

PERFORMANCE MONITORING PLAN FOR THE 200-ZP-1 GROUNDWATER OPERABLE UNIT REMEDIAL ACTION

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



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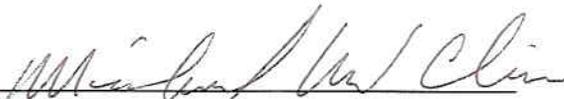
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Terms

amsl	above mean sea level
CCU	Cold Creek unit
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
COC	contaminant of concern
CSM	conceptual site model
CY	calendar year
DOE	U.S. Department of Energy
DS	decision statement
EPA	U.S. Environmental Protection Agency
FY	fiscal year
gpm	gallons per minute
HEIS	Hanford Environmental Information System
IC	institutional control
MCL	maximum contaminant level
MNA	monitored natural attenuation
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
ROD	Record of Decision
SAP	sampling and analysis plan
TCE	trichloroethene
VOC	volatile organic compound

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1 Introduction

This revision of the performance monitoring plan (PMP) guides groundwater monitoring data collection activities and reflects necessary changes subsequent to implementing the 200-ZP-1 Groundwater Operable Unit (OU) remedial action. The selected remedy is described in the Record of Decision (ROD) for the 200-ZP-1 OU (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*). Operations at the 200 West pump and treat (P&T) began in July 2012. This PMP presents the types of data that will be collected, the well networks that will be monitored, the frequency of data collection, and the analysis of the data to satisfy the requirements of the 200-ZP-1 OU ROD. This PMP is not designed to monitor the treatment process of the treatment plant, does not serve as a compliance monitoring program for the treated effluent discharge from the treatment plant, and is not used to monitor the performance of any remedial activities for the 200-UP-1 OU. Monitoring of remedial activities for the 200-UP-1 OU is described in DOE/RL-2015-14, *Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action*.

This PMP is a flexible, living document that may be modified based on changing hydraulic and contaminant distribution conditions at the 200-ZP-1 OU. Frequent modifications to the network are probable due to changing conditions (e.g., some wells in the PMP monitoring network will go dry due to P&T operations). Improvements to the conceptual site model (CSM), groundwater flow model, and three-dimensional contaminant distributions based on information from newly drilled extraction and injection wells could also influence the PMP. Therefore, the PMP must be adaptable enough to specify performance monitoring regimes that make sense for the changing state of the site.

The 200-ZP-1 OU includes several groundwater plumes that span 13 km² (5 mi²) beneath the 200 West Area of the Hanford Site (Figure 1). The 200 Areas, which include the 200 East and 200 West Areas, contain permanent waste management facilities and former reprocessing facilities associated with plutonium concentration and recovery operations. The remedial investigation and feasibility studies (DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*; DOE/RL-2007-28, *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit*) concluded that without remedial action, 200-ZP-1 groundwater contaminants would exceed risk threshold values for future industrial workers and residents using the groundwater as a drinking water supply. The contaminant concentrations also exceed federal and state maximum contaminant levels (MCLs) and state groundwater cleanup standards for using groundwater as a drinking water source. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the major contaminant of concern (COC) for the OU is carbon tetrachloride. Other COCs include total chromium, hexavalent chromium, nitrate, trichloroethene (TCE), iodine-129, technetium-99, and tritium.

The 200-ZP-1 OU ROD (EPA et al., 2008) presents the selected groundwater remedial action for restoring the aquifer and cleanup levels for the COCs. DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan (RD/RAWP)*, describes the design and implementation of the remedial action process required by the 200-ZP-1 OU ROD. This PMP is an enforceable part of the RD/RAWP and describes the monitoring activities associated with the remedial action process, the remedial action objectives (RAOs), and the preferred remedial action selected to meet the RAOs.

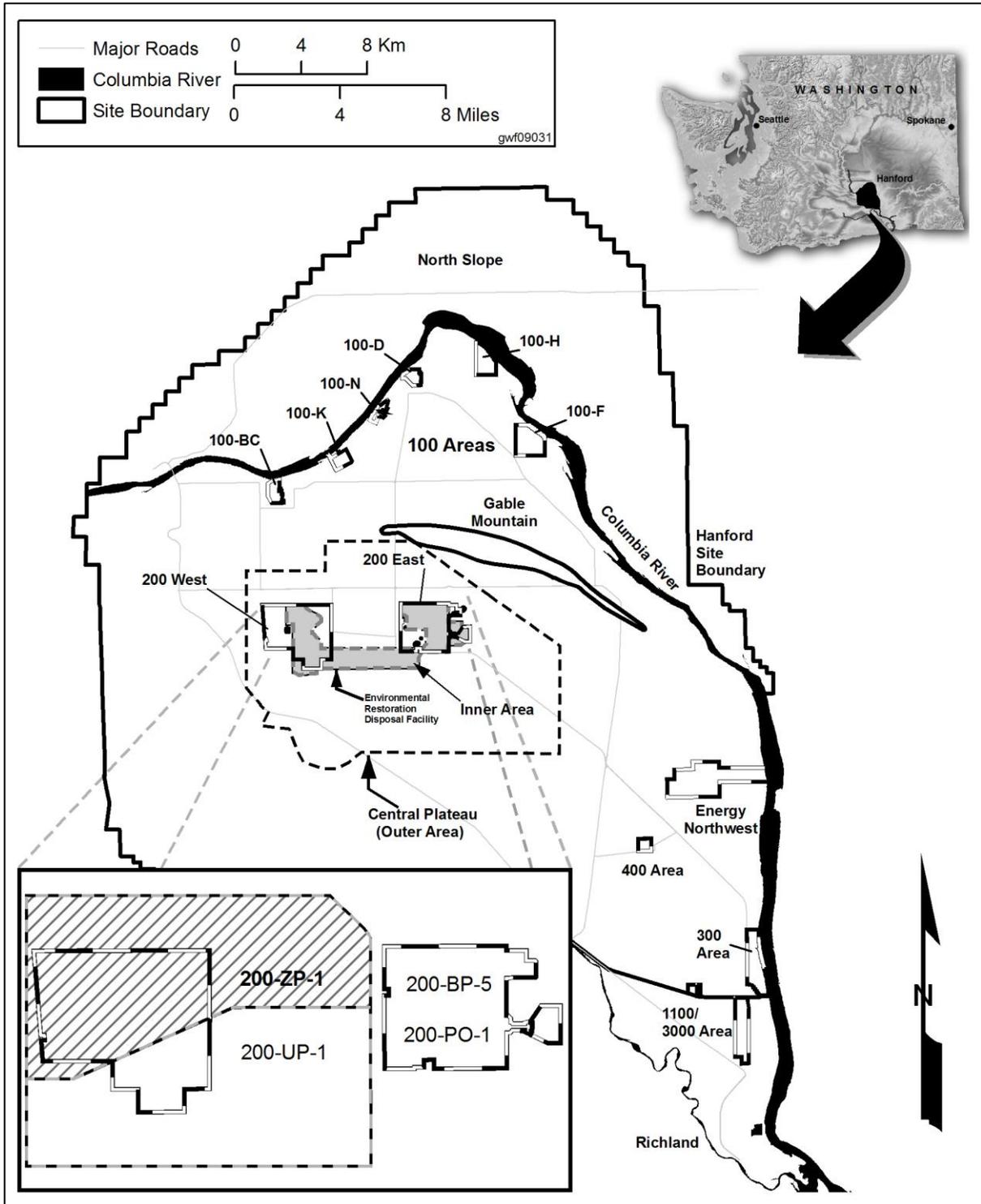


Figure 1. Site Location

1.1 Remedial Action Objectives

Through its groundwater protection program, Washington State determined that the 200-ZP-1 OU aquifer meets the *Washington Administrative Code* definition for potable groundwater and has recognized it as a potential source of domestic drinking water. Consistent with the state's beneficial use determination, the contaminated groundwater will be restored to support future use as a potential domestic drinking water supply. In accordance with this goal, the RAOs for remediating contaminated 200-ZP-1 OU groundwater are as follows:

- **RAO #1:** Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving cleanup levels (Table 1). This objective is to be achieved within the entire 200-ZP-1 OU groundwater plume area. The estimated time frame to achieve cleanup levels is within 150 years.¹
- **RAO #2:** Apply institutional controls to prevent groundwater use until the cleanup levels (Table 1) are achieved. Within the entire OU groundwater plume area, institutional controls (ICs) must be maintained and enforced until cleanup levels are achieved, which is estimated to be within 150 years.¹
- **RAO #3:** Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by 200-ZP-1 OU contaminants. This final objective is applicable to the entire 200-ZP-1 OU groundwater plume area. Columbia River protection from 200-ZP-1 OU contaminants must continue until the cleanup levels are achieved, which is estimated to be within 150 years.¹

Table 1. Cleanup Levels for 200-ZP-1 OU Groundwater

COC	Cleanup Level	Units
Carbon tetrachloride	3.4*	µg/L
Chromium (total)	100	µg/L
Hexavalent chromium	48	µg/L
Nitrate	10,000	µg/L
Trichloroethene	1*	µg/L
Iodine-129	1	pCi/L
Technetium-99	900	pCi/L
Tritium	20,000	pCi/L

* The U.S. Department of Energy will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act—Cleanup" (carbon tetrachloride and trichloroethene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy. Groundwater standards are applicable or relevant and appropriate requirements which are used in the CERCLA cleanup process to select cleanup levels.

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

COC = contaminant of concern

OU = operable unit

¹ The RAOs identify the estimated time frame to achieve cleanup levels as 150 years. Fate and transport modeling identifies this time frame as 125 years, which is more conservative than the RAOs.

1.2 200-ZP-1 Operable Unit Selected Remedy

The selected remedy for the 200-ZP-1 OU has four components: (1) groundwater P&T, (2) monitored natural attenuation (MNA), (3) flow-path control, and (4) ICs. The first three components, which are the subject of this PMP, require periodic groundwater monitoring and data evaluation to assess remedy performance and determine when remedial action is complete. The fourth component does not require groundwater monitoring and is addressed separately in DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*. Descriptions of the first three components are presented in the following subsections.

1.2.1 Pump and Treat Component

The 200 West P&T design, well installations, and operations capture and treat contaminated groundwater to reduce the 200-ZP-1 COC mass by a minimum of 95 percent within 25 years. The P&T component is being implemented in combination with MNA to achieve the cleanup levels listed in Table 1 for all COCs within 125 years. Modeling performed for DOE/RL-2006-24 indicates that groundwater carbon tetrachloride greater than 100 µg/L corresponds to about 95 percent of the carbon tetrachloride mass currently in the aquifer. The estimated pumping rate required to reduce this mass by 95 percent within 25 years is 7,570 L/min (2,000 gallons per minute [gpm]) using 20 extraction wells and 16 injection wells.

Following extraction, the COCs in groundwater (except for tritium) will be treated to achieve the cleanup levels listed in Table 1. The treated groundwater will then be returned to the aquifer through injection wells. There is no cost-effective treatment technology to remove tritium from groundwater. However, the short half-life of tritium (12.3 years) will result in its decay below the cleanup standard before it naturally migrates from the 200 West Area industrial land-use zone.

The RD/RAWP (DOE/RL-2008-78) considers the need for treating other constituents (e.g., uranium) that may be captured by 200-ZP-1 OU extraction wells. While not 200-ZP-1 COCs, these constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs.

1.2.2 Monitored Natural Attenuation Component

In addition to the 200 West P&T, natural attenuation processes will help reduce COC concentrations to achieve cleanup levels (Table 1). During the early stages of remedy implementation, the 200 West P&T accounts for a majority of the contaminant mass removal. In the outer regions of the plume, and during the latter stages of P&T operation, natural attenuation plays an increasing role in reducing COC concentrations. Natural attenuation processes expected to contribute to COC concentration reductions include abiotic degradation, volatilization (for TCE and carbon tetrachloride), dispersion, sorption, and natural radioactive decay (for tritium). As presented in the 200-ZP-1 OU ROD (EPA et al., 2008), it is estimated that natural attenuation processes will reduce COC concentrations to 200-ZP-1 OU ROD cleanup levels within 100 years of final 200 West P&T operations. The overarching requirement is to meet the groundwater cleanup levels listed in Table 1 within 125 years.

1.2.3 Flow-Path Control Component

Flow-path control will be achieved by injecting treated groundwater into the aquifer to the northeast and east (downgradient) of the groundwater contamination (Figure 2). Injecting treated water at these locations will slow the natural eastward flow of most of the groundwater and keep the 200-ZP-1 COCs within the hydraulic capture zone of the extraction wells. Injection wells installed to the west (upgradient) will redirect groundwater flow to the east (toward the extraction wells), minimizing the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Gap toward the

Columbia River. Flow-path control also increases the time available for natural attenuation processes to reduce COC concentrations in areas not captured by the extraction wells.

1.3 Implementation of the Selected Remedy

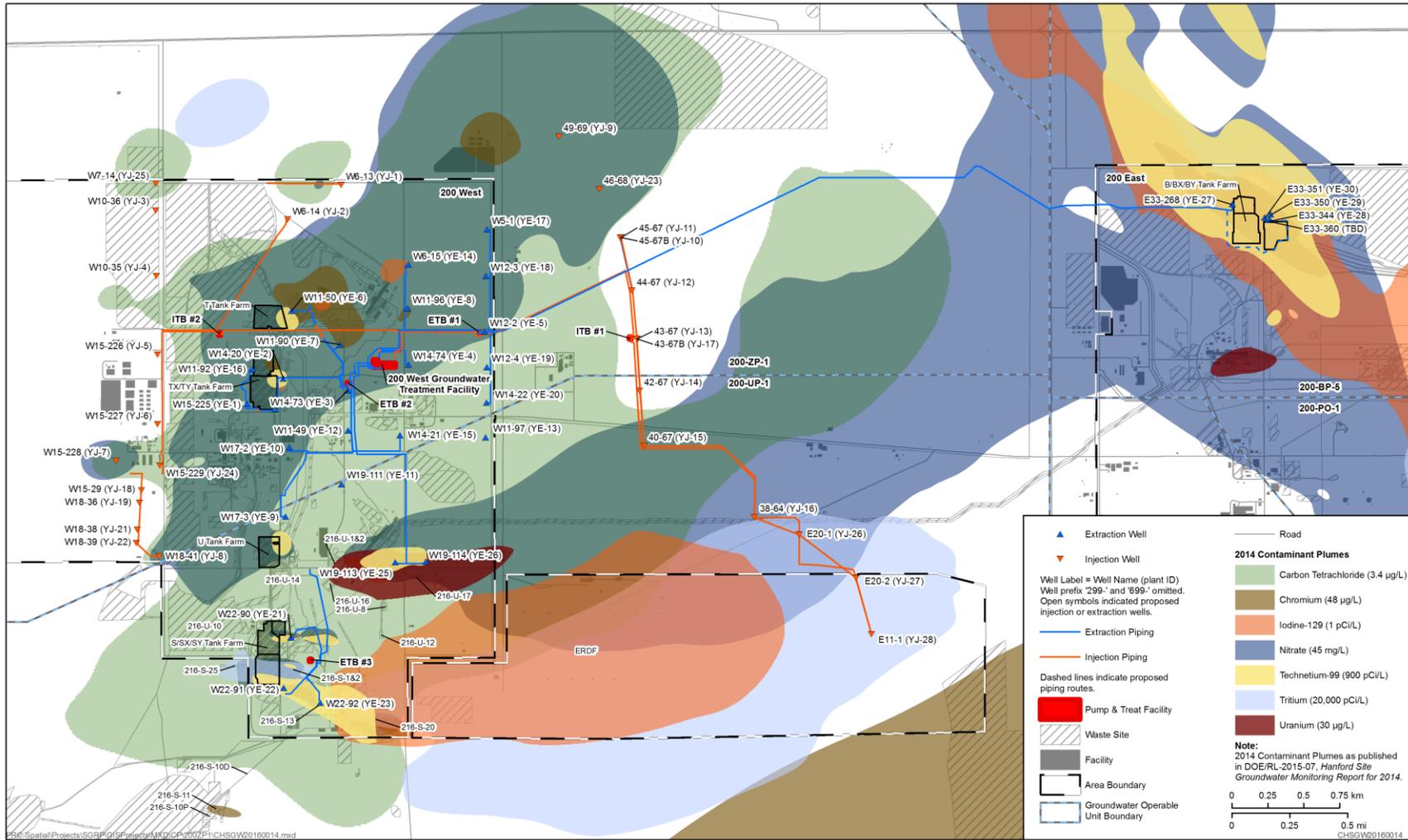
Since the 200-ZP-1 OU ROD (EPA et al., 2008) was signed in 2008, the 200 West P&T was constructed, 30 new extraction wells and 21 new injection wells were installed, and five interim P&T system injection wells were connected to the 200 West P&T system. The 200 West P&T, with a hydraulic capacity of 9,464 L/min (2,500 gpm), began operations in 2012 after interim facility operations ended. The design of the new 200 West P&T extraction, injection, and monitoring well field continues to evolve as data are collected and analyzed from drilling, sampling, and testing of new wells. If sampling results indicate that contamination below Ringold unit 8 (also known as the Ringold lower mud unit) is higher than the levels above the unit, changes to well designs and locations will be made to address this contamination and meet the ROD cleanup levels. These changes may include constructing extraction wells below Ringold unit 8 and injecting treated water to provide a vertical gradient to block eastern COC migration above the basalt and prevent contaminants from penetrating the basalt. If contamination is above the levels being addressed by MNA below Ringold unit 8, then extraction, injection, and monitoring well construction may be required below Ringold unit 8 to monitor contaminant migration and containment.

The new extraction wells are in areas with carbon tetrachloride greater than 100 µg/L (Figure 2). This design focuses active treatment on the most contaminated groundwater in this relatively large plume. The eastern injection wells are in areas with carbon tetrachloride less than 100 µg/L but possibly greater than 5 µg/L (Figure 2). Groundwater contaminated above cleanup levels downgradient of the eastern injection wells will be addressed by natural attenuation. The western injection wells are located where carbon tetrachloride concentrations are around 5 µg/L.

The 200 West P&T extracts some groundwater and associated contaminants originating from the 200-UP-1 OU. However, since the 200-UP-1 contribution is minimal, three categories of monitoring well networks have been defined for the 200-ZP-1 OU:

1. A volatile organic compound (VOC) network for monitoring carbon tetrachloride and TCE throughout the entire 200 West Area.
2. A monitoring network that includes only monitoring wells within the 200-ZP-1 OU.
3. Contaminant-specific networks for total and hexavalent chromium, iodine-129, nitrate, tritium, technetium-99, and uranium (uranium is a 200-UP-1 OU COC monitored in the 200-ZP-1 OU for tracking purposes only). The contaminant-specific network wells are a subset of the 200-ZP-1 network wells.

The carbon tetrachloride plume shown in Figure 2 represents the initial plume condition after P&T started in 2012. The transport model carbon tetrachloride concentrations are documented in ECF-200ZP1-13-0006, *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY 2012) 200 Areas Pump-and-Treat Report*.



Source: DOE/RL-2013-14, Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations.

Figure 2. 200 West P&T Well Field and Pipeline Routes Overlying the Carbon Tetrachloride Plume

The following appendices support this PMP:

- Appendix A presents the data quality objective results used to develop the sampling approaches.
- Appendix B presents data collection details in the sampling and analysis plan (SAP) for the 200-ZP-1 OU.
- Appendix C presents the sampling schedule for the performance monitoring network.
- Appendix D presents maps of carbon tetrachloride error variance supporting the data gap analysis.
- Appendix E presents the hydraulic monitoring well network and well construction details.
- Appendix F presents the 200-ZP-1 OU performance monitoring well network construction details and sample interval depth information.

2 Conceptual Site Model

This chapter summarizes 200 West Area geology, hydrogeology, and groundwater information from the 200-ZP-1 OU ROD (EPA et al., 2008) and is included to provide an overview of the current understanding of the CSM.

2.1 Local Geology

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington State. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the western end of the Central Plateau, near the center of the Hanford Site (Figure 1). The Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. The overlying sediments are about 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford formation, which consist of sand and gravel with some silt layers (Figures 3, 4, and 5). Surface elevations range from 200 to 217 m (660 to 712 ft) above mean sea level (amsl).

2.2 Local Hydrogeology

The sediment thickness above the water table (the vadose zone) ranges from 40 to 75 m (132 to 246 ft). Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the upper Ringold unit), the Cold Creek unit (CCU), and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and CCU. Perched water (water above the water table) has historically been documented above the CCU at 200 Area locations. However, since most area liquid waste discharges were stopped in 1995, perched water is now infrequently encountered in the 200 Areas.

Recharge to the 200 West Area unconfined aquifer is from artificial and natural sources. Natural recharge originates from precipitation, with recharge estimates ranging from 0 to 10 cm/yr (0 to 4 in./yr), largely dependent on soil texture and the type and density of vegetation. Artificial recharge historically occurred when effluents such as cooling water and process wastewater were disposed to the ground. The largest sources of artificial recharge ceased in 1995, with continuing Central Plateau artificial recharge largely due to sanitary sewage treatment and disposal systems; leaks from potable and raw water lines; two state-approved land disposal structures (Low-Level Waste Management Areas 3 and 4); and small-volume, uncontaminated, miscellaneous liquid waste streams. Small volumes of uncontaminated water may be used for dust suppression and contamination control during waste site excavation and facility construction activities.

2.3 Groundwater

Groundwater is found in an upper, primarily unconfined aquifer and in deeper, confined aquifers within the Ringold Formation and sedimentary interbeds in the basalt. The Columbia River is the primary discharge area for the unconfined and confined aquifers. The 200 West Area is located about 8 km (5 mi) south of the Columbia River. The 200-ZP-1 OU unconfined aquifer occurs in the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River). In general, the direction of groundwater flow through the Central Plateau is easterly (from the 200 West Area to the 200 East Area).

Historical discharges to the ground greatly altered the groundwater flow regime, especially around the 216-U-10 Pond in the 200 West Area and the 216-B-3 Pond in the 200 East Area. Discharges to the 216-U-10 Pond resulted in a groundwater mound more than 26 m (85 ft) above the aquifer. Discharges to the 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area, deflecting it north through Gable Gap (between Gable Mountain and Gable Butte) or south of the 216-B-3 Pond (Figure 6). As the hydraulic effects of these two discharge sites diminish, groundwater is expected to flow east through the Central Plateau, with some flow continuing through Gable Gap.

The depth to the water table in the 200 West Area varies from about 50 m (164 ft) in the southwest corner near the former 216-U-10 Pond to greater than 100 m (328 ft) in the north. The groundwater flow is primarily to the east, except in the northern portion of the 200 West Area where the flow is to the east-northeast. Groundwater flow is locally influenced by the 200 West P&T and permitted effluent discharges (State Approved Land Disposal Site [SALDS]) at Low-Level Waste Management Areas 3 and 4. The groundwater flow rates typically range from 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d) across the 200-ZP-1 OU (EPA et al., 2008). The water table continues to decline at a rate of approximately 0.21 m/yr (0.69 ft/yr) because the large artificial recharge that created the elevated water table was eliminated when production ceased at the Hanford Site.

2.4 Contaminant Distribution

Figures 4 and 5 show cross sections of the carbon tetrachloride concentrations in the 200 West Area. The figures depict a plume that is present at the water table in the source area and gradually enters the aquifer as it migrates downgradient. The downward migration of the plume is stopped by the relatively fine-grained Ringold unit 8, which acts as a hydraulic barrier to vertical groundwater flow. Ringold unit 8 is discontinuous and relatively thin in places. This allows the carbon tetrachloride plume to migrate downward to the basalt bedrock in those areas where the Ringold unit 8 is missing. The carbon tetrachloride plume does not extend into the basalt bedrock that defines the bottom of the unconfined aquifer system. Both the basalt bedrock and the Ringold unit 8 rise to the northeast and force the carbon tetrachloride plume to gradually rise toward the surface as it migrates eastward and as the saturated thickness of the aquifer decreases.

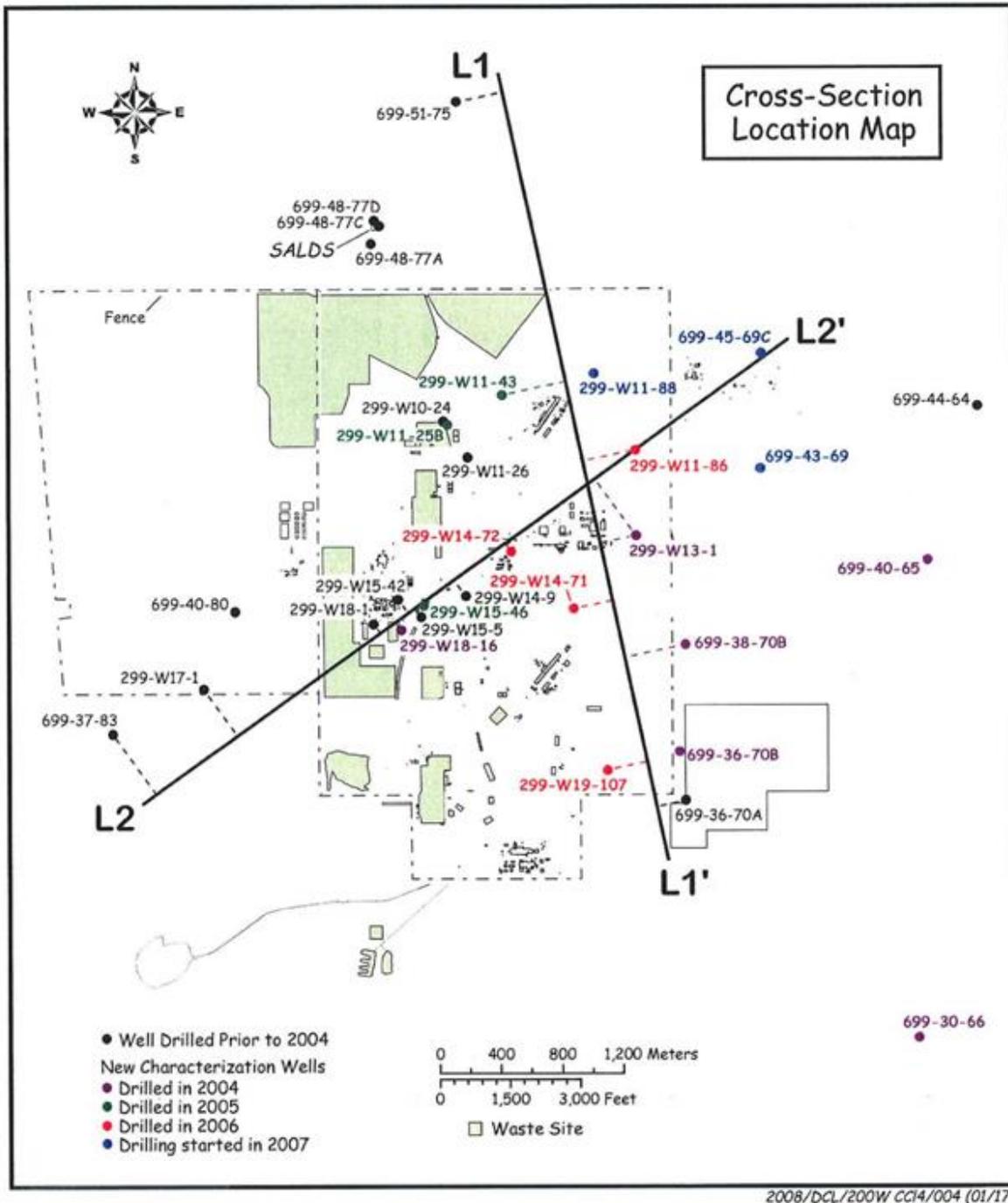


Figure 3. Location of Cross Sections, Including Wells Used for Interpretation

3 Conceptual Site Model Uncertainties

Several uncertainties associated with the current CSM could impact the success of 200-ZP-1 OU remedial action. These uncertainties include (1) the effectiveness of the Ringold unit 8 as a barrier to vertical contaminant migration, (2) Ringold unit 8 continuity, and (3) contaminant plume thickness near source areas. Near the contaminant source areas, Figures 4 and 5 depict 60 m (197 ft) of saturated aquifer above

the confining unit (Ringold unit 8). Below the confining unit, about 15 m (49 ft) of saturated aquifer is above the basalt bedrock. The continuity of the confining unit and its effectiveness as a hydraulic barrier to the vertical migration of contaminants are important to the design of the new extraction well field. If the Ringold unit 8 confining unit is an effective hydraulic barrier and contaminants have not migrated below it, then the extraction wells should be completed above Ringold unit 8. If the Ringold unit 8 confining unit is not an effective hydraulic barrier, is more discontinuous than previously believed, or contamination has migrated below it, then the extraction wells may need to extract groundwater from above and below the Ringold unit 8. If contamination has migrated below Ringold unit 8, the possibility of the carbon tetrachloride plume extending into the basalt bedrock may need to be further evaluated.

Few deep wells are near the source areas that monitor carbon tetrachloride to the top of Ringold unit 8 and below it to the top of the basalt bedrock; therefore, the thickness of the plume under the source area is relatively uncertain. A detailed discussion of how the uncertainties are being addressed is presented in Section 4.1.2.

4 Design of the Performance Monitoring Program

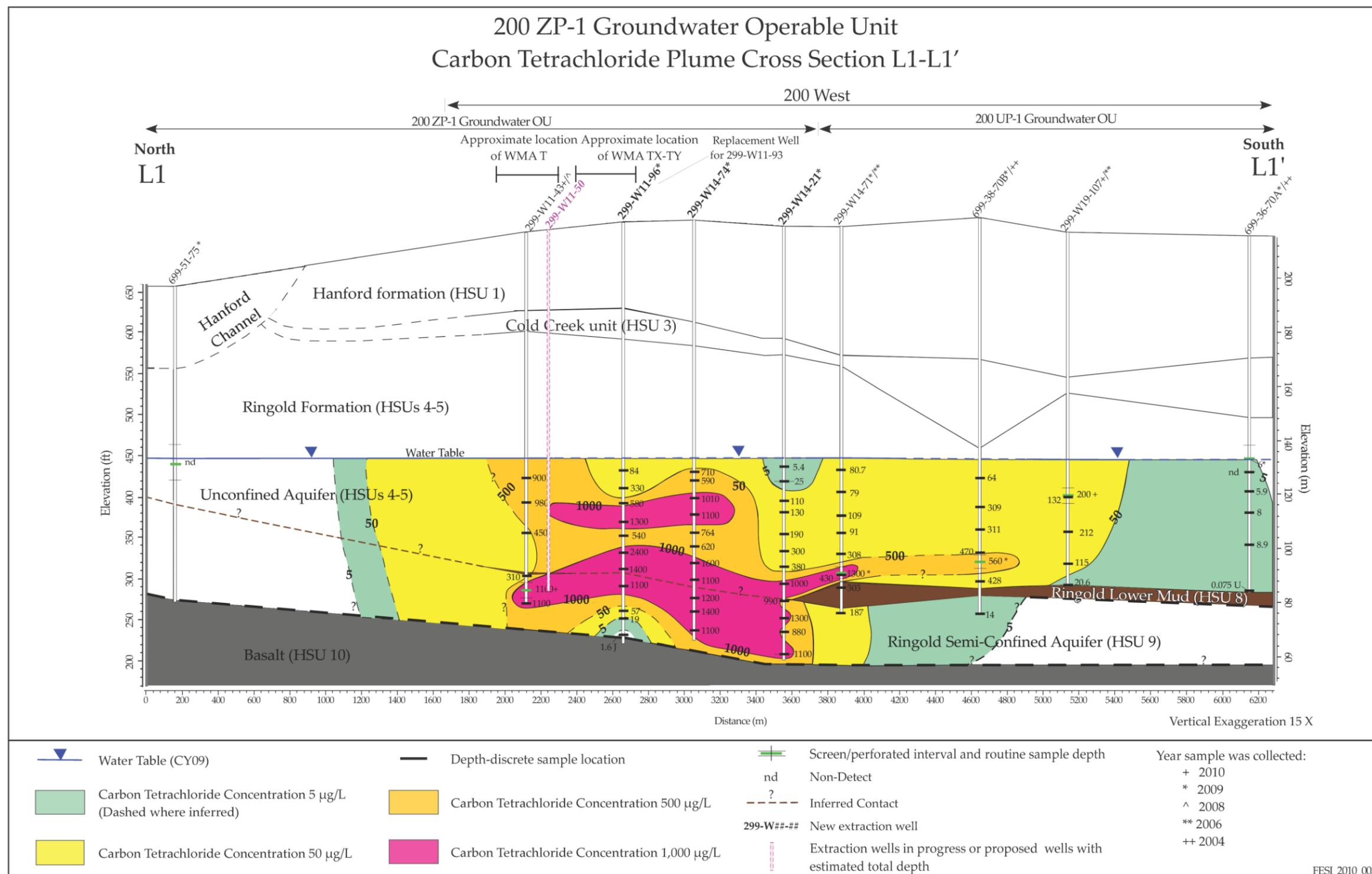
This chapter presents the groundwater monitoring activities associated with implementing the 200-ZP-1 OU remedial action. The program for collecting contaminant and hydraulic performance monitoring data is presented in this discussion, as well as guidance on how the monitoring data will be used to evaluate the success of the selected remedial action.

