4
Chlorobenzene		5
Chloroethane		10
Chloroform		5
Chloroprene		10
Dibromochloromethane		5
p-Dichlorobenzene (1,4-Dichlorobenzene)		4
Dichlorodifluoromethane		10
Ethylbenzene		4
Ethyl methacrylate		10
Isobutyl alcohol		500
Methacrylonitrile		10
Methyl bromide (Bromomethane)		10
Methyl chloride (Chloromethane)		10
Methyl iodide (Iodomethane)		10
Methyl methacrylate		10

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Methylene bromide (Dibromomethane)		10
Methylene chloride		5
Propionitrile (Ethyl cyanide)		10
Styrene		5
Tetrachloroethene		5
Toluene		5
trans-1,3-Dichloropropene		5
Trichloroethene (TCE)		1
Trichlorofluoromethane		10
Vinyl acetate		50
Vinyl chloride (chloroethene)		10
Xylenes (total)		10
Semivolatile Organic Compounds		
1-Naphthylamine	SW-846 Method 8270	25
1,2-Dichlorobenzene (o-Dichlorobenzene)		10
1,2,4-Trichlorobenzene		13
1,2,4,5-Tetrachlorobenzene		20
1,4-Dioxane		500
1,4-Naphthoquinone		50
2-Acetylaminofluorene		25
2-Chloronaphthalene		10
2-Chlorophenol		5
2-Methylphenol (o-Cresol)		5
2-Methylnaphthalene		10
2-Naphthylamine		25
2-Nitrophenol (o-Nitrophenol)		5
2-Picoline		20
2,3,4,6-Tetrachlorophenol		5
2,4-Dichlorophenol		5

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
2,4-Dimethylphenol		5
2,4-Dinitrophenol		5
2,4-Dinitrotoluene		10
2,4,5-Trichlorophenol		5
2,4,6-Trichlorophenol		5
2,6-Dichlorophenol		5
2,6-Dinitrotoluene		10
3-Methylcholanthrene		50
3- and 4-Methylphenol (m- and p-Cresol)		10
3,3′-Dichlorobenzidine		10
3,3′-Dimethylbenzidine		50
4-Aminobiphenyl		50
4-Bromophenyl phenyl ether		10
4-Chloro-3-methylphenol (p-Chloro-m-cresol)		5
4-Chlorophenyl phenyl ether		10
4-Nitroquinoline 1-oxide		25
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)		5
5-Nitro-o-toluidine		20
7,12-Dimethylbenz[a]anthracene		20
Acenaphthene		10
Acenaphthylene (Acenaphthylene)		10
Acetophenone		10
Aniline		10
Anthracene		10
Aramite		50
Benz[a]anthracene (Benzo[a]anthracene)		10
Benz[e]acephenanthrylene (Benzo[b]fluoranthene)		10
Benzo[k]fluoranthene		10

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Benzo[ghi]perylene		5.5
Benzo[a]pyrene		10
Benzyl alcohol		10
Bis(2-chloroethoxy)methane		10
Bis(2-chloroethyl)ether		2
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))		10
Bis(2-ethylhexyl) phthalate		6
Butyl benzyl phthalate		10
p-Chloroaniline (4-Chloroaniline)		10
Chlorobenzilate		20
Chrysene		5
Diallate		20
Dibenz[a,h]anthracene		10
Dibenzofuran		10
m-Dichlorobenzene (1,3-Dichlorobenzene)		10
Diethyl phthalate		10
O,O-Diethyl O-2-pyrazinyl phosphorothioate		20
Dimethoate		20
p-(Dimethylamino)azobenzene		2
alpha, alpha-Dimethylphenethylamine		200
Dimethyl phthalate		10
Di-n-butyl phthalate		10
m-Dinitrobenzene		15
Di-n-octyl phthalate		10
Dinoseb (2-sec-Butyl-4,6-dinitrophenol)		2.5
Diphenylamine		20
Disulfoton		2
Ethyl methanesulfonate		10
Famphur		17

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Fluoranthene		10
9H-Fluorene (Fluorene)		10
Hexachlorobenzene		2
Hexachlorobutadiene		10
Hexachlorocyclopentadiene		10
Hexachloroethane		5
Hexachlorophene		500
Hexachloropropene		25
Indeno(1,2,3-cd)pyrene		10
Isodrin		20
Isophorone		10
Isosafrole		20
Kepone		100
Methapyrilene		81
Methyl methanesulfonate		10
Methyl parathion		14
Naphthalene		10
Nitrobenzene		10
o-Nitroaniline (2-Nitroaniline)		10
m-Nitroaniline (3-Nitroaniline)		10
p-Nitroaniline (4-Nitroaniline)		10
p-Nitrophenol (2-Nitrophenol)		5
N-Nitrosodi-n-butylamine		10
N-Nitrosodiethylamine		10
N-Nitrosodimethylamine		5
N-Nitrosodiphenylamine		10
n-Nitroso-di-n-dipropylamine (N-Nitrosodipropylamine; Di-n-propylnitrosamine)		10
N-Nitrosomethylethalamine		10

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
n-Nitrosomorpholine		10
N-Nitrosopiperidine		2
N-Nitrosopyrrolidine		10
Parathion		14
Pentachlorobenzene		10
Pentachloroethane		10
Pentachloronitrobenzene		2
Pentachlorophenol		1.5
Phenacetin		20
Phenanthrene		10
Phenol		5
p-Phenylenediamine		400
Phorate		5
Pronamide		20
Pyrene		10
Pyridine		5
Safrole		2
Tetraethyl dithiopyrophosphate		6.5
o-Toluidine		20
O,O,O-Triethyl phosphorothioate		50
sym-Trinitrobenzene		100
Aroclor 1016	SW-846 Method 8082	0.5
Aroclor 1221		0.5
Aroclor 1232		0.5
Aroclor 1242		0.5
Aroclor 1248		0.5
Aroclor 1254		0.5
Aroclor 1260		0.5
Pesticides		

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
4,4′-DDD	SW-846 Method 8081	0.1
4,4′-DDE		0.1
4,4′-DDT		0.1
Aldrin		0.05
alpha-BHC		0.05
beta-BHC		0.05
delta-BHC		0.05
gamma-BHC		0.05
Chlordane		0.5
Dieldrin		0.05
Endosulfan I		0.05
Endosulfan II		0.1
Endosulfan sulfate		0.1
Endrin		0.1
Endrin aldehyde		0.1
Heptachlor		0.05
Heptachlor epoxide		0.05
Methoxychlor		0.5
Toxaphene		2
Herbicides		
2,4-D; 2,4-Dichlorophenoxyacetic acid	SW-846 Method 8151	20
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid		1
Silvex; 2,4,5-TP		1

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable PQL[b] (µg/L)
Dioxins		
2,3,7,8-Tetrachlorodibenzo-p-dioxin	SW-846 Method 8290	0.01
Polychlorinated dibenzo-p-dioxins		0.01
Polychlorinated dibenzofurans		0.01

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

Ten most prominent tentatively identified compounds will be reported and evaluated as part of the groundwater quality assessment.

