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Revision 0

Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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Richland, Washington 99352

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Executive Summary

Waste Management Area (WMA) S-SX, which incorporates the S and SX Tank Farms, is regulated under Washington State's "Hazardous Waste Management Act" (RCW 70.105) and its implementing requirements in WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards." The Washington State Department of Ecology (Ecology) has been authorized by the U.S. Environmental Protection Agency, in accordance with *Authorized State Hazardous Waste Programs*, to conduct its hazardous waste regulatory program in lieu of the *Resource Conservation and Recovery Act of 1976* (RCRA), including the requirements in 40 CFR 265, Subpart F ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring"). The WMA S-SX is also subject to the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989), with Ecology identified as the lead regulatory agency for the unit.

The WMA S-SX was placed in assessment monitoring in 1996 because of elevated specific conductance, and a groundwater quality assessment plan was implemented (WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX*). An assessment report of the initial findings was issued in January 1998 (PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*), which concluded that multiple source locations exist in the WMA to explain the observed spatial and temporal groundwater contamination patterns.

The assessment plan was updated in 1999 (PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*) for continued RCRA groundwater quality assessment, as required by 40 CFR 265.93 ("Preparation, Evaluation, and Response"). Four subsequent interim change notices were issued to PNNL-12114 to address changes to the monitoring well network.

This document supersedes PNNL-12114, includes information from previous routine quarterly groundwater monitoring at WMA S-SX, and updates the groundwater monitoring project management organization.

The plan describes the WMA S-SX facility and operating history, waste characteristics, hydrogeology, previous monitoring at the WMA, groundwater and vadose zone

contamination associated with the WMA, and the conceptual model for the WMA. The plan addresses the following:

- Adequacy of the wells monitoring groundwater at WMA S-SX
- Sampling requirements and schedule
- Analytes, groundwater parameters, and analytical methods necessary to determine extent of contamination from WMA S-SX
- Procedures for evaluating groundwater quality data
- Reporting requirements

This assessment plan is the principal controlling document for conducting groundwater monitoring at WMA S-SX.

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Terms

CAS	Chemical Abstracts Service
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CY	calendar year
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ID	identification
N/A	not applicable
NAVD88	North American Vertical Datum of 1988
OU	operable unit
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
WMA	waste management area

1 Introduction

Since 1944, the Hanford Site's single-shell tanks (SSTs) have stored both radioactive and dangerous chemical waste generated from plutonium-production and separation activities. The 149 SSTs are recognized as dangerous waste management units and are regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA), RCW 70.105 ("Hazardous Waste Management"), and its implementing requirements (WAC 173-303, "Dangerous Waste Regulations"). Only dangerous chemical waste is regulated by RCRA; radioactive waste is regulated by the *Atomic Energy Act of 1954*.

Two SST farms in the 200 West Area, the S Tank Farm and the SX Tank Farm, comprise Waste Management Area (WMA) S-SX (Figure 1-1). A RCRA interim status detection groundwater monitoring program for the SSTs was implemented in 1989 (WHC-SD-EN-AP-012, *Interim Status Groundwater Monitoring Plan for the Single-Shell Tanks*), and monitoring began at WMA S-SX in 1990. The WMA was placed in assessment status monitoring in 1996 due to elevated specific conductance in downgradient monitoring wells (WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX*).

This document presents a revised groundwater assessment plan for WMA S-SX that supersedes the previous groundwater assessment plan (PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*) and four subsequent interim change notices. Background information is summarized in this document, and references are provided to other documents for additional detail.

The specific objective of this revised groundwater assessment plan is to fulfill the requirements specified in WAC 173-303-400(3) ("Interim Status Facility Standards"), incorporating by reference 40 CFR 265.93 ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response"). These requirements specify that the concentration, rate, and extent of migration of dangerous waste constituents in the groundwater must be determined. To meet this objective, this plan defines a network of groundwater monitoring wells; specifies the sampling frequency; and lists the dangerous constituents, indicators, and supporting constituents to be monitored in groundwater. This monitoring plan has been prepared to be consistent, to the extent possible, with the final status monitoring plan that will be incorporated into the *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste* (WA7890008967, as amended) in the future.

Chapter 2 of this plan summarizes background information, including a description of the WMA and the types of waste present, 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 site conceptual model to assist in development of the groundwater monitoring program. Chapter 3 describes the RCRA groundwater monitoring program, including the wells monitored, sampling frequency and protocols, and the constituents analyzed. Chapter 4 describes data evaluation, interpretation, and reporting. A list of the references cited is provided in Chapter 5. Appendix A provides the quality assurance project plan (QAPjP), and Appendix B provides construction information for wells 299-W22-26 and 299-W22-89.

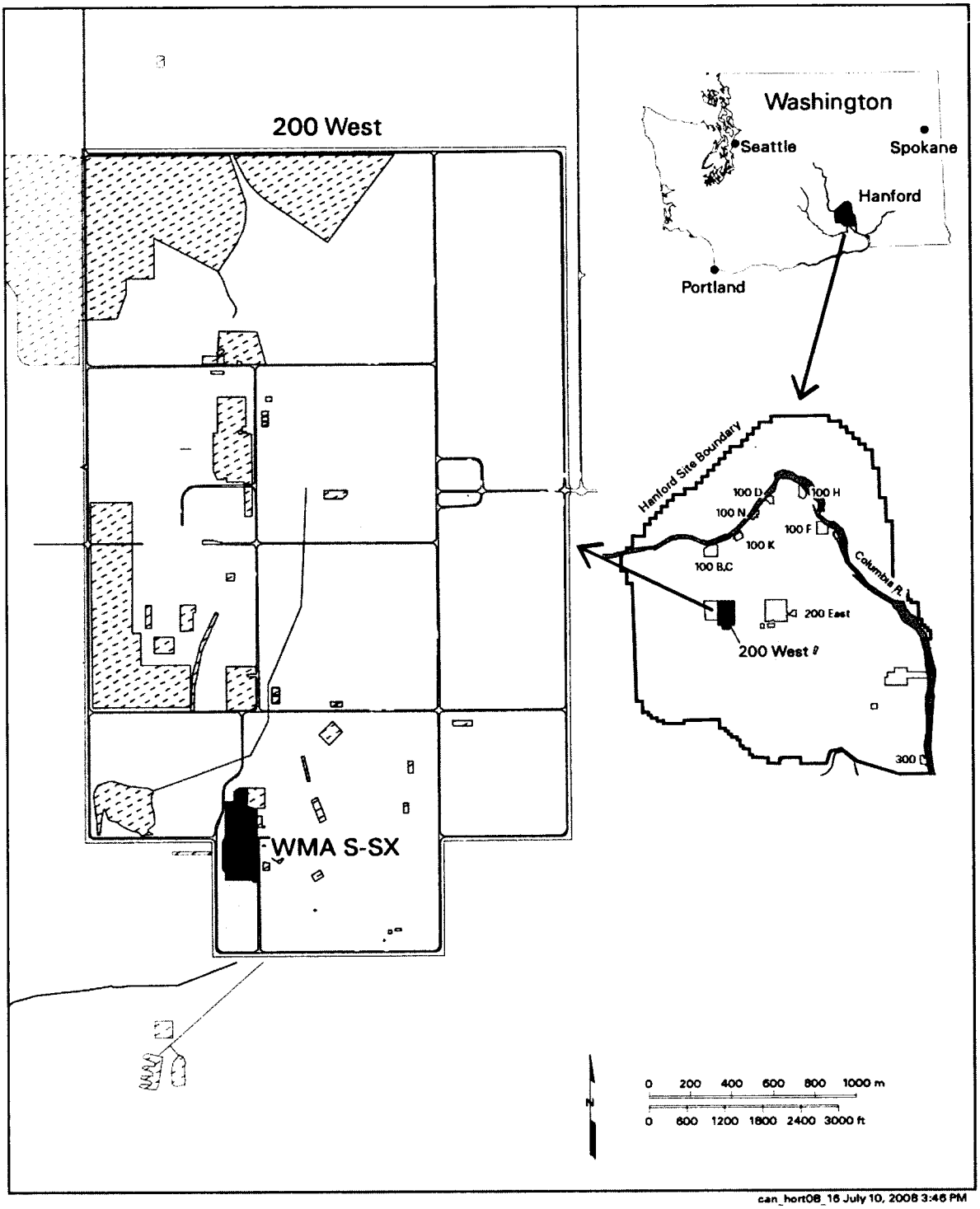

Figure 1-1. Location of WMA S-SX

2 Background

This chapter describes WMA S-SX, the regulatory requirements for groundwater monitoring, and waste characteristics. It also summarizes the hydrogeology beneath the WMA, outlines a conceptual model for contaminant migration, describes groundwater contamination in the uppermost aquifer, and addresses the data quality objectives (DQOs).

2.1 Facility Description and Operational History

The WMA S-SX consists of two tank farms: S Tank Farm and SX Tank Farm (Figure 2-1). The S Tank Farm consists of 12 tanks of 2.9 million L (758,000 gal) capacity each (total of 34.4 million L [9.1 million gal]), and the SX Tank Farm consists of 15 tanks with a capacity of 3.8 million L (1 million gal) each (total of 56.8 million L [15 million gal]) (RPP-7884, *Field Investigation Report for Waste Management Area S-SX*). The WMA also includes ancillary equipment consisting of three catch tanks, one receiver tank, six diversion boxes, associated piping, valve pits, and pumps (RPP-7884; DOE/RL-91-60, *S Plant Aggregate Area Management Study Report*). Both tank farms received waste generated from the reduction-oxidation process in the 1950s and 1960s.

One tank in the S Tank Farm (S-104) and 10 tanks in the SX Tank Farm (SX-104, and SX-107 through SX-115) are known or assumed to have experienced a leak/release (HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2009*, Rev. 261). To minimize future leaks/releases, all of the SSTs at the Hanford Site have been interim stabilized and the drainable liquid in each tank has been removed and transferred to double-shell tanks[1] (DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*). While this reduces the possibility of a future leak/release, releases may still be possible because some residual liquid generally remains in an interim-stabilized tank. Additional details on the operational history of the S and SX Tank Farms are provided in DOE/ORP-2008-01, as well as *Subsurface Conditions Description for the S-SX Waste Management Area* (HNF-4936) and *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area S-SX at the Hanford Site* (PNNL-11810).

2.2 Regulatory Basis

In May 1987, the U.S. Department of Energy (DOE) issued a final rule (10 CFR 962, "Byproduct Material") stating that the hazardous waste components of mixed waste are subject to RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized 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.

Groundwater monitoring is conducted at WMA S-SX in accordance with WAC 173-303-400(3) and, by reference, 40 CFR 265, Subpart F ("Ground-Water Monitoring"), which requires monitoring to determine whether dangerous waste or dangerous waste constituents from the waste site have entered the groundwater. The WMA S-SX was placed in assessment monitoring (40 CFR 265.93[d][4]) after elevated concentrations of waste constituents and indicator parameter measurements (e.g., chromium and specific conductance) in downgradient monitoring wells were observed and confirmed.

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[1] A more precise definition of an interim stabilized tank is one that contains less than 189,000 L (50,000 gal) of drainable interstitial liquid and less than 18,900 L (5,000 gal) of supernatant (HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2009*, Rev. 261).