4.1 Contaminant Monitoring

Contaminant monitoring data will be collected over the projected 125-year lifetime of the remedial action to evaluate performance, optimize effectiveness, and determine when the remedial action is complete. The selection of the contaminant monitoring well network, sampling frequency, and analytical parameters are discussed in the following subsections.

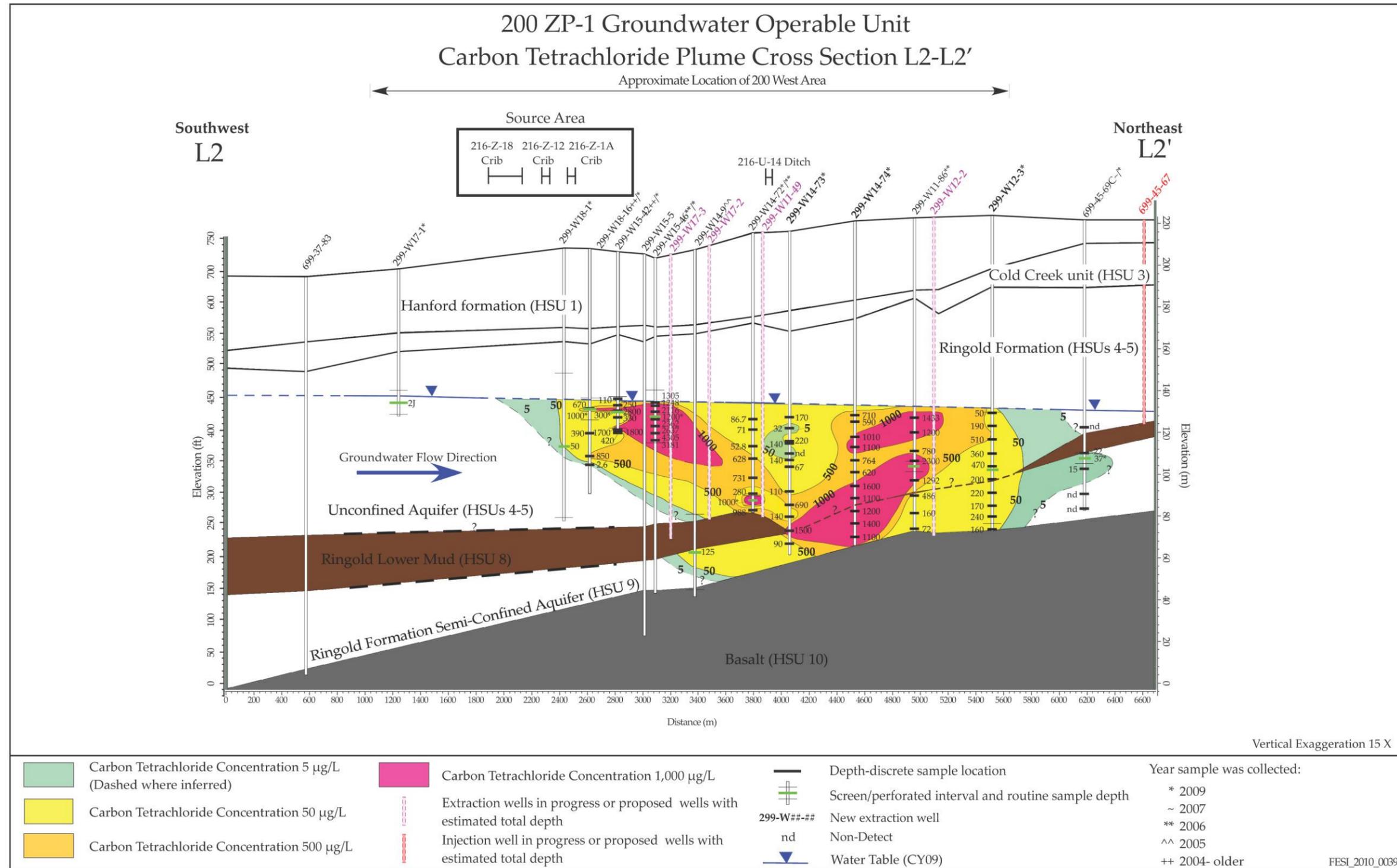
4.1.1 Contaminant Monitoring Network

The 200-ZP-1 OU, VOC, and other contaminant-specific well networks are presented in this PMP. The VOC and other contaminant-specific well networks are scheduled to be sampled annually, while the 200-ZP-1 OU network wells are scheduled to be sampled for all of the COCs every 5 years to support *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* 5-year reviews. Sampling the VOC and 200-ZP-1 well networks for the other contaminant-specific network COCs will generate sufficient data for quantitative analyses to address the nine decision statements (DSs) identified in the SAP (Appendix B, Section B1.3.2). These analyses include plume shell development (using the data to prepare three-dimensional depictions of the extent of contamination) and contaminant transport modeling (to predict if the remedial system will remove 95 percent of the COC mass within 25 years and achieve cleanup levels within 125 years). Sampling the VOC and other contaminant-specific networks will also provide data for qualitative analyses to address DSs #1, #2, and #5. These analyses include determining if new releases have occurred; evaluating trends in high-concentration plume areas; and determining if contamination is expanding downgradient, laterally, or vertically.



Source: This figure is modified from DOE/RL-2006-24, Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit.

Figure 4. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Northwest to Southeast (L1 to L1')



Source: This figure is modified from DOE/RL-2006-24, Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit.

Figure 5. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Southwest to Northeast (L2 to L2')

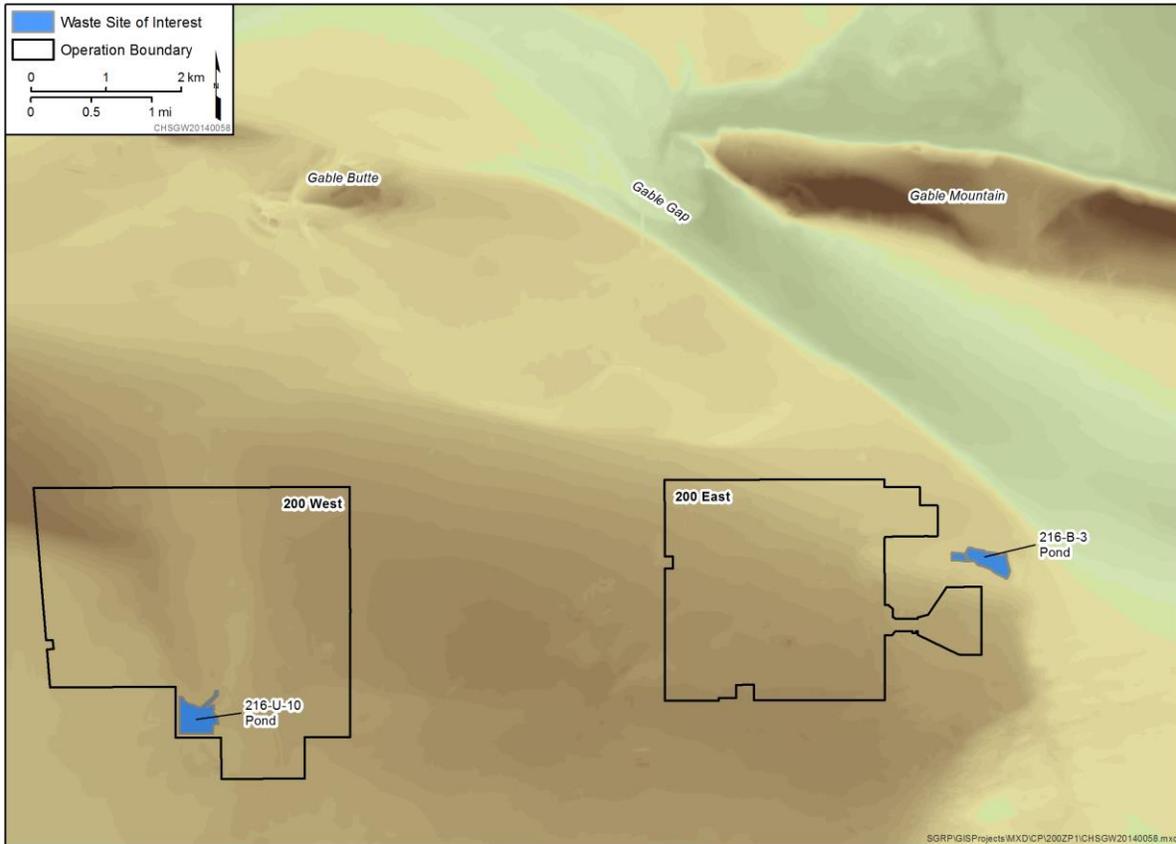


Figure 6. Aerial View of Gable Butte, Gable Gap, Gable Mountain, and the 200 Areas, Including U Pond and B Pond

The monitoring networks shown in Figures 7 through 13 will evolve over time as the 200 West P&T and natural attenuation processes reduce contaminant concentrations and plume sizes. Some plume areas will be cleaned up more quickly than others, and extraction wells will likely be shut down in stages as they become increasingly inefficient. Additionally, many of the shallow monitoring wells may go dry in areas that are the furthest from the east and west injection wells. Therefore, while the 200 West P&T is operating, the monitoring well networks and constituent analyses will be evaluated annually. These evaluations will determine if monitoring wells will be dropped from the networks and if new wells should be added to the VOC or other contaminant-specific well networks. Well network or COC analysis changes resulting from annual reviews will be made in concurrence with the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA). After the 200 West P&T is shut down (estimated in 2037), DOE and EPA will refine the data quality objectives and establish a monitoring scheme consistent with accepted technologies and techniques. At a minimum, the contaminant monitoring networks would be evaluated every 5 years in accordance with the CERCLA 5-year review process.

When developing the initial list of monitoring wells for the VOC network, a master list of available monitoring wells was queried from the well reports in the Environmental Dashboard Application database for the 200-ZP-1 and 200-UP-1 OUs. This query included well coordinates, construction information, and historical well purposes. Many of the well query results had missing information, especially for the older wells. This master list of monitoring wells was then reduced by determining if wells were missing crucial information, were found to be dry, or were located outside the performance monitoring area of interest. Many wells on the master list were missing screen top and screen bottom elevation data; however, this

information was included in the 2008 carbon tetrachloride plume shell data set. For these wells, the mid-screen elevation was included in Appendix C from the 2008 plume shell data set.

The remaining potential monitoring wells were then imported into the latest carbon tetrachloride plume shell grid and compared to the three-dimensional carbon tetrachloride plume shell to qualitatively evaluate their redundancy. At this stage of the evaluation, there was a relatively dense (i.e., well separation ranging from 40 to 260 m [131 to 853 ft]) network of shallow monitoring wells in the tank farm areas and a much more widely spaced (i.e., well separation ranges from 500 to 1,900 m [1,640 to 6,234 ft]) network of monitoring wells further to the east or deeper in the aquifer. Closely spaced monitoring wells were thinned out by considering their three-dimensional spatial proximity to other monitoring wells and their carbon tetrachloride concentrations. Monitoring wells that defined the high- and low-concentration areas were maintained, while wells that provided little added definition of the three-dimensional carbon tetrachloride plume shell were excluded. The goal of this evaluation was to improve future carbon tetrachloride plume shell development by providing a more spatially consistent and complete network of wells that monitor elevations from the basalt bedrock to the water table and can provide a more appropriate density of carbon tetrachloride data relative to the large scale of the plume.

After the potential monitoring well network was reduced by considering the usefulness of each well for defining the carbon tetrachloride plume, the other COCs were similarly considered. Monitoring wells that defined the high concentrations of other COCs, or were otherwise important to their plume definitions, were added back into the network. This step added some wells in the tank farm areas and also wells that are potentially downgradient of the carbon tetrachloride plume leading edge (other COCs, such as nitrate, have plume leading edges that extend further east).

The contaminant monitoring well network was established during the fiscal year (FY)/calendar year (CY) 2012 baseline sampling (before the July 2012 startup of the 200 West P&T). Some wells initially proposed for the VOC well network were rejected due to inaccessibility or lack of water. The VOC network includes 95 wells (Figure 7), and associated construction details are presented in Appendix F. The other contaminant-specific well networks include variable numbers of wells (Figures 8 through 13). The VOC monitoring network covers the entire 200 West Area, and 47 of the wells in the other contaminant-specific networks are in the 200-UP-1 OU. The 47 wells in the 200-UP-1 OU were not considered for monitoring the other 200-ZP-1 COCs. The remaining 48 wells comprise the 200-ZP-1 OU network. Sampling coordination between 200-UP-1 and 200-ZP-1 OU reduces redundancy and costs.

4.1.2 Data Gaps in Monitoring Well Coverage

A comparison of the available monitoring well coverage to the latest three-dimensional carbon tetrachloride plume shell revealed several areas that lack coverage. These data gaps resulted in areas of relatively large uncertainty in the carbon tetrachloride plume shell. In support of this data gap analysis, maps of kriged carbon tetrachloride error variance were produced for several elevation intervals in the aquifer. These maps reveal the areas in the kriged three-dimensional carbon tetrachloride plume shell with the greatest error variance or relative uncertainty (Appendix D). While these maps provide information about data distribution uncertainty, the maps depend on the kriging parameters used to generate them.

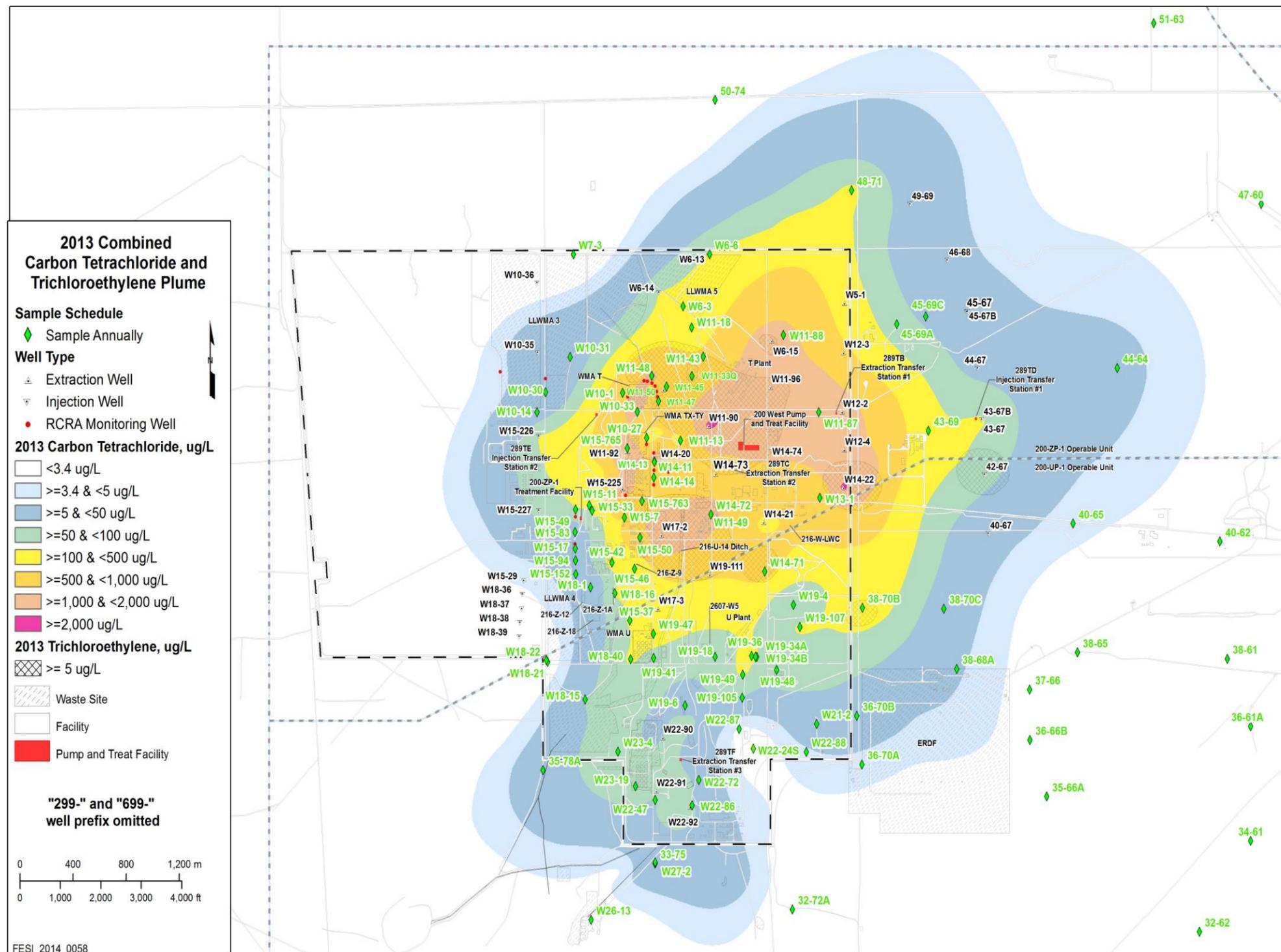


Figure 7. Contaminant Monitoring Well Network (VOC)

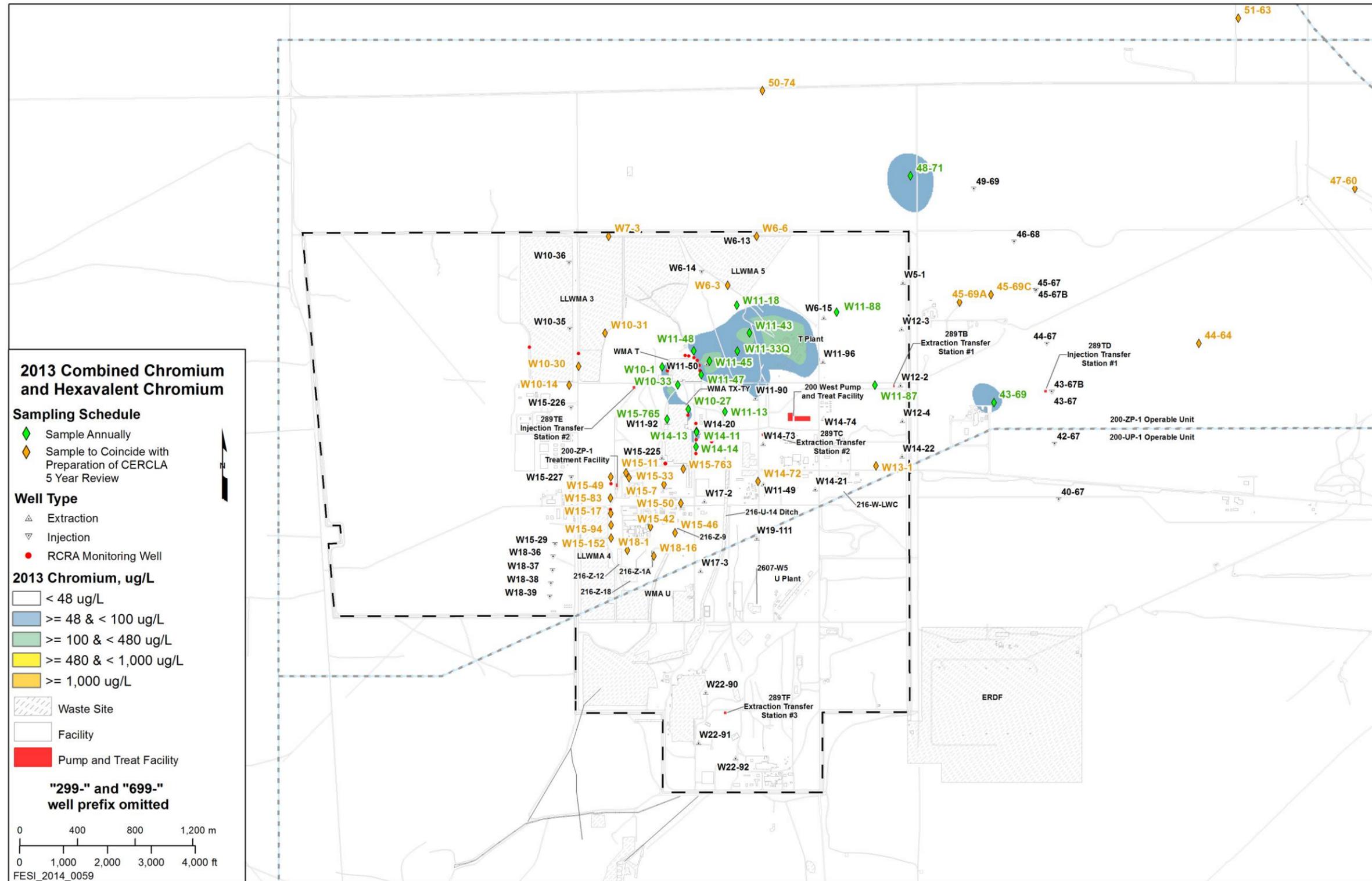


Figure 8. Contaminant-Specific Monitoring Well Network (Chromium)

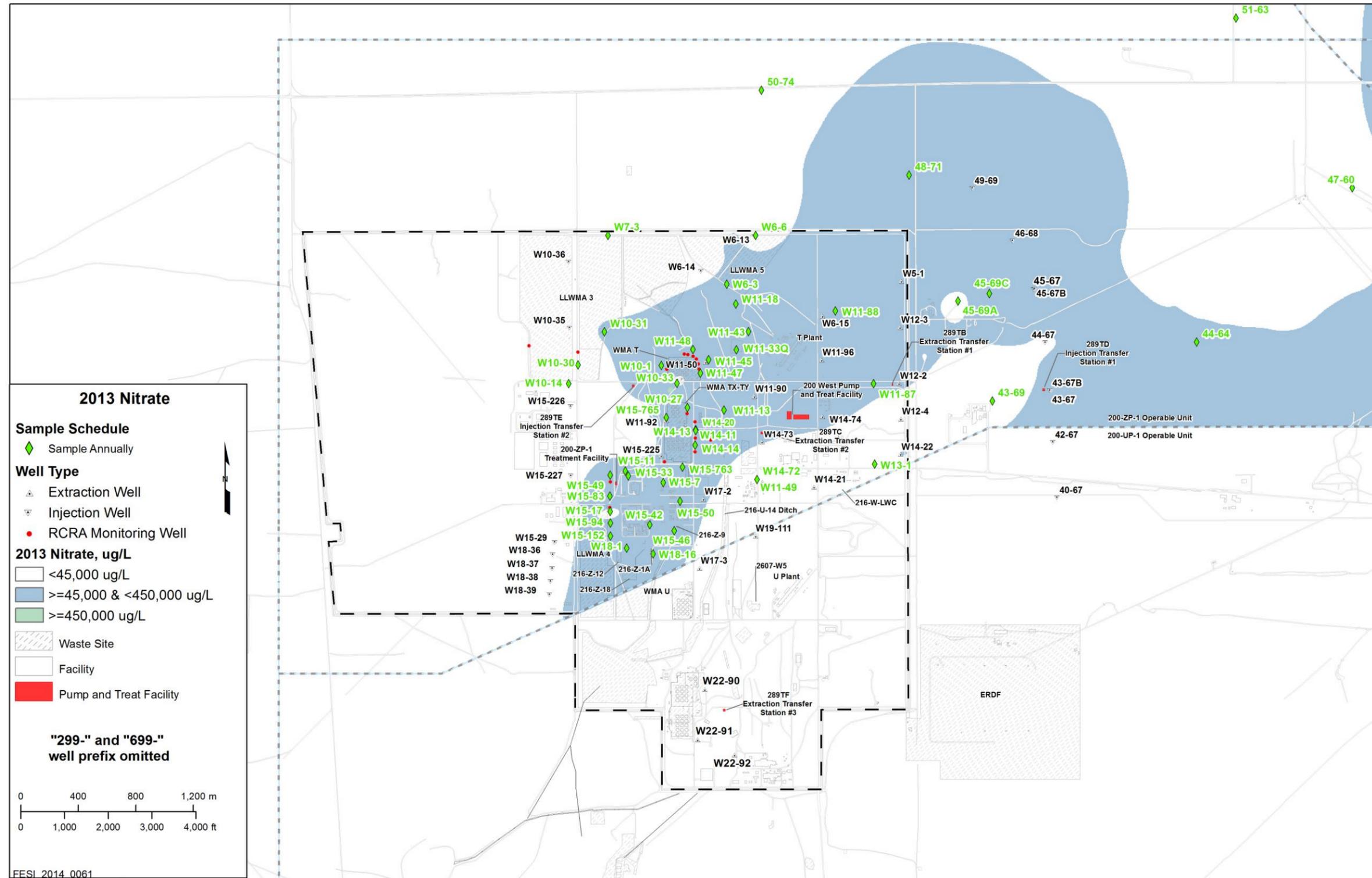


Figure 10. Contaminant-Specific Well Monitoring Network (Nitrate)

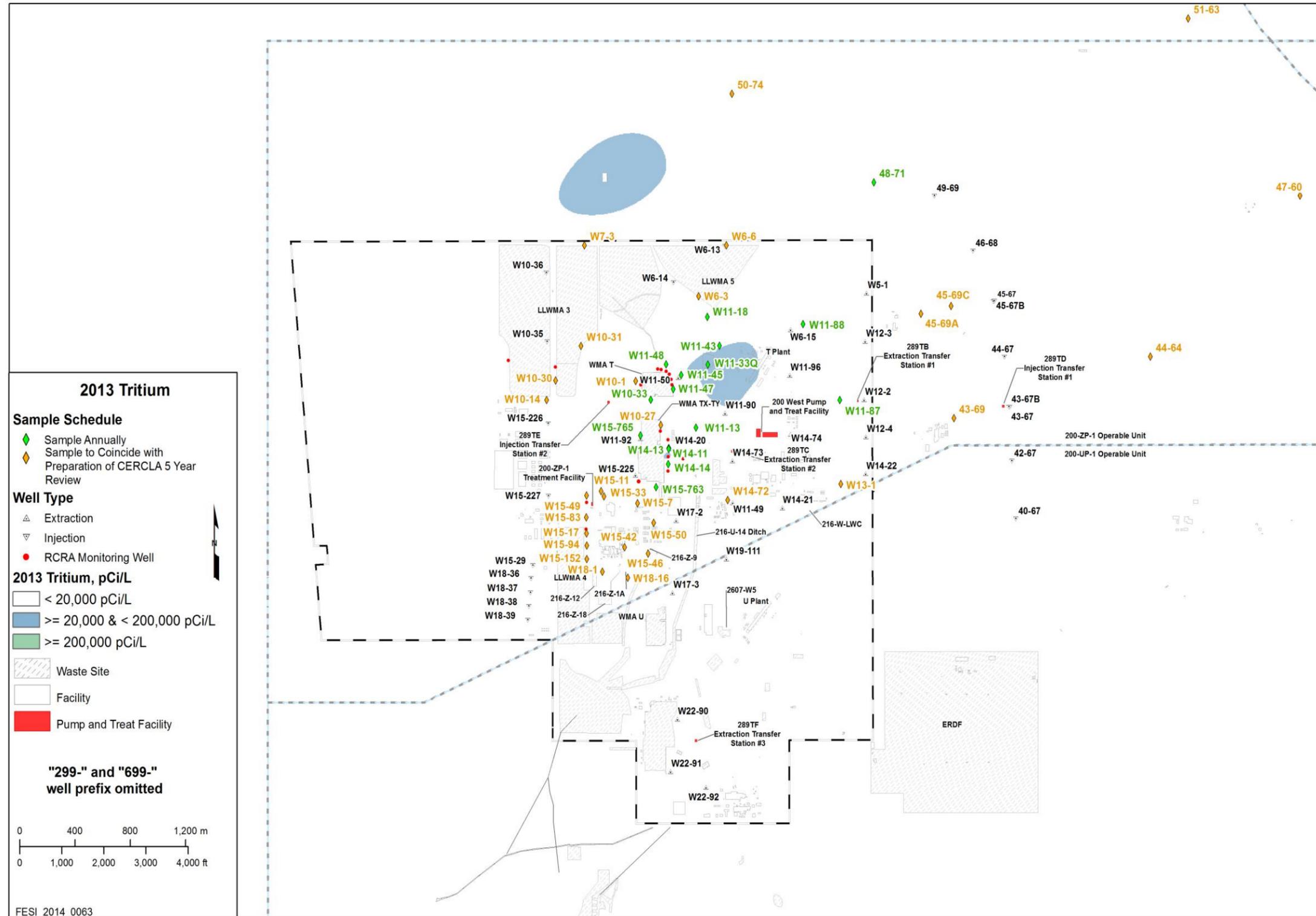


Figure 12. Contaminant-Specific Monitoring Well Network (Tritium)

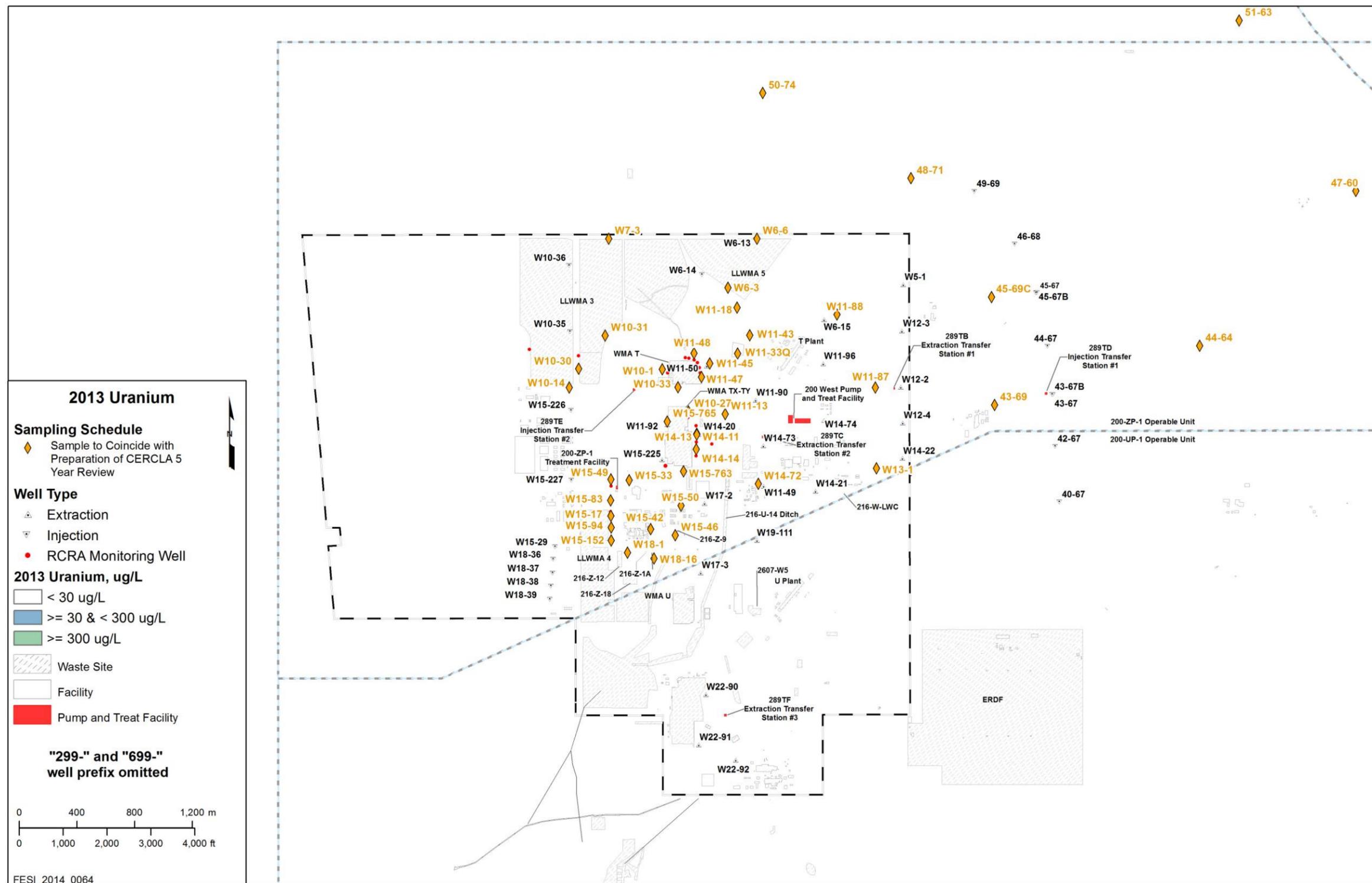


Figure 13. Contaminant-Specific Well Monitoring Network (Uranium)

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To reduce some of the more significant uncertainty in the carbon tetrachloride plume delineation, several new monitoring wells are proposed (Figure 14). Table 2 lists the locations and estimated mid-screen elevations of the proposed new monitoring wells. Priority rankings (highest priority is 1, lowest priority is 8) were assigned to each well based on the well's potential to reduce carbon tetrachloride distribution uncertainty. While some of these data gaps may be temporarily filled by one-time sampling when the proposed new extraction wells are drilled, the data gaps will remain and add uncertainty to future plume shells and transport simulations if not installed as proposed.