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

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

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

A3.3 Quality Control

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

Table A-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field Duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed When needed, the minimum is one for every analytical method, for analyses performed where detection limit and	Precision, including sampling, analytical, and interlaboratory

Table A-4. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
	precision and accuracy criteria have been defined in the Analytical Performance Requirements (Table A-3)	
Full Trip Blanks	One in 20 well trips	Cross-contamination from containers or transportation
Field Transfer Blanks	One each day volatile organic compounds are sampled	Contamination from sampling site
Equipment Blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required Otherwise, one for every 20 samples[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[b]		
Laboratory Duplicates	1 per analytical batch[c]	Laboratory reproducibility and precision
Matrix Spikes	1 per analytical batch[c]	Matrix effect/laboratory accuracy
Post-Preparation Spike	1 per analytical batch[c]	Matrix effect/laboratory accuracy
Matrix Spike Duplicates	1 per analytical batch[c]	Laboratory accuracy and precision
Laboratory Control Samples	1 per analytical batch[c]	Laboratory accuracy
Method Blanks	1 per analytical batch[c]	Laboratory contamination
Surrogates	1 per analytical batch[c]	Recovery/yield

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

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

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

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

EPA = U.S. Environmental Protection Agency

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action
General Chemical Analyses			
Alkalinity	MB	< MDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory Duplicate	≤ 20% RPD[b]	Data reviewed[a]
	MS	75–125% recovery	Flagged with "N"
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Cyanide	MB	< MDL < 5% sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS and MSD	75–125% recovery	Flagged with "N"
	Laboratory Duplicate or MS/MSD	≤ 20% RPD[b]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Sulfide	MB	< MDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	Laboratory Duplicate or MS/MSD	≤ 20% RPD[b]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Anions			
Anions by IC[e]	MB	< MDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	Laboratory Duplicate or MS/MSD	≤ 20% RPD[b]	Data reviewed[a]

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Metals			
ICP-AES Metals[e]	MB	< RDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS or PS, and MSD	75–125% recovery	Flagged with "N"
	MS/MSD	≤ 20% RPD	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Mercury by Cold Vapor Atomic Absorption	MB	< RDL < 5% Sample concentration	Flagged with "C"
	LCS	80–120% recovery	Data reviewed[a]
	MS and MSD	75–125% recovery	Flagged with "N"
	Laboratory Duplicate or MS/MSD	≤ 20% RPD	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS[e]	MB	< MDL[c] < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS or PS and MSD or PSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MS/MSD or PS/PSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[b]
	EB, FTB, FXR	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action
Semivolatile Organic Compounds			
Semivolatiles by GC or GC/MS[e]	MB	< MDL < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS and MSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MS/MSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Polychlorinated Biphenyls by GC[e]	MB	< MDL < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS and MSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	Laboratory Duplicate or MS/MSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Pesticides			
Pesticides by GC[e]	MB	<MDL < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS and MSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	Laboratory Duplicate or MS/MSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[a]

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Herbicides			
Herbicides by GC[e]	MB	< MDL < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS and MSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	Laboratory Duplicate or MS/MSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"
Dioxins			
Dioxins by GC/MS[e]	MB	< MDL < 5% sample concentration	Flagged with "B"
	LCS	Statistically derived[d]	Data reviewed[a]
	MS and MSD	%Recovery statistically derived[d]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	Laboratory Duplicate or MS/MSD	%RPD statistically derived[d]	Data reviewed[a]
	SUR	Statistically derived[d]	Data reviewed[a]
	EB, FTB	< 2 times MDL	Flagged with "Q"
	Field Duplicate	≤ 20% RPD[b]	Flagged with "Q"

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

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

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

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

c. For common laboratory contaminants such as methylene chloride, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.

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

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action

e. See Table A-3 for constituent list.

EB	=	equipment blank	LCS	=	laboratory control sample
EPA	=	U.S. Environmental Protection Agency	MB	=	method blank
FEAD	=	format for electronic analytical data	MDL	=	method detection limit
FTB	=	full trip blank	MS	=	matrix spike
FXR	=	field transfer blank	MSD	=	matrix spike duplicate
GC	=	gas chromatography	PS	=	post-digestion spike
GC/MS	=	gas chromatography/mass spectrometry	PSD	=	post-digestion spike duplicate
IC	=	ion chromatography	QC	=	quality control
ICP AES	=	inductively coupled plasma-atomic emission spectroscopy	RPD	=	relative percent difference
			SUR	=	surrogate

Data Flags:

B (organics)	=	analyte was detected in both the associated QC blank and the sample
C (inorganics/wetchem)	=	The analyte was detected in both the sample and the associated QC blank and the blank value exceeds 5% of the measured concentration present in the associated sample
N	=	all except GC/MS – matrix spike outlier
T	=	volatile organic analysis and semivolatile organic analysis GC/MS – matrix spike outlier
Q	=	associated QC sample is out of limits

A3.3.1 Field Quality Control Samples

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

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

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

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

Field Transfer Blanks: preserved volatile organic analysis sample vials filled with high-purity reagent water at the sample collection site where volatile organic compounds are collected. The samples will be

prepared during sampling to evaluate potential contamination attributable to field conditions. After collection, field transfer blank (FXR) sample vials will be sealed and placed in the same storage containers with the samples collected the same day for the associated sampling event. FXR samples will be analyzed for volatile organic compounds only.

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

A3.3.2 Laboratory Quality Control Samples

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

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

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

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

Post-Digestion Spike: the same as MS; however, the spiking occurs after sample preparation and before analysis.

Post-Digestion Spike Duplicate: the same as MSD; however the spiking occurs after sample preparation and before analysis.