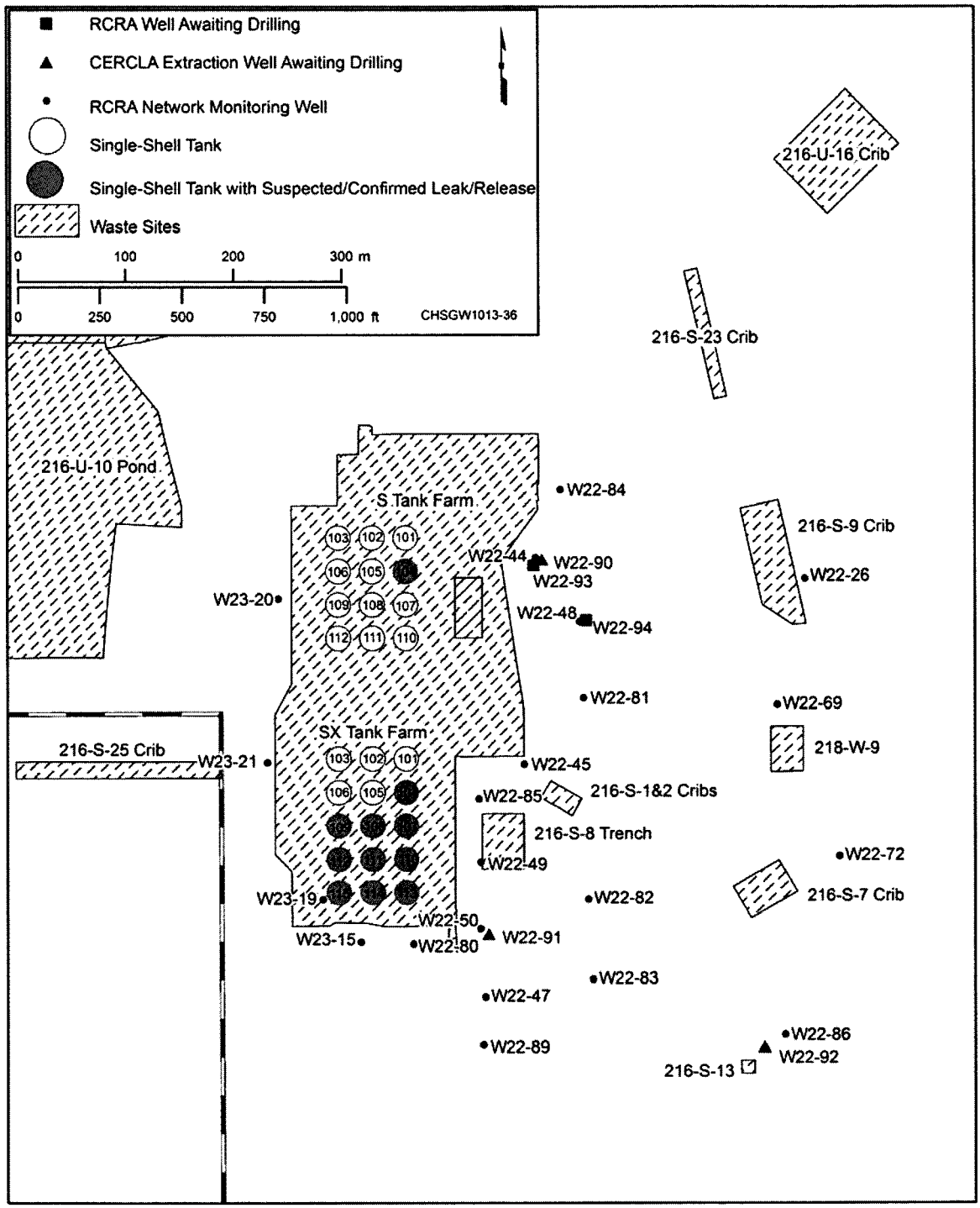

Figure 2-1. WMA S-SX and Vicinity

An assessment report of the initial findings was issued in January 1998 (PNNL-11810), which concluded that multiple source locations in the WMA exist to explain the observed spatial and temporal groundwater contamination patterns and that continued investigation was warranted, as required by 40 CFR 265.93(d)(7)(i). The investigation has continued under several updates to the monitoring plan, most recently in PNNL-12114-ICN-4.

2.3 Waste Characteristics

Table 2-1 lists the dangerous constituents found in the Dangerous Waste Permit Application Part A form (WA7890008967). Mobile tank waste constituents identified in the groundwater include nitrate and chromium (DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*).

Table 2-1. Dangerous Wastes in the Single-Shell Tank System (Dangerous Waste Permit Application Part A Form)

Dangerous Waste Code	Contaminant Description	Dangerous Waste Code	Contaminant Description
D001	Ignitable waste	D030	2,4-Dinitrotoluene
D002	Corrosive waste	D033	Hexachlorobutadiene
D003	Reactive waste	D034	Hexachloroethane
D004	Arsenic	D035	Methyl ethyl ketone
D005	Barium	D036	Nitrobenzene
D006	Cadmium	D040	Trichloroethylene
D007	Chromium	D041	2,4,5-Trichlorophenol
D008	Lead	D043	Vinyl chloride
D009	Mercury	F001	1,1,1-Trichloroethane
D010	Selenium	F002	Methylene chloride
D011	Silver	F003	Acetone, methyl isobutyl ketone
D018	Benzene	F004	Cresol-m, -o, -p
D019	Carbon tetrachloride	F005	Methyl ethyl ketone
D022	Chloroform	WP01	Extremely hazardous waste/ persistent dangerous waste
D028	1,2-Dichloroethane	WP02	Dangerous waste/persistent dangerous waste
D038	Pyridine	WT01	Extremely hazardous waste/ toxic dangerous waste
D029	1,1-Dichloroethylene	WT02	Dangerous waste/toxic dangerous waste
D039	Tetrachloroethylene		

Notes:

1. This table is based on the Dangerous Waste Permit Application Part A form (WA789000896).
2. Analytes associated with the "F001" through "F005" waste codes are from WHC-MR-0517, *Listed Waste History at Hanford Facility TSD Units*.

2.4 Geology and Hydrology

The generalized stratigraphy of the Hanford Site is shown in Figure 2-2. The local stratigraphy beneath WMA S-SX consists of unconsolidated to semiconsolidated sediments overlying basalt bedrock of the Columbia River Basalt Group. The sedimentary units present, in descending sequence, include the following:

- Sand and gravel backfill
- Sand and gravel of the Hanford formation
- Fine-grained Cold Creek unit
- Sand and gravel of the Ringold Formation Unit E
- Fine-grained Ringold Formation lower mud unit
- Sand and gravel of Ringold Formation Unit A (which overlies the basalt)

Note that the Ringold Formation upper fines (member of Savage Island and member of Taylor Flat) are not present beneath the WMA. The water table occurs within the Ringold Formation Unit E, and the vadose zone beneath the WMA is approximately 68 m (223 ft) thick. The base of the aquifer is the fine-grained Ringold Formation lower mud unit. The water table elevation is approximately 135 m (443 ft) (North American Vertical Datum of 1988 [NAVD88]). The unconfined aquifer is approximately 70 m (230 ft) thick. A more detailed description of the geology of the WMA is provided in HNF-4936 and PNNL-12114. The *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington* (PNNL-13858) describes the hydrogeology of the entire 200 West Area and vicinity.

Figure 2-3 shows the March 2009 water table map for the WMA and vicinity. The groundwater flow direction is toward the east beneath the WMA at an average hydraulic gradient of 1.8×10^{-3}. The average flow direction beneath the S Tank Farm in the north is almost due east at approximately 85 degrees azimuth, while the average flow direction beneath the SX Tank Farm has a slightly more southerly component at approximately 100 degrees azimuth. Analysis of water-level data indicates that the groundwater flow rate beneath the WMA is between 4 and 104 m/yr (13 and 340 ft/yr) (depending on the hydraulic conductivity and effective porosity), with a best value of 33 m/yr (108 ft/yr) (average hydraulic conductivity of 6.1 m/d [20 ft/d] and effective porosity of 0.12 from constant-rate pumping tests). No significant difference exists in the hydraulic gradient magnitude between the S and SX Tank Farms. Since January 2004, water levels in the monitoring wells have been declining at rates from 0.21 to 0.27 m/yr (0.69 to 0.89 ft/yr), with an average decline of 0.25 m/yr (0.82 ft/yr). Analysis of periodic water-level measurements indicates that the hydraulic gradient magnitude and flow direction have been relatively stable since the late 1990s.

2.5 Summary of Previous Groundwater Monitoring

In 1996, the groundwater monitoring program for WMA S-SX was changed from indicator parameter evaluation to groundwater assessment because specific conductance in three downgradient monitoring wells exceeded the critical mean value. Results from the ensuing investigation concluded that waste from the WMA had entered and compromised groundwater quality (PNNL-11810; PNNL-13441, *RCRA Groundwater Quality Assessment Report for Waste Management Area S-SX [November 1997 through April 2000]*; and PNNL-13801, *Groundwater Quality Assessment Report for Waste Management Area S-SX [April 2000 through December 2001]*). Subsequent annual assessment results have been included in the Hanford Site annual groundwater reports (e.g., DOE/RL-2010-11).

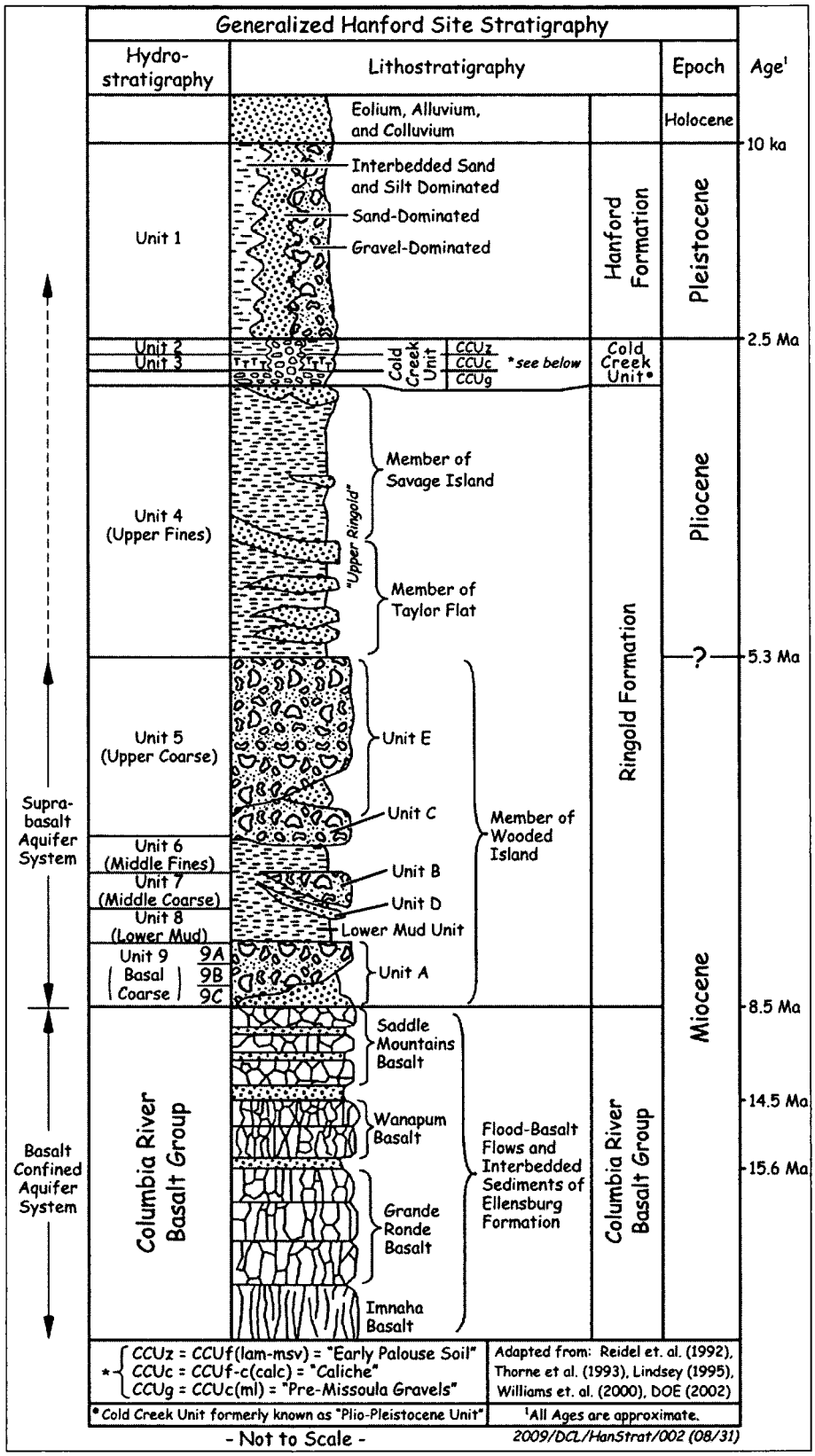

Figure 2-2. Generalized Stratigraphy of the Hanford Site

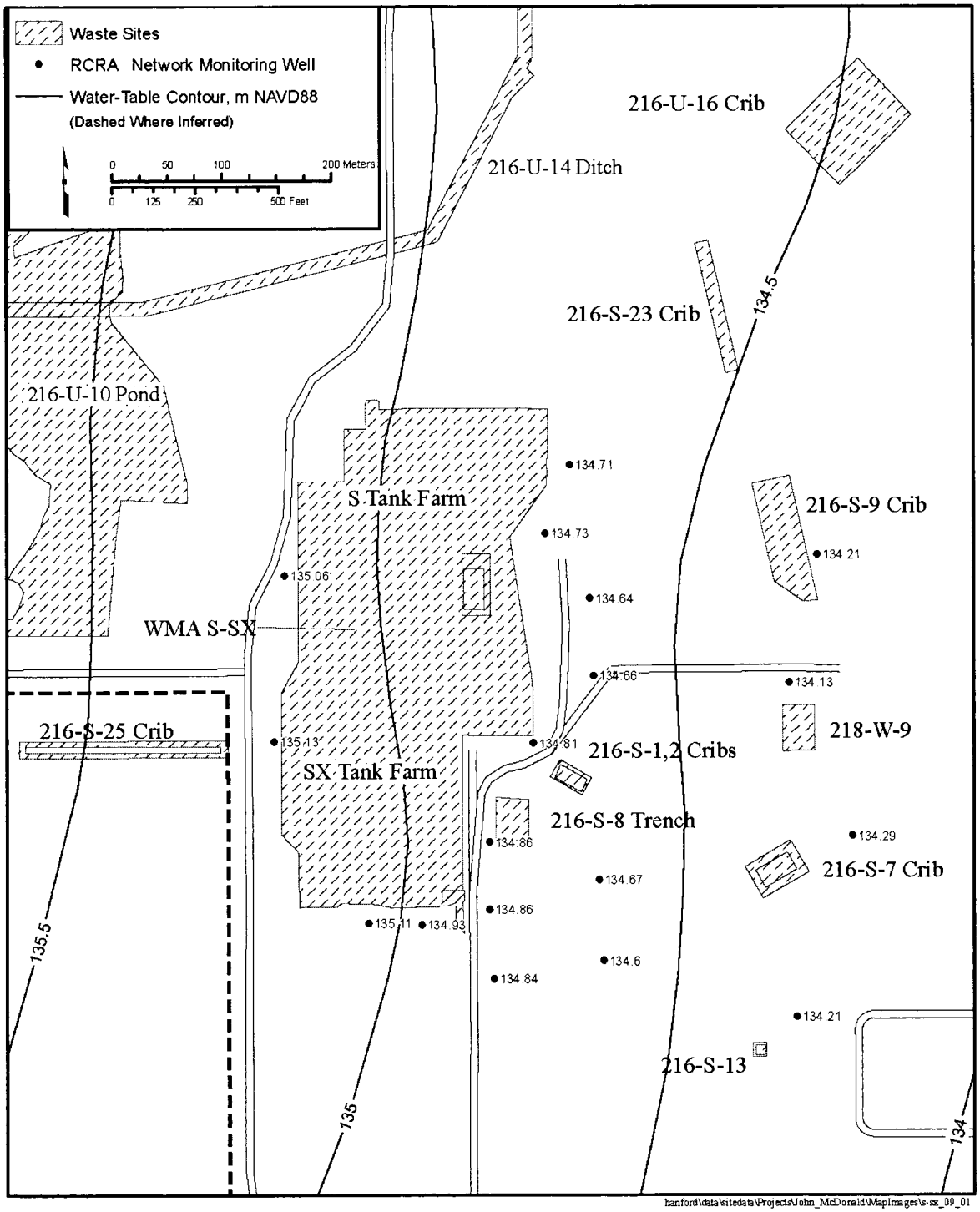

Figure 2-3. Water Table Map for WMA S-SX, March 2009

2.5.1 Groundwater Contamination

The following discussion is summarized from DOE/RL-2010-11 and represents the conditions present in calendar year (CY) 2009.