Proposed new monitoring wells MW1A, MW1B, and MW2 would help delineate the northern and northeastern boundaries of the carbon tetrachloride plume. Well 299-W11-87 has carbon tetrachloride (1,980 µg/L) at 103 m (338 ft) amsl, and well 299-W11-88 has carbon tetrachloride (850 µg/L) at 94 m (308 ft) amsl; however, no monitoring wells are screened at elevations to delineate the northern and northeastern extent of these concentrations. These new monitoring wells, installed in 2016, are also positioned between the western and eastern injection wells, within the area of groundwater extraction.

Proposed new monitoring wells MW3A, MW3B, and MW3C would fill gaps in the monitoring network between upgradient wells (e.g., 299-W10-33 and 299-W14-11) and downgradient wells (e.g., 299-W11-86 and 299-W11-87). This data gap represents about 1,325 m (4,347 ft) in the middle of the 200 West P&T extraction well field, with upgradient and downgradient carbon tetrachloride concentrations greater than 1,000 µg/L. The screen for MW3A should be completed below Ringold unit 8 to help delineate the northern extent of the deep carbon tetrachloride found at well 299-W13-1. The screens for MW3B and MW3C would be completed above Ringold unit 8.

Proposed new monitoring wells MW4A and MW4B would improve deep monitoring coverage near the source areas west of the TX/TY Tank Farms. These proposed new monitoring wells are also intended to provide deep monitoring coverage near the first 200 West P&T extraction well (299-W15-225) that was installed in 2009. The screens for MW4A and MW4B would be completed above Ringold unit 8.

Proposed new monitoring wells MW5A and MW5B would provide monitoring coverage above and below the existing monitoring well screen at well 299-W14-72 (mid-screen elevation of 88 m [289 ft] amsl). As with proposed new monitoring wells MW3A, MW3B, and MW3C, these proposed new wells are located in the middle of the new 200 West P&T extraction well field, upgradient of well 299-W13-1, which monitors deep aquifer carbon tetrachloride concentrations greater than 500 µg/L. The screen for MW5A is intended to be completed below Ringold unit 8, and the screen for MW5B would be completed above Ringold unit 8.

Proposed new monitoring wells MW6A and MW6B would provide deep (mid-screen elevations of 80 and 106 m [263 and 348 ft] amsl) monitoring coverage northeast of the U Tank Farm near the carbon tetrachloride source areas. These wells would help delineate the high-concentration southern boundary of the carbon tetrachloride plume under the source areas. The screen for MW6A would be completed below Ringold unit 8, and the screen for MW6B would be completed above Ringold unit 8.

Proposed new monitoring wells MW7A and MW7B would help delineate the downgradient extent of contamination found at sampling location 299-W13-1 and would help fill in the gap in monitoring coverage between monitoring wells 299-W13-1 and 699-40-65. Proposed new monitoring wells MW8A and MW8B would help delineate the downgradient extent of contamination found at 299-W11-87 and help fill the 1,880 m (6,168 ft) data gap in monitoring coverage between wells 299-W11-87 and 699-44-64. The screen for MW7B would be completed above Ringold unit 8 (if there is sufficient saturated thickness), and the screen for MW7A would be completed below Ringold unit 8. The proposed new monitoring wells are located upgradient of the 200 West P&T system eastern injection wells and downgradient of the extraction wells.

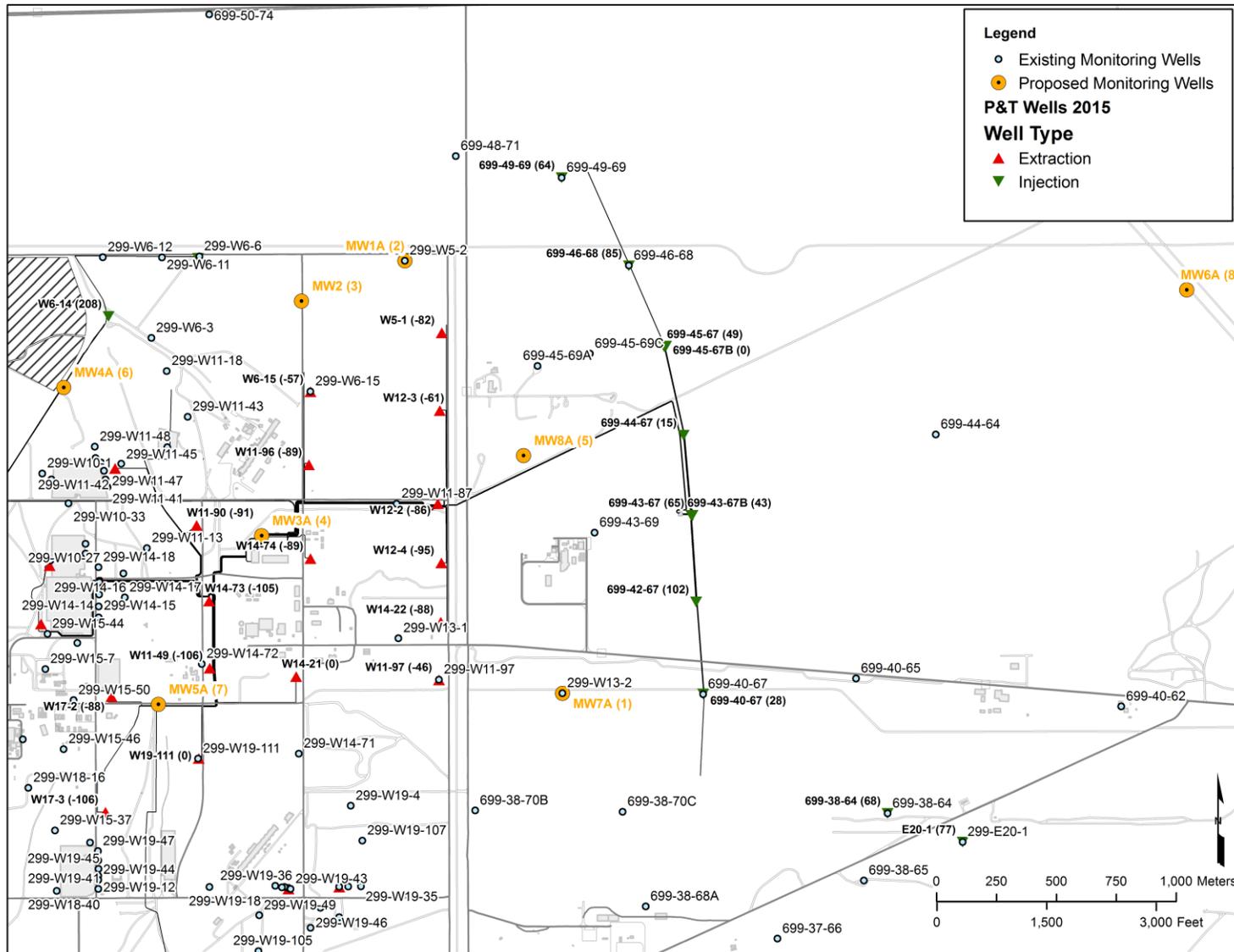


Figure 14. Proposed New 200-ZP-1 OU Monitoring Wells

Table 2. Proposed New Monitoring Wells

Well Priority	Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)
1	MW7B	568833	135819	120
	MW7A	568833	135819	100
2	MW1A	568175	137621	90
	MW1B	568175	137621	110
3	MW2	567744	137453	111
4	MW3A	567578	136476	73
	MW3B	567578	136476	92
	MW3C	567578	136476	112
5	MW8A	568670	136810	98
	MW8B	568670	136810	120
6	MW4A	566752	137093	80
	MW4B	566752	137093	100
7	MW5A	567147	135774	70
	MW5B	567147	135774	110
8	MW6A	571438	137500	80
	MW6B	571438	137500	106

amsl = above mean sea level

In 2016, proposed new wells MW1A, MW1B, MW7A, and MW7B were drilled and constructed. Depth-discrete data were collected during drilling, and the new wells are included in the SAP (Appendix B) as 299-W5-2 (with mid-screened intervals at 90 m [MW1A] and 110 m [MW1B] elevation) and 299-W13-2 (with mid-screened intervals at 100 m [MW7A] and 120 m [MW7B] elevation).

4.1.3 Contaminant Monitoring Frequency

An initial baseline sampling round was conducted using the VOC well network for all COCs and uranium during FY/CY 2012. This was followed by another sampling round of the VOC well network for all COCs and uranium in FY/CY 2013 to generate data after the first year of 200 West P&T remedial system operations. The data collected from this sampling event, in addition to the data collected from drilling and sampling the new extraction and injection wells, were used to construct baseline three-dimensional contaminant plume shells for each COC. This data set is the most comprehensive sampling data available and represents the most accurate initial masses and plume volumes for each COC (DOE/RL-2013-14, *Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit*

Pump-and-Treat Operations). These initial masses will be used to calculate the mass removal statistics for each COC over the life of the 200 West P&T remedial system operation to support DS #4.

During early operation of the 200 West P&T, groundwater samples have been collected from the VOC and contaminant-specific monitoring well networks annually. The groundwater flow velocities typically range from 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d) across the 200-ZP-1 OU, with an upper bound value of 0.5 m/d (1.64 ft/d) that corresponds to a maximum groundwater flow rate of about 180 m/yr (591 ft/yr). For the closely spaced, shallow monitoring wells in the tank farm areas (well separation ranging from 40 to 260 m [131 to 853 ft]), the minimum time for groundwater at one well to reach the next downgradient well ranges from 0.2 to 1.4 years. For the more widely spaced monitoring locations (well separation ranging from 500 to 1,900 m [1,640 to 6,234 ft]), the minimum time for groundwater at one well to reach the next downgradient well ranges from 2.7 to 10.5 years. There is minimal recharge of the aquifer from precipitation, and there are no signs of seasonal fluctuations in groundwater flow. Thus, contaminant sampling and subsequent delineation of contaminant distributions on an annual basis is appropriate given the size of the plumes, the groundwater flow velocities, and well spacing within the available monitoring well network.

Contaminant monitoring network sampling will coincide with CERCLA 5-year review preparations to provide a comprehensive data set to assess the progress of the remedial action against the RAOs and the DSs. This sampling may also include vertical profile sampling in existing monitoring wells to delineate each contaminant plume in three-dimensional space. In future 200 West P&T operations, when contaminant concentrations change less rapidly, the annual sampling frequency of the monitoring well networks will be re-evaluated.

After the P&T system is shut down (estimated for 2137), the frequency of contaminant monitoring will be evaluated based on the observed rate of change of the contaminant plumes. The contaminant monitoring frequency for monitoring wells near the last extraction wells shut down should be adequate to monitor for possible contaminant rebound in the years following well shutdown. Contaminant monitoring samples will be collected at least every 5 years to support CERCLA 5-year reviews.

Each extraction well is currently sampled quarterly. The data are needed to track contaminant mass removal, calibrate the COC plume shells, and optimize the mass removal performance for each extraction well. While extraction well contaminant concentrations are only needed every other year (biennially) for plume shell calibration purposes, it is prudent to monitor extraction well concentrations quarterly. The pumping rates and effective screen intervals of each extraction well can be used to optimize the contaminant mass removed per volume of groundwater extracted. The quarterly data are also needed to track contaminant mass removal during the remedial action. Some COCs may be detectable above cleanup levels in samples from individual extraction wells but may not be detectable in combined treatment plant influent samples. Therefore, without individual extraction well sampling results, the mass removal for COCs cannot be tracked using only combined treatment plant influent samples.

Once contaminant distributions and system operations have stabilized, the extraction well sampling frequency and the list of COCs will be evaluated and possibly changed with DOE and EPA concurrence.

4.1.4 Contaminant Monitoring Analytical Parameters

During the initial baseline sampling, contaminant samples collected from the monitoring wells were analyzed for the COCs and other potential contaminants listed in Table A-1 of Appendix A, as well as the biogeochemical and field screening parameters listed in Table A-2 of Appendix A. Subsequently, the constituents monitored were reviewed, and a reduced list of constituents was developed for each monitoring well with the intention of analyzing for the entire suite of contaminants and parameters listed

in Tables A-1 and A-2 of Appendix A every 5 years to coincide with CERCLA 5-year reviews. The review of constituents assessed the data trends in the Hanford Environmental Information System (HEIS) database from 1990 through 2013 for each well and considered constituents for elimination with respect to the baseline plumes prepared for DOE/RL-2013-14. The review found that the analytical parameters analyzed for each monitoring well are sufficient to delineate each contaminant plume in three-dimensional space, with subcleanup level concentrations surrounding each contaminant plume to define their boundaries.

The initial HEIS database query was limited to tritium, total and hexavalent chromium, iodine-129, technetium-99, and uranium² in 200-ZP-1 OU monitoring wells only. Carbon tetrachloride, nitrate, and TCE were not considered for reduction in analyses because they are everywhere in the 200-ZP-1 OU. Data with specific laboratory and review qualifiers were omitted from the data set, along with in-process and vertical profile data. Data were also omitted if they were considered inconclusive, such as data points with minimum detection limits or minimum detectable activities greater than the 200-ZP-1 OU ROD (EPA et al., 2008) cleanup levels. Undetected qualified data for radiological constituents were also replaced with one-half of the minimum detectable activity.

The data for each constituent were assembled to show the number of samples collected from 1990 through 2013, with subdata categories for the number of nondetects, the number of nondetects greater than the cleanup level, the number of detections, the number of detections greater than the cleanup level with the associated year(s), the first year sampled, the latest year sampled, and data trends in the context of the cleanup level. Each constituent and well was then evaluated against appropriate plume maps to determine if reduced analysis frequencies were appropriate. This evaluation considered the geographic location of the well with respect to the plume and data trends. Wells that were within the plume, were above the cleanup level, had increasing trends, were recently above the cleanup level (warranting continued monitoring), or were the first well downgradient were not considered for reduction. In some cases, the first well downgradient, or the sentinel well, was an extraction well on a quarterly monitoring schedule. The wells considered for reduced monitoring frequency did not have detections above the cleanup level and were stable or downward-trending below the cleanup level.

Contaminant monitoring samples collected from the extraction wells and the combined treatment plant influent and effluent will be analyzed for the contaminants listed in Table A-1 in Appendix A.

Beginning in FY 2014, the frequency of sampling for biogeochemical parameters analyzed to track natural attenuation processes was reduced to once every 5 years in conjunction with CERCLA 5-year reviews. Also, annual sampling for the full suite of parameters listed in Table A-2 in Appendix A was part of the remedial system baseline sampling, and this annual sampling frequency was reduced to once every 5 years due to active P&T operations beginning in FY 2014. When the 200 West P&T operations cease, the frequency of sampling for these parameters will be re-evaluated.

4.2 Hydraulic Monitoring

Hydraulic monitoring data will be collected over the lifetime of the remedial action to evaluate performance and optimize effectiveness. The selection of the hydraulic monitoring well network and measurement frequency are described in the following subsections.

² Uranium is included for tracking purposes only and is not a COC in the 200-ZP-1 OU.

4.2.1 Hydraulic Monitoring Network

The hydraulic monitoring well network is shown in Figure 15, and the available well construction details are listed in Appendix E. Hydraulic monitoring will be conducted for the duration of 200 West P&T operation. The hydraulic monitoring well network was derived using the same master list of available monitoring wells previously described for developing the contaminant monitoring network. This list was reduced to provide a more consistently spaced network of well screens, covering elevations ranging from the basalt bedrock to the water table surface elevation. Since hydraulic stresses are more homogeneous than contaminant concentrations, this network is less dense and more regularly spaced than the COC monitoring network. A few monitoring wells near the new 200 West P&T extraction wells were added to the network to provide data regarding extraction well influence on local hydraulic conditions in the aquifer. The monitoring wells cover a spatial area that exceeds the boundaries of the plumes and the 200 West P&T, so the hydraulic monitoring data can provide useful model calibration data.

Many of the hydraulic monitoring wells have transducers and data loggers to semicontinuously measure groundwater elevations. These wells are shown in Figure 15 and listed in Appendix E. The hydraulic monitoring well locations were chosen for the following reasons:

- Around the margins of the plumes, the wells help confirm inward or very much reduced gradients.
- In the core of the plumes, near the extraction wells, the wells collectively identify the magnitude and shape of the depression caused by pumping.
- Between the 200-ZP-1 and 200-UP-1 OUs, the wells help identify flow directions, which will become more important over time.

After shutting down the 200 West P&T operation, the hydraulic monitoring network will be re-evaluated. The density of the monitoring well network will likely be reduced to reflect the return of hydraulic gradients to a more regional groundwater flow pattern.

4.2.2 Hydraulic Monitoring Frequency

While the 200 West P&T is operating, a synoptic (concurrent) set of hydraulic monitoring data will be collected annually from the hydraulic monitoring well network, coordinated with the annual sitewide water table mapping task (generally in March) to avoid duplication of effort. Also, pre-remedial system startup data was collected from the network to provide baseline 200-ZP-1 OU hydraulic data. Changing remedial system groundwater extraction and injection rates result in changes to the three-dimensional groundwater head field, which can affect extraction well performance and plume capture success. The 200-ZP-1 OU water table continues to decline at a rate of about 0.21 m/yr (0.69 ft/yr) due to eliminating the historical large influx of artificial recharge that created the elevated water table. Therefore, annual hydraulic monitoring is prudent to ensure that the remedial system is operating optimally.

Many of the hydraulic monitoring wells are instrumented with transducers and data loggers to measure semicontinuous groundwater elevations. The aggressive pumping rates, low aerial recharge, and limited lateral inflow could cause some extraction well pumping rates to become unsustainable. Thus, the transient data logger groundwater elevation data will be evaluated to monitor the sustainability of the extraction well field and to optimize pumping, possibly by rebalancing upgradient and downgradient injection to ensure implementation of a sustainable remedy.

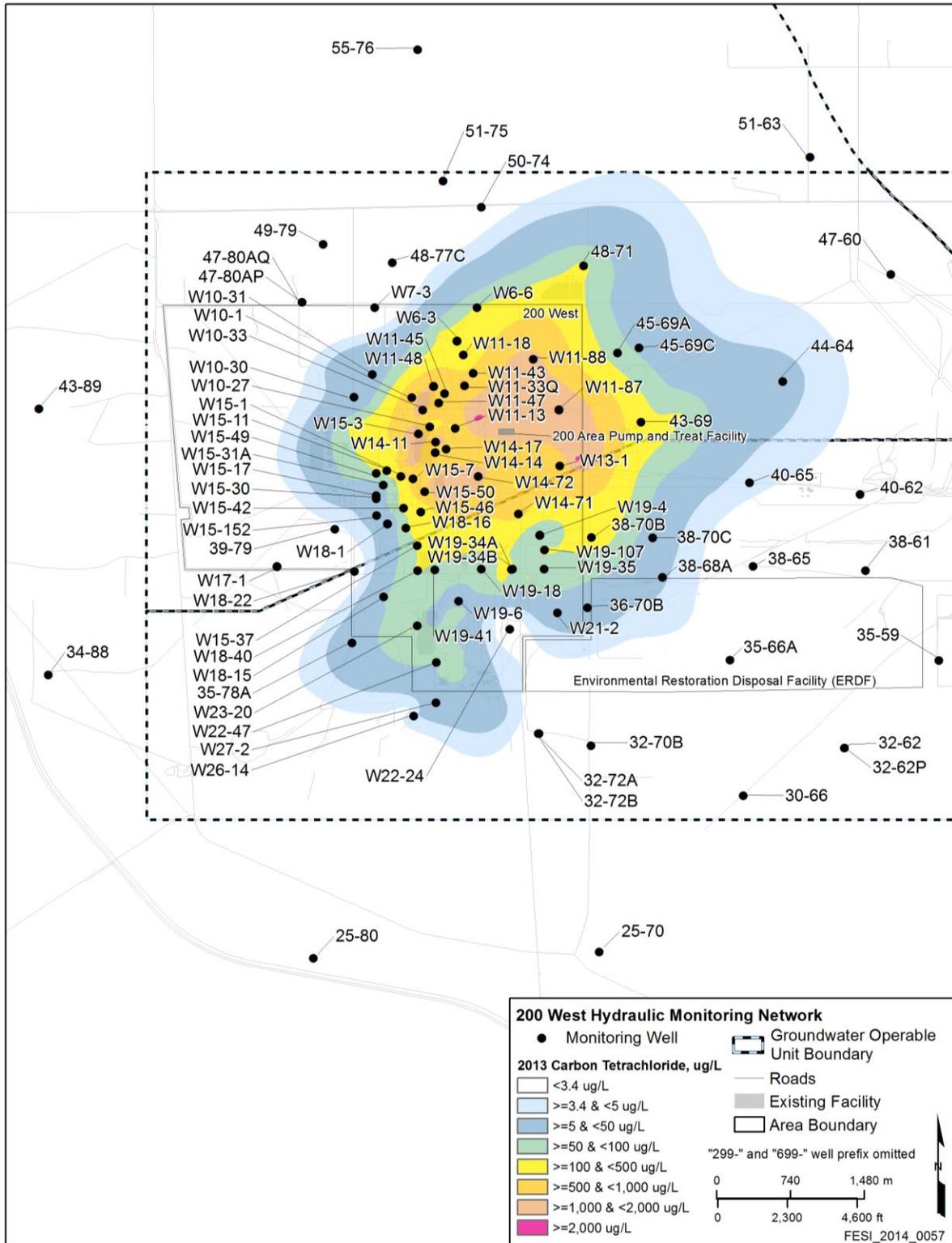


Figure 15. Hydraulic Monitoring Well Network

While the 200 West P&T is operating, flow rates will be measured in each extraction and injection well, and for the combined treatment plant influent, on a semicontinuous basis.

After the 200 West P&T is shut down, the frequency of hydraulic monitoring in monitoring wells will be evaluated based on how rapidly the water table stabilizes. At a minimum, a synoptic set of hydraulic monitoring data will be collected from the hydraulic monitoring well network every 5 years, coordinated with the annual sitewide water table mapping task, and in compliance with CERCLA 5-year reviews.

4.3 Performance Monitoring Analysis and Reporting

Results of performance monitoring will be analyzed and reported annually during the remedy. The first monitoring event was documented in the DOE/RL-2013-14. A suggested performance monitoring report outline, which is applicable during the early years of the remedy, is shown below. It should be noted, however, that not all of the report elements included in the suggested outline may be applicable to each performance period.

Suggested Performance Monitoring Report Outline (page 1 of 2)

1 Introduction

- 1.1 Purpose
- 1.2 Period of Performance
- 1.3 Report Organization

2 Remedial System Operation

- 2.1 Overview of Remedial System
- 2.2 Remedial System Monitoring Data
 - 2.2.1 Extraction and Injection Well Flow Rates
 - 2.2.2 Extraction Well Sampling Data
 - 2.2.3 Treatment Plant Influent and Effluent Flow Rates
 - 2.2.4 Treatment Plant Influent and Effluent Sampling Data
- 2.3 Analysis of Remedial System Monitoring Data
 - 2.3.1 Extraction Well Mass Removal
 - 2.3.2 Treatment Plant Mass Removal

3 Hydraulic Monitoring

- 3.1 Hydraulic Monitoring Network
- 3.2 Hydraulic Monitoring Data
 - 3.2.1 Synoptic Survey Data
 - 3.2.2 Transducer Data
- 3.3 Analysis of Hydraulic Monitoring Data
 - 3.3.1 Evaluation of Two-Dimensional Water Table
 - 3.3.2 Impacts to Remedy from Changing Groundwater Elevations

4 Contaminant Monitoring

- 4.1 Contaminant Monitoring Network and Parameters
- 4.2 Contaminant Monitoring Data
 - 4.2.1 Contaminants of Concern
 - 4.2.2 Natural Attenuation Daughter Products and Field Parameters

Suggested Performance Monitoring Report Outline (page 2 of 2)

- 4.3 Analysis of Contaminant Monitoring Data
 - 4.3.1 Evaluation of Two-Dimensional Contaminant of Concern Plume Boundaries
 - 4.3.2 Contaminant Plume Cross Sections
 - 4.3.3 New Releases of Contaminants of Concern
 - 4.3.4 Downgradient Plume Expansion
 - 4.3.5 Natural Attenuation Rates and Transformation Products
- 4.4 Plume Shell Development
 - 4.4.1 Contaminant Data Sets
 - 4.4.2 Interpolation of Contaminant Concentrations
 - 4.4.3 Plume Shell Masking
 - 4.4.4 Contaminant Mass and Volume
 - 4.4.5 Plume Shell Uncertainty
- 5 Groundwater Flow Model Development**
 - 5.1 Model Calibration
 - 5.1.1 Model Calibration Data Set
 - 5.1.2 Analysis of Calibration Residuals
 - 5.2 Simulated Three-Dimensional Hydraulic Capture
 - 5.3 Impact of Calibration Residuals on Simulated Hydraulic Capture
- 6 Contaminant Transport Modeling**
 - 6.1 Contaminant Transport Parameters
 - 6.2 Contaminant Transport Model Calibration
 - 6.2.1 Comparison of Observed and Simulated Extraction Well Concentrations
 - 6.2.2 Comparison of Observed and Simulated Remedial System Mass Removal
 - 6.3 Predictive Contaminant Transport Simulations
 - 6.3.1 Evaluation of 25-Year 95 Percent Contaminant of Concern Mass Removal Milestone
 - 6.3.2 Evaluation of 125-Year Contaminant of Concern Cleanup Milestone
- 7 Progress Toward Meeting Remedial Action Objectives**
- 8 Conclusions**
 - 8.1 Changes to the Conceptual Site Model
 - 8.2 Key Decisions Addressed by Performance Monitoring Data Collection
 - 8.2.1 Decision Statement #1
 - 8.2.2 Decision Statement #2
 - 8.2.3 Decision Statement #3
 - 8.2.4 Decision Statement #4
 - 8.2.5 Decision Statement #5
 - 8.2.6 Decision Statement #6
 - 8.2.7 Decision Statement #7
 - 8.2.8 Decision Statement #8
 - 8.2.9 Decision Statement #9
- 9 Recommendations**
- 10 References**

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Appendix A
Data Quality Objectives

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Terms

COC	contaminant of concern
DQO	data quality objective
DS	decision statement
EPA	U.S. Environmental Protection Agency
gpm	gallons per minute
MDL	method detection limit
MNA	monitored natural attenuation
N/A	not applicable
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
RAM	residual analysis method
ROD	Record of Decision

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A1 Data Quality Objectives

The data quality objectives (DQOs) for the 200-ZP-1 Operable Unit (OU) performance monitoring plan (PMP) were developed in accordance with EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process*. The DQO process involves a series of logical steps that guide managers or staff to establish a plan for the resource-effective acquisition of environmental data.

The DQO process is used to establish performance and acceptance criteria, which serve as the basis for designing the plan for collecting data of sufficient quality and quantity to support the goals of the study. The DQO process consists of the following seven iterative steps:

1. State the problem.
2. Identify the goal(s) of the study.
3. Identify the information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Each of the steps is further discussed in the following sections.

A2 State the Problem

The first step in the DQO process is to define the problem. For the 200-ZP-1 OU, sufficient monitoring data must be collected to optimally operate the groundwater pump and treat (P&T) system and verify that the contaminated groundwater is being remediated to the level specified in the Record of Decision (ROD) for 200-ZP-1 (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*).

A3 Identify the Goal(s) of the Study

The second step of the DQO process identifies key decisions and goals that must be addressed to achieve the final solution to the problem. As stated in ROD (EPA et al., 2008), the selected remedy combines P&T, monitored natural attenuation (MNA), flow-path control, and institutional controls to solve the problem. The performance monitoring goals for the first three of these components are addressed by this PMP. Monitoring data shall be collected over the life of the remedial action to evaluate its performance and optimize its effectiveness. The key questions that the data collection must address, along with alternative actions that may result based on analysis of the collected data, are presented below as a series of decision statements (DSs).

- **DS #1:** Determine if there are any new releases of contaminants of concern (COCs) that could impact the effectiveness of the remedy and necessitate changes to the remedial action and PMP; otherwise, continue with the current remedial action and PMP.
- **DS #2:** Determine if potentially toxic and mobile transformation products are being generated at concentrations high enough to justify their inclusion in the list of COCs with associated cleanup levels; otherwise, continue with the current list of COCs and associated cleanup levels.

- **DS #3:** Determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system, natural attenuation processes, and the flow-path control actions, thereby necessitating changes to the remedial action and PMP; otherwise, continue with the current remedial action and PMP.
- **DS #4:** Determine if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the P&T phase of the remedy; otherwise, evaluate modifications to the P&T system that could achieve the stated goal for the P&T phase of the remedy.
- **DS #5:** Determine if contamination is expanding downgradient, laterally or vertically after the P&T component has been turned off, thereby necessitating an evaluation of the predicted success of the remedial action; otherwise, continue with the current remedial action and PMP.
- **DS #6:** Determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years, and thereby achieve the overall remedial goal; otherwise, evaluate modifications to the remedial action that could achieve the stated goal for the overall remedy.
- **DS #7:** Determine if remediation has been successfully completed and a recommendation can be made for no further action; otherwise, continue with the current remedial action and PMP or determine if a technical impracticability waiver should be invoked.
- **DS #8:** Determine if certain areas of the contaminant plumes are not responding to P&T remediation as expected, and therefore require the evaluation of other technologies for a more focused remedy; otherwise, no new action is required.
- **DS #9:** Once 95 percent of the mass of COCs have been removed, determine if there is rebound in COC groundwater concentrations, which would require the P&T system to be turned back on; otherwise, leave the P&T system off and continue with MNA.

A4 Identify the Information Inputs

The third step of the DQO process identifies the data and information that may be needed to resolve the DSs listed in Section A3. The types and specifications of data that are collected are as follows:

- **Contaminant sampling data for the groundwater monitoring network:** Contaminant sampling for the monitoring well network is spatially sufficient to include possible 200 West Area contaminant sources, as well as delineate the horizontal and vertical extent of COC contamination above the cleanup levels. The groundwater samples are analyzed for the COCs listed in Table A-1. Analytical method detection limits (MDLs) are equal to or less than the cleanup levels listed in Table 1 (in Chapter 1 of this PMP). Groundwater samples are also analyzed for COC degradation products (Table A-1), as well as key biogeochemical and field parameters (Table A-2). The maximum acceptable detection limits for the COC degradation products are listed in Table A-1.