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

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

Surrogate: a compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, yet are not normally encountered. SURs are expected to respond to the preparation and measurement systems

in a manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

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

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

Constituent/ Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time
Alkalinity	500 mL	Narrow mouth poly or glass	Store ≤ 6°C	14 days
Cyanide	250 mL	Narrow mouth poly or glass	Store ≤ 6°C, Adjust pH to ≥12 with Sodium Hydroxide	14 days
Sulfide	250 mL	Narrow mouth poly or glass	Store ≤ 6°C, Adjust pH to >9 with Zinc Acetate and Sodium Hydroxide	7 days
Anions by IC[c]	60 mL	Narrow mouth poly or glass	Store ≤ 6°C	48 hours
ICP Metals[c]	250 mL	Narrow mouth poly or glass	Adjust pH to < 2 with nitric acid	6 months
Mercury	250 mL	Narrow mouth glass	Adjust pH to < 2 with nitric acid	28 days
Volatiles[c]	4 × 40 mL	Amber glass VOA vial	Store ≤ 6°C, Adjust pH to < 2 with H_2SO_4 or HCl	14 days
Semivolatiles[c]	4 × 1 L	Narrow mouth amber glass with Teflon®-lined lid	Store ≤ 6°C	7 days before extraction 40 days after extraction
Polychlorinated Biphenyls[c]	4 × 1 L	Narrow mouth amber glass with Teflon-lined lid	Store ≤ 6°C	6 months
Herbicides by GC[c] Pesticides by GC[c]	4 × 1 L	Narrow mouth amber glass with Teflon®-lined lid	Store ≤ 6°C	7 days before extraction 40 days after extraction
Dioxins by GC/MS[c]	4 × 1L	Narrow mouth amber glass with Teflon®-lined lid	Store ≤ 6°C	30 days before extraction

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

Constituent/ Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time
				45 days after extraction

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

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

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

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

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

c. See Table A-3 for constituent list.

EPA = U.S. Environmental Protection Agency
GC = gas chromatography
GC/MS = gas chromatography/mass spectrometry
H_2SO_4 = sulfuric acid
HCl = hydrochloric acid
IC = ion chromatography
ICP = inductively coupled plasma
VOA = volatile organic analysis

A3.4 Measurement Equipment

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

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

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

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

A3.6 Instrument/Equipment Calibration and Frequency

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

A3.7 Inspection/Acceptance of Supplies and Consumables

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

A3.8 Nondirect Measurements

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

A3.9 Data Management

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

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

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

A4 Assessment and Oversight

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

A4.1 Assessments and Response Actions

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

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

A4.2 Reports to Management

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

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A5 Data Review and Usability

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

A5.1 Data Review and Verification

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

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

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

A5.2 Data Validation

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

A5.3 Reconciliation with User Requirements

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

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A6 References

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Appendix B

Sampling Protocol

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Terms

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

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B1 Introduction

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

This appendix provides more specific elements of the sampling protocols and techniques used for the RCRA groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, the constituents to be analyzed for, and the sampling frequency for the groundwater monitoring at the Waste Management Area A-AX.

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B2 Sampling Methods

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

- Field screening measurements
- Groundwater sampling
- Water level measurements

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

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

Absent any special requirements from project scientists, wells are purged utilizing the three borehole volume method. Stable field readings are also required as specified above. The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gal/min) depending on the pump, although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged a minimum of 1 hour and then sampled once stable field readings are obtained.

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

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

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

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

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

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

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

B2.1 Decontamination of Sampling Equipment

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

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

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

B2.2 Water Levels

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

B3 Documentation of Field Activities

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

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

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

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

B3.1 Corrective Actions and Deviations for Sampling Activities

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

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

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

B4 Calibration of Field Equipment

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

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

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B5 Sample Handling

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

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

B5.1 Containers

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

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

B5.2 Container Labeling

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

B5.3 Sample Custody

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

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

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

- Project name
- Collectors' names
- Unique sample number
- Date and time of collection

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

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

B5.4 Sample Transportation

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

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

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2004-18, *Waste Control Plan for the 200-PO-1 Groundwater Operable Unit*. For waste designation purposes, the wells listed in Table 3-3 will be surveyed in the Hanford Environmental Information System and the maximum concentrations for each analyte within the most recent 5 years evaluated for use in creating a waste profile, if required. Offsite analytical laboratories are responsible for disposal of unused sample quantities. Pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the DOE Richland Operations Office is required before returning unused samples or waste from offsite laboratories.

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B7 Health and Safety

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

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Appendix C

Well Construction

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C1 Introduction

This appendix provides the following information for the Waste Management Area A-AX 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-9 provide the well construction and completion summary for Wells 299-E24-20, 299-E24-22, 299-E24-33, 299-E25-40, 299-E25-41, 299-E25-2, 299-E25-93, 299-E25-94, and 299-E25-237.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
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 WMA A-AX Network

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft]) NAVD88	Elevation Bottom of Open Interval (m [ft]) NAVD88	Open Interval Length m (ft)
299-E24-20	TU	124.98 (410.0)	118.84 (389.9)	6.1 (20.1)
299-E24-22	TU	122.30 (401.3)	111.61 (366.2)	10.7 (35.1)
299-E24-33	TU	122.24 (401.1)	111.49 (365.8)	10.8 (35.4)
299-E25-40	TU	126.28 (414.3)	119.88 (393.3)	6.4 (21.0)
299-E25-41	TU	126.89 (416.3)	120.49 (395.3)	6.4 (21.0)
299-E25-2	TU	122.07 (400.5)	109.88 (360.5)	12.2 (40.0)
299-E25-93	TU	122.44 (401.7)	111.76 (366.7)	10.7 (35.1)
299-E25-94	TU	121.34 (398.1)	110.67 (363.1)	10.7 (35.1)
299-E25-237	TU	123.15 (404.0)	112.48 (369.0)	10.7 (35.1)

Reference: NAVD88, *North American Vertical Datum of 1988.*

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

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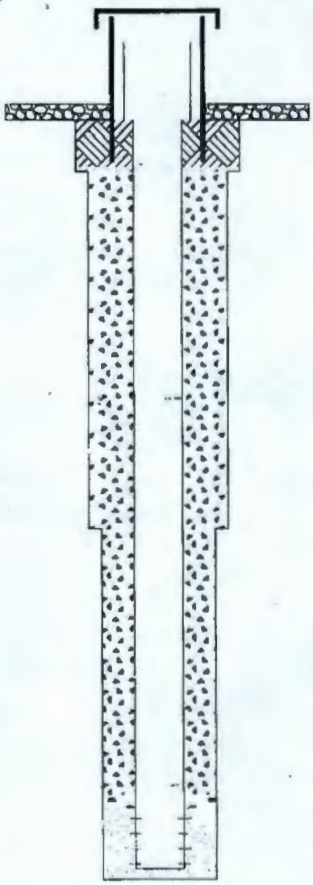
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-E24-20 A4756
Drilling Fluid Used:	NA	Additives Used:	None	TEMPORARY WELL NO:	None
Driller's Name:	K. Olson	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	KEH Constr. Forces	Company Location:	Hanford	Coordinates: E	Not documented
Date Started:	31Jan91	Date Completed:	14Mar91	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: 281.6 ft 13Mar91
(Ground surface) 285.64 ft 02May91