Groundwater beneath WMA S-SX is contaminated with nitrate and chromium, which are attributed to two general source areas within the WMA: (1) a source area in the S Tank Farm, and (2) a source area south in the SX Tank Farm. Nitrate contamination also has additional sources in the vicinity, most notably the 216-S-25 Crib. Chromium is the only constituent in groundwater listed in Ecology Publication 97-407, Appendix 5 (*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") occurring in groundwater that likely originated from WMA S-SX. In the northern portion of the WMA, downgradient from the S Tank Farm, concentrations of the mobile tank waste constituents nitrate and chromium have increased substantially in well 299-W22-44 since late 2006 (Figure 2-4; see Figure 2-1 for well locations). At the end of CY 2009, the dissolved chromium concentration was 579 µg/L and nitrate was 276 mg/L. Concentrations of these constituents in the upgradient well for the S Tank Farm (299-W23-20) were either below the detection limit or well below drinking water standards, indicating that the tank farm is the source.

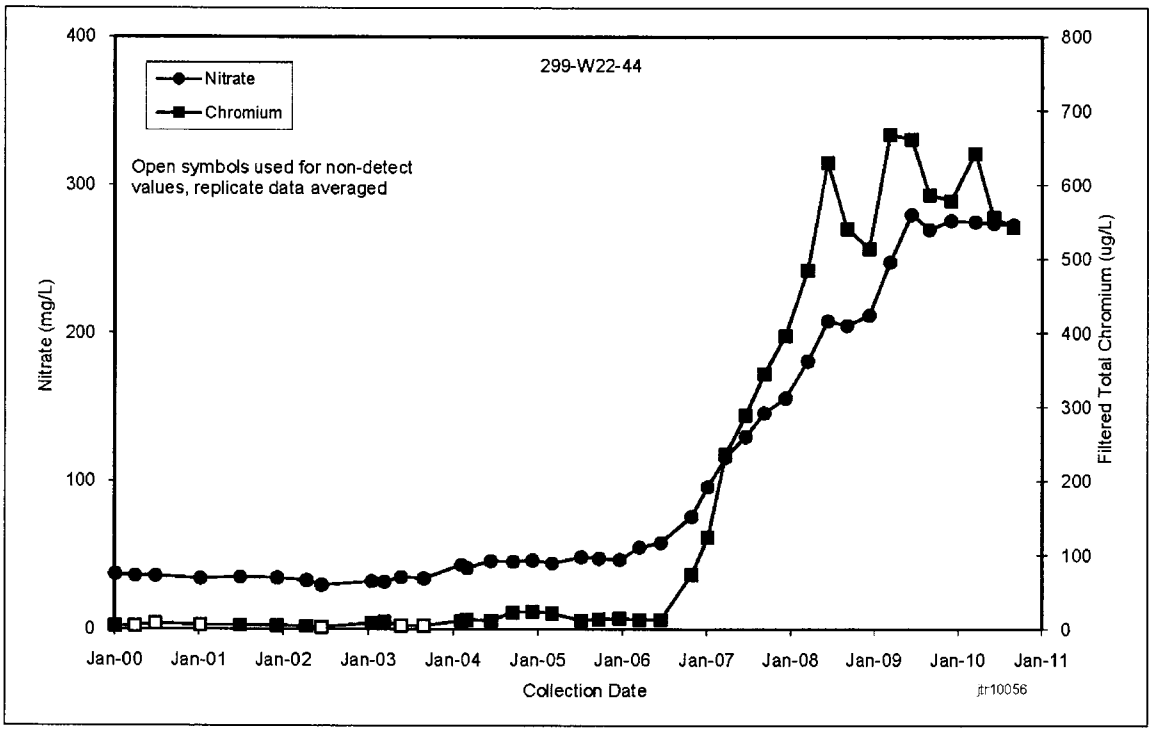

Figure 2-4. Concentrations of the Nitrate and Dissolved Chromium in Well 299-W22-44, Downgradient from S Tank Farm

Groundwater beneath the SX Tank Farm in the southern portion of the WMA is also contaminated with nitrate and chromium. The contaminated groundwater extends from the source area near well 299-W23-19 toward the east-southeast approximately 500 m (1,640 ft). Low-concentration areas occur in these plumes around wells 299-W22-80 and 299-W23-15. Concentrations of the major anions and cations in these wells are consistent with groundwater background and are not indicative of a raw water source diluting the aquifer. An in-well tracer test and time-series sampling during extensive purging at well 299-W22-80 indicated that relatively clean water may be migrating into the bottom of the well, moving up the wellbore, and diluting contaminant concentrations in the upper portion of the plume

(PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*). A similar process is assumed to be occurring at well 299-W23-15. During CY 2009, average concentrations in well 299-W23-19 were 480 mg/L for nitrate and 950 µg/L for dissolved chromium (DOE/RL-2010-11). Some of the nitrate originated from the 216-S-25 Crib. Both nitrate and chromium are migrating eastward, and the concentrations decline with distance from the source.

Other constituents are also found in groundwater beneath the WMA, and some of the constituents are attributed to the WMA while others are not. For current groundwater contamination plume maps at WMA S-SX, refer to the most recent Hanford Site annual groundwater monitoring report (e.g., DOE/RL-2010-11 for CY 2009 plume maps).

2.5.2 Vadose Zone Contamination

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

- All SSTs at the Hanford Site have been interim stabilized.
- Interim measures have been implemented to reduce the forces driving contamination downward to the groundwater, such as the following:
  - Constructing berms around the tank farms to divert surface water runoff away from the facility
  - Testing all nearby water lines and removing the leaking water lines from service
  - Capping all vadose zone monitoring boreholes in the tank farms.

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

DOE/ORP-2008-01 presents the results of recent tank farm vadose zone studies, including the following:

- Characterization wells installed by drilling or direct-push technology (used for geophysical monitoring, sediment sampling, and, in some cases, installation of down-hole instrumentation)
- Surface geophysical surveys
- Borehole geophysical logging of dry wells adjacent to tanks and lateral access tubes beneath tanks

The results of these studies indicate significant vadose zone contamination in the vicinity of tanks SX-108 and SX-115, which includes the dangerous constituent chromium and the supplemental constituent nitrate (RPP-7884). These contaminants were not found at high concentrations below the Cold Creek unit where boreholes were drilled near tanks SX-108 and SX-115; however, the presence of the mobile tank waste constituents in groundwater adjacent and downgradient to tank SX-115 indicates that breakthrough of these constituents to the groundwater did occur beneath this tank. It is suspected that long-term leaking of utility water lines near the southwestern corner of the WMA provided the driving force for the contaminants to reach groundwater (PNNL-11810; DOE/ORP-2008-01).

A surface geophysical investigation at the S Tank Farm showed a low-resistivity plume (i.e., elevated ions) beneath tank S-104, which is the only tank in the S Tank Farm assumed or known to have experienced a leak/release (RPP-RPT-30976, *Surface Geophysical Exploration of S Tank Farm at the Hanford Site*). This plume is the likely source for the groundwater contamination downgradient of the S Tank Farm.

2.6 Conceptual Model

DOE/ORP-2008-01 summarizes a conceptual model of tank leak/release pathways to the groundwater, and Appendix A of the document presents the conceptual model in detail. The following summary is from that document.

2.6.1 Contaminant Sources

Tank leak/release events began with rapid discharge of some waste fluid volume into the subsurface from a point of entry likely having a small spatial extent (on the order of inches to rarely feet). This discharge temporarily increased the moisture content of the unsaturated soil, particularly at the point of entry. Points of entry included poorly sealed openings in the tank structure, ruptured areas of steel tank liners combined with nearby underlying concrete shell fractures, and breaks in waste transfer lines. Natural processes then redistributed the excess moisture within the vadose zone, eventually returning the soil to ambient conditions.

The migration process occurred, for the most part in partially saturated soils, because leak/release volumes were not sufficient to fill the soil pore spaces for an appreciable length of time or very far from the point of entry. This condition is referred to as "unsaturated flow." In addition to vertical flow, lateral flow occurred because soil layers with different hydraulic properties tend to be layered more or less horizontally by sediment deposition processes. Consequently, flow in the lateral direction could occur and be enhanced by the unsaturated conditions.

2.6.2 Driving Forces

External sources of water or other liquid may have acted to drive contamination downward. Infiltration of fresh water (as well as precipitation and unintentional, manmade releases such as leaking water lines) may move residual waste remaining in the soil downward to the groundwater. The catastrophic break of a 14 in. raw waterline that caused flooding of the S and SY Tank Farms in 1996 is an extreme example in which over 2.2 million L (570,000 gal) of water were released in 2 hours. The portion of this water that reached the S Tank Farm had infiltrated into the ground within a day (DOE/ORP-2008-01).

As waste fluids are migrating within the vadose zone, numerous contaminants are reacting chemically with the vadose zone soil/water system to varying degrees. Water extracts of contaminants from sediments collected from two boreholes near tank SX-108 (PNNL-13757-3, *Characterization of Vadose Zone Sediment: Borehole 41-09-39 in the S-SX Waste Management Area*; PNNL-13757-4, *Characterization of Vadose Zone Sediment: Slant Borehole SX-108 in the S-SX Waste Management Area*) confirmed the variable mobility of the contaminants.

2.6.3 Migration

After mobile contaminants reach groundwater beneath WMA S-SX, the contaminants travel in the downgradient direction toward the east. Travel times estimated for contaminants in the southern plume yield a groundwater velocity of approximately 30 m/yr (100 ft/yr) (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*). This is in agreement with the estimated flow velocity of 33 m/yr (108.3 ft/yr) based on water-level measurements and hydrologic testing results (Section 2.4). Similar flow velocities are expected for both the north and south plumes from WMA S-SX.

2.7 Data Quality Objectives

The DQO process ensures that data gathered during an investigation are of the appropriate quantity and quality to meet specific objectives. The DQOs for the first determination groundwater quality assessment are presented in WHC-SD-EN-AP-191. The results of the first determination investigation indicated that

multiple sources within WMA S-SX contributed to groundwater contamination and that a continued groundwater quality assessment investigation was warranted (PNNL-11810). The DQOs for the continued groundwater quality assessment are presented in PNNL-12114.

The current groundwater monitoring network for WMA S-SX is a result of these previous investigations and DQOs. Assessment monitoring is ongoing at the WMA in accordance with interim status regulations. The DQO parameters, regulatory interim status requirements, and associated reports supporting the regulatory requirements are outlined in Table 2-2.

Table 2-2. DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA S-SX

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Scope	**40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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… **40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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. **40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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 wells; (ii) Sampling and analytical methods for those hazardous wastes or hazardous waste constituents in the facility; (iii) Evaluation procedures, including any use of previously gathered ground-water quality information; and (iv) A schedule of implementation.	WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX* PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, as modified by interim change notice This plan, Sections 3.1 and 3.2, Chapter 4, and Appendix A

Table 2-2. DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA S-SX

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Number and location of wells Point(s) of compliance	**40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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.	WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX* PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, as modified by interim change notice This plan, Chapters 1 and 3, and Appendix A
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. WAC 173-160 may be used as guidance in the installation of wells.	WHC-SD-EN-AP-191, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area S-SX* PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, as modified by interim change notice This plan, Section 3.2 and Appendix B

Table 2-2. DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA S-SX

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Frequency of sampling Types of analysis or measurement Method detection limits or accuracy and precision Methods used to evaluate the collected data	**40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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 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; or (ii) May cease to make the determinations required under paragraph (d)(4) of this section, if the ground-water quality assessment plan was implemented during the post-closure care period. **40 CFR 265.93, "Preparation, Evaluation, and Response"; as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).** (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.	PNNL-12114, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*, as modified by interim change notice This plan, Section 3.1, Chapter 4, and Appendix A

Notes: The references cited in this table are listed in the reference section (Chapter 5) of this plan.