Table A-1. Contaminant Monitoring Constituents

Constituent	Maximum Acceptable Detection Limit	Units	Data Use
Contaminants of Concern			
Carbon tetrachloride	3.4 ^a	µg/L	Delineate carbon tetrachloride plume
Chromium (total)	100	µg/L	Delineate chromium plume
Hexavalent chromium	48	µg/L	Delineate chromium plume
Nitrate	10,000 ^b	µg/L (as N)	Delineate nitrate plume
Trichloroethene	1 ^a	µg/L	Delineate trichloroethene plume
Iodine-129	1	pCi/L	Delineate iodine-129 plume
Technetium-99	900	pCi/L	Delineate technetium-99 plume
Tritium	20,000	pCi/L	Delineate tritium plume
Other Potential Contaminants			
Uranium (from the 200-UP-1 Operable Unit)	30 ^b	µg/L	Delineate uranium plume
Chloroform	70 ^b	µg/L	Evaluate carbon tetrachloride natural attenuation
Dichloromethane	5 ^b	µg/L	Evaluate carbon tetrachloride natural attenuation
Chloromethane	N/A ^c	N/A	Evaluate carbon tetrachloride natural attenuation
cis-1,2-Dichloroethene	70 ^b	µg/L	Evaluate trichloroethene natural attenuation
Vinyl chloride	2 ^b	µg/L	Evaluate trichloroethene natural attenuation
Chloride	1,000	µg/L	Evaluate chlorinated solvent natural attenuation
Nitrite	1,000 ^b	µg/L (as N)	Evaluate nitrate natural attenuation

a. The U.S. Department of Energy will clean up contaminants of concern for the 200-ZP-1 Operable Unit subject to WAC 173-340, "Model Toxics Control Act—Cleanup" (carbon tetrachloride and trichloroethene) so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. Federal drinking water standard.

c. No federal drinking water standard.

N/A = not applicable

Table A-2. Biogeochemical and Field Screening Monitoring Parameters

Constituent	Typical Method	Units	Data Use
Biogeochemical Parameters			
Total organic carbon	EPA 415.1	mg/L	Evaluate natural attenuation
Total dissolved solids	EPA 160.1	mg/L	Evaluate natural attenuation, identify new releases
Sulfate	EPA 300.0A	mg/L	Evaluate natural attenuation
Sulfide	EPA 9215	mg/L	Evaluate natural attenuation
Iron	EPA 6010B	µg/L	Evaluate natural attenuation
Manganese	EPA 6010B	µg/L	Evaluate natural attenuation
Alkalinity	EPA 310.1	mg/L (as carbonate)	Evaluate natural attenuation
Carbonate content (bicarbonate and carbonate)	EPA 310.1	mg/L (as carbonate and bicarbonate)	Evaluate natural attenuation
Field Screening Parameters			
Temperature	Hach HQ40d (or equivalent)	°C	Evaluate well purge for sampling
pH	Hach HQ40d (or equivalent)	pH unit	Evaluate well purge for sampling
Specific conductance	EPA 1201.1	mS/cm	Evaluate well purge for sampling
Turbidity	Hach 2100P Turbidimeter HQ40d (or equivalent)	NTU	Evaluate well purge for sampling
Dissolved oxygen	Hach HQ40d (or equivalent)	mg/L	Evaluate natural attenuation
Reduction-oxidation potential	USGS, 2015, <i>National Field Manual for the Collection of Water-Quality Data</i>	mV	Evaluate natural attenuation

Note: Hach® is registered trademark of the Hach Company, Loveland, Colorado.

EPA = U.S. Environmental Protection Agency

- Hydraulic monitoring network data:** The hydraulic monitoring well network covers an area larger than the area covered by the P&T extraction and injection wells. The spatial density of monitoring wells is the greatest in the area bounded by the east and west injection well fences (shown in Figure 2 in Chapter 1 of this PMP). The monitoring wells have sufficient vertical coverage to monitor elevations ranging from the basalt bedrock up to the water table interface. Operating extraction wells are not included in the groundwater elevation monitoring well network. The hydraulic monitoring data includes manually measured groundwater elevations collected as a synoptic data set (i.e., data that are all collected on the same day or at least under the same pumping and recharge conditions)

and transducer-measured groundwater elevations collected semicontinuously. Measured groundwater elevations are accurate to the nearest 0.61 cm (0.02 ft).

- **Remedial system monitoring data:** Extraction and injection well flow rates are measured at each well on a semicontinuous basis using in-line flow meters accurate to 5 percent of the pumping rate. Combined influent and effluent contaminant monitoring samples are collected from the treatment plant influent and effluent sampling ports while the extraction wells are pumping, preferably at design rates. The samples are analyzed for the COCs listed in Table 1 (in Chapter 1 of this PMP), and the analytical MDLs are equal to or less than the cleanup levels listed in Table 1. Extraction well contaminant monitoring samples are collected from the sampling port at each individual extraction well while the well is pumping, preferably at the design rate. The samples are analyzed for the COCs listed in Table-1, and the analytical MDLs are equal to or less than the cleanup levels listed in Table 1.

A4.1 Data Inputs to Resolve Decision Statement #1

Groundwater sampling data collected from the contaminant monitoring well network are necessary to determine if new COC releases occur. The sampling data are used to establish concentration trends in monitoring wells and to delineate the three-dimensional boundary of each contaminant plume at the cleanup-level concentration.

Hydraulic monitoring data, extraction and injection well flow rate data, and extraction well contaminant sampling data are needed to determine if any new COC releases could impact remedy effectiveness. Hydraulic monitoring data and the 200 West Area calibrated groundwater flow model are used to evaluate if any new releases are outside of the hydraulic capture zone of the P&T system. Extraction and injection well flow rates are needed for model input. The contaminant transport model is used to predict if any new COC releases will impact either the goal of 95 percent mass removal within 25 years or the goal of aquifer cleanup within 125 years. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, is needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data are used to determine if any new COC releases could impact the treatment process.

A4.2 Data Inputs to Resolve Decision Statement #2

Groundwater sampling data collected from the contaminant monitoring well network are used to determine if potentially toxic and mobile transformation products are generated within the OU. Monitoring for potential COC degradation products is critical for evaluating natural attenuation processes and may indicate that COC degradation products are present at concentrations that could impact the success of the remedial action. The analytical MDLs listed in Table A-1, which are the federal drinking water maximum contaminant levels, are the comparison levels needed to evaluate the concentrations of any potentially toxic and mobile transformation products.

A4.3 Data Inputs to Resolve Decision Statement #3

Hydraulic monitoring data and groundwater contaminant sampling data are used to determine if changes occur in environmental conditions that may reduce the efficacy of the P&T system, natural attenuation processes, and flow-path control actions. Groundwater elevations have been decreasing in the 200 West Area for several years and are expected to decrease further in the P&T system extraction well field. These decreases in groundwater elevation may cause monitoring wells to go dry and may require removing the wells from the monitoring well network. The aggressive pumping rates, low aerial recharge,

and limited lateral inflow could also cause some extraction well pumping rates to be unsustainable. Thus, groundwater elevation data are needed to monitor the hydraulic response of the aquifer to the operation of the P&T system. Monitoring COC degradation products, as well as the biogeochemical and field measurement parameters, is critical for evaluation of the natural attenuation processes. Thus, groundwater sampling data collected from the contaminant monitoring well network are used to monitor changes that may be occurring in environmental conditions that could reduce the efficacy of the natural attenuation processes.

A4.4 Data Inputs to Resolve Decision Statement #4

Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well and combined treatment plant influent and effluent contaminant sampling data are used to verify and predict if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less. The 200 West Area calibrated groundwater flow and contaminant transport model is also used to predict if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less. A contaminant transport run spanning at least 25 years will be needed for each COC. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, is needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data may be used to calibrate each COC plume shell. Current and anticipated extraction and injection well flow rates will also be needed as input to the model. A starting mass for each COC was needed to calculate percentage contaminant mass reduction for each COC. The starting masses for each COC are provided in DOE/RL-2009-38, *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan*, although the current plume shells and starting masses are re-evaluated after completing drilling and sampling at each new extraction and injection well location. The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data are used to calculate the actual contaminant mass removed by the P&T system.

A4.5 Data Inputs to Resolve Decision Statement #5

Groundwater contaminant sampling data collected from the monitoring well network will be used to determine if contamination is expanding downgradient, laterally or vertically, after the P&T system has been shut down. Plots of measured contaminant concentration trends in downgradient monitoring wells may be needed to evaluate the expansion and migration of the contaminant plumes. Additionally, three-dimensional contaminant plume shells (constructed from the groundwater contaminant sampling data for each COC) may be needed to evaluate contaminant distributions and calculate plume volumes and contaminant masses.

A4.6 Data Inputs to Resolve Decision Statement #6

Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well contaminant sampling data are used to determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years. The existing 200 West Area calibrated groundwater flow and contaminant transport model is also used to predict if the P&T system will achieve cleanup levels for all COCs within 125 years. A contaminant transport run spanning at least 125 years is needed for each COC. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, will be needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data may be used to calibrate each COC plume shell. Current and anticipated extraction and injection well flow rates will also be needed as input to the model if the simulation starts while the P&T system is still operating.

A4.7 Data Inputs to Resolve Decision Statement #7

Groundwater contaminant sampling data will be used to determine if remediation has been successfully completed.

A4.8 Data Inputs to Resolve Decision Statement #8

Groundwater contaminant sampling data are used to determine if certain areas of the contaminant plumes are not responding to P&T remediation.

A4.9 Data Inputs to Resolve Decision Statement #9

Groundwater contaminant sampling data will be used to determine if there is a rebound in groundwater contaminant plumes after 95 percent of the mass of COCs have been removed and the P&T system has been turned off.

A5 Define the Boundaries of the Study

In the fourth step of the DQO process, the spatial and temporal features pertinent to the decision-making process are identified. The 200-ZP-1 performance monitoring network must verify that cleanup levels have been achieved in all areas of the groundwater plumes. Spatially, this covers an area from the western injection well fence to the eastern leading edges of the plumes. Elevations range from the top of the basalt bedrock to the water table surface elevation. The current 200-ZP-1 conceptual site model does not include any COC concentrations greater than cleanup levels in the basalt bedrock. Performance monitoring is expected to continue until cleanup levels have been achieved, which is estimated to be 125 years.

A6 Develop the Analytic Approach

The fifth step of the DQO process involves developing an analytical approach that outlines how the performance monitoring data will be used to make decisions regarding the progress of the selected remedy. The analytical approach for using the data inputs to resolve each of the DSs is presented in the following subsections.

A6.1 Approach to Resolve Decision Statement #1

Groundwater contaminant sampling data will be evaluated to determine if any new COC releases have occurred. Monitoring well concentration trends will be evaluated, and the sampling data will be used to update the three-dimensional plume shell for each contaminant. If contaminant concentrations in a monitoring well are stable or increasing, and there is no known upgradient dissolved-phase contaminant mass to support these stable or increasing concentrations, a new release may have occurred. Dissolved-phase contaminant mass may also be present in a low-conductivity zone or contaminant mass may be adsorbed onto fine-grained, low-conductivity materials that is slowly solubilizing and acting as a continuing source. Whatever the mechanism, it should be evident from evaluation of concentration trends in monitoring data and comparison of current to previous contaminant plume shells, that if an area of a COC plume is not responding to the P&T system, then that area should be evaluated as a possible new COC release. Understanding the three-dimensional distribution of the contaminant concentrations as the contaminant plumes evolve is essential to the success of the selected remedy. Contaminant plume shells will be used for the following:

- Visualizing the distribution of dissolved-phase groundwater contamination in three dimensions
- Estimating the dissolved-phase contaminant mass and volume of the plumes
- Initializing contaminant concentrations in the groundwater model for running contaminant transport simulations

Plume shells are constructed by interpolating the scattered concentration data points to a grid using ordinary kriging. Kriging is a linear, unbiased, least-squares spatial interpolation method that uses a weighted-average estimator to approximate the value of a regionalized variable at a spatial location (Isaaks and Srivastava, 1989, *An Introduction to Applied Geostatistics*). The kriging process is used to generate a single best estimate of each contaminant distribution. Each plume shell should be masked to mitigate artifacts of the kriging process that would otherwise produce hydraulically unreasonable extrapolations of contaminant concentrations into areas with no data coverage. The mask is applied in plan view and is used to define the maximum lateral extent of contamination present at concentrations above cleanup levels. Outside the plan view mask boundary, interpolated contaminant concentrations are set to 0 µg/L. Using kriging to generate plume shells in this manner should mitigate some of the subjectivity that can accompany manual contouring of contaminant concentration data.

Observed extraction well effluent concentrations can be used along with the contaminant transport model to calibrate the COC plume shells and the model. The COC plume shells can be imported into the contaminant transport model, which can then be run to obtain simulated extraction well contaminant concentrations. These simulated concentrations can then be compared to the observed extraction well concentrations to calibrate the plume shells and model in an iterative process. This calibration process may result in changes to the plume shells and model and is another way to use all available lines of evidence to monitor the remedy performance.

A new release can impact the effectiveness of the remedy in several ways. The contaminant concentration could exceed the maximum design concentration for the contaminant in the combined treatment plant influent. The 200 West Area calibrated groundwater flow and contaminant transport model is used to predict the influent contaminant concentrations in individual extraction wells. The individual extraction well influent concentrations can be summed to predict the combined treatment plant contaminant influent concentrations. The simulated treatment plant influent concentrations can then be compared to the maximum design concentrations to determine if a new release has added sufficient contaminant mass to a contaminant plume to impact the treatment process.

A new release can also impact the effectiveness of the remedy if the spatial position of the new release is outside the hydraulic capture zone of the P&T system extraction wells. The three-dimensional hydraulic capture zones of the remedial system extraction wells are delineated using particle-tracking simulations and a groundwater flow model solution. In these simulations, one particle is started in each model cell in the area of the hydraulic monitoring network. Particles that are started in the model cells located within the capture zones migrate to an extraction well and are captured. Particles starting in model cells outside the capture zones discharge to exit points in the model other than the extraction wells. The capture zones are then illustrated by three-dimensional visualization software, which creates bounding surfaces between the captured and uncaptured portions of the aquifer. Superimposing the three-dimensional capture zones over the three-dimensional plume shells reveals whether each COC is being captured by the P&T system. These three-dimensional capture zones can be presented in plan view as a set of two-dimensional slices through the aquifer, superimposed over the applicable two-dimensional slices through the three-dimensional contaminant plume shells. Comparison of the capture zones to the COC distributions is used to evaluate contaminant capture.

Early in the life of the remedy, the majority of extracted water will likely come from storage depletion in the aquifer, which will diminish over time as the extracted water increasingly originates from horizontal flow toward the wells. However, the ultimate steady-state extent of capture may take considerable time to develop and may never be achieved in the center of the extraction well field. Since some of the treated groundwater directed to the eastern injection well field will be lost to the regional eastward groundwater flow regime, aggressive pumping rates, low aerial recharge, and limited lateral inflow could cause groundwater elevations in some extraction wells to continue decreasing over the life of the remedial action. This situation could result in a valid capture zone that can only be simulated using a transient model solution with particle migration over the time period of the transient model run. In the early life of the remedy, such capture zones would be very limited in aerial extent and of limited usefulness for evaluating plume capture and optimizing pumping rates. If the end of the transient model run is considered to be a snapshot in time and is treated as a quasi-steady-state, and if the particles are allowed to migrate to their final destinations as in a steady-state run, then a more extensive and useful capture zone can be generated. It should be noted that the simulated quasi-steady-state capture zone will be less extensive laterally than the true steady-state capture zone, and this difference should be taken into account when evaluating plume capture.

If plume capture is being evaluated shortly after system startup, other methods of capture analysis can be used that focus on measured groundwater elevations and gradient analysis. These methods also evaluate capture at one point in time and do not generate the steady-state capture zone. While two-dimensional kriging of water-level data with hydrologic drift terms can be used to present the extraction well hydraulic capture zones using two-dimensional particle tracking, the capture zones are of limited usefulness for evaluating the capture of complex three-dimensional contaminant plumes. Because 70 to 80 m (229.7 to 262.5 ft) of saturated aquifer in the OU and potential low-conductivity zones (Ringold unit 8) may divide the contaminant plumes into upper and lower lobes, the extraction well hydraulic capture zones are best generated and visualized in three dimensions using the groundwater flow model with three-dimensional particle tracking.

Finally, the new release could add enough contaminant mass to the plume to adversely impact either the goal of 95 percent mass removal within 25 years or the goal of aquifer cleanup within 125 years. These potential impacts to the effectiveness of the remedy could necessitate changes to the remedial action and this PMP.

Several potential changes can be made to the remedial action to accommodate new releases. Individual extraction well pumping rates and production intervals can be adjusted so the combined treatment plant influent concentrations remain within design limits. Individual extraction well pumping rates and production intervals can also be adjusted to extend hydraulic capture into the area of the new release. Additional extraction wells can be added to the system to capture the new release, and these may be newly constructed extraction wells or existing monitoring wells converted to extraction wells. Additional treatment capacity can be added to the treatment plant to handle the higher contaminant concentrations caused by new releases.

Changes can be made to the PMP to accommodate new releases. New monitoring wells can be added to help delineate the three-dimensional extent of the new contaminant release; these may be newly constructed monitoring wells or existing monitoring wells not previously included in the network.

A6.2 Approach to Resolve Decision Statement #2

Groundwater sampling data are evaluated to determine if potentially toxic and mobile transformation products are generated within the OU. This evaluation is typically performed by analyzing concentration changes in the parent COC and the COC degradation products. This analysis applies to COCs that are commonly degraded in the environment and, for the 200-ZP-1 OU, includes carbon tetrachloride, trichloroethene, and nitrate. The rates of decline in the parent compounds and the formation of the degradation products will be used to derive degradation rates. The degradation rates will be included in the 200 West Area contaminant transport model and will be used to evaluate if natural attenuation will achieve cleanup levels within the 125-year time period specified in the ROD (EPA et al., 2008).

If potentially toxic and mobile transformation products are generated at high enough concentrations, it is possible that they may pose a risk to the success of the selected remedy and should be included in the list of COCs with associated cleanup levels. Concentrations of toxic and mobile transformation products will be compared to the federal drinking water maximum contaminant levels (Table A-1) to evaluate their inclusion in the list of COCs. DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*; and DOE/RL-2007-28, *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit*, can be reviewed to determine if the potential risks posed by transformation products were analyzed and what concentrations were considered when the current list of COCs was developed.

If it is determined that one or more potentially toxic and mobile transformation products should be included in the list of COCs, then the PMP should be modified to include them as COCs.

A6.3 Approach to Resolve Decision Statement #3

Groundwater elevation data are necessary to determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system and the flow-path control actions. The data include transient groundwater elevations measured using transducers with data loggers and more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys.

Groundwater elevations have been decreasing in the 200 West Area for several years and are expected to continue decreasing in the P&T system extraction well field. The decreases in groundwater elevation may cause monitoring wells to go dry, resulting in well removal from the monitoring network. In the short term, the aggressive pumping rates, low aerial recharge, and limited lateral inflow could cause some extraction well pumping rates to become unsustainable. Thus, the transient data logger groundwater elevation data may be evaluated to monitor the sustainability of the extraction well field and to optimize pumping, possibly by re-balancing upgradient and downgradient injection to ensure that a sustainable remedy is implemented. The more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys should be used to generate water table maps to evaluate groundwater elevations and their impacts on the monitoring well networks and flow-path control actions.

The potentiometric surface of water table elevations is generated from the hydraulic monitoring data to help understand groundwater flow directions in the 200-ZP-1 OU. Water table elevations are best reported as a two-dimensional plan view map. The two-dimensional water table elevation map is best generated by kriging the data with an expression (drift term) that describes the response of groundwater levels to pumping at the extraction wells (Tonkin and Larson, 2002, "Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift"). This kriging method eliminates the need to include water levels measured in the extraction wells, which can introduce significant errors to the water table map. If groundwater flow directions vary with depth, several two-dimensional plan view maps may be needed for different elevation intervals in the aquifer.

Groundwater monitoring for key biogeochemical and field parameters will be used to determine if changes occur in environmental conditions that may reduce the efficacy of natural attenuation processes.

To evaluate remediation by natural attenuation, it must be determined if contaminant mass is being destroyed. The biogeochemical parameters (Table A-2) help identify if the appropriate conditions exist in the aquifer to support COC destruction. The monitoring constituents (Tables A-1 and A-2) can be used in mass balance calculations to determine if decreases in contaminant and electron acceptor/donor levels can be directly correlated to increases in daughter compounds. The simplest way to accomplish this is by mapping concentration changes in reactants (e.g., contaminants, electron acceptors and donors) or products of the biogeochemical process (e.g., dissolved iron and chloride) that degrade or immobilize contaminants. These maps can be measured to determine if transformation processes are active at the site. Calculated biodegradation rate constants can be developed from time-series data of measured COC concentrations, in conjunction with aquifer hydrogeologic parameters (e.g., seepage velocity and dilution).

A6.4 Approach to Resolve Decision Statement #4

The groundwater contaminant transport model is used to predict if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less. This analysis uses the three-dimensional contaminant plume shell for each COC as the starting concentration and transports the contaminant plume forward in time for at least 25 years. Current and future anticipated extraction and injection well flow rates are needed as input to the model. Using the simulated extraction well contaminant concentrations and flow rates, the contaminant mass removed by each extraction well can be calculated. The percentage mass removed for each COC can be calculated by summing the simulated mass removed by each extraction well and dividing that by the starting mass for each COC.

If the model simulation predicts that 95 percent of the contaminant mass will not be removed in 25 years or less, modifications to the P&T system should be evaluated. Improvements in mass removal may be achieved through P&T system optimization. This usually involves using the model to evaluate changes to extraction and injection well flow rates and production intervals (by packing off the upper or lower screen interval) to maximize contaminant mass removal. If the 95 percent mass removal goal cannot be met through system optimization, then other options might include adding more extraction wells, increasing the capacity of the treatment plant and pumping existing extraction wells harder, or evaluating other technologies for a more focused remedy.

The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data are used to calculate the actual contaminant mass removed by the P&T system. Contaminant mass removal can be calculated by multiplying the difference in the treatment plant influent and effluent contaminant concentrations by the influent flow rate and the elapsed time at that concentration and flow rate. Some COCs may not be detectable in the combined treatment plant influent samples but are detectable in samples collected from one or more of the extraction wells. In this case, more accurate mass removal can be calculated using individual extraction well contaminant sampling and flow rate data and summing the individual extraction well masses removed to obtain the total mass removal for the COCs.

While the ROD (EPA et al., 2008) states that the system will be designed to capture and treat contaminated groundwater to reduce the mass of the COCs by a minimum of 95 percent within 25 years, using mass removal as the only remediation metric to shut down the system could be problematic. The most likely scenario is that some extraction wells will cleanup faster than others and before the 95 percent mass removal milestone for each COC has been reached. These wells will be shut down based

on their influent contaminant concentrations and the monitoring well sample concentrations within their hydraulic capture zones. The ROD states that carbon tetrachloride concentrations in groundwater above 100 µg/L correspond to about 95 percent of the mass of carbon tetrachloride residing in the aquifer. Therefore, it may be appropriate to shut down individual extraction wells when their carbon tetrachloride concentrations (as measured in the extraction wells and monitoring wells within the hydraulic capture zones) fall below 100 µg/L. However, this assumes that the other COCs have been remediated to acceptable levels, and the ROD only includes the final cleanup levels for the other COCs. The P&T system shutdown would likely consist of a series of judgment-based decisions regarding both concentration and mass removal remediation metrics. Potential rebound of contaminant concentrations will be monitored by the long-term natural attenuation monitoring program, and extraction wells will be reactivated if necessary.

A6.5 Approach to Resolve Decision Statement #5

Groundwater sampling data will be evaluated to determine if contamination is expanding downgradient, laterally or vertically, after the P&T system has been shut down. The P&T system is designed to capture carbon tetrachloride concentrations above 100 µg/L, and some carbon tetrachloride contamination may likely be present downgradient of the P&T system that is beyond the remedial system capture zone. The downgradient migration of this lower concentration contamination should not be supported by any upgradient, higher concentration contamination that has escaped capture by the remedial system.

The trends in measured concentrations for downgradient monitoring wells will be analyzed to draw conclusions about the expansion and migration of the contaminant plumes. Three-dimensional contaminant plume shells will be updated for each COC using the most current sampling data. Plume volume and contaminant mass statistics can be generated from the plume shells. The contaminant distributions and statistics can be compared to those from the previous plume shell versions to evaluate expansion or contraction of each COC plume.

If evaluation of groundwater sampling data indicates that a COC plume may be expanding downgradient while the remedial system is still operating, several courses of action may be taken. Extraction and injection well flow rates and production intervals may be adjusted to improve the hydraulic capture of escaping contaminant mass. New extraction wells may be installed to capture the escaped contaminant mass that is supporting the downgradient plume expansion.

A6.6 Approach to Resolve Decision Statement #6

The groundwater contaminant transport model is used to predict if the current remedy design will achieve cleanup levels for all COCs within 125 years. This analysis can be accomplished by using the three-dimensional contaminant plume shell for each COC as the starting concentration and transporting the contaminant plume forward in time for at least 125 years. Current and future anticipated extraction and injection well flow rates can be supplied to the model as input. An animation can be made for each COC, displaying the contaminant concentrations greater than or equal to the cleanup level as the plume migrates over time. If the simulated contaminant concentrations remain significantly above cleanup levels during the 125-year period, the remedy goal may not be achieved within the desired remedial time frame.

If the model simulation predicts that the 125-year aquifer cleanup goal may not be achieved, modifications to the remedial action should be evaluated. The P&T system may require longer operation to remove additional contaminant mass to meet the aquifer cleanup goal. While the system is operating, improvements in mass removal may be achieved through P&T system optimization, as previously described.

A6.7 Approach to Resolve Decision Statement #7

The groundwater sampling data will be evaluated to determine if the remediation has been successfully completed. If contaminant concentrations in all monitoring wells, for all COCs, have decreased to below the cleanup levels for at least 5 years, then a recommendation should be made for no further action.

A6.8 Approach to Resolve Decision Statement #8

The groundwater sampling data will be evaluated annually to determine if any areas of the contaminant plumes are not responding to P&T remediation. If one or more areas are identified, options will be evaluated.

A6.9 Approach to Resolve Decision Statement #9

Annual (or less frequent) groundwater sampling data will be collected and analyzed for each of the COCs to determine if there is rebound in COC concentrations.

A7 Specify Performance or Acceptance Criteria

The sixth step of the DQO process involves deriving the performance or acceptance criteria that the collected data need to achieve in order to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels. Typically, the decision rule as a statistical hypothesis test is specified in this section, and the consequences of making incorrect decisions from the test are examined. However, statistical tests of the monitoring data to support the end of this remedial action have not been developed as part of this PMP and may not be applicable. More quantitative specifications of data quality should be defined and presented as part of the quality assurance project plan when the performance monitoring criteria have been agreed upon by the stakeholders. This section presents the potential uncertainties associated with the performance monitoring data to be collected and the potential impacts of those uncertainties.

A7.1 Groundwater Levels

Groundwater-level data consist of several components:

- Depth-to-water measurement
- Surveyed elevation of the top of casing
- Surveyed northing and easting coordinates of the well
- Elevation interval in the aquifer of which the depth to water is representative (well screen top and bottom elevations)

The most critical components of groundwater-level data are the depth-to-water measurement and the top-of-casing elevation. Elevations for the top of casing are typically to the nearest 0.3 cm (0.01 ft), and depth-to-water measurements are typically to the nearest 0.61 cm (0.02 ft). Errors on the order of a couple of hundredths of a foot can be significant in situations where small horizontal hydraulic gradients are expected (e.g., in hydraulic stagnation zones between competing extraction wells) or when calculating vertical hydraulic gradients. In such sensitive areas, capture zone analyses can result in significant errors, leading to loss of plume capture or wasted over-pumping.

Groundwater elevation errors can be detected by preparing a two-dimensional water table map and looking for irregularities in the elevation contours. A groundwater elevation data set can also be compared to the previously collected data set to look for irregularities. While difficult to detect, these errors can be managed by designing hydraulic capture zones with a margin of safety so small errors in measured groundwater elevations do not lead to loss of plume capture.

Ground surface elevations are typically provided to the nearest 0.03 m (0.10 ft), which is used along with the top and bottom screen depths, to calculate the top and bottom screen elevations. Errors up to 1.5 m (5 ft) in top and bottom screen elevations would likely have little impact on the use of groundwater elevation data because hydraulic stresses are transmitted fairly easily through the aquifer. Since much of the well construction data for the 200-ZP-1 OU monitoring wells is historical, screened interval data from monitoring wells may be uncertain. However, well screen elevation errors are likely not a concern for groundwater elevation data since the vertical spatial position of groundwater elevation measurement is typically taken as the mid-screen elevation in the well. These mid-screen elevation data points can be used in the groundwater flow model by comparing them to simulated heads taken from model grid cell center elevations.

Typically, surveyed northing and easting coordinates are provided to the nearest 0.03 m (0.10 ft). However, errors of up to 1.5 m (5 ft) in well coordinates should have little impact on any processes or decisions. In addition, well coordinates are relatively easy to verify in the field; thus, well coordinate errors are likely not a concern.

A7.2 Pumping Rates

Measured pumping rates are used to monitor system performance and ensure that the system is operating within design specifications. Pumping rates are also used in model calibration, plume shell calibration, model simulations, and extraction well contaminant mass removal calculations. Pumping rates should be measured on a semicontinuous basis using in-line flow meters accurate to 5 percent of the flow rate.

Extraction well flow rate errors can be detected by comparing the sum of the extraction well pumping rates to the combined influent flow rate at the treatment plant. Pumping rate errors of a couple of gallons per minute would have little impact on the simulated capture zone for an extraction well pumping at 379 L/min (100 gallons per minute [gpm]). For mass removal calculations for an extraction well with an influent carbon tetrachloride concentration of 1,000 µg/L, for every 3.8 L/min (1 gpm) error in flow rate, there would be about a 2 kg/yr error in calculated contaminant mass extracted. If the carbon tetrachloride plume is assumed to have a dissolved-phase mass above the cleanup level of 1,221 kg, then this error is 0.2 percent of the plume mass. To put this in perspective, under current Hanford Site laboratory contracts using SW-846, *Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods, Third Edition; Final Update V*, Method 8260, the reported carbon tetrachloride concentrations are to be accurate to within ±20 percent. For an extraction well pumping at 379 L/min (100 gpm) with an influent carbon tetrachloride concentration of 1,000 µg/L, this percentage of error could result in the calculated mass extracted being under or over reported by about 40 kg/yr. This is equivalent to a 76 L/min (20 gpm) flow rate error for a 379 L/min (100 gpm) flow rate. Therefore, pumping rate errors of a couple of gallons per minute should have little impact on any decisions.

A7.3 Contaminant Concentrations

Contaminant concentration data consist of several components, including the actual groundwater sample, subsequent laboratory analysis, and the three-dimensional spatial position from which the sample originated in the aquifer. Contaminant concentrations from analytical laboratory analyses are needed to

construct three-dimensional contaminant plume shells, to calculate the contaminant mass extracted from the extraction wells, and to ultimately verify the achievement of cleanup levels. To meet this goal, the analytical method detection limits should be equal to or less than the cleanup levels.

Failure to set analytical laboratory detection limits equal to or less than the cleanup levels could result in groundwater contaminant monitoring data of insufficient quality to determine if cleanup is successful. Since three-dimensional contaminant plume shells are usually constructed with the lowest concentration isosurface set at the cleanup level, use of analytical laboratory detection limits above the cleanup levels will result in a lack of data to establish the plume shell outer boundaries. This will result in errors in the reported mass and volume statistics, errors in extraction well capture analyses, and errors in simulated contaminant transport.

Other types of errors, such as random nonrepresentative samples or laboratory analyses, should have limited impact on any significant decisions regarding remedy performance. Typically, if a sample result seems erroneous and the result is critical (i.e., the result significantly changes the conceptual site model, indicates loss of capture, or falsely indicates plume cleanup), the sampling is repeated at that location to verify the result. Significant decisions are not generally based on one sample result. An erroneous sample result could impact the kriged concentrations in a limited area of a contaminant plume shell. However, the plume shells are usually regenerated annually, so the error would be relatively short lived.