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 15 ft : Slightly Silty Gravelly Sand
15 - 20 ft : Gravelly Sand
20 - 25 ft : Slightly Silty Gravelly Sand
25 - 27 ft : Gravelly Silt
27 - 35 ft : Gravelly Sand
35 - 90 ft : Sandy Gravel
90 - 95 ft : Gravelly Sand
95 - 100 ft : Slightly Gravelly Sand
100 - 105 ft : Sand
105 - 115 ft : Sandy Gravel
115 - 125 ft : Gravelly Sand
125 - 130 ft : Sandy Gravel
130 - 135 ft : Gravelly Sand
135 - 140 ft : Sand
140 - 160 ft : Gravelly Sand
160 - 185 ft : Sand
185 - 200 ft : Slightly Gravelly Sand
200 - 210 ft : Sand
210 - 215 ft : Gravelly Sand
215 - 220 ft : Sand
220 - 225 ft : Slightly Gravelly Sand
225 - 230 ft : Sand
230 - 240 ft : Slightly Gravelly Sand
240 - 250 ft : Gravelly Sand
250 - 255 ft : Slightly Gravelly Sand
255 - 265 ft : Gravelly Sand
265 - 275 ft : Sand
275 - 280 ft : Gravelly Sandy Silt
280 - 290 ft : Gravelly Sand
290 - 295 ft : Sandy Gravel
295 - 300 ft Sand
300 - 304.02 ft : Sandy Gravel



304.02 ft : Borehole drilled depth

0 - 20.33 ft : 13-in. 12-3/4" CS Temp. Casing
20.33 - 163.1 ft : 11-in. 10-3/4" CS Temp. Casing
163.1 - 304.02 ft : 9-in. 8-5/8" CS Temp. Casing

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 18.3 ft.

Type of Surface Seal: 4x4 Concrete Pad

Fill	*Casing*	*Screen*
0 - 18.3 ft : 13-inch hole Cement	0 - 20.33 ft : 13 inch 12-3/4" CS Temp. Casing	
18.3 - 20.33 ft : 13-inch hole 8-20 Mesh Bentonite Crumbles	0 - 279.23 ft : 4 inch 4" Perm. Casing	
20.33 - 163.1 ft : 11-inch hole 8-20 Mesh Bentonite Crumbles	20.33 - 163.1 ft : 11 inch 10-3/4" CS Temp. Casing	
	163.1 - 304.02 ft : 9 inch 8-5/8" CS Temp. Casing	
163.1 - 269.3 ft : 9-inch hole 8-20 Mesh Bentonite Crumbles		
269.3 - 274.7 ft : 9-inch hole 1/4" - 3/8" Bentonite Pellets		279.23 - 299.35 ft : 4 inch 4" .010 SS Wire Wrap Pipe Size
274.7 - 299.65 ft : 9-inch hole 8-12 Silica Sand	299.35 - 299.65 ft : 4 inch End Cap	
299.65 - 304.02 ft : 9-inch hole 8-12 Silica Sand		

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 07Jan98
Print Date: 07Jan98

Figure C-1. Well 299-E24-20 Construction and Completion Summary

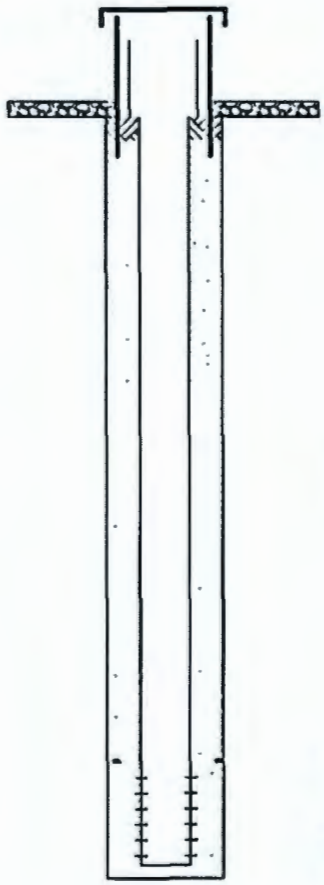
AS-BUILT WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Becker Hammer	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-E24-22 C4123
Drilling Fluid Used:	Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	Paul Lodder	WA State Lic Nr:	1628	Coordinates: N	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Coordinates: E	Not documented
Date Started:	16Jul03	Date Completed:	17Jul03	Start Card #:	R05132
				Elevation Ground Surface:	

Depth to Water: 286.02 ft 17Jul03
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 2 ft : Backfill
2 - 15 ft : Sand (s)
15 - 25 ft : gravelly Sand (gS)
25 - 175 ft : Sand (S)
175 - 180 ft : gravelly Sand (gS)
180 - 220 ft : Sand (S)
220 - 225 ft : gravelly Sand (gS)
225 - 270 ft : Sand (S)
270 - 272 ft : silty/clay (m)
272 - 281 ft : Sand (S)
281 - 285 ft : gravelly Sand (gS)
285 - 290 ft : Sand (S)
290 - 300 ft : gravelly Sand (gS)
300 - 310 ft : sandy Gravel (sG)
310 - 330 ft : silty sandy Gravel (msG)



Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10 ft

Type of Surface Seal: 4x4 Concrete Pad

Fill	Casing	Screen
0 - 10 ft : 9-inch hole Cement surface seal	0 - 286.21 ft : 4 inch 304 SS sch 5 csg	
10 - 276.5 ft : 9-inch hole Granular bentonite		
276.5 - 281.1 ft : 9-inch hole 1/4" bentonite pellets		286.21 - 321.26 ft : 4 inch 304 SS wire wrap .020 slot scrn
281.1 - 323.68 ft : 9-inch hole 10/20 Silica sand	321.26 - 323.68 ft : 4 inch SS sump/end cap	
323.68 - 330 ft : 9-inch hole 10/20 Silica sand		

330 ft : Borehole drilled depth

0 - 330 ft : 9-in. Becker Hammer 9"X6" dual wall temp drive pipe

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 06Oct03
Print Date: 07Oct03

Figure C-2. Well 299-E24-22 Construction and Completion Summary

WELL SUMMARY SHEET

Start Date: 04/16/04
Finish Date: 06/02/04
Page 1 of 2

Well ID: C4257
Well Name: 299-E24-33
Location: N. west of 241 Tank Farm/200 East
Project: RCRA / CERCLA drilling, FY 2004
Prepared By: Charlene Martinez
Date: 06/04/04
Reviewed By: L.D. Walker
Date: 6/10/04
Signature: Charlene Martinez
Signature: LD Walker

CONSTRUCTION DATA

Description:

10 5/8" OD temporary casing set to 245' bgs

6" ID SS protective casing set +1.09' above permanent

4" ID SS304 riser (schedule 5): +2.05' → 275.1'

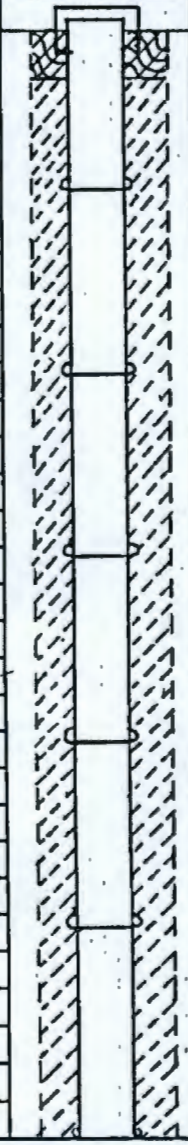
Portland Cement Grout: 11' → 0'

Granular Bentonite: 11' → 245.6'

All depths in feet below ground surface.