3 Groundwater Monitoring Program

This chapter lists the wells monitored, constituents analyzed, and sampling frequency for WMA S-SX. The quality assurance and quality control requirements are provided in the QAPjP (Appendix A).

3.1 Constituent List and Sampling Frequency

The constituent list for groundwater sampling includes the analytes on the RCRA groundwater monitoring list that may be present in SST waste. To identify these analytes, the list of primary nonradiological constituents potentially present in SST waste (RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*) was compared to those constituents listed in Appendix 5 of Ecology Publication 97-407, which references 40 CFR 264, Appendix IX. Those constituents in RPP-23403 that are on the groundwater monitoring list (i.e., listed in Appendix 5 of Ecology Publication 97-407) are included in Table 3-1.

Table 3-1. Constituents on the RCRA Groundwater Monitoring List Potentially Present in the Single-Shell Tank Farm System

Constituent	CAS ID	Constituent	CAS ID
Volatile Organic Compounds			
1,1,1-Trichloroethane	71-55-6	Chloroform	67-66-3
1,1,2,2-Tetrachloroethane	79-34-5	Ethylbenzene	100-41-4
1,1,2-Trichloroethane	79-00-5	Isobutanol	78-83-1
1,1-Dichloroethene	75-35-4	Methylene chloride	75-09-2
1,2-Dichloroethane	107-06-2	Tetrachloroethene	127-18-4
2-Butanone (methyl ethyl ketone)	78-93-3	Toluene	108-88-3
2-Propanone (acetone)	67-64-1	Trans-1,3-dichloropropene	10061-02-6
4-Methyl-2-pentanone (MIBK)	108-10-1	Trichloroethene	79-01-6
Benzene	71-43-2	Trichlorofluoromethane	75-69-4
Carbon disulfide	75-15-0	Vinyl chloride (chloroethene)	75-01-4
Carbon tetrachloride	56-23-5	Xylenes	1330-20-7
Chlorobenzene	108-90-7		
Semivolatile Organic Compounds			
1,2,4-Trichlorobenzene	120-82-1	Aroclor-1260	11096-82-5
2,4,5-Trichlorophenol	95-95-4	Butylbenzylphthalate	85-68-7
2,4,6-Trichlorophenol	88-06-2	Di-n-butylphthalate	84-74-2
2,4-Dinitrotoluene	121-14-2	Di-n-octylphthalate	117-84-0
2-Chlorophenol	95-57-8	Fluoranthene	206-44-0

Table 3-1. Constituents on the RCRA Groundwater Monitoring List Potentially Present in the Single-Shell Tank Farm System

Constituent	CAS ID	Constituent	CAS ID
2-Methylphenol (o-cresol)	95-48-7	Hexachlorobutadiene	87-68-3
3-Methylphenol (m-cresol)	108-39-4	Hexachloroethane	67-72-1
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7	Naphthalene	91-20-3
4-Methylphenol (p-cresol)	106-44-5	Nitrobenzene	98-95-3
Acenaphthene	83-32-9	N-nitroso-di-n-propylamine	621-64-7
Aroclor-1016	12674-11-2	n-Nitrosomorpholine	59-89-2
Aroclor-1221	11104-28-2	1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1
Aroclor-1232	11141-16-5	2-Nitrophenol (o-Nitrophenol)	88-75-5
Aroclor-1242	53469-21-9	Pyrene	129-00-0
Aroclor-1248	12672-29-6	Pyridine	110-86-1
Aroclor-1254	11097-69-1		
Inorganic Constituents (Nonradiological)			
Antimony (Sb)	7440-36-0	Lead (Pb)	7439-92-1
Arsenic (As)	7440-38-2	Mercury (Hg)	7439-97-6
Barium (Ba)	7440-39-3	Nickel (Ni)	7440-02-0
Beryllium (Be)	7440-41-7	Selenium (Se)	7782-49-2
Cadmium (Cd)	7440-43-9	Silver (Ag)	7440-22-4
Chromium (Cr)	7440-47-3	Sulfide (S^{2-})	18496-25-8
Cobalt (Co)	7440-48-4	Thallium (Tl)	7440-28-0
Copper (Cu)	7440-50-8	Vanadium (V)	7440-62-2
Cyanide (CN^-)	57-12-5	Zinc (Zn)	7440-66-6

Notes: This table lists the primary nonradiological constituents provided in RPP-23403, which are also on the RCRA groundwater monitoring list (i.e., also listed in Appendix 5 of Ecology Publication 97-407, which references 40 CFR 264, Appendix IX).

Of the 72 analytes listed in Table 3-1, only chromium has been found in groundwater and has been attributed to releases from the WMA, as described in Section 2.5.1. In addition, nitrate is present in the groundwater and has been attributed to the WMA. Carbon tetrachloride is also found in the groundwater but originates from waste sites associated with the Plutonium Finishing Plant. Thus, chromium and the supporting constituent nitrate (along with the other supporting constituents alkalinity, major cations [metals], and major anions) are routinely sampled for RCRA in the network monitoring wells (Table 3-2).

The supporting constituents provide information on general chemistry and allow for charge-balance computations to assess laboratory performance.

Table 3-2. Monitoring Network, Constituent List, and Sampling Frequency for WMA S-SX

Well	WAC Compliant	RCRA	Supporting Parameters				Field-Measured Parameters					Table 3-1 Analytes
		Chromium[a]	Nitrate	Alkalinity	Anions[b]	Metals[c]	pH	Specific Conductance	Temperature	Turbidity	Water Levels	
299-W22-26	N[d]	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	Once
299-W22-44	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Once
299-W22-45	C	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	Once
299-W22-47	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Once
299-W22-48	C	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	Once
299-W22-49	C	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	Once
299-W22-50	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Once
299-W22-69	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-72	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-80	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-81	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-82	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-83	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-84	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-85	C	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	Once
299-W22-86	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W22-89	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W23-15	C	A	A	A	A	A	A	A	A	A	A	N/A
299-W23-19	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	N/A	Once
299-W23-20	C	A	A	A	A	A	A	A	A	A	A	Once
299-W23-21	C	A	A	A	A	A	A	A	A	A	A	Once

Table 3-2. Monitoring Network, Constituent List, and Sampling Frequency for WMA S-SX

Well	WAC Compliant	RCRA	Supporting Parameters				Field-Measured Parameters					Table 3-1 Analytes
		Chromium[a]	Nitrate	Alkalinity	Anions[b]	Metals[c]	pH	Specific Conductance	Temperature	Turbidity	Water Levels	

Notes:

1. Wells completed at the top of the unconfined aquifer.
2. Bold/italic print indicates upgradient well.
3. Abbreviations in this table include the following:
   - A = to be sampled annually
   - C = well is constructed as a resource protection well under WAC 173-160
   - N = well is not constructed as a resource protection well under WAC 173-160
   - Q = to be sampled quarterly
   - SA = to be sampled semiannually

a. Filtered and unfiltered total chromium.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate.

c. Metals (filtered and unfiltered) include, but are not limited to, calcium, magnesium, potassium, and sodium.

d. See Appendix B for construction details. Well is usable as a "Screening well...to assist in defining the extent of contamination..." as stated in EPA and Ecology's "Policy on Remediation of Existing Wells and Acceptance Criteria for RCRA and CERCLA" (Nord and Day, 1990).

Sampling for the remaining constituents identified in Table 3-1 will be performed once during the first available sample event after this plan is in effect to determine if these constituents have impacted groundwater quality. Sampling will be performed in the upgradient and near-field downgradient monitoring wells (Table 3-2). Those constituents not detected in groundwater will be removed from future sampling. If an organic constituent from Table 3-1 is detected in a groundwater sample and it is not attributed to contamination from another facility (e.g., carbon tetrachloride from the Plutonium Finishing Plant), a confirmation sample will be collected at the next scheduled sample event, with split samples sent to different analytical laboratories. If the detection is confirmed by positive results from both laboratories, the constituent will be added to the list of analytes for routine sampling to evaluate the extent of contamination. If the detection is not confirmed, the analyte will be removed from future sampling.

Some of the inorganic constituents included in Table 3-1 occur naturally in groundwater (e.g., barium, selenium, vanadium, and zinc). Detections of an inorganic constituent will be evaluated to determine if the constituent is present naturally by comparison to sample results from the upgradient wells and comparisons to Hanford Site background values (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*). If it is determined that an inorganic constituent may be present as a contaminant from the WMA, confirmation samples will be collected (as described for the organic constituents). If contamination is confirmed, then the constituent will be added to the routine sample list to evaluate the extent of contamination. If the contamination is not confirmed, the constituent will be removed from future sampling.

Prior to this plan revision, all network monitoring wells were sampled on a quarterly frequency because RCRA regulations require that, for sites in assessment monitoring, the owner/operator "...determine (i) the rate and extent of migration of the dangerous waste or dangerous waste constituents in the groundwater; and (ii) the concentrations of the dangerous waste or dangerous waste constituents in the groundwater..." and the owner/operator "...must continue to make [these] determinations...on a quarterly basis until final closure of the facility..." (40 CFR 265.9, as referenced by WAC 173-303-400). However, if these objectives can be met without performing quarterly sampling for each well in the monitoring network, then the monitoring program would not collect unnecessary information and would be more cost effective.

To evaluate the need for quarterly sampling of each network monitoring well, constituent trends based on the quarterly sampling results were qualitatively compared to the same trends plotted with a reduced sampling frequency. For example, Figure 3-1 depicts the chromium sample results in well 299-W22-83 at both quarterly and annual sampling frequencies. The trend for each frequency is nearly identical, indicating that no loss of resolution in the trend would occur if this well was sampled annually rather than quarterly. However, the situation is different for nitrate in 299-W23-19, which is shown in Figure 3-2 at both quarterly and annual frequencies. For well 299-W23-19, the short-duration nitrate increases are not adequately resolved by annual sampling; in fact, the first nitrate increase in 2003 is missed entirely. Even at a semiannual frequency (not depicted), the peak nitrate concentrations are not very well resolved. Thus, quarterly sampling is needed to adequately document changing constituent concentrations in this well.

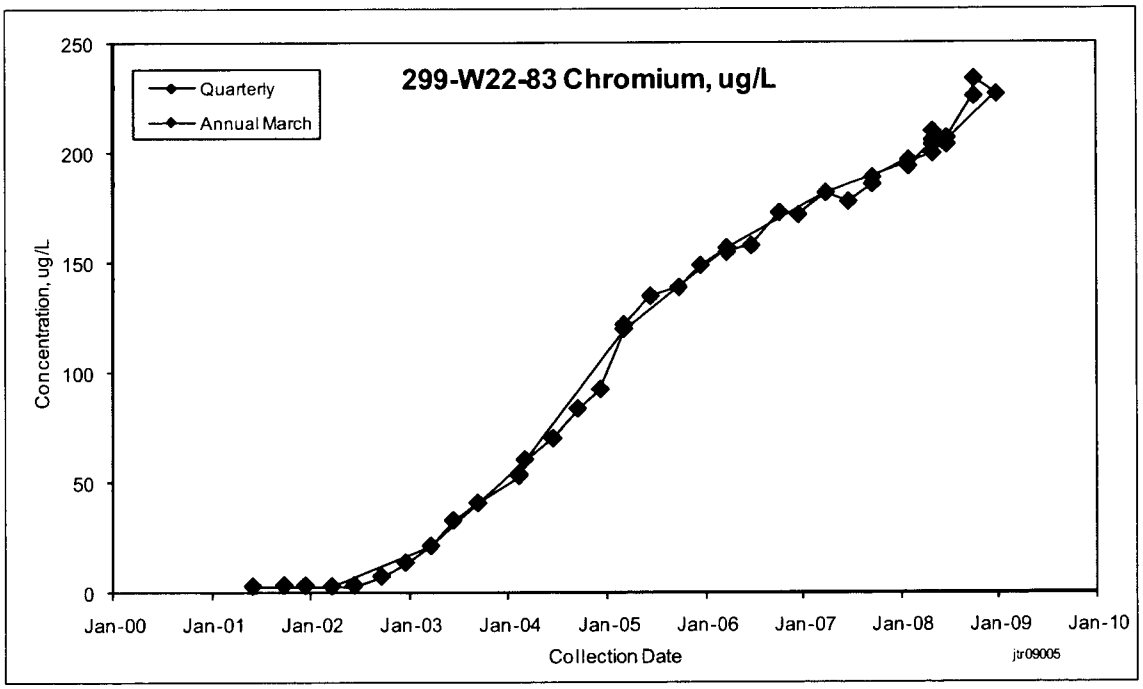

Figure 3-1. Comparison of Quarterly and Annual Sample Frequency Trends for Chromium in Well 299-W22-83