Horizontal spatial position errors are usually of such a small magnitude that they would have little impact on any processes or decisions. Surveyed northing and easting coordinates are provided to the nearest 0.03 m (0.10 ft). Errors up to 1.5 m (5 ft) in well coordinates would usually have little impact. In addition, well coordinates are relatively easy to verify in the field; thus, well coordinate errors are not a concern.

Ground surface elevations typically are provided to the nearest 0.03 m (0.10 ft), which is usually used along with the top and bottom screen depths to calculate the top and bottom screen elevations. Errors in top and bottom screen elevations of a couple of feet would likely have little impact on the use of concentration data. However, contaminant concentrations tend to be highly vertically heterogeneous, and an error of 3.0 m (10 ft) or more in a screened interval could introduce significant errors in the three-dimensional contaminant plume shells. Since much of the well construction data is historical for the older 200-ZP-1 OU monitoring wells, the potential exists for significant errors in the reported well screened intervals. Such errors could potentially lead to errors in the three-dimensional contaminant plume shells and potential loss of plume capture.

Another vertical spatial position problem with the 200-ZP-1 OU monitoring wells is that many of the wells have relatively long screened intervals. The screen length for groundwater monitoring wells typically ranges from 1.5 m (5 ft) to 4.6 m (20 ft); however, many 200-ZP-1 OU monitoring wells have screen lengths in excess of 9.1 m (30 ft). The variations in screen length can lead to uncertainties in the vertical position from which groundwater samples were extracted and can cause high contaminant concentration intervals to be diluted by less contaminated groundwater from other aquifer intervals. Again, such errors could potentially lead to errors in the three-dimensional contaminant plume shells and loss of plume capture.

Vertical spatial position errors in contaminant concentration sampling data are relatively difficult to detect and manage. Well construction information for a particular monitoring well should be reviewed if samples collected from the well do not make sense in relation to other upgradient and downgradient samples. However, the relatively low density of samples usually makes it difficult to detect these types of errors. In general, the uncertainty in three-dimensional contaminant plume delineation caused by the sparse sampling network is much greater than all of the other sources of contaminant concentration uncertainty. This uncertainty is then added to by the relative coarseness of the contaminant transport

model grid and the uncertainty in the model transport parameters. These errors are mostly managed by using professional judgment when evaluating the three-dimensional plume shells and resulting model simulations for consistency with the conceptual site model and hydrologic principles, as well as by questioning any discrepancies.

A7.4 Other Measured Parameters

Key biogeochemical parameters included with laboratory analyses are listed in Table A-2. Evaluation of these parameters may provide a better understanding of natural attenuation conditions and reaction pathways within the reactive zones of the plumes. Errors in the measurement of these parameters would usually have little impact on decisions regarding natural attenuation processes.

Key groundwater parameters measured in the field at each sampled monitoring well during each monitoring round are listed in Table A-2. These parameters may be monitored continuously in a flow-through cell apparatus during monitoring well sampling. Stable readings are an indication that sufficient purge water has been withdrawn from a well and that a representative sample of the groundwater can be collected. These parameters are also important for MNA processes. Errors in the field measurement of these parameters would usually have little impact on any decisions regarding natural attenuation processes.

A7.5 Model Predictions

The groundwater flow and transport model is an important tool for simulating hydraulic capture and predicting whether the remedial goals of 95 percent mass reduction within 25 years and aquifer cleanup within 125 years will be achieved. However, uncertainties are associated with the use of the model that can lead to a sense of false confidence in the accuracy of the model predictions. These uncertainties can be minimized by using multiple lines of evidence to increase the confidence in model predictions by ensuring that all available data are used. Some of the available methods are described below.

The ability of the groundwater flow model to accurately simulate hydraulic capture should be evaluated by using a residual analysis method (RAM) technique. The RAM technique compares the simulated head distribution from the model to the measured groundwater elevations and displays the difference in terms of hydraulic capture. This is a useful technique for determining if the model calibration is adequate and ensures that the available data are used to make important decisions regarding plume capture and remedial system optimization. The RAM technique for analyzing hydraulic data includes the following steps:

1. Calculate the head residuals between the groundwater elevations measured at the synoptic monitoring wells and the simulated heads from the groundwater flow model using the remedial system extraction and injection rates recorded during the synoptic monitoring event.
2. Analyze the spatial distribution of model results and the application of head residuals to amend the model results and produce an estimated potentiometric head distribution that closely approximates the measured data while retaining the hydraulic insight of the model.
3. Apply the amended flow field to generate estimated remedial system hydraulic capture zones.

Particle tracking should be used to generate the capture zones using both the unadjusted, simulated head field and the RAM-amended head field that more closely matches the actual hydraulic conditions based on the measured groundwater elevations. Application of the RAM technique may indicate that the current 200 West Area groundwater flow model is not adequate to accurately predict plume capture and migration, in which case the model should be recalibrated. The groundwater elevation data collected

during the most recent water-level monitoring event would provide the calibration targets for the model recalibration.

The ability of the groundwater transport model to accurately simulate plume migration depends, in part, on the accuracy of the starting concentration distribution (three-dimensional plume shell) and the contaminant transport parameters used in the model. The three-dimensional plume shell for each contaminant will adequately represent the available sampling data at the sampling locations based on the method of construction (kriging). The uncertainty involves the areas in between the sampling locations and the outer boundaries of the plume shells. Thus, the accuracy of each three-dimensional plume shell can be increased by providing additional sampling locations. Another method that can be used to reduce this uncertainty involves using measured extraction well contaminant concentrations as calibration targets for the contaminant transport model and adjusting each plume shell contaminant distribution until the simulated extraction well concentrations agree with the measured extraction well concentrations.

The outer plume boundaries (both horizontal and vertical) can also be controlled during kriging by using control points and masking to ensure that the plume boundaries do not extend above the water table and, in general, agree with the conceptual site model and professional judgment. Using these methods ensures that available lines of evidence are being used to construct three-dimensional contaminant distributions.

The contaminant transport parameters used in the model can be evaluated by migrating older plume shell versions forward in time and comparing the simulated contaminant concentrations to the most recent measured contaminant concentrations at select monitoring well locations. This evaluation can reduce the uncertainty in the transport parameters that control the physical, chemical, and biological processes that influence contaminant fate and transport and may result in changes to the model parameters that control dispersion, retardation, and biodegradation. These methods ensure that available lines of evidence are being used to reduce the uncertainty associated with model predictions.

A8 Develop the Plan for Obtaining Data

The seventh step of the DQO process is to develop the sampling and analysis design to collect the data needed to address the goals of the selected 200-ZP-1 OU remedy. The design for collecting contaminant concentration, hydraulic, and flow rate monitoring data is presented in Chapter 4 in the main text and Appendix B of this PMP.

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Appendix B

200-ZP-1 Groundwater Operable Unit Sampling and Analysis Plan

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Terms

AEA	alpha energy analysis
ALARA	as low as reasonably achievable
amsl	above mean sea level
ASTM	formerly American Society for Testing & Materials
BTR	buyer's technical representative
CAS	Chemical Abstracts Service
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
COC	contaminant of concern
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DOH	Department of Health
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DS	decision statement
DUP	duplicate
EB	equipment blank
ECO	environmental compliance officer
Ecology	Washington State Department of Ecology
ERDF	Environmental Restoration Disposal Facility
EPA	U.S. Environmental Protection Agency
FSO	Field Sampling Operations
FTB	full trip blank
FWS	field work supervisor
FXR	field transfer blank
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry

HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Document</i> (DOE-RL-96-68)
HEIS	Hanford Environmental Information System
IATA	International Air Transport Association
IC	ion chromatography
ICP	inductively coupled plasma
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
ID	identification
LCS	laboratory control sample
LLBG	Low-Level Burial Grounds
LLWMA	low-level waste management area
MB	method blank
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	method detection limit
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NCO	nuclear chemical operator (sampler)
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RCT	radiological control technician

ROD	Record of Decision
RPD	relative percent difference
SAF	sample authorization form
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
TCE	trichloroethene
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i> (Ecology et al., 1989)
VOA	volatile organic analysis
VOC	volatile organic compound
WMA	waste management area
WTPH-D	Washington State Department of Ecology total petroleum hydrocarbons as diesel
WTPH-G	Washington State Department of Ecology total petroleum hydrocarbons as gasoline

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B1 Introduction

This appendix presents the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sampling and analysis plan (SAP) for the 200-ZP-1 Groundwater Operable Unit (OU) (Figure B-1). As part of the performance monitoring plan (PMP), which is an enforceable part of DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, this SAP is considered an enforceable part of the work plan. This SAP describes monitoring activities associated with implementation of the selected remedy for the 200-ZP-1 OU, as presented in the Record of Decision (ROD) for 200-ZP-1 (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*). This SAP supersedes previous CERCLA groundwater sampling and analysis documents for the OU, including DOE/RL-2003-55, *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit*.

The CERCLA groundwater monitoring requirements in the 200-ZP-1 OU are addressed by this SAP. Programmatic requirements for other sampling within the 200-ZP-1 area (e.g., *Resource Conservation and Recovery Act of 1976* [RCRA]) will continue to be performed pursuant to other sampling plans, and those requirements are not included in this SAP. RCRA groundwater monitoring is conducted for Waste Management Areas (WMAs) T and TX-TY and for Low-Level Waste Management Areas (LLWMAs) 3 and 4 under separate plans. The data collected under the separate plans are supplementary groundwater quality information to the CERCLA OU process.

DOE/RL-2015-56, *Hanford Atomic Energy Act Surveillance Groundwater Monitoring Plan*, issued in December 2015, includes monitoring specifications of the upper basalt-confined aquifer and the Ringold confined aquifer. Groundwater within the upper basalt-confined aquifer is monitored because it is a potential pathway for contaminants to move offsite. The confined to semiconfined aquifer within Ringold unit A is present beneath most of the Hanford Site. The confined aquifer sampling will be continued under DOE/RL-2015-56 and is not included under this SAP.

The 200-ZP-1 OU comprises groundwater contaminated by releases from facilities and waste sites associated with former plutonium concentration and recovery operations at Z Plant and plutonium separation operations at T Plant. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, located at the western end of the Central Plateau. The 200 West Area lies about 8 km (5 mi) south of the Columbia River and 11 km (7 mi) from the nearest Hanford Site boundary. The 200-ZP-1 OU includes several groundwater contaminant plumes that span about 13 km² (5 mi²) beneath the 200 West Area.

Contaminants of concern (COCs) identified in the 200-ZP-1 OU ROD (EPA et al., 2008) include carbon tetrachloride, trichloroethene (TCE), total chromium (trivalent and hexavalent), nitrate, iodine-129, technetium-99, and tritium. Carbon tetrachloride is the primary COC, with the other COCs (except nitrate) occurring in smaller, commingled plumes that lie within the carbon tetrachloride plume boundary.

This SAP consists of six sections, with the remainder of this section addressing the project scope and objectives, background, summary of data quality objectives (DQOs), groundwater monitoring well network, COCs, and project schedule. Section B2 discusses the quality assurance (QA) requirements; Section B3 provides the field sampling plan; Sections B4 and B5 address waste management and health and safety requirements, respectively; and Section B6 provides the references.

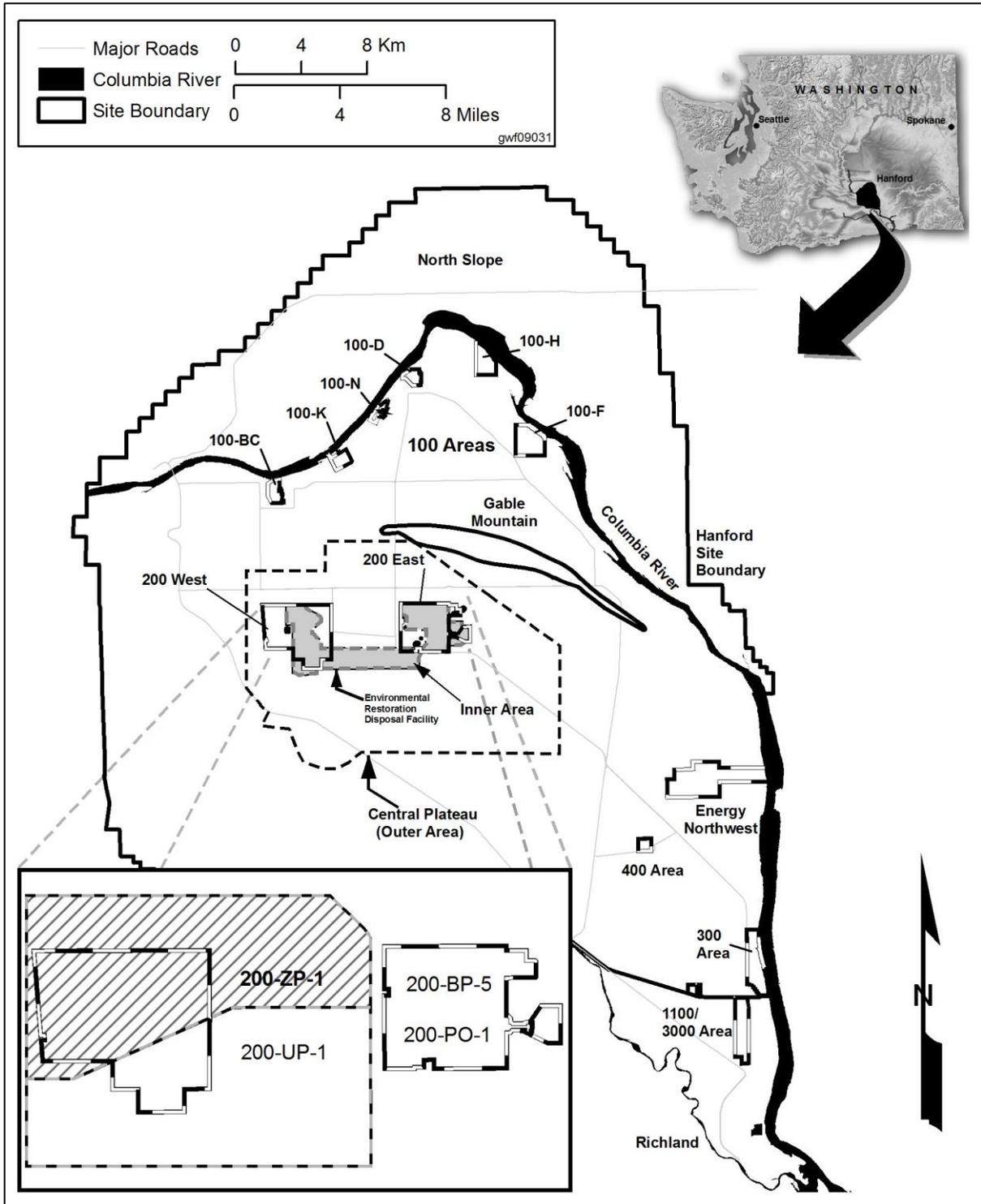


Figure B-1. Site Location

B1.1 Project Scope and Objectives

The objectives of this SAP are as follows:

- Describe the methods used to collect the data necessary to assess performance of the 200 West pump and treat (P&T)
- Assess monitored natural attenuation (MNA) in the 200-ZP-1 OU
- Assess flow-path control elements of the selected remedy in the 200-ZP-1 OU

This SAP includes the 200-ZP-1 OU ROD (EPA et al., 2008) COCs: carbon tetrachloride, total chromium (trivalent and hexavalent), TCE, nitrate, iodine-129, technetium-99, and tritium.

As part of the DQO process described in Appendix A, historical sampling locations and the analytical results generated from the 200-ZP-1 OU monitoring network from January 1990 through December 2012 were reviewed in conjunction with this SAP. The locations of monitoring wells with respect to the 2012 plume configurations were analyzed to optimize the well network and sampling requirements. This analysis focused on defining the wells needed for contaminant monitoring and their sampling frequencies.

The monitoring well network identified in this SAP is designed to collect groundwater data sufficient to assess the performance of the remedy from P&T operation through MNA. This SAP data will be reported in the annual Hanford Site groundwater monitoring report. Performance monitoring under this SAP will continue until remedial action objectives (RAOs) are met.

Table B-1 identifies the existing documents that have current sampling requirements associated with the 200-ZP-1 OU and identifies which of the existing documents are superseded by this SAP.

B1.2 200-ZP-1 Operable Unit Background

The 200 Areas are located on a broad, relatively flat plain that constitutes a local topographic high, commonly referred to as the Central Plateau. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, located at the western end of the Central Plateau.

Hydrogeology, groundwater flow, contaminant plumes, and sources of contamination are summarized in the following subsections. An overview of the DQO process directing the sampling objectives is provided, and the contaminants are identified.

B1.2.1 Site Geology/Hydrology

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington State (Figure B-1). The Central Plateau, which includes the 200 Areas, is a relatively flat, prominent terrace near the center of the Hanford Site. The geology underlying the 200 West Area comprises, in descending order, the Hanford formation, the Cold Creek unit, the Ringold Formation, and the Columbia River Basalt Group. The suprabasalt sediments are about 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford formation, which are composed of sand and gravel, with some silt layers (Figures B-2, B-3, and B-4).

Table B-1. Summary of Sampling Plans with Overlapping Requirements

Document Number/Rev.	Document Title	Scope	Data Use	New 200-ZP-1 OU SAP
DOE/RL-2009-115, Rev. 1	<i>Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action</i>	Provides groundwater data necessary to track the extent and concentration of groundwater contaminant plumes.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring requirements identified in this updated SAP will supersede the requirements identified in the previous 200-ZP-1 OU groundwater monitoring plan (DOE/RL-2009-115, Rev. 1).
DOE/RL-2009-124, Rev. 5	<i>200 West Pump and Treat Operations and Maintenance Plan</i>	Outlines the activities necessary to operate, maintain, and monitor the performance of the 200 West P&T from startup of operations through decommissioning of the system.	Monitor performance of the treatment system.	Monitoring requirements identified in this updated SAP will supersede the requirements identified in DOE/RL-2009-124, Appendices D and E.
DOE/RL-2015-56, Rev. 0	<i>Hanford Atomic Energy Act Surveillance Groundwater Monitoring Plan</i>	The document identifies the locations, sampling frequency, and analytical requirements under the <i>Atomic Energy Act of 1954</i> and includes confined aquifer wells located across multiple groundwater OUs.	Monitoring results support Hanford Site environmental surveillance under the <i>Atomic Energy Act of 1954</i> .	Sampling and analysis of wells monitoring the confined aquifer within the 200-ZP-1 OU interest area are addressed in DOE/RL-2015-56. Monitoring of the confined aquifer wells are not included in this SAP.

Table B-1. Summary of Sampling Plans with Overlapping Requirements

Document Number/Rev.	Document Title	Scope	Data Use	New 200-ZP-1 OU SAP
DOE/RL-2009-68, Rev. 2	<i>Interim Status Groundwater Monitoring Plan for the LLBG WMA-3</i>	Obtain necessary groundwater data to reach the objectives of determining concentrations of specified groundwater quality parameters annually, concentrations of groundwater contamination indicator parameters semiannually, and annual evaluation of the water table.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring of the LLWMA-3 wells are not included in this SAP.
DOE/RL-2009-69, Rev. 2	<i>Interim Status Groundwater Monitoring Plan for the LLBG WMA-4</i>	Obtain necessary groundwater data to reach the objectives of determining: concentrations of specified groundwater quality parameters annually, concentrations of groundwater contamination indicator parameters semiannually, and annual evaluation of the water table.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring of the LLWMA-4 wells are not included in this SAP.
DOE/RL-2009-66, Rev. 1	<i>Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T</i>	Assessment monitoring is required by RCRA to determine the rate and extent of migration of the dangerous waste or dangerous waste constituents in the groundwater and the concentration of dangerous waste or dangerous waste constituents in the groundwater.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring of the WMA T wells are not included in this SAP.

Table B-1. Summary of Sampling Plans with Overlapping Requirements

Document Number/Rev.	Document Title	Scope	Data Use	New 200-ZP-1 OU SAP
DOE/RL-2009-67, Rev. 1	<i>Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY</i>	Assessment monitoring is required by RCRA to determine the rate and extent of migration of the dangerous waste or dangerous waste constituents in the groundwater and the concentration of dangerous waste or dangerous waste constituents in the groundwater.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring of the WMA TX-TY wells are not included in this SAP.
DOE/RL-2000-72, Rev. 1	<i>Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds</i>	The objective is to perform assessment monitoring to detect increasing trends that can be attributed to the LLBG and to ensure that the performance objectives for groundwater protection are met (e.g., 4 mrem/yr for groundwater pathway) and that appropriate data are collected to evaluate the performance and conduct composite analysis.	Results address the full extent of the remedy performance evaluations reported in the annual Hanford Site groundwater monitoring report. Sample results from this SAP for any well within the 200-ZP-1 OU will be analyzed as part of the remedy performance.	Monitoring of the LLBG performance assessment wells are not included in this SAP.

- LLBG = Low-Level Burial Grounds
- LLWMA = low-level waste management area
- OU = operable unit
- P&T = pump and treat
- RCRA = *Resource Conservation and Recovery Act of 1976*
- SAP = sampling and analysis plan
- WMA = waste management area

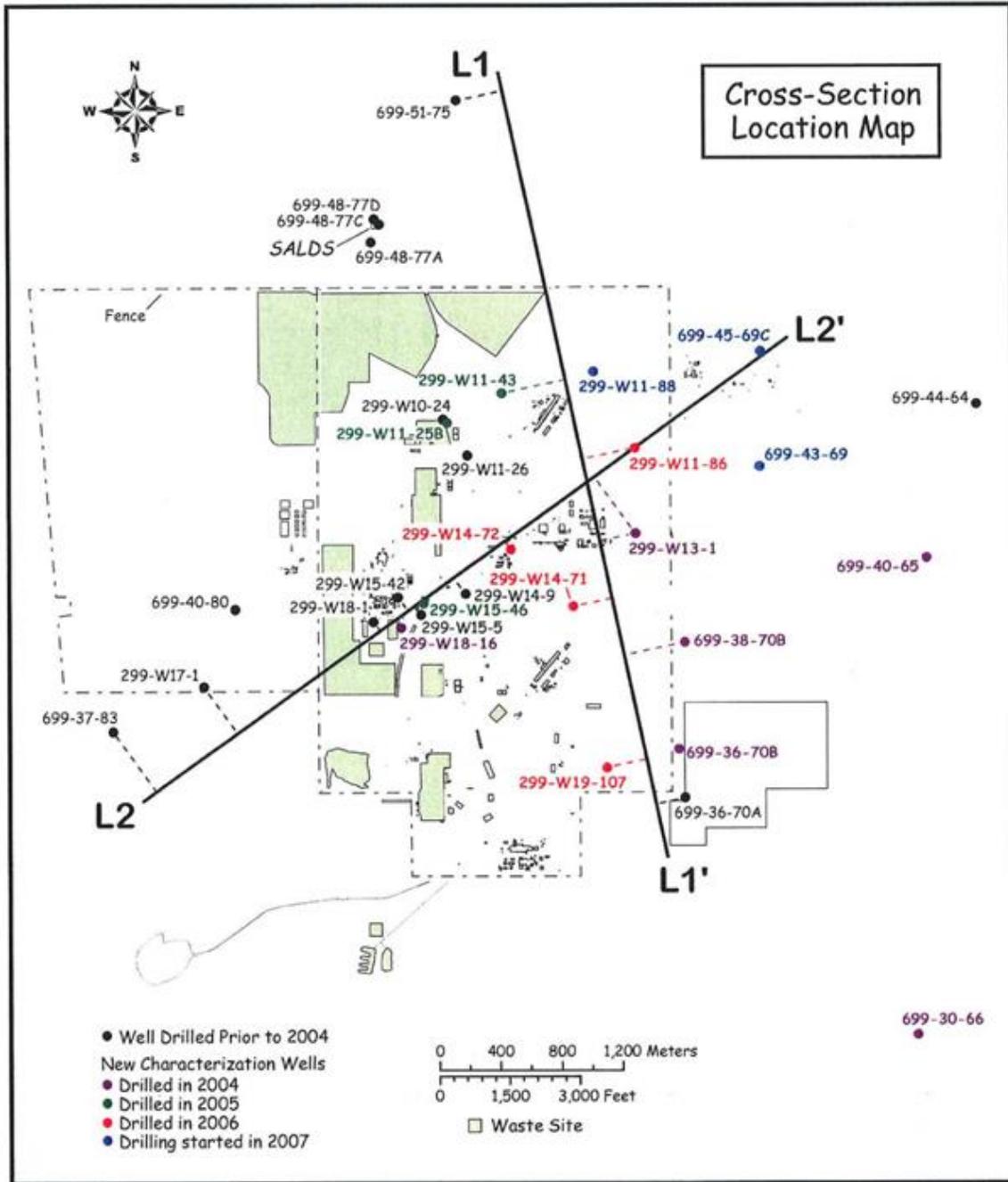


Figure B-2. Location of Geologic Cross Sections

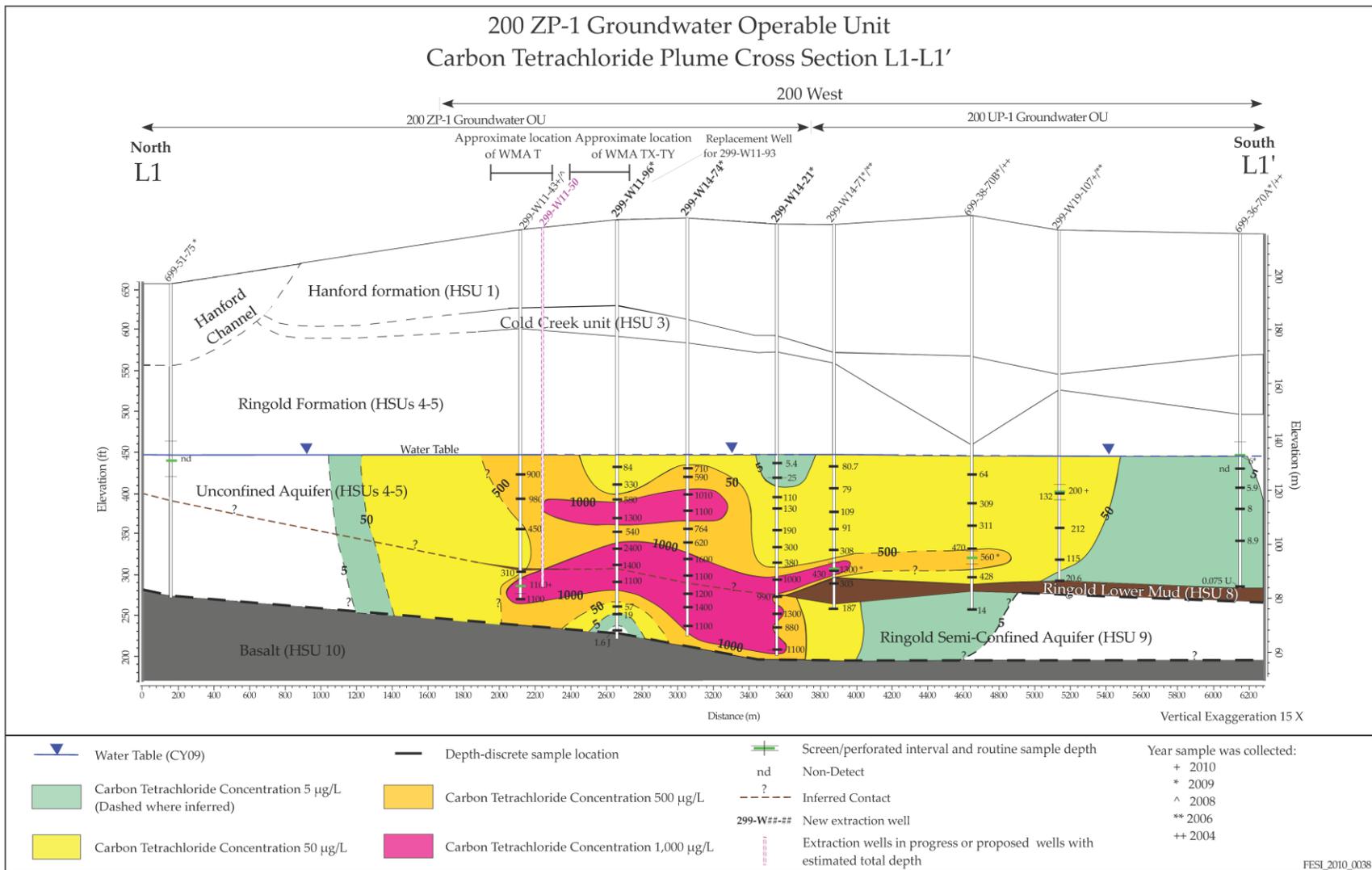


Figure B-3. Geologic Cross Section L1 to L1' (North to South)

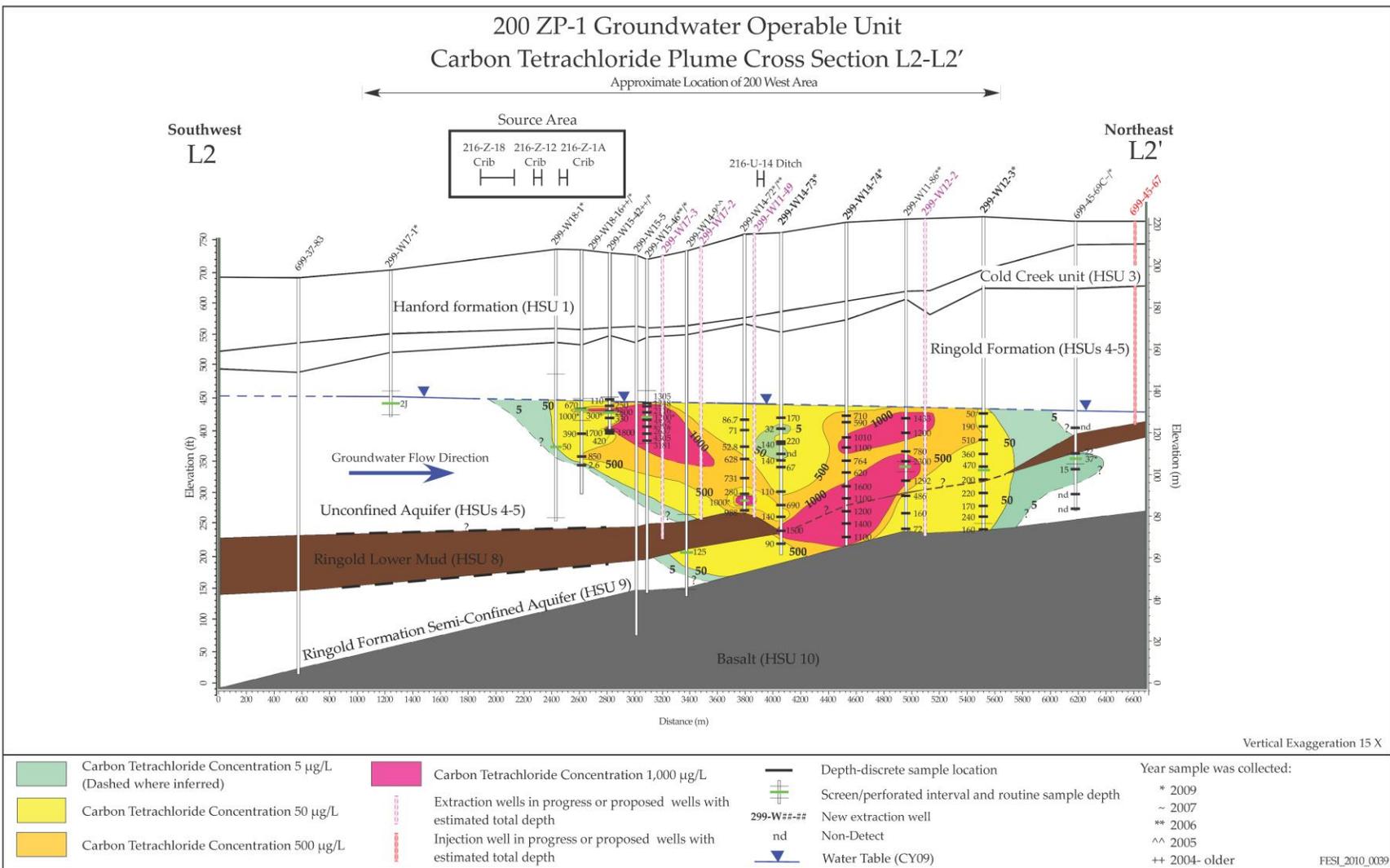


Figure B-4. Hydrogeologic Cross Section L2 to L2' (Southwest to Northeast)

The uppermost aquifer in the 200-ZP-1 OU is an unconfined aquifer that occurs in the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where the water table is lower (the Columbia River). The water table depth in the 200 West Area varies from about 50 m (164 ft) in the southwest corner near the former 216-U-1 Pond to greater than 100 m (328 ft) to the north.