All temporary casing removed from ground.

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 40, 80, 120, 160, 200

Graphic Log:

Lithologic Description:

0 - 0.3' Crushed gravel (drilled)
0.3' - 23' SAND(S)
23' - 26' gravelly SAND(gS)
26' - 40' SAND(S)
40' - 58' slightly silt gravelly sand (mgS)
58' - 78' SAND(S)
68' - silt lens (<0.3' thick)
78' - 90' slightly silt gravelly sand (mgS)
90' - 115' gravelly SAND(gS)
115' - 252' SAND(S)

Figure C-3. Well 299-E24-33 Construction and Completion Summary

WELL SUMMARY SHEET

Start Date: 04/11/04
Finish Date: 06/02/04
Page 2 of 2

Well ID: C4257	Well Name: 299-E24-33
Location: 1 west of AX Tank Farm/200 East	Project: RCRA/CERCLA drilling. FY2004
Prepared By: Charlene Martinez Date: 06/04/04	Reviewed By: L.D. Walker Date: 6/10/04
Signature: Charlene Martinez	Signature: L.D. Walker

CONSTRUCTION DATA

Description:

9 5/8" OD carbon steel casing set from 265'-315'

Portland Cement Grout: 246.6' → 264.7'

3/8" Bentonite Pellets: 264.7' → 269.4'

10-20 mesh Colorado Sand Silica 269.4' → 315.4'

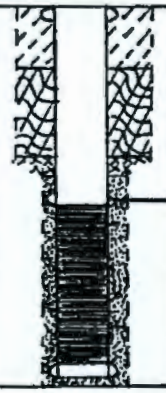
4" ID SS 304, sched.5, 0.020-inch slot wellscreen: 275.1' → 310.1'

4" ID SS 304, sched.5 sump: 310.1' → 313.1'

All depths in feet below ground surface.

All temporary casing removed from ground.

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 240, 280, 320, 360, 400

Graphic Log:

Lithologic Description:

252'-255.5' sandy GRAVEL (sG)
255.5'-267.5' SILT (m)
267.5'-268.5' sandy SILT (sm)
268.5'-274' silty sandy GRAVEL (msG)
274'-275' SAND (S)
275'-280' sandy GRAVEL (sG)
280'-290' SAND (S)
290'-292' silty sandy GRAVEL (msG)
292'-313' sandy GRAVEL (sG)
313'-315.4' silty sandy GRAVEL (msG)

TD = 315.4' bgs
Static water TD 274.35' bgs (06/02/04)

A-6003-643 (03/03)

Figure C-3. Well 299-E24-33 Construction and Completion Summary (continued)

A 4789

Battelle
Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E25-40 Geologist M.D. Lockett Goodwin Page 1 of 3

Reviewed by V. T. McGhan Date 12-4-89

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
143.7' of 10" CARBON STEEL CASING		5		SAND (Tr Cobbles)
		10		SAND
CEMENT GROUT		15		SAND
		20		SAND (Tr. Cobbles)
273.1' of 8" CARBON STEEL CASING		25		"
		30		"
		35		"
		40		SANDY GRAVEL
		45		SAND
FALTGT INSTALLED CENTRALIZERS		50		"
		55		"
253.25' of 4" DIA. STAINLESS STEEL CASING		60		"
		65		SLIGHTLY GRAVELLY SAND
		70		Sl. Gravelly SAND
		75		Sandy GRAVEL
		80		Gravelly SAND
		85		Gravelly SAND
8-20 BENTONITE		90		Gravelly SAND
		95		gravelly SAND
		100		SAND
		105		SAND
		110		SAND
		115		SAND
		120		SAND
		125		SAND
		130		SAND

A-1800-166 (2/87)

Figure C-4. Well 299-E25-40 Construction and Completion Summary

Battelle, Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E25-40 Geologist M.O Lubrecht, Goodwin Page 2 of 3

Reviewed by [illegible] Date 12-4-89

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
10" DIA. CARBON STEEL		135		SAND
CASING 0'- 143.7'		140		SAND
		145		SAND
		150		SAND
8" DIA. CARBON STEEL		155		"
CASING 0'- 273.1'		160		"
		165		Slightly Gravelly Sand
		170		"
		175		SAND
		180		"
		185		"
		190		"
		195		Sandy GRAVEL
		200		" "
		205		" "
		210		SLIGHTLY GRAVELLY SAND
		215		" " "
		220		SAND
		225		"
8-20 BENTONITE		230		"
		235		"
		240		"
3/8" VOLCLAY TABLETS		245		"
		250		SLIGHTLY MUDDY SAND
16-30 COL. SILICA SAND		255		MUD
		260		SLIGHTLY GRAVELLY SAND

A-1800-188 (3/87)

Figure C-4. Well 299-E25-40 Construction and Completion Summary (continued)

Battelle
Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E25-40 Geologist LUBRECHT, GOODWIN Page 3 of 3

Reviewed by W. L. McKlem Date 12-4-89

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
10-SLOT, STAINLESS STEEL CHANNEL PACK SCREEN -210		265		SANDY GRAVEL
		270		" "
		275	T.D. 274'	

A-1800-188 (3/8)

Figure C-4. Well 299-E25-40 Construction and Completion Summary (continued)

A4790

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E25-41 Geologist M Lobrecht Page 1 of 3

Reviewed by [illegible] Date 12-7-99

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
10" CARBON STEEL CASING 0–136'7 1/2" (TEMPORARY)		5		SAND
		10		SAND
		15		Sl. Muddy SAND
		20		Sandy GRAVEL
280'3" of 8" CARBON STEEL CASING		25		Sandy GRAVEL
		30		SAND
		35		SAND
		40		Muddy Sandy GRAVEL
257.05' 4" STAINLESS STEEL CASING		45		Sl. Gravelly SAND
		50		SAND
		55		SAND
		60		Sl. Gravelly SAND
		65		Sl. Gravelly SAND
		70		Gravelly SAND
		75		Gravelly SAND
		80		Sl. Gravelly SAND
		85		Gravelly SAND
		90		Gravelly SAND
		95		Gravelly SAND
		100		SAND
		105		SAND
		110		SAND
		115		SAND
		120		Interbedded SAND & muddy C SAND
		125		Interbedded SAND & muddy C SAND
		130		SAND