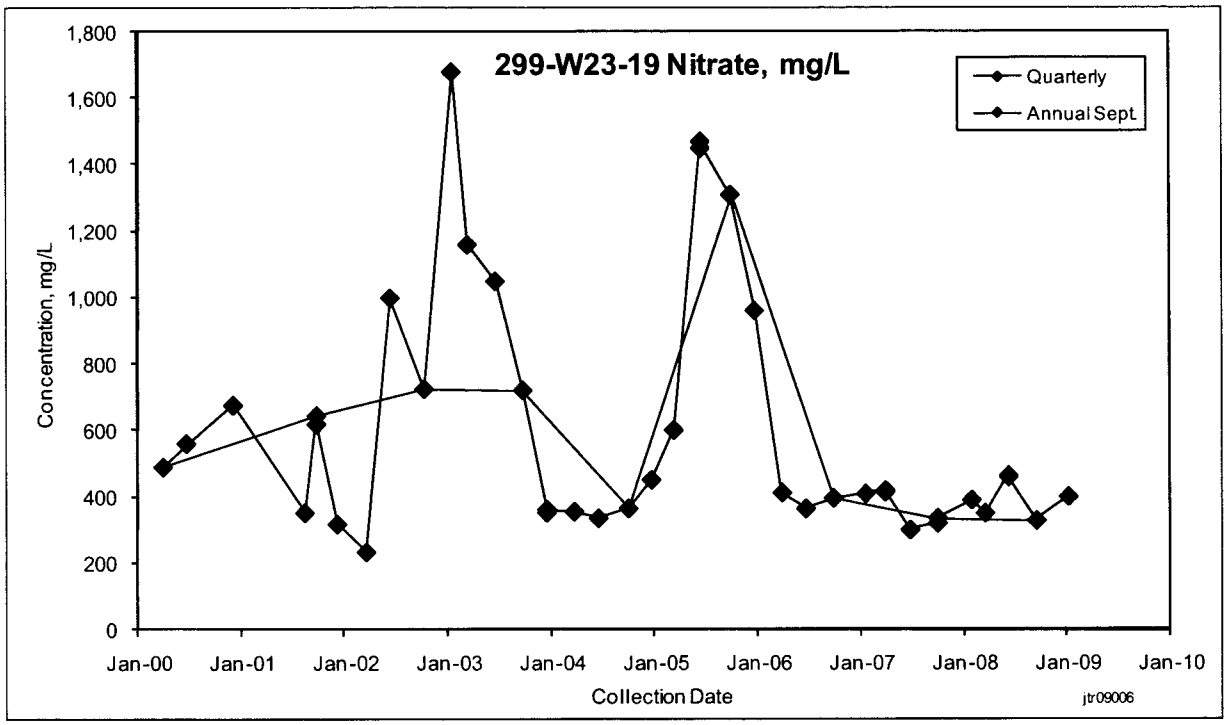

Figure 3-2. Comparison of Quarterly and Annual Sample Frequency Trends for Nitrate in Well 299-W23-19

A frequency trend analysis was performed for all wells in the monitoring network. The results indicated that constituent concentrations do not change very rapidly in the majority of the intermediate and far-field downgradient monitoring wells. Because of their distance from the source, short-term concentration variations are no longer present in the trends due to dispersion. For this reason, the sampling frequency for most of the intermediate and far-field downgradient monitoring wells was changed from quarterly to annually.

For the near-field downgradient wells, substantial concentration variations were more likely to occur in wells located within the high-concentration portions of contaminant plumes; therefore, near-field downgradient wells within high-concentration areas remained on a quarterly sampling frequency. Most near-field downgradient wells not within a high-concentration area are sampled on a semiannual basis. Such sampling is performed to spatially bound the existing plumes and to identify new plumes. This is consistent with sites in interim status detection monitoring, which are sampled semiannually. Finally, sampling of the upgradient wells is performed to establish background water quality conditions, and this objective can be accomplished with a lower frequency of sampling; therefore, the sampling frequency for the upgradient wells was also changed to annually. Table 3-3 describes the rationale for the new sampling frequencies for the entire monitoring well network.

Table 3-3. WMA S-SX Monitoring Well Network Sample Frequencies

Well	Sample Frequency	Rationale
299-W22-44, 299-W22-47, 299-W22-50, and 299-W23-19	Quarterly	Near-field downgradient monitoring wells located within higher concentration areas of existing contaminant plumes. These wells have exhibited substantial constituent concentration variability. A quarterly sampling frequency is needed to track concentration variations.
299-W22-45, 299-W22-48, 299-W22-49, and 299-W22-85	Semiannually	Near-field downgradient monitoring wells located outside of higher concentration areas of contaminant plumes. These wells bound the existing plumes and are also monitored to identify new contaminant plumes. A semiannual sampling frequency is used to meet both of these objectives. This frequency is consistent with the requirements for sites in interim status detection monitoring, which shares the common objective of identifying new contaminant plumes.
299-W22-84 and 299-W22-89	Annually	Near-field, cross-gradient monitoring wells exhibiting very low constituent concentrations. These wells are too far north or south of existing source areas to be useful for identifying new contaminant plumes; thus, there is no need to sample these wells more frequently than annually.
299-W22-80 and 299-W23-15	Annually	Near-field downgradient monitoring wells, but samples collected from these wells are apparently not representative of upper aquifer conditions due to vertical flow in the wellbores. These wells are sampled annually in case conditions change (PNNL-15070).
299-W22-69, 299-W22-72, 299-W22-81, 299-W22-82, 299-W22-83, and 299-W22-86	Annually	Intermediate and far-field downgradient monitoring wells that exhibit constituent concentrations of low variability and/or low concentrations. An annual sampling frequency is adequate to define the concentration trends in these wells.
299-W22-26	Semiannually	Far-field downgradient monitoring well but it is within a high-concentration area of a contaminant plume and has exhibited increasing concentrations over a period of several years.
299-W23-20 and ***299-W23-21***	Annually	Upgradient wells monitored to establish background water quality conditions. An annual sampling frequency is sufficient to meet this objective.

Notes: Bold/italic print in the table indicates upgradient wells.

3.2 Monitoring Well Network

Table 3-2 includes the list of wells monitored for WMA S-SX, and Figure 2-1 shows the well locations. Many of the wells are co-sampled for the 200-UP-1 Operable Unit (OU) for the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), although CERCLA sampling is at a lower frequency for some wells. Sampling is coordinated to avoid duplication of analyses and additional well trips. Two additional wells, 299-W22-26 and 299-W22-89, were added to the network

as part of this plan update. The sample results from well 299-W22-26 help to delineate the downgradient extent of contamination from the S Tank Farm. Well 299-W22-89 was installed in June 2010 to bound the southern extent of the plume from the SX Tank Farm at a near-field downgradient distance from the source.

Maintenance issues and sampling logistics sometimes delay scheduled sampling events. If a well on a quarterly sample frequency is delayed by 2 months or more, that event will be cancelled, as it is nearly time for the next quarterly sampling event. If sampling of a well scheduled on a semiannual frequency is delayed by 4 months, that event will be cancelled. For wells on an annual sample frequency, attempts will be made to sample the well within the calendar year scheduled.

Table 3-4 summarizes well depth information, including the depth of the water column in each monitoring well. All wells are constructed of stainless-steel casing and screens with full annular seals, with the exception of well 299-W22-26, which has a perforated carbon-steel casing. All wells are equipped with dedicated sampling pumps. With the exception of wells 299-W22-26 and 299-W22-89, as-built diagrams showing details of construction for each well are available in PNNL-12114 or subsequent interim change notices. The as-built diagram for wells 299-W22-26 and 299-W22-89 are shown in Appendix B.

Table 3-4. WMA S-SX Well Depths and Water Table Elevation

Well	Year Drilled	Water Table Elevation, June/July 2010 (m)[a]	Casing Elevation (m)[a]	Open Interval Bottom Elevation (m)[a]	Water Column, June/July 2010 (m)
299-W22-26	1963	134.11	208.38	133.05	1.16
299-W22-44	1991	134.48	207.76	132.97	1.51
299-W22-45	1992	134.52	204.13	131.94	2.58
299-W22-47	2005	134.54	206.28	125.17	9.37
299-W22-48	1999	134.36	207.90	133.60	0.76
299-W22-49	1999	134.57	204.72	132.94	1.63
299-W22-50	2000	134.61	205.01	133.13	1.48
299-W22-69	2006	134.00	207.95	124.04	9.96
299-W22-72	2006	133.95	208.02	124.44	9.51
299-W22-80	2000	134.69	200.85	126.80	7.89
299-W22-81	2001	134.36	206.64	126.13	8.23
299-W22-82	2001	134.37	206.87	126.51	7.86
299-W22-83	2001	134.35	207.02	126.70	7.65
299-W22-84	2001	134.47	208.51	126.41	8.06
299-W22-85	2001	134.58	204.41	126.86	7.72
299-W22-86	2006	134.01	206.41	124.46	9.55

Table 3-4. WMA S-SX Well Depths and Water Table Elevation

Well	Year Drilled	Water Table Elevation, June/July 2010 (m)[a]	Casing Elevation (m)[a]	Open Interval Bottom Elevation (m)[a]	Water Column, June/July 2010 (m)
299-W22-89	2010	134.39[b]	206.137	124.42	9.97
299-W23-15	1991	134.83	200.84	132.00	2.83
299-W23-19	1999	134.86[c]	202.49	128.94	5.92
299-W23-20	2000	134.86	203.80	126.75	8.25
299-W23-21	2000	134.89	203.35	126.47	8.68

Notes: Bold/italic print indicates upgradient wells.

a. NAVD88.

b. From September 2010.

c. No water-level measurements available for well 299-W23-19. The water table elevation was estimated by trend surface analysis of the June/July 2010 water-level measurements from the other nearby network monitoring wells.

With the exception of well 299-W23-19, water-level measurements are collected in each well at the time of sampling. In addition, water-level measurements are collected from many of the wells shown in Table 3-2 within a single day during March of each year to support water table mapping. Water-level measurements are not collected from well 299-W23-19, as this well is located within the SX Tank Farm security fence, adjacent to tank SX-115 and it is in a radiological control area. The pump discharge line and electrical wires for the sampling pump in this well pass through an underground pipe into a vault located outside the tank farm boundary. This allows the well to be sampled from the vault without field personnel entering the radiological control area. However, this configuration does not allow for water-level measurements to be collected, as routine access to the wellbore itself is not attained.

The water table elevation beneath WMA S-SX has been declining at an average rate of approximately 0.25 m/yr (0.82 ft/yr) (DOE/RL-2010-11). The decline is the result of reduced effluent discharges to ground at the Hanford Site since the peak discharge occurred in the 1980s. The water table elevation in the 200 West Area is expected to decline a minimum of an additional 4 to 6 m (13.1 to 16.4 ft) before equilibrium conditions are re-established (DOE/RL-2010-11).

As a consequence of the declining water table elevation, some monitoring wells at the WMA may go dry in the near future. When a well is within a few years of going dry, a replacement well is proposed. In addition, new wells may also be installed if needed to better characterize the nature and extent of contamination in the groundwater. All new RCRA wells proposed for installation at the Hanford Site are negotiated annually by Ecology, DOE, and EPA under the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989) Milestone M-24-00. At the time this plan was revised, two new wells were scheduled to be installed during CY 2011 (299-W22-93 and 299-W22-94) to replace existing wells going dry (299-W22-44 and 299-W22-48, respectively) (Figure 2-1).

In the future, the rate of decline of the water table beneath WMA S-SX may change in response to planned remedial action measures. The WMA S-SX is part of the larger 200-UP-1 CERCLA groundwater OU. In accordance with the *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington* (EPA/ROD/R10-97/048), a groundwater pump-and-treat system is being designed targeting the technetium-99 plumes from the S and SX Tank

Farms (DOE/RL-97-36, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*). The system is expected to become operational in December 2011. As currently planned (at the time this document was prepared), extraction wells will be installed near monitoring wells 299-W22-44, 299-W22-50, and 299-W22-86 (Figure 2-1). The pumped water will be transferred to the 200 West Area groundwater treatment facility for treatment and then returned to the aquifer via injection wells in the 200-ZP-1 Groundwater OU (in the northern 200 West Area). Operation of this pump-and-treat system will impact water levels in the RCRA monitoring wells and may also cause local changes in groundwater flow direction. The extraction wells are being designed to accommodate 75 to 110 L/min (20 to 30 gal/min) flow rates. Drawdown in most of the RCRA monitoring wells is estimated to range from approximately 0.2 to 0.5 m (approximately 0.7 to 1.6 ft) and is not expected to exceed approximately 0.75 m (approximately 2.5 ft) in the monitoring wells closest to the extraction wells.

In addition, in the *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site Benton County, Washington* (EPA et al., 2008), the selected remedy is a combination of pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls. Model simulations predict the groundwater flow direction at WMA S-SX will become northeasterly in the future due to operation of this system. Therefore, evaluation of the adequacy of the monitoring well network at WMA S-SX and the need for replacement wells will be an ongoing process, and the list of new wells under consideration for installation at the WMA will evolve.

3.3 Sampling and Analysis Protocol

Groundwater monitoring at WMA S-SX follows the conventions of the project and is discussed in the QAPjP (Appendix A).

4 Data Evaluation and Reporting

This chapter discusses data evaluation and reporting for WMA S-SX.

4.1 Data Review

Data review, validation, and verification are discussed in the QAPjP (Appendix A).

4.2 Interpretation

After sampling and water-level data are validated and verified, acceptable data are used to interpret groundwater conditions at WMA S-SX. 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 in groundwater flow directions.
- **Plume maps:** Map distributions of chemical constituents in the aquifer to determine 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.

4.3 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 to monitor groundwater quality in the uppermost aquifer (see Appendix A). Wells proposed for installation at WMA S-SX are described in Section 3.2.