B1.2.2 Groundwater Flow

Groundwater flows predominantly east beneath the Central Plateau, from the 200 West Area to the 200 East Area, at velocities typically ranging from 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d). Historical effluent discharges in the 200 West Area altered the groundwater flow regime, especially around the 216-U-10 Pond. Seepage from this pond raised the water table elevation, which in turn temporarily deflected groundwater flow to the north. As the discharges ceased, the water table declined and the eastwardly groundwater flow pattern was restored.

B1.2.3 Sources of Groundwater Contamination

Groundwater COCs identified in the 200-ZP-1 OU ROD (EPA et al., 2008) include carbon tetrachloride, chromium (total and hexavalent), iodine-129, nitrate, technetium-99, TCE, and tritium. Carbon tetrachloride is the main COC in groundwater, forming a plume about 13 km² (5 mi²) in area extending north, south, and east from the source areas. The primary carbon tetrachloride and TCE sources were associated with discharges of liquid waste from plutonium separation processes at the Plutonium Finishing Plant to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. Figures B-3 and B-4 show the vertical distribution of carbon tetrachloride in the 200-ZP-1 OU. The lateral distribution of carbon tetrachloride (and the collocated TCE contamination), six additional COCs (including uranium in the 200-UP-1 OU), and extraction/injection well locations are shown in Figure B-5.

Sources of chromium, hexavalent chromium, iodine-129, nitrate, TCE, technetium-99, and tritium contamination in 200-ZP-1 OU were releases from past leaks in single-shell tanks and pipelines in WMA T and WMA TX-TY, and liquid waste disposal from plutonium-processing operations to cribs and trenches adjacent to the WMAs. Except for nitrate, the remaining contaminant plumes within the 200-ZP-1 OU are located within the boundaries of the carbon tetrachloride plume (Figure B-5).

B1.2.4 Contaminant Plumes

In accordance with the 200-ZP-1 OU ROD (EPA et al., 2008), contaminant distributions within the 200-ZP-1 OU are represented by three categories:

1. A high-concentration zone of carbon tetrachloride close to ponds, cribs, and trenches used to dispose liquid wastes. Data do not indicate a continuing source.
2. A larger, dispersed or low-concentration zone of carbon tetrachloride that has migrated from discharge locations or that overlies the high-concentration zone. This less contaminated groundwater can occur above the high-concentration zone where large quantities of lower concentration effluent were discharged during or after the high-concentration waste discharges.
3. An area of technetium-99 contamination near WMA T and WMA TX-TY.

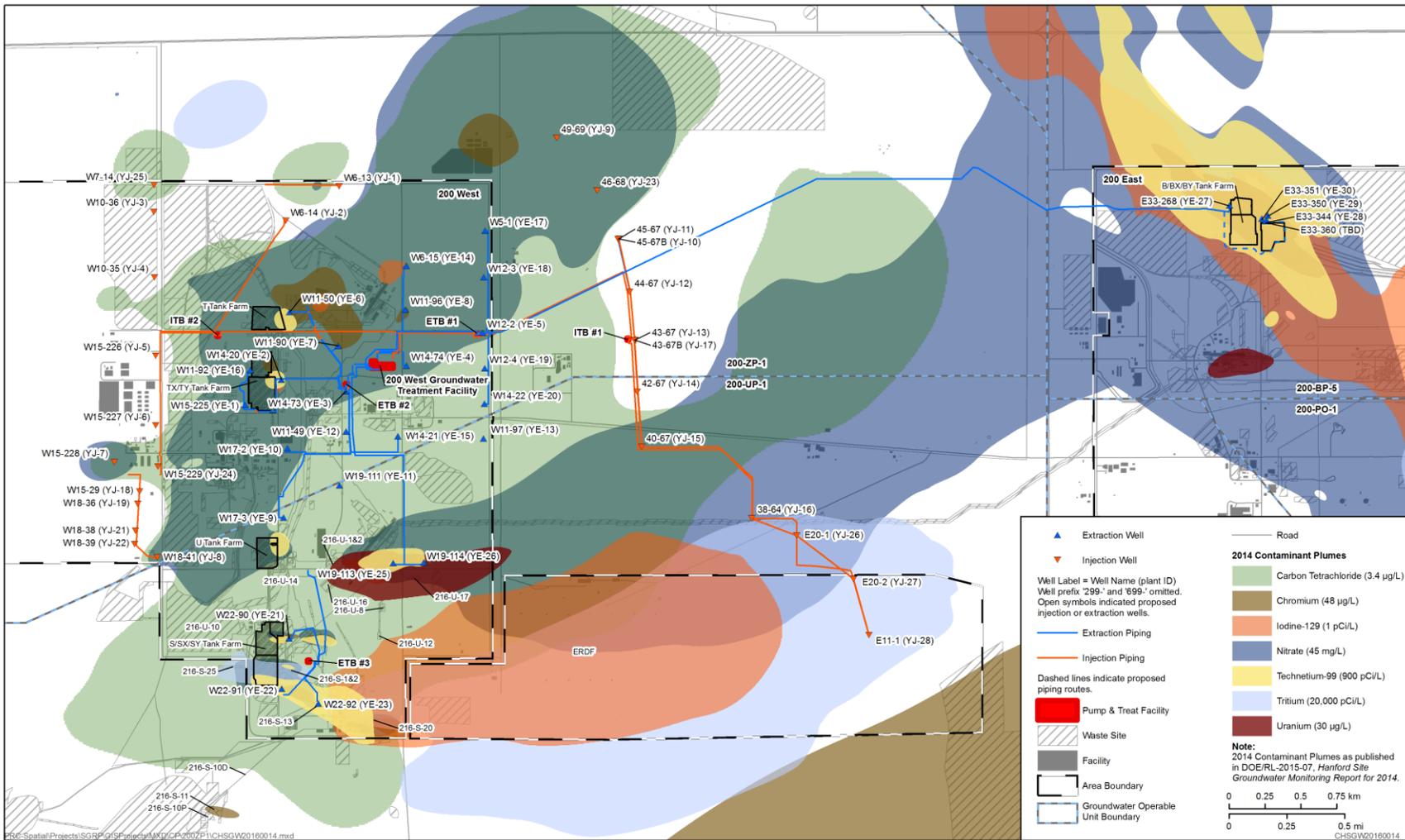


Figure B-5. Contaminant Plumes and 200 West P&T Well Layout

The monitoring program obtains data from a network of monitoring wells that were re-evaluated in 2014 to develop a constituent-specific set of analyses for each well. The development of the monitoring network considered the inventory of sites that may have the potential for future COC releases (Figure B-5). For each contaminant (excluding carbon tetrachloride and TCE), each well identified for monitoring was evaluated in the context of geographic location relative to the plume in the 200-ZP-1 OU and the data trends relative to the cleanup level (this evaluation included data collected as part of the PMP efforts, including data that date back to 1990). For volatile organic compounds (VOCs) such as carbon tetrachloride and TCE, the monitoring well network extends into the 200-UP-1 OU in order to track the plume and mass removal to meet the performance metrics provided in the 200-ZP-1 OU ROD (EPA et al., 2008). The contaminant-specific sampling will be augmented by sampling each well for all COCs every 5 years to document the presence or absence of contamination in each well and to support the preparation of the CERCLA 5-year review.

Table B-2 presents the final cleanup levels for 200-ZP-1 OU groundwater. These cleanup levels were developed using federal drinking water maximum contaminant levels; the criteria and equations in WAC 173-340, “Model Toxics Control Act—Cleanup” Method B cleanup levels for potable groundwater (WAC 173-340-720(4)(b)(iii)(A) and (B), and WAC 173-340-720(7)(b), “Groundwater Cleanup Standards”); and federal standards for radionuclides.

Table B-2. Final Cleanup Levels for 200-ZP-1 OU Groundwater

COC	Units	Final Cleanup Level
Carbon tetrachloride	µg/L	3.4*
Trichloroethene	µg/L	1*
Chromium (total)	µg/L	100
Hexavalent chromium	µg/L	48
Nitrate-nitrogen	mg/L	10
Iodine-129	pCi/L	1
Technetium-99	pCi/L	900
Tritium	pCi/L	20,000

* The U.S. Department of Energy will clean up COCs for the 200-ZP-1 Operable Unit subject to the requirements of WAC 173-340, “Model Toxics Control Act—Cleanup” (carbon tetrachloride and trichloroethene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

COC = contaminant of concern

B1.3 Data Quality Objectives Summary

In association with development of this SAP, the DQO process was performed to support the identification of sampling requirements appropriate for the current SAP objectives. The DQO process and its resulting application to refine the well network and focus the sampling requirements is provided in Appendix A. The purpose of the DQO process was to support optimization of the routine monitoring network for the 200-ZP-1 OU. Each of the DQO steps is summarized in the following subsections.

B1.3.1 Statement of the Problem

Step 1 of the DQO process is to define the problem. In the case of the 200-ZP-1 OU, sufficient monitoring data must be collected and evaluated to operate the groundwater P&T system optimally and to verify that the contaminated groundwater is being remediated to the levels identified in the 200-ZP-1 OU ROD (EPA et al., 2008).

B1.3.2 Identify the Goals of the Study

Step 2 of the DQO process identifies the key decisions and goals that must be addressed to achieve the final solution to the problem. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the selected remedy combines P&T, MNA, flow-path control, and institutional controls to solve the problem. This SAP addresses the performance monitoring goals for the first three of these components. Monitoring data shall be collected over the remedial action lifecycle to evaluate its performance and optimize its effectiveness. The key questions that the data collection must address and the alternative actions that may result from the analysis of collected data are presented in the following decision statements (DSs):

- **DS #1:** Determine if there are any new releases of COCs that could affect the effectiveness of the remedy and necessitate changes to the remedial action or the PMP; otherwise, continue with the current remedial action and the PMP.
- **DS #2:** Determine if potentially toxic or mobile transformation products are being generated at concentrations large enough to justify their inclusion in the list of COCs with associated cleanup levels; otherwise, continue with the current list of COCs and associated cleanup levels.
- **DS #3:** Determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system, natural attenuation processes, and the flow-path control actions, thereby necessitating changes to the remedial action or the PMP; otherwise, continue with the current remedial action and the PMP.
- **DS #4:** Determine if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the P&T phase of the remedy; otherwise, evaluate modifications to the P&T system that could achieve the stated goal for the P&T phase of the remedy.
- **DS #5:** Determine if contamination is expanding downgradient, laterally, or vertically, after the P&T component has been turned off, thereby necessitating an evaluation of the predicted success of the remedial action; otherwise, continue with the current remedial action and the PMP.
- **DS #6:** Determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years, and thereby achieve the overall remedial goal; otherwise, evaluate modifications to the remedial action that could achieve the stated goal for the overall remedy.
- **DS #7:** Determine if remediation has been successfully completed and a recommendation can be made for no further action; otherwise, continue with the current remedial action and the PMP or determine if a technical impracticability waiver should be invoked.
- **DS #8:** Determine if certain areas of the contaminant plumes are not responding to P&T remediation as expected and, therefore, require the evaluation of other technologies for a more focused or “hot spot” remedy; otherwise, no new action is required.
- **DS #9:** Once 95 percent of the mass of COCs has been removed, determine if there is rebound in COC concentrations, which would require the P&T system to be turned back on; otherwise, leave the P&T system off and continue with MNA.

B1.3.3 Identify the Information Inputs and Analytical Approach

Steps 3 and 5 of the DQO process identify the data and analytical approach necessary to resolve the DSs listed in Section B1.3.2. This information is summarized in Table B-3.

B1.3.4 Define the Boundaries of the Study

Step 4 of the DQO process, identifies the spatial and temporal features pertinent to the decision-making process. The 200-ZP-1 OU performance monitoring network must verify that cleanup levels have been achieved in all areas of the OU groundwater plumes. Spatially, this covers an area from the western injection well fence to the eastern leading edges of the plumes. Elevations range from the top of the basalt bedrock to the water table interface. The current 200-ZP-1 OU conceptual site model does not include any COC concentrations greater than cleanup levels in the basalt bedrock. Performance monitoring is expected to continue until cleanup levels have been achieved, which is estimated to be 125 years (25 years for active P&T and 100 years for MNA).

B1.3.5 Specify Performance or Acceptance Criteria

Step 6 of the DQO process involves deriving the performance or acceptance criteria that the collected data must achieve in order to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates within acceptable levels. Typically, the decision rule as a statistical hypothesis test is specified in this step, and the consequences of making incorrect decisions from the test are examined. However, statistical tests of the monitoring data to support ending remedial action were not developed in the DQO process; therefore, typically accepted performance criteria for the data gathered under this SAP are listed in Table B-4.

B1.3.6 Develop the Plan for Obtaining Data

Step 7 of the DQO process is to develop the sampling and analysis design to generate the data needed to address the nine DSs. The design for collecting contaminant concentration, hydraulic, and flow rate monitoring data is presented in Chapter 4 of the PMP. The monitoring well network is described in Section B1.4; and the designs for the water level, flow rate, COC, and MNA programs are presented in Section B3.

B1.4 Groundwater Monitoring Well Network

The data necessary to address the DSs described in Section B1.3.2 will be collected over the projected 125-year lifetime of the remedial action to evaluate performance, optimize effectiveness, and determine when the remedial action is complete. The selection of the contaminant monitoring well network, sampling frequency, and analytical parameters are discussed in Section 4.1 of the PMP.

Table B-3. DQO Step 3 and Step 5 – Information Inputs and Analytical Approach

DS #	Data Inputs*	Analytical Approach*
DS #1: Determine if there are any new releases of COCs that could affect the effectiveness of the remedy and necessitate changes to the remedial action or the PMP, or both.	Groundwater sampling data collected from the contaminant monitoring well network Hydraulic monitoring data, extraction and injection well flow rate data, and extraction well contaminant sampling data.	Groundwater contaminant sampling data will be evaluated to determine if any new releases of COCs have occurred. Contaminant monitoring well sampling concentration trends will be evaluated, and the sampling data will be used to update the three-dimensional plume shell for each contaminant. If contaminant concentrations in a monitoring well are stable or increasing and there is no known upgradient dissolved-phase contaminant mass to support these stable or increasing concentrations, then there may be a new release.
DS #2: Determine if potentially toxic or mobile transformation products are being generated at concentrations large enough to justify their inclusion in the list of COCs with associated cleanup levels.	Groundwater sampling data collected from the contaminant monitoring well network	Groundwater sampling data will be evaluated to determine if potentially toxic or mobile transformation products are present within the OU. This evaluation is typically performed by analyzing concentration changes in the parent COC and the COC degradation products. This analysis applies to COCs that are commonly degraded in the environment, and in the case of the 200-ZP-1 OU, includes carbon tetrachloride, trichloroethene, and nitrate. The rates of decline in the parent compound and the formation of the degradation products will be used to derive degradation rates. The degradation rates will be included in the 200 West Area contaminant transport model and will be used to evaluate whether natural attenuation will achieve cleanup levels within the time period specified in EPA et al., 2008, <i>Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington</i> .
DS #3: Determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system, natural attenuation processes, and flow-path control actions, thereby necessitating changes to the remedial action or PMP.	Hydraulic monitoring data and groundwater contaminant sampling data	Groundwater elevation data will be necessary to determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system and the flow-path control action. The data should include transient groundwater elevations measured using transducers with data loggers and more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys. The transient data logger groundwater elevation data may be evaluated to monitor the sustainability of the extraction well field and to optimize pumping, possibly by rebalancing upgradient and downgradient injection to ensure that a sustainable remedy is implemented. The more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys should be used to generate water table maps to evaluate groundwater elevations and their impacts on the monitoring well networks and flow-path control actions. The potentiometric surface of water table elevations will be defined using hydraulic monitoring data to help understand groundwater flow directions in the 200-ZP-1 OU. Groundwater monitoring for key biogeochemical and field parameters will be used to determine if changes occur in environmental conditions that may reduce the efficacy of natural attenuation processes. In order to evaluate remediation by natural attenuation, it needs to be determined if contaminant mass is being degraded. The biogeochemical parameters help identify if the appropriate conditions exist in the aquifer to support COC degradation. The monitoring constituents can be used in mass balance calculations to determine if decreases in contaminant and electron acceptor and donor concentrations can be directly correlated to increases in daughter compounds. The simplest way to accomplish this is by mapping the concentration changes in reactants (contaminants, electron acceptors, and donors) or products of the biogeochemical process (e.g., dissolved iron and chloride) that degrade or immobilize the contaminants. These maps can be measured to determine if transformation processes are active at the site. Biodegradation rate constants can be calculated from time-series data of the measured COC concentrations in conjunction with aquifer hydrogeologic parameters such as seepage velocity and dilution.
DS #4: Determine if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the P&T phase of the remedy.	Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well and combined treatment plant influent and effluent contaminant sampling data	The groundwater contaminant transport model will be used to predict if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less. This analysis will use the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and will then transport the contaminant plume forward in time for at least 25 years. Current and future anticipated extraction and injection well flow rates will be needed as input to the model. Using the simulated extraction well contaminant concentrations and flow rates, the contaminant mass removed by each extraction is calculated. The percentage mass removed for each COC will be calculated by summing the simulated mass removed by each extraction well and dividing that by starting mass for each COC. Initial masses are provided in ECF-200ZP1-13-0006, <i>Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report</i> ; and DOE/RL-2013-14, <i>Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations</i> . The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data will be used to calculate the actual contaminant mass removed by the P&T system. Contaminant mass removal can be calculated by multiplying the difference in the treatment plant influent and effluent contaminant concentrations by the influent flow rate and the elapsed time at that concentration and flow rate. However, some COCs may not be detectable in the combined treatment plant influent samples but are detectable in samples collected from one or more of the extraction wells. In this case, a more accurate mass removal can be calculated using the individual extraction well contaminant sampling and flow rate data and summing the mass removed from the individual extraction wells to obtain the total mass removal for the COC.

Table B-3. DQO Step 3 and Step 5 – Information Inputs and Analytical Approach

DS #	Data Inputs*	Analytical Approach*
DS #5: Determine if contamination is expanding downgradient, laterally or vertically after the P&T component has been turned off, thereby necessitating an evaluation of the predicted success of the remedial action.	Groundwater contaminant sampling data collected from the monitoring well network	Groundwater sampling data will be evaluated to determine if contamination is expanding downgradient, laterally or vertically, after the P&T system has been shut down. The trends in measured concentrations for downgradient monitoring wells will be analyzed to draw conclusions about the expansion or migration of the COC plumes. Three-dimensional contaminant plume shells will be updated for each COC using the most current sampling data. Plume volume and contaminant mass statistics can be generated from the plume shells. The contaminant distributions and statistics can be compared to those from the previous plume shell versions to evaluate expansion or contraction of each COC plume. If evaluation of groundwater sampling data indicates that a COC plume may be expanding downgradient and the remedial system is still operating, several courses of action may be taken. Extraction and injection well flow rates or production intervals may be adjusted to improve the hydraulic capture of escaping contaminant mass, or new extraction wells may be installed to capture escaped contaminant mass that is contributing to downgradient plume expansion.
DS #6: Determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years, and thereby achieve the overall remedial goal.	Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well contaminant sampling data	The groundwater contaminant transport model will be used to predict if the current remedy design will achieve cleanup levels for all COCs within 125 years. This analysis can be accomplished by using the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and transporting the contaminant plume forward in time for at least 125 years. Current and future anticipated extraction and injection well flow rates can be supplied to the model as input. An animation can be made for each COC, displaying the contaminant concentrations greater than or equal to the cleanup level as the plume contracts over time. If the simulated contaminant concentrations remain significantly above the cleanup level during the 125-year remediation period, the remedy goal may not be achieved within the desired remedial time frame.
DS #7: Determine if remediation has been successfully completed and a recommendation can be made for no further action.	Groundwater contaminant sampling data	Groundwater sampling data will be evaluated to determine if the remediation has been successfully completed. If contaminant concentrations in all monitoring wells, for all COCs, have decreased to below the cleanup levels for at least 5 years, then a recommendation should be made for no further action.
DS #8: Determine if certain areas of the contaminant plumes are not responding to P&T remediation as expected, and therefore require the evaluation of other technologies for a more focused or “hot spot” remedy.	Groundwater contaminant sampling data	Groundwater sampling data will be evaluated annually to determine if any areas of the contaminant plumes are not responding to P&T remediation. If one or more areas are identified, options will be evaluated.
DS #9: Once 95 percent of the mass of COCs has been removed, determine if there is rebound in COC concentrations, which would require the P&T to be turned back on.	Groundwater contaminant sampling data	Groundwater sampling data will be collected and analyzed for each of the COCs to determine if there is a rebound in COC concentrations.

* A detailed explanation of the data included in this table is provided in the PMP.

COC = contaminant of concern

DS = decision statement

OU = operable unit

P&T = pump and treat

PMP = performance monitoring plan

Table B-4. DQO Step 6 – Typical Acceptance and Performance Criteria

Required Data	Acceptance/Performance Criteria
Groundwater level (depth to water, top of casing, northing and easting coordinates, and well screen top and bottom elevations)	Depth to water should be specified to the nearest 0.61 cm (0.02 ft). Top of casing should be specified to the nearest 0.03 m (0.1 ft). Northings and eastings should be specified to the nearest 0.03 to 1.5 m (0.1 to 5 ft). Well screen top and bottom should be specified to the nearest 0.03 m (0.10 ft) (± 1.5 m [5 ft]).
Pumping rates	Pumping rates should be measured on a semicontinuous basis using inline flow meters accurate to 5 percent of the flow rate.
Contaminant concentrations	Precision is ≤ 20 percent for most contaminants and ≤ 20 percent for radionuclide contaminants. Analytical method must be able to provide data equal to or less than the cleanup levels.
Biogeochemical parameters	Precision is ≤ 20 percent. Errors in the measurement of these parameters have little impact on any significant decisions regarding natural attenuation processes.
Groundwater field parameters	Precision is ≤ 20 percent. Errors in the field measurement of these parameters have little impact on any significant decisions regarding natural attenuation processes.

The monitoring program obtains data from a network of monitoring wells that have been evaluated to develop a constituent-specific set of analyses for each well. The monitoring network considers the inventory of sites that may have the potential for future COC release. For each contaminant (except carbon tetrachloride and TCE), wells identified for monitoring were evaluated considering their geographic location relative to the plume, depth of screen relative to contamination depth, and the data trends relative to the cleanup levels for data collected as part of the PMP effort and since 1990. For VOCs such as carbon tetrachloride and TCE, the monitoring network extends into the 200-UP-1 OU to track the plume, mass removal, and meet the performance metrics provided in the 200-ZP-1 OU ROD (EPA et al., 2008). The contaminant-specific sampling will be augmented by sampling each well for all COCs every 5 years to support the preparation of the CERCLA 5-year review. Sampling the monitoring well network for all COCs on a 5-year basis will generate sufficient data for quantitative analysis to support addressing all nine DSs; however, annual sampling from the contaminant-specific well list will provide data for assessing DSs #1, #2, and #5. This includes determining if there are any new COC releases; evaluating concentration trends in high-concentration plume areas; and determining if contamination is expanding downgradient, laterally or vertically. Therefore, while the P&T system is operating, the list of plume and constituent-specific analyses will be evaluated annually to determine if analyses will be added or dropped for each well. Vertical sampling will be performed when drilling new wells to support remedy assessment against the RAOs (DS #5).

B1.4.1 Existing Monitoring Wells

The monitoring well network will change over time as remedy components reduce COC concentrations and the plumes contract. Some aquifer areas will be cleaned up more quickly, and many of the shallow monitoring wells may go dry in areas furthest from the injection wells. Therefore, while the P&T system is operating, the contaminant monitoring well networks will be evaluated annually to determine if monitoring wells will be dropped from the network or if other wells should be added. These changes will

be presented in an amended version of this SAP, subject to U.S. Environmental Protection Agency (EPA) review and concurrence.

B1.4.2 Proposed New Monitoring Wells

Several areas where existing monitoring well coverage may be inadequate are identified in Section 4.1.2 of the PMP to evaluate remedial action effectiveness. To address potential gaps in the monitoring well network, new monitoring wells may be installed (Table B-5) using DOE/RL-2010-72, *Sampling and Analysis Plan for Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit* procedures.

Table B-5. Proposed New Monitoring Wells

Well Priority	Temporary Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)
1	MW7B	56883	135819	120
	MW7A	56883	135819	100
2	MW1A	568175	137621	90
	MW1B	568175	137621	110
3	MW2	56774	137453	111
4	MW3A	567578	136476	73
	MW3B	567578	136476	92
	MW3C	567578	136476	112
5	MW8A	568670	136810	98
	MW8B	568670	136810	120
6	MW4A	566752	137093	80
	MW4B	566752	137093	100
7	MW5A	567147	135774	70
	MW5B	567147	135774	110
8	MW6A	571438	137500	80
	MW6B	571438	137500	106

amsl = above mean sea level

B1.5 Contaminants

Specific contaminants for CERCLA groundwater monitoring are listed in Table B-6. The CERCLA COCs listed are those identified in the 200-ZP-1 OU ROD (EPA et al., 2008).

Table B-6. Analytes for 200-ZP-1 OU Groundwater Monitoring

Constituent	CAS Number	Data Use
Contaminants of Concern		
Carbon tetrachloride	56-23-5	Delineate carbon tetrachloride plume
Chromium (total)	7440-47-3	Delineate chromium plume
Chromium (hexavalent)	18540-29-9	Delineate chromium plume
Iodine-129	15046-84-1	Delineate iodine-129 plume
Nitrate-N	14797-55-8	Delineate nitrate plume
Technetium-99	14133-76-7	Delineate technetium-99 plume
Trichloroethene	79-01-6	Delineate trichloroethene plume
Tritium	10028-17-8	Delineate tritium plume
Other Constituents		
Uranium (from the 200-UP-1 Operable Unit)	7440-61-1	Delineate uranium plume
Alkalinity	N/A	Evaluate natural attenuation
Carbonate content (bicarbonate and carbonate)	N/A	Evaluate natural attenuation
Chloroform	67-66-3	Evaluate carbon tetrachloride natural attenuation
Chloride	16887-00-6	Evaluate chlorinated solvent natural attenuation
Chloromethane	74-87-3	Evaluate carbon tetrachloride natural attenuation
cis-1,2-Dichloroethene	156-59-2	Evaluate trichloroethene natural attenuation
Dichloromethane	75-09-2	Evaluate carbon tetrachloride natural attenuation
Iron	7439-89-6	Evaluate natural attenuation
Manganese	7436-96-5	Evaluate natural attenuation
Nitrite-N	14797-65-0	Evaluate nitrate natural attenuation
Sulfate	14808-79-8	Evaluate natural attenuation
Sulfide	18496-25-8	Evaluate natural attenuation
Total dissolved solids	N/A	Evaluate natural attenuation, identify new releases
Total organic carbon	N/A	Evaluate natural attenuation
Vinyl chloride	75-01-4	Evaluate trichloroethene natural attenuation

Table B-6. Analytes for 200-ZP-1 OU Groundwater Monitoring

Constituent	CAS Number	Data Use
Field Measurements		
Dissolved oxygen	N/A	Evaluate natural attenuation
Oxidation-reduction potential	N/A	Evaluate natural attenuation
pH	N/A	Evaluate well purge for sampling
Specific conductance	N/A	Evaluate well purge for sampling
Temperature	N/A	Evaluate well purge for sampling
Turbidity	N/A	Evaluate well purge for sampling

CAS = Chemical Abstracts Service

N/A = not applicable

B1.6 Project Schedule

This SAP will direct the CERCLA monitoring activities needed for 200-ZP-1 OU for 125 years (until 2137; 25 years for active P&T and 100 years for monitoring natural attenuation). The yearly sampling schedule is established by the Sample Management and Reporting (SMR) organization to optimize the overall number of sampling trips and limit schedule redundancy. The SMR organization tracks overlapping requirements so single sampling events can be used to co-sample wells and optimize schedules.

B2 Quality Assurance Project Plan

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

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities:

- Section B2.1, Project Management
- Section B2.2, Data Generation and Acquisition
- Section B2.3, Assessment and Oversight
- Section B2.4, Data Review and Usability

B2.1 Project Management

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

B2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the U.S. Department of Energy, Richland Operations Office (DOE-RL) project manager in obtaining approval of the SAP and future proposed revisions. The project organization (regarding routine groundwater monitoring) is described in the following subsections and is illustrated in Figure B-6.