A-1600-188 (2/87)

Figure C-5. Well 299-E25-41 Construction and Completion Summary

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AS-BUILT DIAGRAM

Well Number 299 - E25 - 41 Geologist M. LUEBECHT Page 2 of 3

Reviewed by [illegible] Date 12-7-99

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
139' 7 1/2" of 10" CARBON STEEL CASING		135		SAND
		140		"
		145		"
280' 3" of 8" CARBON STEEL CASING		150		"
		155		"
		160		"
		165		"
257.42' of 4" STAINLESS STEEL CASING		170		"
		175		"
		180		slightly Gravelly SAND
		185		" " "
		190		SAND
		195		"
		200		Sandy GRAVEL
		205		Sandy GRAVEL
		210		gravelly SAND
		215		" "
		220		MUDDY SANDY GRAVEL
		225		" " "
		230		GRAVELLY SAND
		235		" "
		240		" "
		245		" "
		250		" "
		255		SANDY MUD
		260		" "

A-1800-186 (3/87)

Figure C-5. Well 299-E25-41 Construction and Completion Summary (continued)

Battelle
Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E25-41 Geologist M. LUBRECHT Page 3 of 3

Reviewed by [illegible] Date 12-7-89

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description D/W @ 262.24 9-22-89
280' 3" of 6" CARBON STEEL CASING		265		SANDY MUD
		270		MUDDY SANDY GRAVEL
		275		SANDY GRAVEL
2101' of 4" CHANNEL PACK SCREEN (10 SLOT)				
COMPLETION SYMBOLS:				
CEMENT GROUT				
BENTONITE CRUMBLES				
BENTONITE PELLETS				
SILICA SAND				
CASING JOINT				
CASING CENTRALIZER				

A-1600-186 (3/9)

Figure C-5. Well 299-E25-41 Construction and Completion Summary (continued)

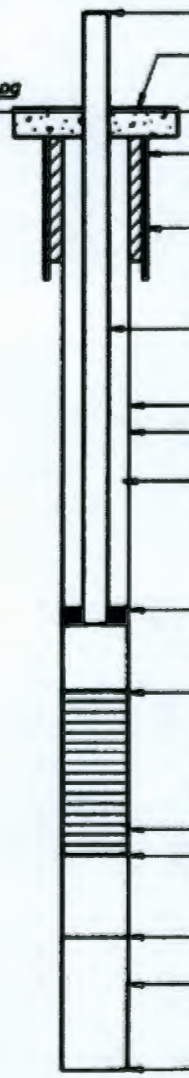
WELL CONSTRUCTION AND COMPLETION SUMMARY AS-BUILT

Drilling Method: Cable Tool	Sample Method: INF	WELL NUMBER: 299-E25-2	TEMPORARY WELL NO.: 216-A-1 #6
Drilling Fluid Used: Water	Additives Used: INF	Hanford Coordinates: N/S N 41270	E/W W 47190
Driller's Name: Row-Jack Richards	TA State Lic. No.: INF	State Coordinates: N INF	E INF
Drilling Company: INF	Company Location: INF	Start Card #: INF	T – R – S –
Date Started: 02/03/54	Date Completed: 03/15/55	Elevation Ground Surface (ft): INF	

Depth to water: 266.0

GENERALIZED STRATIGRAPHY Data source: Driller's Log

0 – 10	Top Soil and Sand
10 – 30	Sandy Silt
30 – 33	Sand and Gravel
33 – 50	Sandy Silt
50 – 60	Sand, Silt
60 – 85	Sandy Silt
85 – 115	Sand, Silt
115 – 122	Gravel
122 – 135	Sandy Silt
135 – 205	Sand and Silt
205 – 210	Gravel
210 – 260	Gravel, Sand
260 – 270	Silt, Sand (Palouse?)
270 – 275	Gravel and Silt
275 – 290	Gravel
290 – 315	Gravel and Sand
315 – 320	Sand
320 – 330	Gravel and Sand
330 – 335	Gravel
335 – 340	Gravel, Sand
340 – 356	Gravel, Sand, Silt
356 – 365	Gravel, Sand, Mud
365 – 375	Basalt



Elevation of casing:	675.04
Elevation of reference point:	INF
Concrete pad dimensions:	INF
Depth of surface seal:	0–240.0
Type of surface seal: Grout between 6-in. & 8-in. casing	
I.D. of surface casing (if present):	N/A
Type of surface casing: N/A	
Depth of surface casing:	N/A
I.D. of riser pipe:	6-in.
Type of riser pipe: INF	
Diameter of borehole:	8-in.
Diameter of outer perforated casing (Remediations):	8-in.
Type of filter: Grout to Packer	
Elevation/depth of top of packer:	240.5
Type of packer: INF	
Elevation/depth of top of screen/perforated interval:	276.0
Description of screen/perforation: Perforated	
I.D. of screen section:	N/A
Elevation/depth of bottom of screen/perforated interval:	316.0
Elevation/depth of top of plugged section:	N/A
Type of filter used in plugged section: N/A	
Elevation/depth of bottom of borehole:	375.0
Elevation/depth of remediated borehole:	368.0

NOTES: N/A: Not Applicable
INF: Insufficient Data

8831752\2E2502

Figure C-6. Well 299-E25-2 Construction and Completion Summary

WELL SUMMARY SHEET

Start Date: 07/01/03
Finish Date: 07/09/03
Page 1 of 2

Well ID: C4122
Well Name: 299-E25-93
Location: East of 241-A Tank Farm
Project: CY03 RCRA Drilling
Prepared By: Charlene Martinez
Date: 07/15/03
Reviewed By: L.D. Walker
Date: 8/11/03
Signature: Charlene Martinez
Signature: L.D. Walker

CONSTRUCTION DATA

Description:

Dual-wall temporary casing used. 9" OD: Inner casing 7 1/4"

Protective casing set (6" ID) + 1.11' above permanent casing

4" ID SS 304 Sched 10 casing: +2.00' → 278.23'

Portland Cement Grout: 0' → 10.5'

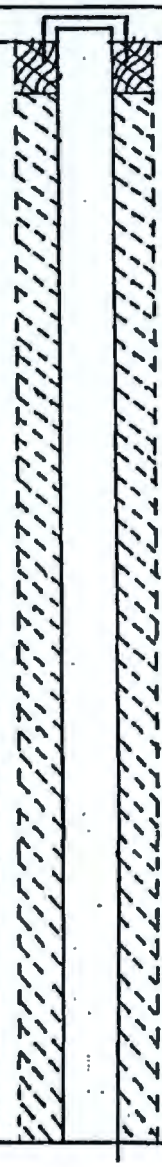
Granular Bentonite: 10.5' → 268.5'

1/4" Bentonite Pellets: 268.5' → 273.1'

All temporary casing removed from ground.