Water-level measurements will continue to be collected before each sampling event, and more comprehensive measurements will continue to be made in March of each year. The data are presented in the annual Hanford Site groundwater monitoring report (e.g., DOE/RL-2010-11).

4.4 Reporting and Notification

The results of assessment 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.

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Appendix A

Quality Assurance Project Plan

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Terms

CRDL	contract-required detection limit
DOE	U.S. Department of Energy
DQO	data quality objective
DUP	laboratory matrix duplicate
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FXR	field transfer blank
GC	gas chromatography
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductively coupled plasma
ICP/MS	inductively coupled plasma/mass spectrometry
LCS	laboratory control sample
MB	method blank
MDA	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
PCB	polychlorinated biphenyl
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
RPD	relative percent difference
RSD	relative standard deviation
SUR	surrogate

TOC	total organic carbon
TOX	total organic halides
TPA	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
VOC	volatile organic compound

A Quality Assurance Project Plan

The contractor's quality assurance (QA) program describes the contractor's QA structure, requirements, implementation methods, and responsibilities. The contractor's environmental QA program plan provides the requirements for collecting and assessing environmental data in accordance with the following:

- 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements"
- DOE O 414.1C, *Quality Assurance*
- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD)
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*

This quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection including the planning, implementation, and assessment of sampling, field measurements, and laboratory analyses. Section 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order* (TPA) (Ecology et al., 1989a), Attachment 2, "Action Plan," require that QA/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. The HASQARD requirements (DOE/RL-96-68) also apply to this work.

The content of this QAPjP is patterned after the QA elements of EPA/240/B-01/003. The QAPjP demonstrates conformance to the Part B requirements of *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use* (ANSI/ASQ E4-2004). This QAPjP is divided into four sections (as designated in EPA/240/B-01/003) that describe the quality requirements and controls applicable to this investigation. This QAPjP is intended to supplement the contractor's environmental QA program plan.

A1 Project Management

This section addresses the basic aspects of project management and will ensure that the project has defined goals, the participants understand the goals and the approaches used, and the planned outputs are appropriately documented.

A1.1 Project/Task Organization

The project organization in regard to planning, sampling, analysis, and data assessment is described in the following subsections and is shown in Figure A-1. For each functional primary contractor role, there is a corresponding oversight role within the U.S. Department of Energy (DOE).

A1.1.1 Regulatory Project Manager

The Washington State Department of Ecology (Ecology) project manager is responsible for oversight of the work being performed under this groundwater monitoring plan. Ecology will work with the DOE Richland Operations Office (RL) to resolve concerns regarding the work as described in this QAPjP. Ecology can request this plan during a regulatory compliance inspection for review.

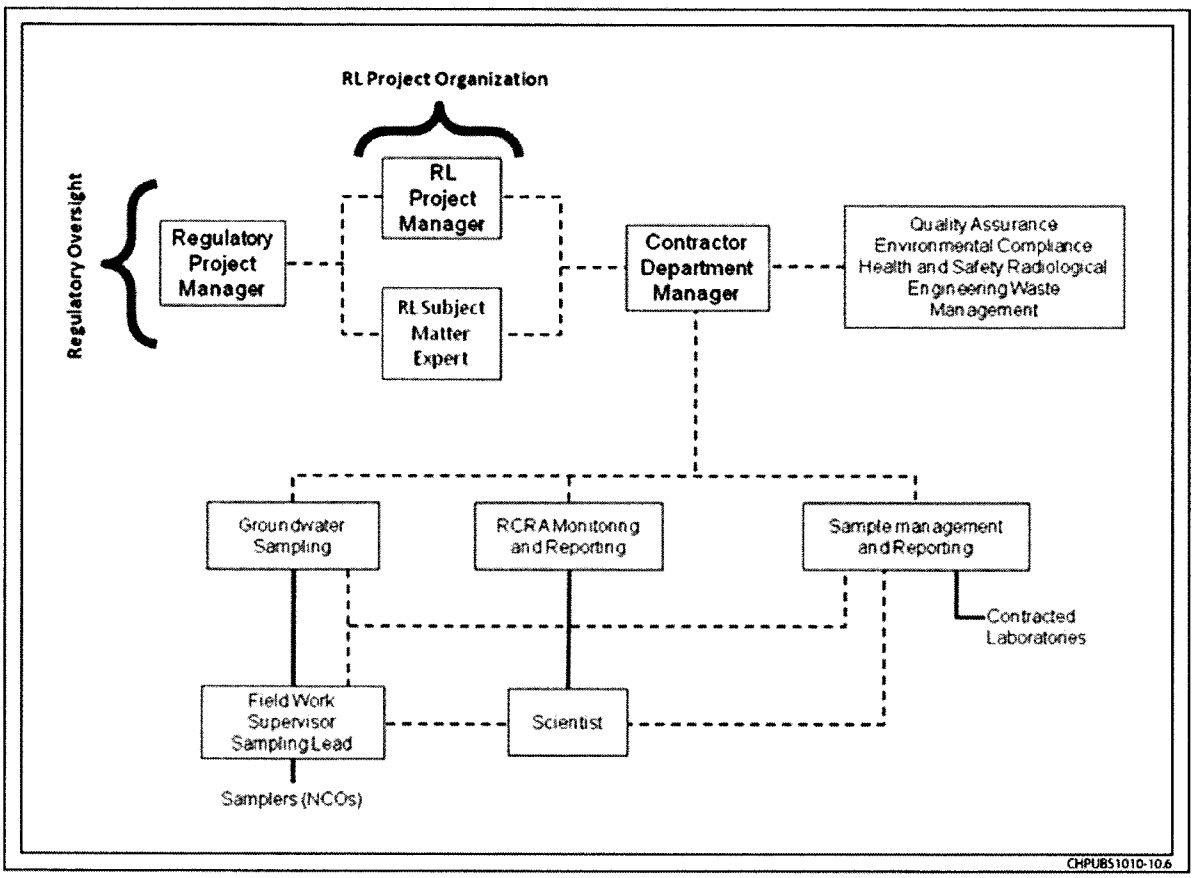

Figure A-1. Project Organization

A1.1.2 U.S. Department of Energy, Richland Operations Office Project Manager

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

A1.1.3 U.S. Department of Energy, Richland Operations Office Subject Matter Expert

The RL subject matter expert is responsible for day-to-day oversight of the contractor's performance of workscope, for working with the contractor and the regulatory agencies to identify and work through issues, and for providing technical input to the RL project manager.

A1.1.4 Contractor Groundwater Remediation Department Manager

The contractor groundwater remediation department manager provides oversight for all activities and coordinates with DOE, the regulatory agencies, and primary contractor management in support of sampling and reporting activities. The remediation department manager also provides support to the RCRA Monitoring and Reporting manager to ensure that work is performed safely and cost effectively.

A1.1.5 Groundwater Sampling Operations

Groundwater sampling operations is responsible for planning and coordinating field sampling resources and provides the field work supervisor for routine groundwater sampling operations. The field work supervisor directs the samplers who collect groundwater samples in accordance with the sampling and analysis plan and in accordance with corresponding standard procedures and work packages. 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.

A1.1.6 RCRA Monitoring and Reporting

The RCRA Monitoring and Reporting manager is responsible for direct management of activities performed to meet RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager coordinates with and reports to DOE and primary contractor management regarding RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager assigns scientists to provide technical expertise.

A1.1.7 Sample Management and Reporting Organization

The Sample Management and Reporting organization coordinates laboratory analytical work to ensure that laboratories conform to HASQARD requirements (or their equivalent), as approved by DOE, the U.S. Environmental Protection Agency (EPA), and Ecology. Sample Management and Reporting receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. Sample Management and Reporting is responsible for informing the RCRA Monitoring and Reporting manager of any issues reported by the analytical laboratories.

A1.1.8 Contract Laboratories

The contract laboratories analyze samples in accordance with established procedures and provide necessary sample reports and explanations of results to support data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

A1.1.9 Quality Assurance

The QA point of contact is matrixed to the subject matter expert and is responsible for QA issues on the project. Responsibilities include overseeing implementation of the project QA requirements; reviewing project documents, including data quality objective (DQO) summary reports, sampling and analysis plans, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA point of contact must be independent of the unit generating the data.

A1.1.10 Environmental Compliance Officer

The environmental compliance officer 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.

A1.1.11 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.

A1.1.12 Waste Management

Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A1.2 Problem Definition/Background

The problem definition, as required by WAC 173-303-400 ("Dangerous Waste Regulations," "Interim Status Facility Standards") and 40 CFR 265, Subpart F ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring"), is outlined in the main text discussion of this monitoring plan. The background is also provided in the monitoring plan.

A1.3 Project/Task Description

The project description is provided in Chapters 3 and 4 of this monitoring plan and includes the selection of appropriate dangerous waste or dangerous waste constituents, collection and analyses of groundwater from the monitoring network, interpretation of analytical results, evaluation of the monitoring network, and reporting.

The target analytes, along with the monitoring wells and frequency of sampling, are provided in Chapter 3.

A1.4 Quality Objectives and Criteria

The quality objectives and criteria for groundwater monitoring are defined in the tables provided in this QAPjP in order to meet the evaluation requirements stated in the monitoring plan.

A1.5 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, "Personnel Training." The field work supervisor, in coordination with line management, will ensure that all field personnel meet training requirements.

A1.6 Documents and Records

The project scientist is responsible for ensuring that the current version of the groundwater monitoring plan is used and for providing any updates to field personnel. Version control is maintained by the administrative document control process. Significant changes to the plan that affect DQOs will be reviewed and approved by DOE and the regulatory agency prior to implementation. Table A-1 defines the types of changes that may be made to the sampling design and documentation requirements.

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 HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file. Records may be stored in either electronic or hardcopy format. 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 TPA (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

Table A-1. Actions and Documentation for Regulatory Notification

Type of Change	Action	Documentation
Temporary addition of wells or constituents, or increased sampling frequency	RCRA Monitoring and Reporting manager approval; notify regulatory agency, if appropriate	Project's schedule tracking system
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, loss of samples in transit, etc.	Electronic notification	RCRA annual report
Planned change to groundwater monitoring activities, including addition or deletion of constituents or wells, change of sampling frequency, etc.	Revise monitoring plan	Revised RCRA groundwater monitoring plan
Anticipated unavoidable changes (e.g., dry wells)	Electronic notification; revise monitoring plan	RCRA annual report and revised groundwater monitoring plan

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 annual Hanford Site groundwater monitoring reports (e.g., DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*).

A2 Data Generation and Acquisition

This section 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.

A2.1 Sampling Process Design (Experimental Design)

The sampling design is based on regulatory requirements and judgmental sampling.

A2.1.1 Regulatory Requirements

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status TSD units.

A2.1.2 Judgmental Sampling

The selection of sampling and analysis requirements is based on knowledge of the feature or condition under investigation and is also based on professional judgment. The TSD unit monitoring is based on professional judgment. Conclusions depend on the validity and accuracy of professional judgment.

A2.2 Sampling Methods

Sampling is described in the contractor's environmental QA program plan, including the following:

- Field sampling methods
- Sample preservation, containers, and holding times
- Corrective actions for sampling activities
- Decontamination of sampling equipment

The groundwater sampling operations supervisor must ensure that situations that may impair the usability of samples and/or data are documented in field logbooks or on nonconformance report forms in accordance with internal corrective action procedures, as appropriate. The groundwater sampling operations supervisor will note any deviations that occur from the standard procedures for sample collection, contaminants of potential concern, sample transport, or monitoring. The groundwater sampling operations supervisor is also responsible for coordinating all activities related to the use of field monitoring equipment (e.g., dosimeters and industrial hygiene equipment). Field personnel will document in the logbook all noncompliant measurements taken during field sampling. Ultimately, the groundwater sampling operations supervisor is responsible for developing, implementing, and communicating corrective action procedures; for documenting all deviations from procedure; and for ensuring that immediate corrective actions are applied to field activities. Problems with sample collection, custody, or data acquisition that adversely impact data quality or impair the ability to acquire data or failure to follow procedure will be documented in accordance with internal corrective action procedures, as appropriate.

A2.3 Sample Handling and Custody

A sampling and data tracking database is used to track samples from the point of collection through the laboratory analysis process. Laboratory analytical results are entered and maintained in the HEIS database. Each sample is identified and labeled with a unique HEIS sample number. The contractor's environmental QA program plan specifies sample handling information, including the following:

- Container requirements
- Container labeling and tracking process
- Sample custody requirements
- Shipping and transportation

Sample custody during laboratory analysis is addressed in the applicable laboratory's standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Storage of samples at the laboratory will be consistent with laboratory instructions prepared by the Sample Management and Reporting organization.

A2.4 Analytical Methods

Information on analytical methods is provided in Tables A-2 and A-3. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor participates in oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

Table A-2. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Continuing Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Metals Analyzed by ICP Method – Unfiltered/Filtered			
Calcium	P, HNO_3 to pH <2	SW-846[d] Method 6010B/C, SW-846 Method 6020[e], or EPA/600 Method 200.8[e]	1,000
Chromium			10
Sodium			500
Potassium			4,000
Magnesium			750
Anions by IC			
Chloride	P	EPA/600 Method 300.0[f]	200
Nitrate			250
Sulfate			500
Other			
Temperature	Field measurement	Instrument/meter	--
Conductivity, field	Field measurement	Instrument/meter	1 µohm
pH, field measurement	Field measurement	Instrument/meter	0.1
Alkalinity	G/P	Standard Method[g] 2320, EPA/600 Method 310.1, EPA/600 Method 310.2	5,000

a. All samples will be collected in plastic (P) or glass (G) containers and will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units, unless otherwise indicated.

d. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. Analytical method adapted from Method 300.0 (EPA-600/4-84-017, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography*).

g. *Standard Methods for the Examination of Water and Wastewater* (AWWA et al., 2005).