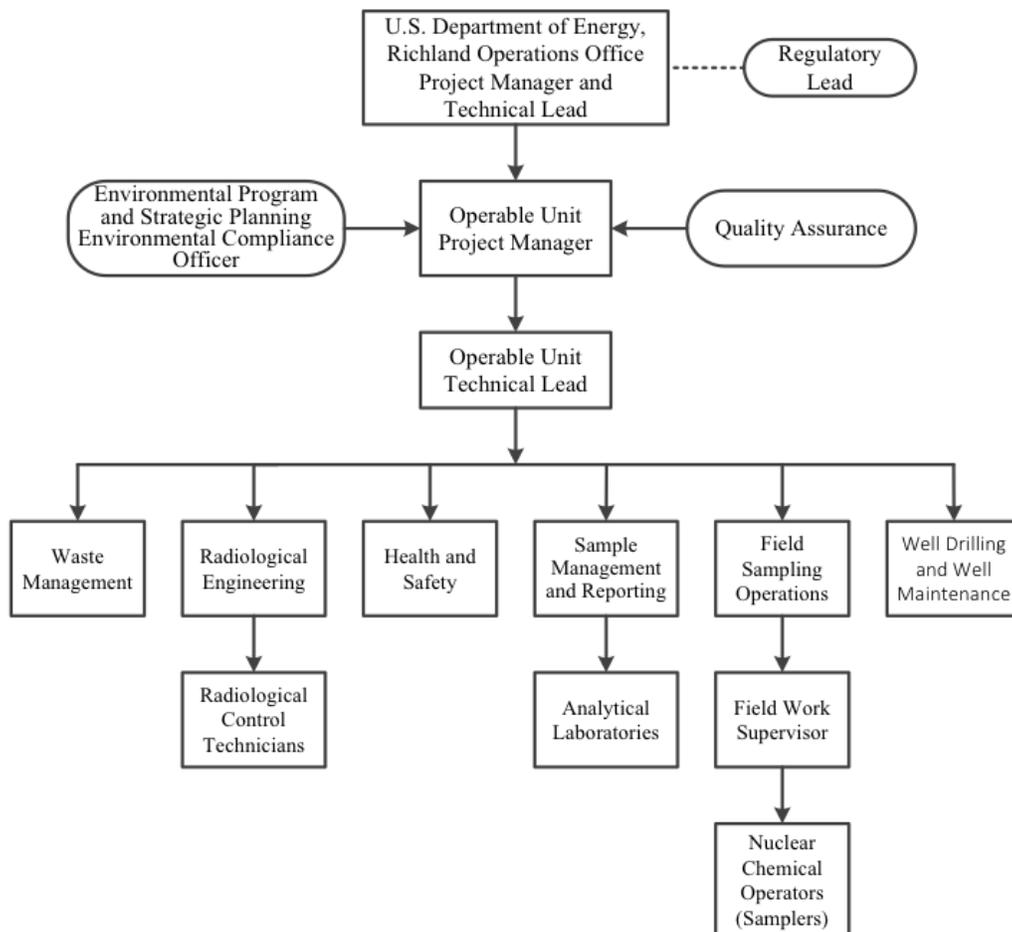


Figure B-6. Project Organization

B2.1.1.1 Regulatory Lead

The lead regulatory agency is responsible for regulatory oversight of cleanup projects and activities. The lead regulatory agency has SAP approval authority for the OUs that they manage. The lead regulatory agency works with DOE-RL to resolve concerns regarding the work described in this SAP in accordance with Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

B2.1.1.2 DOE-RL Project Manager

The DOE-RL project manager is responsible for the following:

- Monitoring the contractor's performance of activities under CERCLA, RCRA, the *Atomic Energy Act of 1954*, and the Tri-Party Agreement (Ecology et al., 1989a) for the Hanford Site
- Obtaining lead regulatory agency approval of the SAP
- Authorizing field sampling activities
- Approving the SAP
- Functioning as primary interface with regulatory agencies

B2.1.1.3 DOE-RL Technical Lead

The DOE-RL technical lead is responsible for the following:

- Providing day-to-day oversight of the contractor's workscope performance
- Working with the contractor and the regulatory agencies to identify and resolve technical issues
- Providing technical input to the DOE-RL project manager

B2.1.1.4 Operable Unit Project Manager

The OU project manager (or designee) is responsible and accountable for the following:

- Performing project-related activities
- Coordinating with DOE-RL, the regulatory agencies, and contractor management in support of sampling activities to ensure that work is performed safely and cost effectively
- Managing sampling documents and requirements, field activities, and subcontracted tasks; and ensuring that the project file is properly maintained

B2.1.1.5 Operable Unit Technical Lead

The OU technical lead is responsible for the following:

- Developing specific sampling design, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process
- Ensuring that sampling and analysis activities, as delegated by OU project manager, are carried out in accordance with the SAP
- Working closely with the environmental compliance officer (ECO), the QA and the Health and Safety organizations, the field work supervisor (FWS), and the SMR organization to integrate these and other technical disciplines in planning and implementing the workscope

B2.1.1.6 Environmental Compliance Officer

The ECO is responsible for the following:

- Providing technical oversight, direction, and acceptance of project and subcontracted environmental work
- Developing appropriate mitigation measures to minimize adverse environmental impacts
- Reviewing plans, protocols, and technical documents to ensure that environmental requirements have been addressed
- Identifying environmental issues affecting operations and developing cost-effective solutions
- Responding to environmental/regulatory issues or concerns
- Overseeing project implementation for compliance with applicable internal and external environmental requirements

B2.1.1.7 Quality Assurance

The QA organization point of contact is responsible for the following:

- Addressing QA issues on the project
- Overseeing implementation of the project QA requirements
- Reviewing project documents (including the DQO summary report, QAPjP, and SAP)
- Reviewing data validation reports from third-party data validation contractors, as appropriate
- Participating in QA assessments on sample collection and analysis activities, as appropriate

B2.1.1.8 Health and Safety

The Health and Safety organization is responsible for the following:

- Coordinating industrial safety and health support within the project in accordance with the health and safety program, job hazard analyses, and other pertinent federal regulations
- Assisting project personnel in complying with the applicable health and safety program
- Coordinating with Radiological Engineering to determine personal protective equipment requirements

B2.1.1.9 Radiological Engineering

Radiological Engineering is responsible for the following:

- Providing radiological engineering and health physics support to the project
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring that appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels
- Interfacing with the project Health and Safety representative and other appropriate personnel as needed to plan and direct project radiological control technician (RCT) support

B2.1.1.10 Sample Management and Reporting Organization

The SMR organization is responsible for the following activities:

- Interfacing between the OU technical lead, Field Sampling Operations (FSO), the Well Maintenance organization, and the analytical laboratories
- Generating field sampling documents, labels, and instructions for field sampling personnel
- Developing the sample authorization form (SAF), which provides information and instructions to the analytical laboratories
- Providing instructions to the FSO nuclear chemical operators (NCOs) (i.e., samplers) on the collection of samples as specified in the SAP
- Monitoring the entire sample and data process
- Coordinating laboratory analytical work and ensuring that the laboratories conform to Hanford Site QA requirements (or their equivalent), as approved by the U.S. Department of Energy (DOE), the EPA, and the Washington State Department of Ecology (Ecology)
- Resolving sample documentation deficiencies or issues associated with FSO, laboratories, or other entities to ensure that project needs are met
- Receiving analytical data from the laboratories
- Ensuring that data are uploaded into the Hanford Environmental Information System (HEIS) database
- Arranging for and overseeing data validation, as requested
- Informing the OU project manager and/or OU technical lead of any issues reported by the analytical laboratories

B2.1.1.11 Analytical Laboratories

Analytical laboratories are responsible for the following:

- Analyzing samples in accordance with established methods
- Providing data packages containing analytical and QC results
- Providing explanations in response to resolution of analytical issues
- Meeting the requirements of this plan
- Being on the Mission Support Alliance evaluated suppliers list
- Being accredited by Ecology for the analyses performed for the Soil and Groundwater Remediation Project

B2.1.1.12 Waste Management

Waste Management is responsible for the following:

- Communicating policies and protocols
- Ensuring compliance for waste storage, transportation, disposal, and tracking in a safe and cost-effective manner

- Identifying waste management sampling/characterization requirements to ensure regulatory compliance
- Interpreting data to determine waste designations and profiles
- Preparing and maintaining other documents to confirm compliance with waste acceptance criteria

B2.1.1.13 Field Sampling Organization

FSO is responsible for the following:

- Planning, coordinating, and conducting field sampling activities
- The FWS directing the NCOs (samplers) and ensuring that the NCOs are appropriately trained and available
- The FWS reviewing the SAP for field sample collection concerns, analytical requirements, and special sampling requirements
- Ensuring that the sampling design is understood by the NCOs and can be performed as specified; this is achieved by performing mock-ups and holding practice sessions with field personnel
- The NCOs collecting all salient samples in accordance with sampling documentation
- Completing field logbook entries, chain-of-custody forms, and shipping paperwork; and ensuring delivery of the samples to the analytical laboratory
- The FWS acting as a technical interface between the OU project manager and the field crew supervisors (e.g., the drilling buyer's technical representative [BTR], and geologist BTR) and ensuring that technical aspects of the field work are met in consultation with the OU project manager and SMR, resolving issues regarding arising from translation of technical requirements to field operations, and coordinating resolution of sampling issues

B2.1.1.14 Well Maintenance

The Well Maintenance manager is responsible for the following:

- Coordinating well maintenance activities
- Coordinating with the OU technical lead to identify field constraints that could affect groundwater sampling

B2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure the generation of analytical data of known and appropriate quality that are acceptable and useful for decision-making purposes. In support of this objective, statistics and data descriptors known as data quality indicators (DQIs) help determine the acceptability and utility of data to the user. The principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These are defined, for the purposes of this SAP, in Table B-7.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section B2.4.3).

B2.1.3 Special Training/Certification

A graded approach is used to ensure that workers receive a level of training commensurate with their responsibilities and compliant with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Pre-job briefings will be held in accordance with work management and work release requirements document evaluation activities and associated hazards, including the following topics:

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

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

B2.1.4 Documents and Records

The OU project manager (or designee) is responsible for ensuring that the current version of the SAP is being used and for providing updates to field personnel. The administrative document control process maintains version control. Changes to the sampling document are in accordance with HASQARD (DOE/RL-96-68) and the Tri-Party Agreement Action Plan (Ecology et al., 1989b). The OU project manager is responsible for tracking all SAP changes, obtaining appropriate review, and alerting DOE-RL of these changes. Appropriate documentation will follow in accordance with the requirements for the particular type of change. Table B-8 summarizes possible changes and their documentation requirements.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: <ul style="list-style-type: none"> • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: <ul style="list-style-type: none"> • Qualify the data before use. • Request reanalysis or remeasurement.
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: <ul style="list-style-type: none"> • Identify the reason for the results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	<p>If data are not comparable to other data sets:</p> <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data, as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	<p>If data set does not meet completeness objective:</p> <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Bias	<p>Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation.</p> <p>Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.</p>	<p>Sampling bias may be revealed by analysis of replicate samples.</p> <p>Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).</p>	<p>For sampling bias:</p> <ul style="list-style-type: none"> • Properly select and use sampling tools. • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media. • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media. <p>Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias.</p> <p>Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.</p>
Sensitivity	<p>Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).</p>	<p>Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation).</p> <p>The lower limit of quantitation is the lowest level that can be routinely quantified and reported by a laboratory.</p>	<p>If detection limits do not meet objective:</p> <ul style="list-style-type: none"> • Request re-analysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

Table B-8. Change Control for Sampling Projects

Type of Change^a	Type of Change (Tri-Party Agreement Action Plan^b)	Action	Documentation
Minor change: Change has no impact on the sample or field analytical result, and little or no impact on performance or cost. Further, the change does not affect the DQOs specified in the SAP.	Minor field change: Changes that have no adverse effect on the technical adequacy of the job or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU project manager (or designee) prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Significant change: Change has a considerable effect on performance or cost, but still allow for meeting the DQOs specified in the SAP.	Minor change: Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU project manager will inform the DOE-RL project manager and the regulatory lead of the change and seek concurrence at a unit managers' meeting or comparable forum. The lead regulatory agency determines there is no need to revise the document.	Documentation of this change approval would be in the unit managers' meeting minutes or a comparable record, such as a change notice. ^c
Fundamental change: Change has significant effect on the sample or the field analytical result, performance, or cost, and the change does not meet the requirements specified in the DQOs in the sampling document.	Revision necessary: Lead regulatory agency determines changes to approved plans require revision to document.	If it is anticipated that a fundamental change will require the approval of the regulatory lead, the applicable DOE-RL project manager will be notified by the OU project manager and will be involved in the decision prior to implementation of a fundamental change. The lead regulatory agency determines the change requires a revision to the document.	Formal revision of the sampling document.

a. Consistent with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)*.

b. Consistent with Sections 9.3 and 12.4 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan).

c. The Tri-Party Agreement Action Plan, Section 9.3, defines the minimum elements of a change notice.

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

DQO = data quality objective

OU = operable unit

SAP = sampling and analysis plan

The FWS, the SMR organization, and appropriate BTR are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the SAP. The SMR organization will ensure that any deviations from the SAP are reflected in revised paperwork for the samplers and the analytical laboratory. The FWS or appropriate BTR will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook) in accordance with corrective action protocols.

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

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

The following records are managed and maintained by SMR personnel:

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

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

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

Records may be stored in either electronic or hardcopy format. Documentation and records, regardless of medium or format, are controlled in accordance with work requirements and processes to ensure that stored records are accurate and can be retrieved. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

B2.2 Data Generation and Acquisition

The following sections present the requirements for analytical methods, measurement and analysis, data collection or generation, data handling, and field and laboratory QC. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

B2.2.1 Analytical Methods Requirements

Analytical method performance requirements for samples collected are presented in Table B-9. In consultation with the laboratory and the OU project manager, the SMR organization can approve changes to analytical methods as long as the new method is based upon a nationally recognized standard method (e.g., EPA or ASTM [formerly American Society for Testing & Materials]) and the new method delivers analytical data that are comparable to those provided by the old method. The new method must achieve project DQOs as well or better than the replaced method and is required due to the nature of the sample (e.g., high radioactivity). The laboratory using the new method must be accredited by Ecology to perform that method. Issues that may affect analytical results are resolved by the SMR organization in coordination with the OU project manager.

Table B-9. Performance Requirements for Groundwater Analysis

CAS Number	Analyte	Survey or Analytical Method	Units	Action Level	Target Detection Limit
56-23-5	Carbon tetrachloride (LL) (COC)	SW-846, Method 8260	µg/L	3.4	1
67-66-3	Chloroform (TP)	SW-846, Method 8260	µg/L	7.17	5
75-09-2	Dichloromethane (TP)	SW-846, Method 8260	µg/L	5	5
74-87-3	Chloromethane (TP)	SW-846, Method 8260	µg/L	N/A	10
79-01-6	Trichloroethene (COC)	SW-846, Method 8260	µg/L	1	1
156-59-2	cis-1,2-Dichloroethene (TP)	SW-846, Method 8260	µg/L	70	5
75-01-4	Vinyl chloride (TP-LL)	SW-846, Method 8260	µg/L	2	2
7440-47-3	Chromium (total) (COC)	SW-846, SW6010/6020 or EPA 200.8	µg/L	100	10
18540-29-9	Hexavalent chromium (COC)	Method 7196	µg/L	48	10
14697-55-8	Nitrate-N (COC)	SW-846, EPA 300.0 or 9056	mg/L	10	0.25
14797-65-0	Nitrite-N (TP)	EPA 300.0 or 9056	mg/L	1	0.25

Table B-9. Performance Requirements for Groundwater Analysis

CAS Number	Analyte	Survey or Analytical Method	Units	Action Level	Target Detection Limit
15046-84-1	Iodine-129 (COC)	Low-energy photon spectroscopy (LL)	pCi/L	1	1
14133-76-7	Technetium-99 (COC)	Liquid scintillation	pCi/L	900	50
10028-17-8	Tritium (COC)	Liquid scintillation	pCi/L	20,000	700
7440-61-1	Uranium (from the 200-UP-1 OU)	SW-846, SW6010/6020 or EPA 200.8	µg/L	30	1
N/A	Total organic carbon (NAP)	EPA 415.1	µg/L	N/A	1,000
N/A	Total dissolved solids	EPA 160.1	mg/L	500	10
14808-79-8	Sulfate (NAP)	EPA 300.0A or 9056	mg/L	250	0.55
18496-25-8	Sulfide (NAP)	EPA 376.1, 4500D, 9034, or 9030	mg/L	N/A	0.50
7439-89-6	Iron (NAP)	SW-846, SW6010/6020	µg/L	300	100
7439-96-5	Manganese (NAP)	SW-846, SW6010/6020	µg/L	50	15 / 5
N/A	Alkalinity (NAP)	EPA 310.1	mg/L	N/A	5
16887-00-6	Chloride	EPA 300.0 or 9056	mg/L	250	0.40

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

CAS = Chemical Abstracts Service

N/A = not applicable

COC = contaminant of concern

NAP = natural attenuation evaluation parameter

EPA = U.S. Environmental Protection Agency

OU = operable unit

LL = low level

TP = transformation product

B2.2.2 Field Analytical Methods

Chemical field screening and radiological field survey data used for site characteristics will be measured in accordance with HASQARD (DOE/RL-96-68) requirements, as applicable. Field analytical methods may also be performed in accordance with manufacturers' manuals. Section B3 provides the parameters identified for field survey analyses.

B2.2.3 Quality Control

The QC requirements specified in the SAP must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample requirements are summarized in Table B-10. Acceptance criteria for field and laboratory QC are shown in Table B-11. Data will be qualified and flagged in the HEIS database, as appropriate.

Table B-10. Project QC Requirements

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field duplicate	One per 20 well trips.	Precision, including sampling and analytical variability
Field split	As needed. When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the analytical performance requirements table.	Precision, including sampling, analytical, and interlaboratory
Full trip blank	One per 20 well trips.	Cross-contamination from containers or transportation
Field transfer blank	One each day that volatile organic compounds are sampled.	Contamination from sampling site
Equipment blank	As needed. If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required. Otherwise, one for every 20 samples. ^a	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical QC^b		
Laboratory duplicate	One per analytical batch. ^c	Laboratory reproducibility and precision
Matrix spike	One per analytical batch. ^c	Matrix effect/laboratory accuracy
Post-preparation spike	One per analytical batch. ^c	Matrix effect/laboratory accuracy
Matrix spike duplicate	One per analytical batch. ^c	Laboratory accuracy and precision
Laboratory control sample	One per analytical batch. ^c	Evaluate laboratory accuracy

Table B-10. Project QC Requirements

Sample Type	Frequency	Characteristics Evaluated
Method blank	One per analytical batch. ^c	Laboratory contamination
Surrogate	One per sample. ^c	Recovery/yield
Tracer	One per sample. ^c	Recovery/yield

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

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

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

QC = quality control

B2.2.3.1 Field Quality Control Samples

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

- **Field duplicates:** Independent samples collected as close as possible to the same time and location as the scheduled sample that are intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.
- **Field splits (SPLITS):** Two samples collected as close as possible to the same time and location that are intended to be identical. The SPLITS will be stored in separate containers and analyzed by different laboratories for the same analytes. The SPLITS are interlaboratory comparison samples used to evaluate comparability between laboratories.
- **Full trip blanks (FTBs):** Bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis (VOA) only or identical to the set that will be collected in the field. It is filled with high-purity reagent water (or dead water from well 699-S11-E12AP for low-level tritium FTBs¹), and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

¹ Because of the low detection levels achieved in the low-level tritium analysis, special low-level tritium water must be used. This low-level tritium water, known as “dead water,” is collected yearly, or as needed, from well 699-S11-E12AP or other approved source.

- **Field transfer blanks (FXRs):** Preserved VOA sample vials filled with high-purity reagent water at the sample collection site where VOC samples are collected. The samples will be prepared during sampling to evaluate potential contamination attributable to field conditions. After collection, FXR sample vials will be sealed and placed in the same storage containers with the samples collected the same day for the associated sampling event. FXR samples will be analyzed for VOCs only.
- **Equipment blanks (EBs):** Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. The EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. The EB samples will be analyzed for the same constituents as the samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

B2.2.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by the laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of matrix spikes (MSs), matrix duplicates, matrix spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), tracers, and method blanks (MBs). These samples are recommended in the guidance documents, are required by EPA protocol (e.g., EPA-600/4-79/20, *Methods for Chemical Analysis of Water and Wastes*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC and their typical frequencies are listed in Table B-10. Acceptance criteria are provided in Table B-11.

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity	MB ^b	< MDL	Flagged with “C”
Conductivity		<5% sample concentration	
Hexavalent chromium	LCS	80 – 120% recovery ^c	Data reviewed ^d
pH	Laboratory duplicate or MS/MSD	≤20% RPD	Data reviewed ^d
Total dissolved solids	Post-preparation spike ^b	75 – 125% recovery ^c	Flagged with “N”
Total organic carbon	EB	<2 times MDL	Flagged with “Q”
Total organic halides	Field duplicate	≤20% RPD ^e	Flagged with “Q”

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
Ammonia, Anions, and Cyanide			
Ammonia Anions by IC Cyanide	MB	< MDL <5% sample concentration	Flagged with "C"
	LCS	80 – 120% recovery ^c	Data reviewed ^d
	Laboratory duplicate or MS/MSD	≤20% RPD	Data reviewed ^d
	MS	75 – 125% recovery ^c	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD ^e	Flagged with "Q"
Metals			
ICP metals ICP/MS metals Mercury	MB	< MDL <5% sample concentration	Flagged with "C"
	LCS	80 – 120% recovery ^c	Data reviewed ^d
	MS/MSD	75 – 125% recovery ^c	Flagged with "N"
	DUP/MSD	≤20% RPD	Data reviewed ^d
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD ^e	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS Total petroleum hydrocarbons by GC	MB	< MDL ^f <5% sample concentration	Flagged with "B"
	LCS	70 – 130%	Data reviewed ^d
	MS/MSD	70 – 130% recovery	Flagged with "T"
	DUP/MSD	≤20%	Data reviewed ^d
	SUR	70 – 130%	Data reviewed ^d
	EB, FTB, FXR	<2 times MDL ^f	Flagged with "Q"
	Field duplicate	≤20% RPD ^e	Flagged with "Q"

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
Semivolatile Organic Compounds			
Semivolatiles by GC/MS	MB	< MDL ^f <5% sample concentration	Flagged with “B”
	LCS	70 – 130%	Data reviewed ^d
	DUP/MSD	≤20% RPD	Data reviewed ^d
	MS/MSD	% recovery statistically derived ^e	Flagged with a “T”
	SUR	70 – 130%	Data reviewed ^d
	EB, FTB	<2 times MDL ^f	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Radiochemical Analyses			
Americium (isotopic) Carbon-14 Gamma scan Gross alpha Gross beta Iodine-129 Plutonium (isotopic) Technetium-99 Tritium Tritium (low level) Uranium (isotopic) Uranium (total)	MB	< MDC <5% sample concentration	Flagged with “B”
	LCS	80 – 120% recovery	Data reviewed ^d
	Laboratory duplicate ^e	≤20% RPD	Data reviewed ^d
	MS ^g	75 – 125% recovery	Flagged with “N”
	Tracer (where applicable)	30 – 105% recovery	Data reviewed ^d
	Carrier (where applicable)	40 – 110% recovery	Data reviewed ^d
	EB, FTB	<2 times MDA	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”

a. Specific analytes and method for determination are available from the Sample Management and Reporting organization.

b. Does not apply to pH, conductivity, total dissolved solids, or alkalinity.

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

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

e. Applies only in cases where one or both results are greater than 5 times the minimum detectable concentration.

f. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.

g. Applies only to isotopic carbon-14, technetium-99, total uranium by ICP/MS, and tritium.

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
DUP = duplicate		MB = method blank	
EB = equipment blank		MDA = minimum detectable activity	
FTB = full trip blank		MDC = minimum detectable concentration	
FXR = field transfer blank		MDL = method detection limit	
GC = gas chromatography		MS = matrix spike	
GC/MS = gas chromatography/mass spectrometry		MSD = matrix spike duplicate	
IC = ion chromatography		QC = quality control	
ICP = inductively coupled plasma		RPD = relative percent difference	
ICP/MS = inductively coupled plasma/mass spectrometry		SUR = surrogate	
LCS = laboratory control sample			
Data flags:			
B (organics)/C (inorganics/wetchem) = analyte was detected in both the associated QC blank and the sample)			
N = all except GC/MS (MS outlier)			
T = volatile organic analytes and semivolatile organic analytes GC/MS (MS outlier)			
Q = associated QC sample is out of limits			

The various types of laboratory QC samples are defined as follows:

- **Laboratory duplicate:** An intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.
- **Matrix spike (MS):** An aliquot of a sample spiked with a known concentration of target analyte(s). The MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.
- **Post-preparation spike:** The same as an MS; however, the spiking occurs after sample preparation.
- **Matrix spike duplicate (MSD):** A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. The MSD results are used to determine the bias and precision of a method in a given sample matrix.
- **Laboratory control sample (LCS):** A control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.
- **Method blank (MB):** An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical procedure, and it is used to quantify contamination resulting from the analytical process.

- **Surrogate (SUR):** A compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. The SUR is typically similar in chemical composition to the analyte being determined, yet it is not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.
- **Tracer:** A known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on tracer recovery.

Laboratories are required to analyze samples within the holding times specified in Table B-12. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilizing, decomposing, or by other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an “H.”

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Gravimetric Determinations				
Residue, filterable total dissolved solids	500 mL	Poly or glass	Store ≤6°C	7 days
Organic Analyses				
Volatile organics	4 × 40 mL	Amber glass VOA vial with Teflon-lined septum lid	Store ≤6°C (if free Cl ₂ , add 4 drops of 10% sodium thiosulfate), adjust pH to <2 with HCl	14 days
Semivolatile organics	4 × 1 L	Amber glass with Teflon-lined lid	Store ≤6°C (if residual Cl ₂ , add 3 mL 10% sodium thiosulfate/gal of sample)	7 days before extraction 40 days after extraction
WTPH-D	4 × 1 L	Amber glass with Teflon-lined lid	Store ≤6°C pH to <2 with HCl	7 days before extraction (14 days if preserved) 40 days after extraction
WTPH-G	4 × 40 mL	Amber glass VOA vial with Teflon-lined septum lid	Store ≤6°C, adjust pH to <2 with HCl	14 days
Total organic halides	1 L	Glass with Teflon-lined lid	Store ≤6°C, adjust pH to <2 with H ₂ SO ₄	28 days
Total organic carbon	250 mL	Amber glass with Teflon-lined lid	Store ≤6°C, adjust pH to <2 with H ₂ SO ₄ or HCl	28 days

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Metals^c				
ICP/MS (with/without mercury)	250 mL	Poly or glass	Adjust pH to <2 with nitric acid	28 days/6 months ^c
ICP/AES (with/without mercury)	250 mL	Poly or glass	Adjust pH to <2 with nitric acid	28 days/6 months ^c
Dissolved metals (with/without mercury)	500 mL	Poly or glass	Filter prior to pH adjustment to <2 with nitric acid	28 days/6 months ^c
Mercury	250 mL	Poly or glass	Adjust pH to <2 with nitric acid	28 days
Miscellaneous Inorganic				
Alkalinity	500 mL	Poly or glass	Store ≤6°C	14 days
Cyanide	250 mL	Poly or glass	Store ≤6°C, adjust pH to >12 with 50% NaOH; if oxidizing agents present, add 5 mL 0.1 N NaAsO ₂ /L or 0.06 g ascorbic acid/L	14 days
Hexavalent chromium	60 mL	Poly or glass	Store ≤6°C	24 hours
pH	60 mL	Poly or glass	None required	Analyze immediately
Specific conductivity	150 mL	Poly or glass	Store ≤6°C	28 days
Inorganic Ions				
Ammonia	125 mL	Poly or glass	Store ≤6°C, adjust pH to <2 with H ₂ SO ₄	28 days
Bromide	125 mL	Poly or glass	Store ≤6°C	28 days
Chloride	125 mL	Poly or glass	Store ≤6°C	28 days
Fluoride	125 mL	Poly or glass	Store ≤6°C	28 days
Nitrate	125 mL	Poly or glass	Store ≤6°C	48 hours
Nitrite	125 mL	Poly or glass	Store ≤6°C	48 hours
Phosphate	125 mL	Poly or glass	Store ≤6°C	48 hours
Sulfate	125 mL	Poly or glass	Store ≤6°C	28 days

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Sulfide	250 mL	Wide-mouth poly or glass	Store $\leq 6^{\circ}\text{C}$, ZnAc+NaOH to pH >9	7 days
Radiochemical Analyses				
Gross alpha/beta (plate count)	500 mL	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Americium/curium by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Carbon-14	2 \times 1 L	Poly or glass	None	6 months
Plutonium isotopic by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Uranium isotopic by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Gamma energy analysis	500 mL	Square poly	Adjust pH to <2 with HNO_3	6 months
Iodine-129	2 \times 4 L	Poly or glass	None	6 months
Neptunium-237	1 L	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Technetium-99 by liquid scintillation	1 L	Poly or glass	Adjust pH to <2 with HCl	6 months
Tritium	1 L	Glass	None	6 months
Total uranium by kinetic phosphorescence analysis	250 mL	Poly or glass	Adjust pH to <2 with HNO_3	6 months

Notes:

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

The information in this table does not represent EPA requirements, it is intended solely as guidance. Selection of container, preservation techniques and applicable holding times should be based on the stated project-specific data quality objectives.

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

b. For preservation identified as store at $\leq 6^{\circ}\text{C}$, the sample should be protected against freezing unless it is known that freezing will not affect the sample integrity.

c. For metals analysis, 28 days/6 months holding time defines 28 days for mercury, 6 months for all other metals.

AEA = alpha energy analysis

EPA = U.S. Environmental Protection Agency

ICP/AES = inductively coupled plasma/atomic emission spectroscopy

ICP/MS = inductively coupled plasma/mass spectrometry

VOA = volatile organic analysis

WTPH-D = Washington State Department of Ecology total petroleum hydrocarbons as diesel

WTPH-G = Washington State Department of Ecology total petroleum hydrocarbons as gasoline

B2.2.4 Measurement Equipment

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

B2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM) or be acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance-tested prior to use in the field.

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

B2.2.6 Instrument and Equipment Calibration and Frequency

Specific field equipment calibration information is provided in Section B3.5. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

B2.2.7 Inspection and Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with the requirements of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended, and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

B2.2.8 Nondirect Measurements

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

B2.2.9 Data Management

The SMR organization, in coordination with the OU project manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management methods.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS) or a project-specific database, whichever is applicable for the data being stored. Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

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

B2.3 Assessment and Oversight

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

B2.3.1 Assessments and Response Actions

Random surveillances and assessments are used to verify compliance with the requirements outlined in this SAP, project field instructions, the project quality management plan, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates corrective actions/deficiencies resolutions in accordance with the QA program, the corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the OU project manager (or designee).

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

B2.3.2 Reports to Management

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

B2.4 Data Review and Usability

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

B2.4.1 Data Review and Verification

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

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors.

Errors identified by the laboratories are reported to the SMR organization's project coordinator, who initiates a sample issue resolution form. This process is used to document analytical errors and to establish resolution with the OU technical lead.

For analytical data in sample media, field screening results are of lesser importance in making inferences regarding risk. Field QA/QC results will be reviewed to ensure that the data are usable.

Review by the OU technical lead will help determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in submittal of a request for data review on questionable data. The laboratory may be asked to check calculations or reanalyze the sample, or the well may be resampled. Results of the request for data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

B2.4.2 Data Validation

Data validation activities will be performed at the discretion of the OU project manager and under the direction of the SMR organization. If performed, data validation activities will be based on EPA functional guidelines.

B2.4.3 Reconciliation with User Requirements

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

B3 Field Sampling Plan

This section identifies the wells monitored, their sampling frequencies, and the constituents analyzed.

B3.1 Sampling Objectives

The objectives of groundwater monitoring in the 200-ZP-1 OU are to define the extent, and track the movement, of the groundwater contaminant plumes, assess performance of the 200 West P&T, assess MNA, and assess flow-path control elements of the selected remedy. These objectives are accomplished by sampling the groundwater at designated wells and analyzing the samples for the identified COCs and other analytes listed in Table B-9.

B3.2 Sample Location, Frequency, and Constituents to be Monitored

The sampling requirements and groundwater monitoring wells comprising the 200-ZP-1 OU network are listed in Appendix C. Appendix F provides information on the hydrogeologic unit monitored by the wells. Table B-13 lists the hydraulic monitoring wells, and Table B-14 identifies the specific constituents to be analyzed and the sampling frequency for the monitoring wells. Appendix A provides the criteria used to identify the wells needed to address the DSs identified during the DQO process. Some wells are

co-sampled with other monitoring programs (e.g., to meet RCRA requirements). Monitoring requirements for the other monitoring programs are described in separate plans. The reported data from these networks is supplementary to the information gathered under this SAP.