All depths are in feet below ground surface.

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 40, 80, 120, 160, 200

Graphic Log:

Lithologic Description:

0'-2' Backfill material
2'-11' SAND(S)
Hanford Formation @ 11' bgs.
11'-20' SAND(S)
20'-25' Gravelly SAND(gS)
25'-35' SAND(S)
35'-45' Gravelly SAND(gS)
45'-106' SAND(S)
106'-115' Gravelly SAND(gS)
115'-215' SAND(S)
215'-220' gravelly SAND(gS)
220'-261.6' SAND(S)

A-6003-643 (03/03)

Figure C-7. Well 299-E25-93 Construction and Completion Summary

WELL SUMMARY SHEET

Start Date: 07/01/03
Finish Date: 07/09/03
Page 2 of 2

Well ID: C4122	Well Name: 299-E25-93
Location: East of 241-A Tank Farm	Project: CY03 RCRA drilling
Prepared By: Charlene Martinez — Date: 07/15/03	Reviewed By: L.D. Walker — Date: 8/11/03
Signature: Charlene Martinez	Signature: LD Walker

CONSTRUCTION DATA

Description:

10-20 mesh silica sand:
273.1' → 320.0'

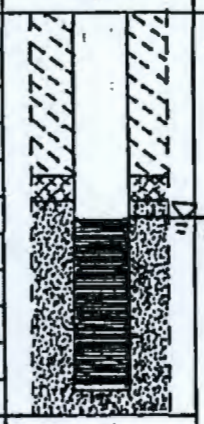
4" ID SS 304 schedule 10
well screen: .020 SLOT
278.23' → 313.26'

4" ID SS 304 schedule 10
sump end cap
313.26' → 315.26'

All temporary casing removed from ground.

All depths are in feet below ground surface.

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 240, 280, 320

Graphic Log:

Lithologic Description:

240.6' - 317' sandy GRAVEL (SG)

Ringold formation @ 317' bgs

317'-320' silty sandy GRAVEL (msG)

TD @ 320' bgs.

static water => 278.04' bgs (07/15/03)

A-6003-643 (03/03)

Figure C-7. Well 299-E25-93 Construction and Completion Summary (continued)

WELL SUMMARY SHEET

Start Date: 09-13-04
Finish Date: 9-27-04
Page 1 of 2

Well ID: C4665
Well Name: 299-E25-94
Location: NE Corner of 242-A Evap. Parking Lot
Project: RCRA CY04 Monitoring Wells
Prepared By: Jess Hocking
Date: 9/27/04
Reviewed By: L.D. Walker
Date: 10-13-04
Signature: Jess Hocking
Signature: LD Walker

CONSTRUCTION DATA

Description	Diagram
4" sch. 5s TP-304/304L Riser 0.5' → 295.1'	
4" sch. 5s TP-304/304L CONT. WIRE-WRAP 0.020-SLOT SCREEN 295.1' → 330.1'	
4" sch. 5s TP-304/304L Sump 330.1' → 331.1'	
10-20 mesh Colorado Silica Sand 333' → 288'	
5/8" Wyoming Bentonite Pellets 288' → 282'	
Portland Cement 282' → 267'	
Pure Wyoming Bentonite Crumbles 267' → 13'	
Portland Cement 13' → 3'	
10" diameter temporary drill casing driven to 332' bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0-4' DRILL PAD / MISC. FILL MATERIAL
		4-44' Sand (S)
		44-45' Silt (M)
		45-70' Sand (S)
40		
		70-77' Slightly silty sand ((m)S)
		77-85' Slightly silty gravelly sand ((m)gS)
80		85-120' Slightly silty sand ((m)S)
120		120-140' Sand (S)
		140-145' Slightly silty sand ((m)S)
		145-150' Sand (S)
		150-160' Silty Sand (mS)
160		160-175' Slightly silty sand ((m)S)
		175-185' Sand (S)
		185-195' Slightly silty sand ((m)S)
		195-230' Sand (S)
200		
		230-235' Slightly silty sand ((m)S)
		235-268' Sand (S)

A-6003-643 (03/03)

Figure C-8. Well 299-E25-94 Construction and Completion Summary

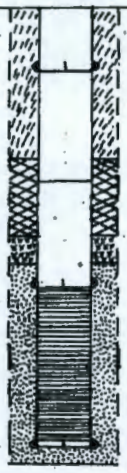
WELL SUMMARY SHEET

Start Date: 09-13-04
Finish Date: 9-27-04
Page 2 of 2

Well ID: C4665
Well Name: 299-E25-94
Location: NE Corner of 242-A Evap. Parking Lot.
Project: RCRA CY04 Monitoring Wells
Prepared By: Jess Hocking
Date: 9/27/04
Reviewed By: L.D. Walker
Date: 10/13/04
Signature: Jess Hocking
Signature: D Walker

CONSTRUCTION DATA

Description	Diagram
NOTE: ALL TEMPORARY CASING HAS BEEN REMOVED FROM THE GROUND.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
240		
		268 - 268.5' Gravelly Sand (gS)
		268.5 - 270' Gravelly silty sand (gmS)
		270 - 271.7' Silty sand (mS)
280		271.7' - 280' Silt (M)
		280 - 285.5' Gravelly sand (gS)
		285.5 - 288' Sandy gravel (sG)
		288 - 296' Silty sandy gravel (msG)
		296 - 325' Sandy gravel (sG)
320		325 - 330' Slightly silty gravelly sand (slgS)
		330 - 333' Gravelly sand (gS)
TD		333 = TD Silty Sandy gravel (msG)
360		
		TD = 333' bgs (9/23/04)
		DTW = 295.6' bgs (9/21/04)

A-6003-643 (03/03)

Figure C-8. Well 299-E25-94 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 1 of 3
		Finish Date: 1-19-2015	
Well ID: CB922		Well Name: 299-E25-237	
Location: S. of WMA A-AX		Project: M24 Drilling	
Prepared by: Julie Johanson	Date: 12-17-14	Reviewed by: J.D. MEHRER	Date: 1/21/15
Signature: Julie Johanson		Signature:	

CONSTRUCTION DATA

Surface Completion:

4'x4'x6" Concrete Pad with brass survey marker and 6 9/16" protective monument (3.00' ags)

Well Completion material:

High Strength Concrete
0.0' bgs - 2.8' bgs

Type I/II Portland Cement
2.8' bgs - 10.42' bgs

Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks)
10.42' bgs - 285.43' bgs

3/8" Bentonite Pellets
285.43' bgs - 287.27' bgs

10-20 Colorado Silica Sand
287.27' bgs - 332.3' bgs

3/8" Bentonite Pellets
332.3' bgs - 334.1' bgs

3/4" Bentonite Chunks
334.1' bgs - 372.04' bgs

Natural Fill
372.04' bgs - 374.78' bgs

Permanent Well:

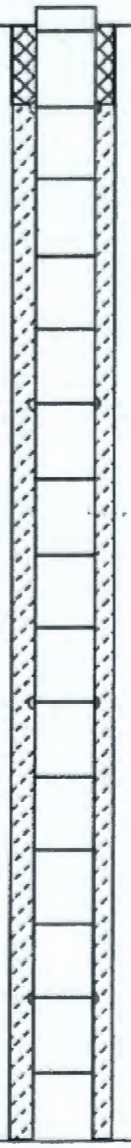
4" ID PVC Blank
1.98' ags - 291.00' bgs

4" ID Stainless Steel 0.020 Slot Screen
291.00' bgs - 326.00' bgs

4" ID Stainless Steel Sump
326.00' bgs - 329.02' bgs

All temporary casing completely removed from ground on 1/15/2015

ags = above ground surface
bgs = below ground surface



GEOLOGIC/HYDROLOGIC DATA

Lithologic Description:

0-0.5: Gravelly Sand (gS) Drill Pad.
0.5-9: Sand (S)
9-18: Gravelly Sand (gS)
18-30: Sand (S)
30-36: Gravelly Sand (gS)
36-58: Sandy Gravel (sG)
58-70: Sand (S)
70-75: Gravelly Sand (gS)
75-80: Sandy Gravel (sG)
80-90: Gravelly Sand (gS)
90-100: Sandy Gravel (sG)
100-105: Gravelly Sand (gS)
105-120: Sandy Gravel (sG)
120-123: Slightly Silty Gravelly Sand((m)gS)
123-167: Sand (S)

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Figure C-9. Well 299-E25-237 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 2 of 3
		Finish Date: 1-19-2015	
Well ID: C8922		Well Name: 299-E25-237	
Location: S. of WMA A-AX		Project: M24 Drilling	
Prepared by: Julie Johanson	Date: 12-17-14	Reviewed by: J.D. MEHRER	Date: 1/21/15
Signature: Julie Johanson		Signature:	

CONSTRUCTION DATA

Well Completion material:

High Strength Concrete
0.0' bgs - 2.8' bgs

Type I/II Portland Cement
2.8' bgs - 10.42' bgs

Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks)
10.42' bgs - 285.43' bgs

3/8" Bentonite Pellets
285.43' bgs - 287.27' bgs

10-20 Colorado Silica Sand
287.27' bgs - 332.3' bgs

3/8" Bentonite Pellets
332.3' bgs - 334.1' bgs

3/4" Bentonite Chunks
334.1' bgs - 372.04' bgs

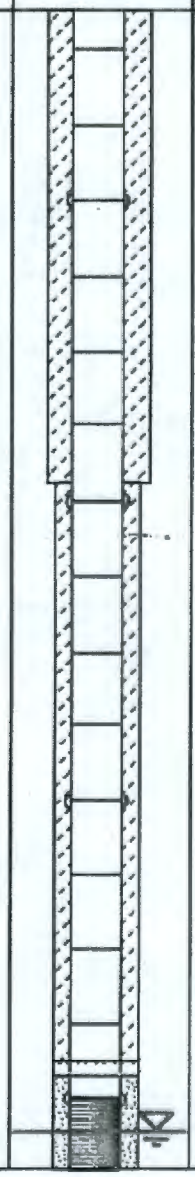
Natural Fill
372.04' bgs - 374.78' bgs

Permanent Well:

4" ID PVC Blank
1.98' ags - 291.00' bgs

4" ID Stainless Steel 0.020 Slot Screen
291.00' bgs - 326.00' bgs

4" ID Stainless Steel Sump
326.00' bgs - 329.02' bgs



GEOLOGIC/HYDROLOGIC DATA

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

Lithologic Description:

123-167: Sand (S)
167-170: Gravelly Sand (gS)
170-220: Sand (S)
220-230: Slightly Silty Sand ((m)S)
230-235: Sand (S)
235-243: Slightly Silty Sand ((m)S)
243-248: Slightly Silty Gravelly Sand((m)gS)
248-278: Sand (S)
278-280.7: Sandy Silt (sM)
280.7-290: Gravelly Silty Sand (gmS)
290-305: Silty Sandy Gravel (msG)
DTW: 295.36' bgs

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Figure C-9. Well 299-E25-237 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 3 of 3
		Finish Date: 1-19-2015	
Well ID: C8922		Well Name: 299-E25-237	
Location: S. of WMA A-AX		Project: M24 Drilling	
Prepared by: Julie Johanson	Date: 12-17-14	Reviewed by: J.D. MEHRER	Date: 1-21-15
Signature: Julie Johanson		Signature:	

CONSTRUCTION DATA

Well Completion:

High Strength Concrete
0.0' bgs - 2.8' bgs

Type I/II Portland Cement
2.8' bgs - 10.42' bgs

Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks)
10.42' bgs - 285.43' bgs

3/8" Bentonite Pellets
285.43' bgs - 287.27' bgs

10-20 Colorado Silica Sand
287.27' bgs - 332.3' bgs

3/8" Bentonite Pellets
332.3' bgs - 334.1' bgs

3/4" Bentonite Chunks
334.1' bgs - 372.04' bgs

Natural Fill
372.04' bgs - 374.78' bgs

Permanent Well:

4" ID PVC Blank
1.98' ags - 291.00' bgs

4" ID Stainless Steel 0.020 Slot Screen
291.00' bgs - 326.00' bgs

4" ID Stainless Steel Sump
326.00' bgs - 329.02' bgs

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
300		290-305: Silty Sandy Gravel (msG)
		305-306: Sand (S) 306-345.78: Silty Sandy Gravel (msG)
325		
350		345.78-366.19: Silty Sandy Gravel (msG) (Hard tool Slurry)
		366.19-374.5: Silty Sandy Gravel (msG)
375		374.5-375: Basalt
		TD: 374.78' bgs

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Figure C-9. Well 299-E25-237 Construction and Completion Summary (continued)

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C2 Reference

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

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