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Metals Analyzed by ICP Method — Unfiltered/Filtered			
Barium	P, HNO_3 to pH <2	SW-845[d] Method 6010B/C, SW-846 Method 6020,[e] or EPA/600 Method 200.8[f]	20
Beryllium			5
Cadmium			5
Chromium			10
Cobalt			20
Copper			10
Nickel			40
Silver			10
Vanadium			25
Zinc			10
Trace Metals – Unfiltered/Filtered			
Antimony	P, HNO_3 to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	6
Arsenic			10
Lead			5
Selenium			10
Thallium			5
Trace Metals – Unfiltered/Filtered			
Mercury	G, HNO_3 to pH <2	SW-846 Method 7470A, EPA/600 Method 200.8	0.5
Volatiles by GC/MS			
1,1-Dichloroethene	G, no headspace	SW-846 Method 8260B	10
1,1,1-Trichloroethane			5
1,1,2,2-Tetrachloroethane			5
1,1,2-Trichloroethane			5
1,2-Dichloroethane			5
2-Butanone (methyl ethyl ketone)			10
2-Propanone (acetone)			20

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
4-Methyl-2-petanone (MIBK)			10
Benzene			5
Carbon disulfide			5
Carbon tetrachloride			5
Chlorobenzene			5
Chloroform			5
Ethylbenzene			5
Isobutanol			500
Methylene chloride			5
Tetrachloroethene			5
Toluene			5
trans-1,3-Dichloropropene			5
Trichloroethene			5
Trichlorofluoromethane			10
Vinyl chloride (chloroethene)			10
Xylenes			10
Semivolatiles by GC/MS			
1,2-Dichlorobenzene (o-Dichlorobenzene)	Amber glass	SW-846 Method 8270D	10
1,2,4-Trichlorobenzene			10
2-Chlorophenol			10
2-Methylphenol (o-cresol)			10
2-Nitrophenol (o-Nitrophenol)			20
2,4-Dinitrotoluene			10
2,4,5-Trichlorophenol			10
2,4,6-Trichlorophenol			10
3-Methylphenol (m-cresol)			20
4-Chloro-3-methylphenol (p-Chloro-m-cresol)			10

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
4-Methylphenol (p-cresol)			10
Acenaphthene			10
Butylbenzylphthalate			10
Di-n-butylphthalate			10
Di-n-octylphthalate			10
Fluoranthene			10
Hexachlorobutadiene			10
Hexachloroethane			10
n-Nitroso-di-n-propylamine			10
n-Nitrosomorpholine			10
Naphthalene			10
Nitrobenzene			10
Pyrene			10
Pyridine			20
PCBs			
Aroclor-1016			0.5
Aroclor-1221			0.5
Aroclor-1232			0.5
Aroclor-1242	G	SW-846 Method 8082	0.5
Aroclor-1248			0.5
Aroclor-1254			0.5
Aroclor-1260			0.5
Other			
Cyanide	P, NaOH to pH >12	SW-846 Method 9012, Standard Method[f] 4500, EPA/600 Method 335.2	5
Sulfide	G/P, 2 mL 2N zinc acetate and NaOH pH >9, cool 4°C	Sulfides – 9030	500

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]

a. All samples will be collected in glass (G) or plastic (P) containers and samples will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units.

d. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. *Standard Methods for the Examination of Water and Wastewater* (AWWA et al., 2005).

Laboratories providing analytical services in support of this QAPjP will report errors to the Sample Management and Reporting project coordinator, who will then initiate a sample disposition record. The error-reporting process is intended to document analytical errors and the resolution of those errors with the project scientist. The corrective action program addresses the following:

- Evaluation of impacts of laboratory QC failures on data quality
- Root-cause analysis of QC failures
- Evaluation of recurring conditions that are adverse to quality
- Trend analysis of quality-affecting problems
- Implementation of a quality improvement process
- Control of nonconforming materials that may affect quality

A2.5 Quality Control

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of field replicates (duplicates), trip or field blanks, and equipment blanks (EBs). Laboratory QC samples estimate the precision and bias of the analytical data. Field and laboratory QC samples are summarized in Table A-4.

Table A-4. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Full trip blank (FTB)	Contamination from containers or transportation	One per 20 well trips
Field transfer blank (FXR)	Contamination from sampling site	One each day; VOCs sampled
Equipment blank (EB)	Contamination from non-dedicated equipment	As needed[a]
Replicate/duplicate sample	Reproducibility	One per 20 well trips

Table A-4. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Laboratory QC		
Method blank (MB)	Laboratory contamination	One per batch
Laboratory duplicate	Laboratory reproducibility	See footnote b
Matrix spike (MS)	Matrix effect and laboratory accuracy	See footnote b
Matrix spike duplicate (MSD)	Laboratory reproducibility/accuracy	See footnote b
Surrogate (SUR)	Recovery/yield	See footnote b
Laboratory control sample (LCS)	Method accuracy	One per batch

a. For portable Grundfos® (registered trademark of Grundfos Pumps Corporation, Colorado Springs, Colorado) pumps, EBs are collected one per 10 well trips. Whenever a new type of non-dedicated equipment is used, an EB shall be collected every time sampling occurs until it can be shown that less frequent collection of EBs is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. As defined in the laboratory contract or quality assurance plan, and/or analysis procedures.

A2.5.1 Field Quality Control Samples

Field QC samples will be collected to evaluate the potential for cross-contamination and field sampling performance. The QC samples and the required frequency for collection are described in this section.

Full trip blanks (FTBs) are prepared by the sampling team prior to traveling to the sampling site. The FTB is filled with high-purity reagent water. The bottles are sealed and transported, unopened, to the field in the same storage containers used for samples collected that day. Collected FTBs are analyzed for the same constituents as the samples. The FTBs are used to evaluate potential contamination of the samples due to the sample bottles, preservative, handling, storage, or transportation.

Field transfer blanks (FXRs) are preserved volatile organic analysis sample bottles that are filled at the sample collection site with high-purity reagent water that has been transported to the field. After collection, FXR bottles are sealed and placed in the same storage containers with the samples from the associated sampling event. The FXR samples are analyzed for volatile organic compounds (VOCs) only. The FXRs are used to evaluate potential contamination caused by conditions in the field.

The EBs are samples in which high-purity reagent water is passed through the pump or placed in contact with the sampling surfaces of the equipment to collect blank samples identical to the sample set that will be collected. The EB bottles are placed in the same storage containers with the samples from the associated sampling event. The EB samples are analyzed for the same constituents as the samples from the associated sampling event. The EBs are used to evaluate the effectiveness of the cleaning process to ensure that samples are not cross-contaminated from previous sampling events.

For the field blanks (i.e., FTBs, FXRs, and EBs), results above two times the method detection limit (MDL) are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the MDL.

Field duplicates, also known as replicates, are two samples that are collected as close as possible to the same time and same location, and they are intended to be identical. Field duplicates are stored and transported together and are analyzed for the same constituents. The field duplicates are used to

determine precision for both sampling and laboratory measurements. The results of the field duplicates must have precision within 20 percent, as measured by the relative percent difference (RPD). Only field duplicates with at least one result greater than five times the MDL or minimum detectable activity (MDA) are evaluated.

Double-blind samples contain a concentration of analyte known to the supplier but unknown to the analyzing laboratory. The laboratory is not informed that the samples are QC samples. The project submits double-blind samples to assess analytical precision and accuracy.

A2.5.2 Laboratory Quality Control Samples

The laboratory QC samples (e.g., method blanks [MBs], laboratory control samples [LCSs]/blank spikes, and MSs) are defined in Chapter 1 of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, and will be run at the frequency specified in that reference, unless superseded by agreement.

A2.5.3 Quality Control Requirements

Table A-5 lists the acceptance criteria for QC samples, and Table A-6 lists the acceptable recovery limits for the double-blind standards. These samples are prepared by spiking Hanford Site background well water with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper concentration limit determined for Hanford Site groundwater. Investigations shall be conducted for double-blind standards that are outside of acceptance limits. The results from these standards are used to determine the acceptability of the associated parameter data.

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity Conductivity pH	MB[b]	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS[e]	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Ammonia and Anions			
Anions by IC Cyanide Sulfide	MB	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
Metals			
Arsenic Cadmium Chromium Lead Mercury Selenium Thallium ICP metals ICP/MS metals	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	MSD	≤20% RPD[c]	Data reviewed[d]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
VOCs			
Volatiles by GC/MS	MB	<MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB, FXR	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Semi-VOCs			
PCBs by GC Phenols by GC Semivolatiles by GC/MS	MB	<2 times MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed[d]
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

a. Refer to Tables A-2 and A-3 for specific analytical methods.

b. Does not apply to pH.

c. Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect ("Y" flag) or rejected ("R" flag).

e. Applies to TOC and TOX only.

f. Applies only in cases where one or both results are greater than five times the detection limit.

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action

g. Determined by the laboratory based on historical data. Control limits are reported with the data.

h. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is less than five times the MDL.

Data flags:

B, C = possible laboratory contamination (analyte was detected in the associated MB)

N = result may be biased (associated MS result was outside the acceptance limits)

Q = problem with associated field QC sample (blank and/or duplicate results were out of limits)

Table A-6. Blind Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)	Precision (% RSD)*
Nitrate	Quarterly	±25%	≤25%
Chromium	Annually	±20%	≤25%

* If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

Holding time is the elapsed time period between sample collection and analysis. The contractor's environmental QA program plan provides a table with holding times. Exceeding the required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in SW-846 or *Methods of Chemical Analysis of Water and Wastes* (EPA/600/4-79/020). Data associated with exceeded holding times are flagged with an "H" in the HEIS database. Data that exceed the holding time shall be maintained but potentially may not be used in statistical analyses.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. The Groundwater Project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems from occurring. Audit results are used to improve performance, and the summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Failure of QC will be determined and evaluated during the data validation and the data quality assessment process. Data will be qualified, as appropriate.

A2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to minimize measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and the onsite organization's QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with SW-846, or with

auditable HASQARD and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

A2.7 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in the environmental QA program plan. Standards used for calibration will be certified and traceable to nationally recognized performance standards. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's QA plan.

A2.8 Inspection/Acceptance of Supplies and Consumables

Supplies and consumables used to support sampling and analysis activities are procured in accordance with internal work requirements and processes that describe the contractor's acquisition system and the responsibilities and interfaces necessary to ensure that items procured/acquired for contractor meet the specific technical and quality requirements. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

Supplies and consumables that are procured by the analytical laboratories are procured, checked, and used in accordance with the laboratory's QA plan.

A2.9 Non-Direct Measurements

Non-direct measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. If evaluation includes data from historical sources, whenever possible such data will be validated to the same extent as the data generated as part of this effort. All data used in evaluations will be identified by source.

A2.10 Data Management

The Sample Management and Reporting organization, in coordination with the RCRA Monitoring and Reporting manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements that govern data management procedures. Electronic data access, when appropriate, will be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b). The HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file.

All field activities will be recorded in the field logbook.

Laboratory errors are reported to the Sample Management and Reporting organization on a routine basis. For reported laboratory errors, a sample disposition record will be initiated in accordance with contractor procedures. This process is used to document analytical errors and to establish resolution of the errors with the RCRA Monitoring and Reporting manager. Sample disposition records become a permanent part of the analytical data package for future reference and for records management.

A3 Assessment and Oversight

The elements discussed in this section address the activities for assessing the effectiveness of project implementation and the associated QA and QC activities. The purpose of the assessment is to ensure that the QAPjP is implemented as prescribed.

A3.1 Assessments and Response Actions

The contractor management, Regulatory Compliance, Quality, and/or Health and Safety organizations may conduct random surveillances and assessments to verify compliance with the requirements outlined in this QAPjP.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratory's QA plan. The primary contractor conducts oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

A3.2 Reports to Management

Reports to management on data quality issues will be made if and when these issues are identified. Issues reported by the laboratories are communicated to the Sample Management and Reporting organization, which initiates a sample disposition record in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the RCRA Monitoring and Reporting manager.

A4 Data Validation and Usability

The elements in this section address the QA activities that occur after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying project objectives. These elements are further discussed in the contractor's environmental QA program plan.

A4.1 Data Review, Verification, and Validation

The criteria for verification may include review for completeness (e.g., all samples were analyzed as requested), use of the correct analytical method/procedure, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

A4.2 Verification and Validation Methods

The work activities shall follow documented procedures and processes for data validation and verification, as summarized below. Validation of groundwater data consists of assessing whether the data collected and measured truly reflect aquifer conditions. Verification means assessing data accuracy, completeness, consistency, availability, and internal control practices to determine overall reliability of the data collected. Other DQOs that shall be met include proper chain-of-custody, sample handling, use of proper analytical techniques as applied for each constituent, and the quality and acceptability of the laboratory analyses conducted.

Groundwater monitoring staff perform checks on laboratory electronic data files for formatting, allowed values, data flagging (i.e., qualifiers), and completeness. Hardcopy results are verified to check for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems

encountered during analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to correct the problem found during the analysis.

The data validation process provides the requirements and guidance for validating groundwater data that are routinely collected. Validation is a systematic process of reviewing verified data against a set of criteria (provided in Section A2.5) to determine whether the data are acceptable for their intended use.

Results of laboratory and field QC evaluations, double-blind sample results, laboratory performance evaluation samples, and holding-time criteria are considered when determining data usability. Staff review the data to identify whether observed changes reflect changes in groundwater quality or potential data errors, and they may request data reviews of laboratory, field, or water-level data for usability purposes. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the data reviews are used to flag the data appropriately in the HEIS database (e.g., "R" for reject, "Y" for suspect, or "G" for good) and/or to add comments.

A4.3 Reconciliation with User Requirements

The data quality assessment 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 data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet project DQOs. The RCRA Monitoring and Reporting manager is responsible for determining if data quality assessment is necessary and for ensuring that, if required, one is performed. The results of the data quality assessment will be used in interpreting the data and determining if the objectives of this activity have been met.

A5 References

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Appendix B

Construction Information for Wells 299-W22-26 and 299-W22-89

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hand tool (nom)
Drilling Fluid Used: Water	Additives Used: Not documented
Driller's Name: Rodda	WA State Lic Nr: Not documented
Drilling Company: Bach Drilling Co	Company Location: Yakima, WA
Date Started: 19Nov63	Date Complete: 20Dec63

WELL NUMBER: 299-W22-26 TEMPORARY WELL NO: _____

Hanford Coordinates: N/S N 36,100 E/W W 74,450

State Coordinates: N 441,211 E 2,220,783

Start Card # Not documented T___ R___ S___

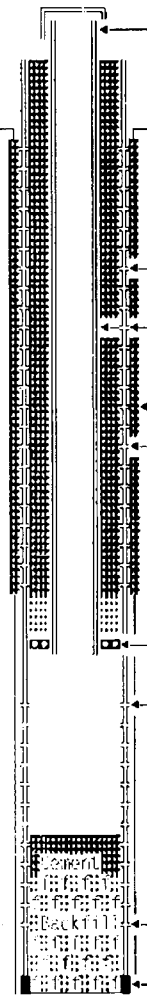
Elevation Ground surface (ft): 676.8 Estimated

Depth to water: 213-ft Dec63
(Ground surface)217.2-ft 08Dec92

GENERALIZED STRATIGRAPHY — Driller's Log

0-5: Fine SAND, SILT
5-10: Coarse SAND and GRAVEL
10-15: Coarse SAND
15-20: Coarse SAND and fine GRAVEL
20-25: Coarse SAND
25-40: Coarse SAND and GRAVEL
40-53: SAND and GRAVEL
53-60: GRAVEL and SAND
60-64: SILT to SAND
64-80: SILT and SAND
80-140: SAND and SILT
140-150: CLAY
150-155: CLAY and SAND
155-172: SAND and GRAVEL
172-175: SAND and SILT
175-179: SAND, SILT and GRAVEL
179-185: SAND and GRAVEL
185-187: GRAVEL, very little SAND
187-195: SAND and GRAVEL
195-197: GRAVEL, very little SAND
197-210: GRAVEL and SAND
210-225: SAND and GRAVEL
225-230: GRAVEL, some SAND
230-240: SAND and GRAVEL
240-255: Pea GRAVEL and SAND
255-275: SAND and GRAVEL
275-280: Quick SAND and GRAVEL
280-300: SAND and GRAVEL (Heaving)

REMEDIATION
May 79 by Evans
Placed sand and cement plug in bottom at about 252-ft.
Perforated 70-190 and 0-70-ft, 2 cuts/rd/ft.
Set 4-in liner and packer to 195-ft.
Placed sand and cement plug on packer. Then grouted annulus.



- Elevation of reference point: [680.30-ft] (top of casing)
- Height of reference point above ground surface [3.5-ft]
- Depth of surface seal [0-190-ft]
  Type of surface seal: Cement grout through perforations
- I.D. of surface casing (if present) [ND]
- Perforated 0-190-ft 2 cuts/rd/ft
- I.D. of riser pipe: [4 & 8-in]
  Type of riser pipe: Carbon steel
- Diameter of borehole: [9-in nom]
- Type of filler: Not documented
- 4-in liner set to 195-ft on packer. 5-gal sand placed above packer.
- Depth top of perforations: [200-ft]
  Description of perforations:
  200-240-ft, 6 cuts/rd/ft
  240-260-ft, 4 cuts/rd/ft
  260-297-ft, 1 cut/rd/ft spiraling
- Depth bottom of perforations: [297-ft]
- Depth bottom of casing: [300-ft]
- Depth bottom of borehole: [300-ft]

Drawing By: RS/2W22-26.ASB Date: 20Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W22-26

WELL DESIGNATION :	299-W22-26
CERCLA UNIT :	200 Aggregate Area Management Study
RCRA FACILITY :	Not applicable
HAN-ORD COORDINATES :	N 36,100 W 74,450
LAMBERT COORDINATES :	N 441,211 E 2,220,783 [HANCONV]
DATE DRILLED :	Dec63
DEPTH DRILLED (GS) :	300-ft
MEASURED DEPTH (CS) :	Not documented
DEPTH TO WATER (CS) :	213-ft, Dec63; 217.2-ft, 08Dec92
CASING DIAMETER :	8-in carbon steel, +3.0↔300-ft; 4-in carbon steel, +3.5↔195-ft
ELEV TOP CASING :	680.30-ft,
ELEV GROUND SURFACE :	676.8-ft, Estimated
PERFORATED INTERVAL :	0↔190, 200↔297-ft
SCREENED INTERVAL :	Not applicable
COMMENTS :	FIELD INSPECTION, 19Apr91, 4 and 8-in carbon steel casing. No pad, no posts, capped and locked. No permanent identification. Not in radiation zone. OTHER: Cement plug in bottom, depth not documented.
AVAILABLE LOGS :	Driller
TV SCAN COMMENTS :	Not applicable
DATE EVALUATED :	Not applicable
EVAL RECOMMENDATION :	Not applicable
LISTED USE :	Separations area Semiannual water level measurement, 24Aug88↔08Dec92; PNL Annual and Semiannual; WHC Semiannual water sample schedule
PUMP TYPE :	Electric submersible.
MAINTENANCE :	

WELL SUMMARY SHEET	Start Date: 6/10/10 Finish Date: 6/21/10	Page 1 of 2

Well ID: C7664		Well Name: 299-W22-89	
Location: 45 meters south of 299-W22-47		Project: 5 M-24 RCRA Monitoring Wells	
Prepared By: Ryan W. Brauchla	Date: 6/23/10	Reviewed By: L. D. Walker	Date: 8-9-10
Signature: Ryan W. Brauchla		Signature: L D Walker	

CONSTRUCTION DATA

Description

Stainless Steel Protective Casing:
+ 3.00 ft above ground surface

Portland Cement Type I/II:
0 - 9.0 ft bgs

4-in I.D. Stainless Steel Type 304L, Permanent Blank Casing:
+ 2.00 - 230.84 ft bgs

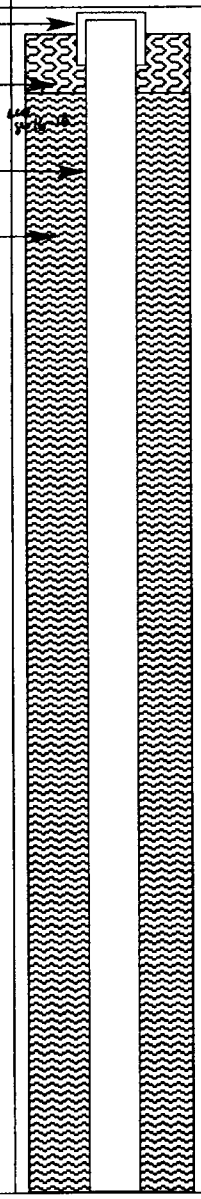
#8 Granular Bentonite Crumbles:
9.0 - 222.0 ft bgs

All temporary drill casing was removed from the ground.

All depths are in feet below ground surface.

Borehole drilled with 9-inch O.D. casing: 0.0 - 332.6 ft bgs.

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 20, 40, 60, 80, 100, 120, 140, 160

Graphic Log

Lithologic Description/Groundwater Sample Depths (ft bgs)

0-1 Gravel (G)
1-8 Sand (S)
8-12 Silty Sand (mS)
12-19 Sand (S)
19-25 Slightly Gravelly Sand (gmS)
25-27 Silty Sand (mS)
27-39 Sand (S)
39-52 Silty Sand (mS)
52-78 Sand (S)
78-82 Gravelly Sand (gS)
82-86 Gravel (G)
86-90 Sand (S)
90-100 Silty Sand (mS)
100-112 Sand (S)
112-137 Silty Sand (mS)
137-142 Silt (M)
142-159 Sandy Silt (sM)
159-163 Silty Sand (mS)
163-167 Silty Sandy Gravel (msG)
167-174 Sand (S)
174-183 Gravelly Sand (gS)

WELL SUMMARY SHEET	Start Date: 6/10/10 Finish Date: 6/21/10	Page 2 of 2
Well ID: C7664	Well Name: 299-W22-89	
Location: 45 meters south of 299-W22-47	Project: 5 M-24 RCRA Monitoring Wells	
Prepared By: Ryan W. Brauchla — Date: 6/23/10	Reviewed By: L.D. Walker — Date: 8-9-10	
Signature:	Signature:	

CONSTRUCTION DATA

Description

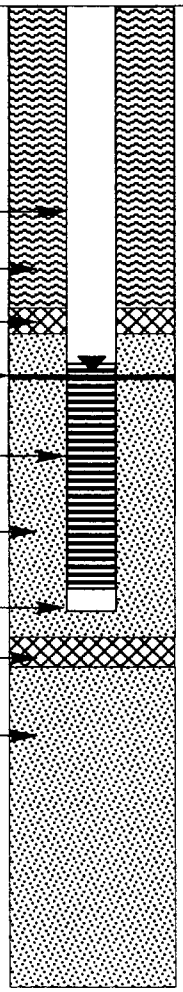
cw 8-16-10
Sch. 10
4-in I.D. Stainless Steel Type 304L, Permanent Blank Casing: + 2.00 - 230.84 ft bgs
#8 Granular Bentonite Crumbles: 9.0 - 222.0 ft bgs
Uncoated Bentonite Pellets: 222.0 - 226.3 ft bgs
Static Water Level: 232.31 ft bgs (6/8/10)
4-in I.D. Stainless Steel Type 316, 20 Slot (0.020-in) Screen: 230.84 - 265.87 ft bgs
Primary Sand Pack
10-20 Mesh Colorado Silica Sand: 226.3 - 272.2 ft bgs
4-in, I.D. Stainless Steel Type 304, Sump/End Cap: 265.87 - 269.19 ft bgs
Coated Bentonite Pellets: 272.2 - 277.1 ft bgs
Backfill Sand Pack
10-20 Mesh Colorado Silica Sand: 277.1 - 332.6 ft bgs

All temporary drill casing was removed from the ground.

All depths are in feet below ground surface.

Borehole drilled with 9-inch O.D. casing: 0.0 - 332.6 ft bgs.

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 200, 220, 240, 260, 280, 300, 320, 340

Graphic Log

Lithologic Description/Groundwater Sample Depths (ft bgs)

174-183 Gravelly Sand (gS)
183-188 Silty Sandy Gravel (msG)
188-249 Sandy Gravel (sG)
249-273 Gravel (G)
273-279 Silty Sandy Gravel (msG)
279-310 Sandy Gravel (G)
310-323 Gravel (G)
323-326 Sandy Gravel (sG)
326-332.6 Gravel (G)
Total Depth Drilled: 332.6 ft bgs (6/14/10)

Distribution

	MS	Quantity
U.S. Department of Energy, Richland Operations Office		
N.M. Bland	A5-11	1
R.D. Hildebrand	A6-38	1
DOE Public Reading Room	H2-53	1
U.S. Department of Energy, Office of River Protection		
L. Huffman	H6-60	1
C.J. Kemp	H6-60	1
R.W. Lober	H6-60	1
CH2M HILL Plateau Remediation Company – Electronic Distribution		
G.A. Aljure	H8-45	
W.R. Faught	H8-15	
R.L. Fleshman	R3-50	
D.A. Gamon	R3-50	
J.W. Lindberg	R3-50	
S.P. Luttrell	R3-50	
C.J. Martin	R3-50	
J.P. McDonald	R3-50	
C.W. Miller	H8-15	
R.W. Oldham	R3-60	
L.C. Swanson	R3-50	
W.R. Thackaberry	R3-60	
G.S. Thomas	R3-50	
J.A. Winterhalder	R3-60	
C.D. Wittreich	H8-15	
M.I. Wood	H8-51	

	MS	Quantity
Washington River Protection Solutions		
S.J. Eberlein	E6-31	1
J.G. Field	E6-31	1
J.J. Luke	R1-51	1
D.A Myers	E6-31	1
C.L. Tabor	E6-31	1
Administrative Record	H6-08	1
Document Clearance	H6-08	1