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W10-1	566663	136735	207.5	57.91	82.3	08/07/1947	No	137.4
299-W10-27	566844	136442	205.6	67.36	78.02	03/23/2001	No	132.9
299-W10-30	566083	136739	211.6	73.86	84.53	03/14/2006	No	132.4
299-W10-31	566266	136968	210.4	73.13	83.82	04/20/2006	No	131.9
299-W10-33	566773	136610	206.0	118.87	124.96	06/15/2007	No	84.1
299-W11-13	567099	136424	211.9	66.45	143.86	07/31/1961	No	106.7
299-W11-18	567182	137161	216.5	69.19	89.916	03/01/1967	No	136.9
299-W11-33Q	567185	136844	217.2	74.41	91.17	09/09/1994	No	134.4
299-W11-43	567270	136971	217.5	129.44	134.01	05/23/2005	No	85.8
299-W11-45	566993	136776	213.6	85.73	90.18	09/02/2005	No	125.7
299-W11-47	566934	136681	210.4	83.58	92.89	01/06/2006	No	122.2
299-W11-48	566882	136846	209.7	84.56	112.01	11/29/2006	Yes	111.4
299-W11-87	568141	136609	223.6	116.36	120.94	03/01/2007	Yes	105.0
299-W11-88	567875	137113	221.9	135.66	147.85	10/03/2007	Yes	80.1
299-W13-1	568149	136049	223.5	119.15	129.81	02/10/2004	No	99.1
299-W14-11	566902	136288	205.1	79.77	82.81	04/26/2005	No	123.8
299-W14-14	566898	136181	205.4	66.13	76.81	11/12/1998	No	134.0
299-W14-17	567007	136218	205.9	67.64	78.32	10/24/2000	No	132.9
299-W14-71	567733	135568	219.4	125.17	129.74	07/27/2006	Yes	92.0
299-W14-72	567328	135941	216.3	126.18	130.76	08/15/2006	No	87.9
299-W15-1	566554	135943	207.0	57.91	82.3	05/02/1947	No	136.9
299-W15-11	566412	136001	208.3	55.78	90.53	03/08/1968	No	135.1
299-W15-152	566309	135550	209.9	71.94	82.61	09/15/2005	No	132.6
299-W15-17	566307	135719	209.8	128.77	131.82	10/28/1987	No	79.5
299-W15-3	566729	136371	205.4	60.96	71.93	09/30/1952	No	139.0

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W15-30	566305	135749	210.2	66.47	78.63	05/05/1995	Yes	137.7
299-W15-31A	566377	135856	208.5	64.76	76.93	05/26/1995	No	137.7
299-W15-37	566716	135248	203.0	64.74	77.98	05/16/1996	No	131.68
299-W15-42	566582	135627	207.4	69.50	84.74	02/26/2002	No	130.3
299-W15-46	566752	135587	204.2	63.86	88.23	10/03/2003	No	128.2
299-W15-49	566307	135973	209.1	71.86	82.52	11/01/2004	No	131.9
299-W15-50	566793	135791	203.2	74.19	84.85	02/28/2005	No	123.7
299-W15-7	566676	135920	204.2	55.47	106.68	03/30/1966	No	123.1
299-W17-1	565311	135039	199.2	58.99	69.67	12/17/2003	No	134.9
299-W18-1	566422	135465	209.1	59.44	111.89	01/12/1959	No	123.4
299-W18-15	566380	134733	202.2	51.82	74.07	04/25/1980	No	139.3
299-W18-16	566605	135426	208.5	71.47	82.13	10/20/2004	No	131.8
299-W18-22	566089	134990	204.9	126.94	136.39	09/25/1987	No	73.2
299-W18-40	566723	134996	203.4	66.53	77.20	09/28/2001	No	131.6
299-W19-107	567998	135206	217.4	94.65	99.22	03/31/2006	Yes	120.5
299-W19-18	567361	135012	214.0	67.06	109.12	12/12/1985	No	125.90
299-W19-34A	567674	135012	215.1	98.82	103.51	05/18/1994	No	113.9
299-W19-34B	567663	135011	215.5	125.46	128.41	12/12/1985	No	88.6
299-W19-35	567992	135015	213.6	73.13	82.3	04/20/1994	No	135.9
299-W19-4	567950	135351	219.0	77.72	135.03	02/15/1960	No	112.3
299-W19-41	566897	135005	206.5	67.07	77.76	09/23/1998	No	134.1
299-W19-6	567133	134694	210.3	115.82	125.27	12/13/1968	No	89.79
299-W21-2	568124	134574	214.9	79.29	89.96	11/22/2004	No	130.2
299-W22-24	567648	134411	212.2	67.06	163.07	09/08/1960	No	97.1
299-W22-47	566909	134076	206.3	69.70	80.37	01/19/2005	No	131.3
299-W23-20	566718	134446	203.8	65.68	76.35	08/21/2000	No	132.8
299-W26-14	566683	133539	205.4	68.08	78.75	04/03/2003	No	132.0

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W27-2	566908	133670	207.4	123.79	126.87	12/18/1992	No	82.1
299-W6-3	567118	137299	214.4	124.82	127.95	10/15/1991	No	87.9
299-W6-6	567319	137639	217.5	127.58	130.84	10/24/1991	No	88.3
299-W7-3	566292	137639	207.2	136.85	145.29	11/23/1987	No	66.1
699-25-70	568545	131172	193.0	53.34	134.11	08/31/1948	No	99.24
699-25-80	565676	131106	189.0	273.41	370.03	11/30/1948	No	321.3
699-30-66	569991	132739	210.5	117.35	120.4	10/13/2004	No	91.6
699-32-62	571010	133216	216.6	83.82	103.63	04/06/1960	No	122.9
699-32-62P	571010	133216	216.6	83.82	146.3	04/06/1960	No	101.5
699-32-70B	568462	133242	204.2	63.09	100.58	08/09/1957	No	122.37
699-32-72A	567943	133363	204.7	65.42	74.56	07/31/1957	No	134.7
699-32-72B	567935	133362	205.1	65.41	74.56	05/18/1994	No	135.1
699-34-88	563012	133950	194.0	146.0	127.02	12/20/1948	No	136.5
699-35-59	571956	134096	222.1	94.48	106.67	10/31/1985	No	121.5
699-35-66A	569858	134099	222.5	79.25	98.15	06/13/1957	No	133.76
699-35-78A	566064	134271	202.4	54.86	85.04	08/17/1950	Yes	132.02
699-36-70B	568428	134626	215.2	80.51	91.17	06/09/2004	No	129.4
699-38-61	571219	134997	228.2	101.83	107.92	11/16/1993	No	123.3
699-38-65	570090	135040	230.7	152.4	155.45	12/31/1959	No	76.8
699-38-68A	569180	134932	219.0	81.59	90.74	06/21/1994	No	132.8
699-38-70B	568469	135331	222.6	123.96	128.53	02/03/2004	No	96.3
699-38-70C	569084	135326	226.7	120.60	125.18	02/17/2004	No	103.8
699-39-79	565891	135412	206.5	54.44	73.152	09/07/1948	Yes	142.7
699-40-62	571164	135764	228.9	102.11	114.0	01/17/1949	No	120.8
699-40-65	570057	135881	231.0	100.0	111.5	02/03/2004	No	125.3
699-43-69	568967	136488	227.4	121.98	132.64	12/11/2007	No	100.1
699-43-89	562917	136620	197.7	43.28	60.35	01/16/1951	No	145.9

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
699-44-64	570391	136897	222.2	96.32	134.72	01/31/1960	No	106.67
699-45-69A	568729	137183	222.1	83.52	111.56	06/22/1948	No	124.6
699-45-69C	568947	137234	222.6	111.86	116.43	07/13/2007	Yes	108.4
699-47-60	571474	137969	199.6	71.63	84.43	07/20/1948	No	121.6
699-47-80AP	565562	137693	218.26	198.12	204.83	11/30/1983	No	16.8
699-47-80AQ	565562	137693	218.26	153.31	156.36	11/30/1983	No	63.4
699-48-71	568388	138057	210.9	138	156.36	09/26/1956	No	63.7
699-48-77C	566469	138087	206.6	88.39	94.49	04/01/1994	No	115.42
699-49-79	565771	138271	211.1	65.58	80.77	07/03/1948	No	137.9
699-50-74	567360	138647	201.4	68.07	78.74	07/12/2005	No	128.0
699-51-63	570664	139148	175.3	47.85	55.78	11/06/1956	No	123.49
699-51-75	566978	138906	196.6	57.91	68.58	10/31/1957	No	133.4
699-55-76	566723	140226	178.7	42.98	67.36	01/18/1959	No	123.5

B3.2.1 Monitoring Network

This SAP organizes the wells within the 200-ZP-1 OU by constituents. Not all of the wells identified for the OU monitoring network are needed to monitor each contaminant. An analysis of the network to identify the wells needed for monitoring specific COC plumes is presented in Chapter 4 of the PMP. The monitoring network is comprised of two well groups: (1) monitoring wells for water-level measurements, and (2) monitoring wells for COC and MNA sampling and analysis. The hydraulic monitoring well locations are shown in Figure B-7, the VOC monitoring well locations are shown in Figure B-8, and the contaminant-specific monitoring well locations are shown in Figures B-9 through B-14. Information for each hydraulic monitoring well is shown in Table B-13, and details of the current monitoring well networks are provided in Appendix F. The sampling schedule for all analytes is provided in Table B-14.

Monitoring locations for each contaminant were selected based on detection and data trends. The data for each constituent were assembled to show the number of samples collected from 1990 through 2012 with sub-data categories for the number of nondetected samples, the number of nondetected samples greater than the cleanup level, the number of detections, the number of detections greater than the cleanup level with the associated year(s), the first year sampled, the latest year sampled, and data trends in the context of the cleanup level. Each constituent and well was then individually evaluated against the appropriate plume map to determine whether a reduction in frequency of analysis for that constituent was appropriate. This evaluation considered the geographic location of the well with respect to the plume and the trend in the data. Wells that were within the plume, were above the cleanup level, had increasing trends, were

recently above the cleanup level, or were the first well downgradient were not considered for reduction. In some cases, the first well downgradient, or the sentinel well, may be an extraction well. Extraction wells are currently on a quarterly monitoring schedule. The wells considered for reduction did not have detections above the cleanup level and were stable or downward trending below the cleanup level. An annual sampling frequency was selected for the VOA and contaminant-specific well networks.

B3.2.2 Water-Level Measurements

Figure B-7 depicts the current hydraulic monitoring network. Table B-13 lists the current wells with pressure transducers installed. Water-level measurements are collected during each groundwater monitoring event. Periodic water-level data recorded by the pressure transducers are downloaded on a quarterly to annual basis, depending on the measurement frequency.

Water-level measurements may also be collected during nonroutine events when a significant change in P&T operation occurs (e.g., during a system-wide shutdown), when groups of wells are idle for 7 days or more, or when pumping rates are simultaneously altered at three or more wells for 7 days or more. The OU project manager has discretion to decide if a nonroutine water-level measurement event is warranted.

B3.2.3 Groundwater Quality Sampling

Groundwater sampling has been performed annually from the contaminant monitoring wells in the 200 West Area since 2011. Beginning in 2014, a contaminant-specific set of wells (Figures B-8 through B-14) were identified for annual sampling based on a review of the wells and the data trends relative to the plumes (DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). All of the 200-ZP-1 OU wells will be sampled in the year prior to the next CERCLA 5-year review.

B3.2.4 Groundwater Extraction Well Pumping Rates

Instantaneous pumping rates and total flow for extraction wells are measured by inline flow meters, and the data are saved to onsite and remote servers. The data servers can be queried as needed to obtain daily, weekly, or monthly average flow rates, as well as total monthly flows.

B3.3 Sampling Methods

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

- Field screening measurements
- Radiological screening
- Groundwater sampling
- Water-level measurements

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

- **pH:** Two consecutive measurements agree within 0.2 pH units.
- **Temperature:** Two consecutive measurements agree within 0.2°C (32.4°F).
- **Conductivity:** Two consecutive measurements agree within 10 percent of each other.
- **Turbidity:** Less than 5 nephelometric turbidity units prior to sampling (or project scientist's recommendation).

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A7136	299-W10-1	RCRA, WMA T	U	N/1947	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4891	299-W10-14	—	LU	N/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C3125	299-W10-27	RCRA, WMA TX-TY	TU	C/2001	A	A	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4989	299-W10-30	AEA and RCRA, LLWMA-3	TU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5194	299-W10-31	AEA and RCRA, LLWMA-3	TU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5855	299-W10-33	—	LU	C/2007	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5465	299-W11-13	—	U	N/1961	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A7284	299-W11-18	—	TU	N/1967	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
B2402	299-W11-33Q	—	TU	N/1994	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4694	299-W11-43	—	LU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4948	299-W11-45	RCRA, WMA T	UU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4990	299-W11-47	RCRA, WMA T	U	C/2006	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5243	299-W11-48	—	LU	C/2006	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5407	299-W11-87	—	LU	C/2007	A	A	5	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5572	299-W11-88	AEA, Ringold confined	LU	C/2007	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4238	299-W13-1	—	MU	C/2004	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C9440	299-W13-2	—	LU	C/2015	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4668	299-W14-11	RCRA, WMA TX-TY	UU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters	
B8549	299-W14-13	DOH and RCRA, WMA TX-TY	TU	C/1998	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
B8547	299-W14-14	RCRA, WMA TX-TY	TU	C/1998	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C5103	299-W14-72	—	LU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A5474	299-W15-11	—	TU	N/1968	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4685	299-W15-152	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A4921	299-W15-17	AEA and RCRA, LLWMA-4	LU	C/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
B2643	299-W15-33	—	UU	C/1995	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3803	299-W15-42	—	UU	C/2002	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3426	299-W15-46	—	UU	C/2003	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4301	299-W15-49	—	UU	C/2004	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4302	299-W15-50	—	MU	C/2005	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A5476	299-W15-7	—	TU	N/1966	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3339	299-W15-763	RCRA, WMA TX-TY	TU	C/2001	A	5	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3397	299-W15-765	RCRA, WMA TX-TY	TU	C/2001	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4683	299-W15-83	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4684	299-W15-94	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A5481	299-W18-1	—	U	N/1959	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4303	299-W18-16	—	TU	C/2004	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C9439	299-W5-2	—	LU	C/2015	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4998	299-W6-3	—	LU	N/1991	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5001	299-W6-6	AEA, Ringold confined, SALDS	LU	N/1991	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5009	299-W7-3	AEA, Ringold confined, SALDS	LU	N/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5573	699-43-69	AEA, Ringold confined	CR	C/2007	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5188	699-44-64	—	TU	N/1960	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5196	699-45-69A	—	TU	N/1948	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5574	699-45-69C	AEA, Ringold confined	MU	C/2007	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5202	699-47-60	200-BP-5, AEA, Ringold confined	TU	N/1948	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5214	699-48-71	SALDS	TU	N/1956	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4697	699-50-74	—	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5231	699-51-63	—	TU	N/1956	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5102	299-W14-71	—	LU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B2753	299-W15-37	200-UP-1	UU	C/1996	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4932	299-W18-15	200-UP-1	TU	N/1980	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A4933	299-W18-21	AEA and RCRA, LLWMA-4, 200-UP-1	TU	C/1987	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4934	299-W18-22	AEA and RCRA, LLWMA-4, 200-UP-1	LU	C/1987	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C3395	299-W18-40	AEA and RCRA, WMA U	TU	C/2001	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4968	299-W19-105	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C5193	299-W19-107	200-UP-1	UU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A7743	299-W19-18	200-UP-1	TU	N/1985	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9517	299-W19-34A	200-UP-1	MU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9513	299-W19-34B	—	MU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B2461	299-W19-36	200-UP-1	UU	C/1995	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4958	299-W19-4	200-UP-1	U	N/1960	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8551	299-W19-41	AEA and RCRA, WMA U	TU	C/1998	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4258	299-W19-47	AEA and RCRA, WMA U	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4300	299-W19-48	200-UP-1	UU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4695	299-W19-49	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4959	299-W19-6	—	MU	N/1968	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4639	299-W21-2	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
C4667	299-W22-47	AEA, WMA S-SX	UU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4970	299-W22-72	AEA, WMA S-SX, 200-UP-1	TU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4971	299-W22-86	AEA, WMA S-SX, 200-UP-1	TU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4977	299-W22-87	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4978	299-W22-88	200-UP-1	TU	C/2008	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8809	299-W23-19	AEA, WMA S-SX	TU	C/1999	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4987	299-W23-4	200-UP-1	U	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8817	299-W26-13	RCRA, S-10, 200-UP-1	TU	C/1999	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5410	299-W27-2	RCRA, S-10	LU	C/1992	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4298	699-30-66	200-UP-1	LU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5128	699-32-62	200-UP-1	TU	N/1960	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5130	699-32-72A	200-UP-1	U	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4974	699-33-75	RCRA, S-10, 200-UP-1	TU	C/2008	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5463	699-34-61	200-UP-1	TU	C/1993	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5139	699-35-66A	200-UP-1, ERDF	TU	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5141	699-35-78A	200-UP-1	TU	N/1950	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5144	699-36-61A	—	TU	N/1948	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C6219	699-36-66B	ERDF, 200-UP-1	TU	C/2007	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A9901	699-36-70A	ERDF, DOH, 200-UP-1	TU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4299	699-36-70B	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C5704	699-37-66	ERDF, 200-UP-1	TU	C/2007	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5464	699-38-61	200-UP-1	TU	C/1993	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5148	699-38-65	200-UP-1	TU	N/1959	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9516	699-38-68A	200-UP-1	TU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4236	699-38-70B	200-UP-1	MU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4256	699-38-70C	200-UP-1	LU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5158	699-40-62	200-UP-1	TU	N/1949	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4235	699-40-65	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Note: Field parameters include temperature, dissolved oxygen, pH, turbidity, and oxidation-reduction measurements.

— = not sampled

5 = sample every 5 years to coincide with preparation of the next *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 5-year review

A = sample annually

AEA = alpha energy analysis

C = well construction is compliant with resource protection requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DOH = Department of Health

ERDF = Environmental Restoration Disposal Facility

ID = identification

LLWMA = low-level waste management area

LU = lower unconfined aquifer

MU = middle unconfined aquifer

N = well construction is not compliant with WAC 173-160

RCRA = *Resource Conservation and Recovery Act of 1976*

SALDS = State-Approved Land Disposal Site

TU = top of unconfined aquifer

U = unconfined aquifer

UU = upper unconfined aquifer

WMA = waste management area

Field parameters for dissolved oxygen and oxidation-reduction potential may be specified by the project.

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

To ensure sample and data usability, the sampling associated with this SAP will be performed in accordance with HASQARD (DOE/RL-96-68) regarding sample collection, collection equipment, and sample handling.

Suggested sample container, preservation, and holding-time requirements are specified in Table B-12 for groundwater samples. These requirements are in accordance with the analytical methods specified in Table B-9. The final container types and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a sample as a filled sample bottle for starting the clock for holding-time restrictions.

Holding time is the elapsed time period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the analytical method, as specified in appropriate EPA methods (e.g., EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*, or SW-846).

B3.3.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with approved sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each sampling activity. Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

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

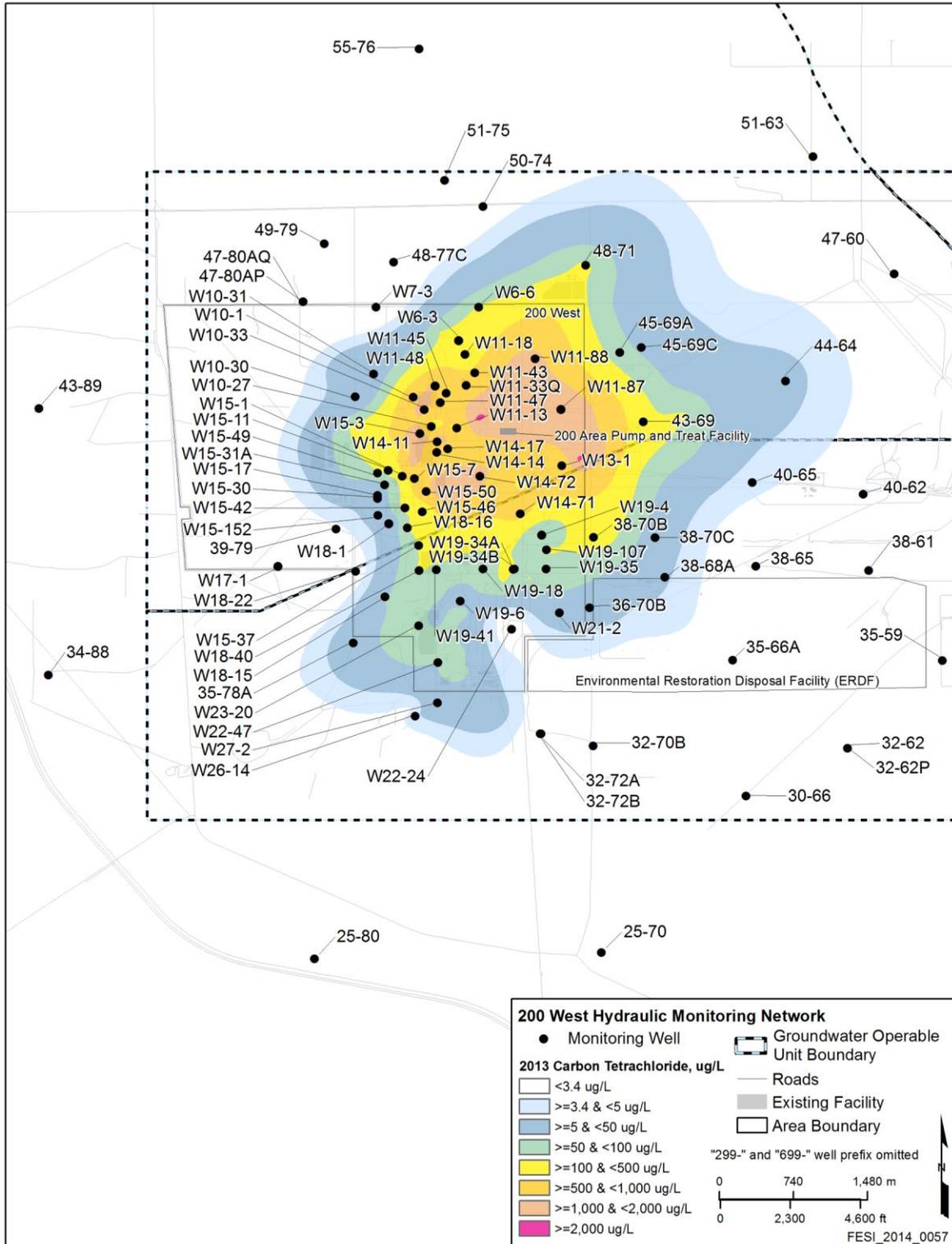


Figure B-7. Hydraulic Monitoring Network

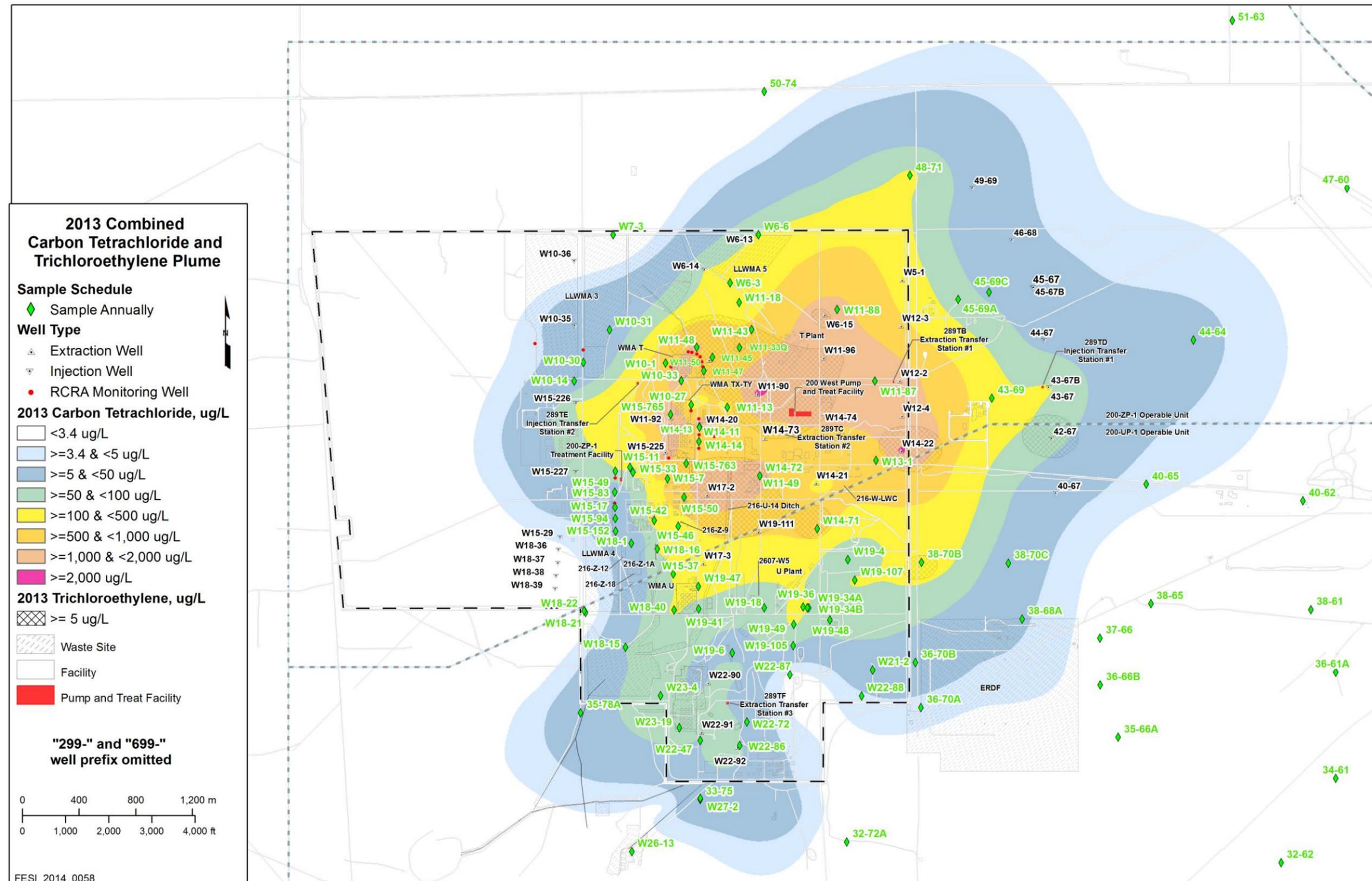


Figure B-8. Contaminant Monitoring Well Network (VOCs)

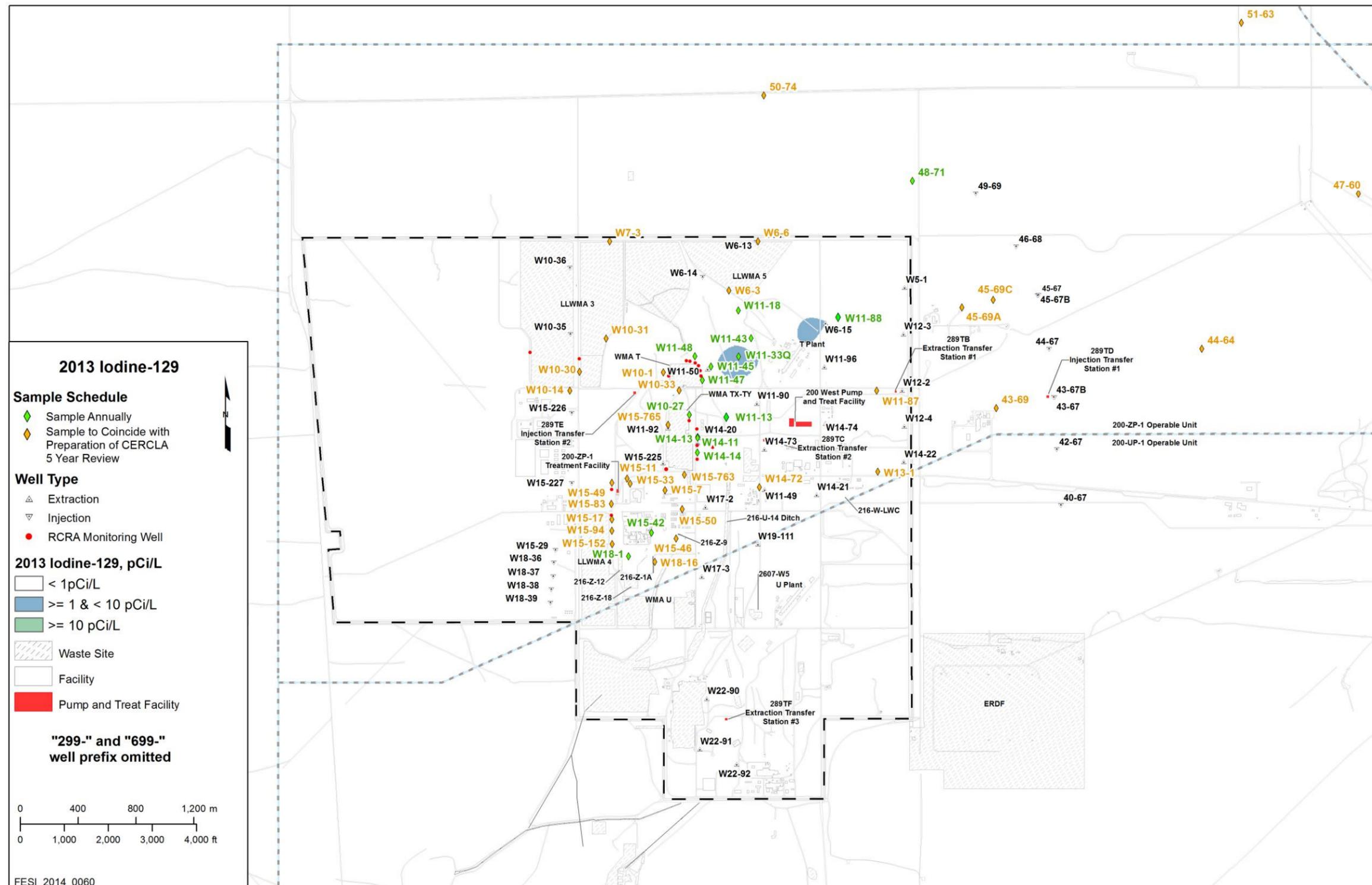


Figure B-10. Contaminant-Specific Monitoring Well Network (Iodine-129)

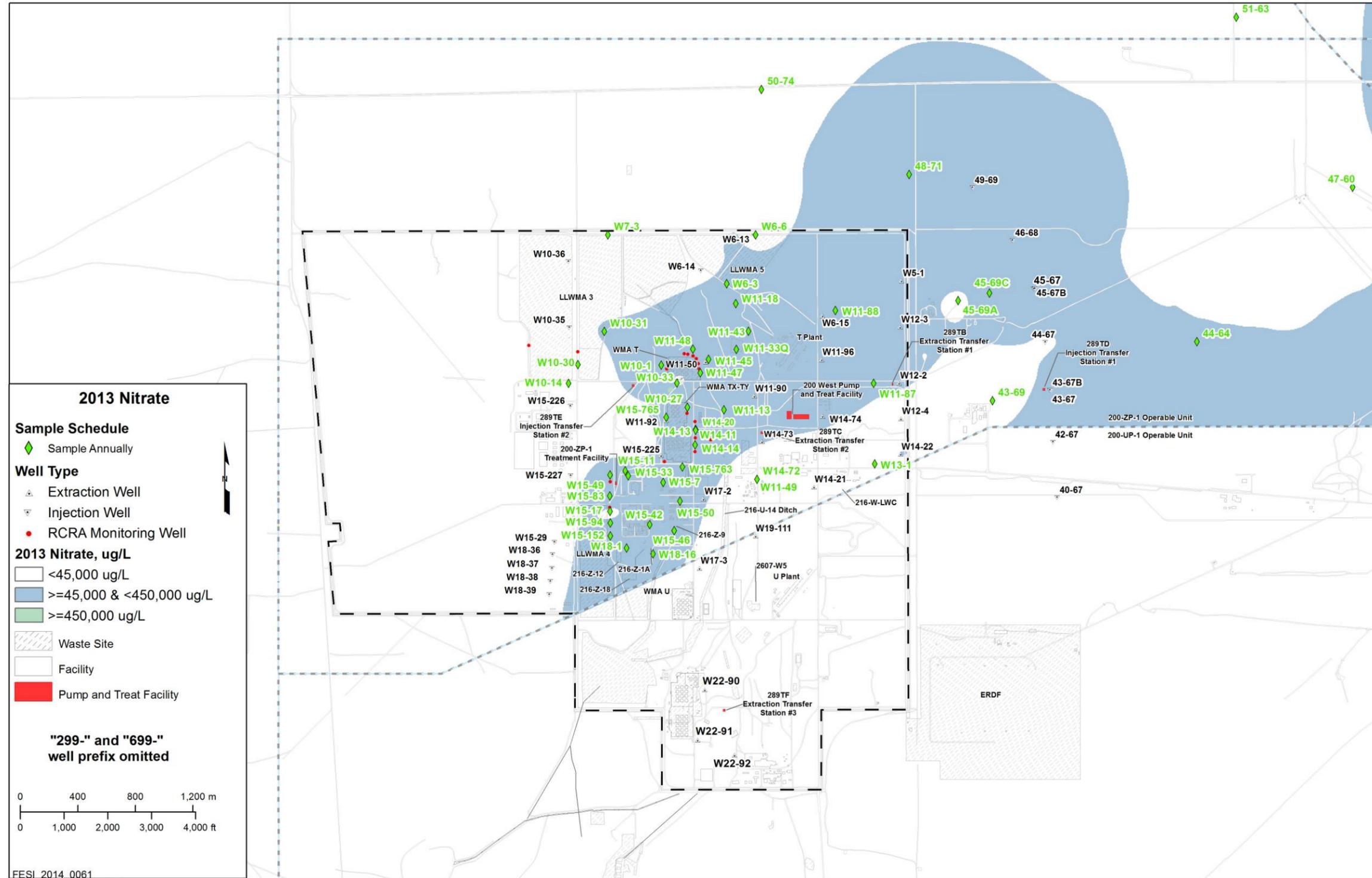


Figure B-11. Contaminant-Specific Monitoring Well Network (Nitrate)

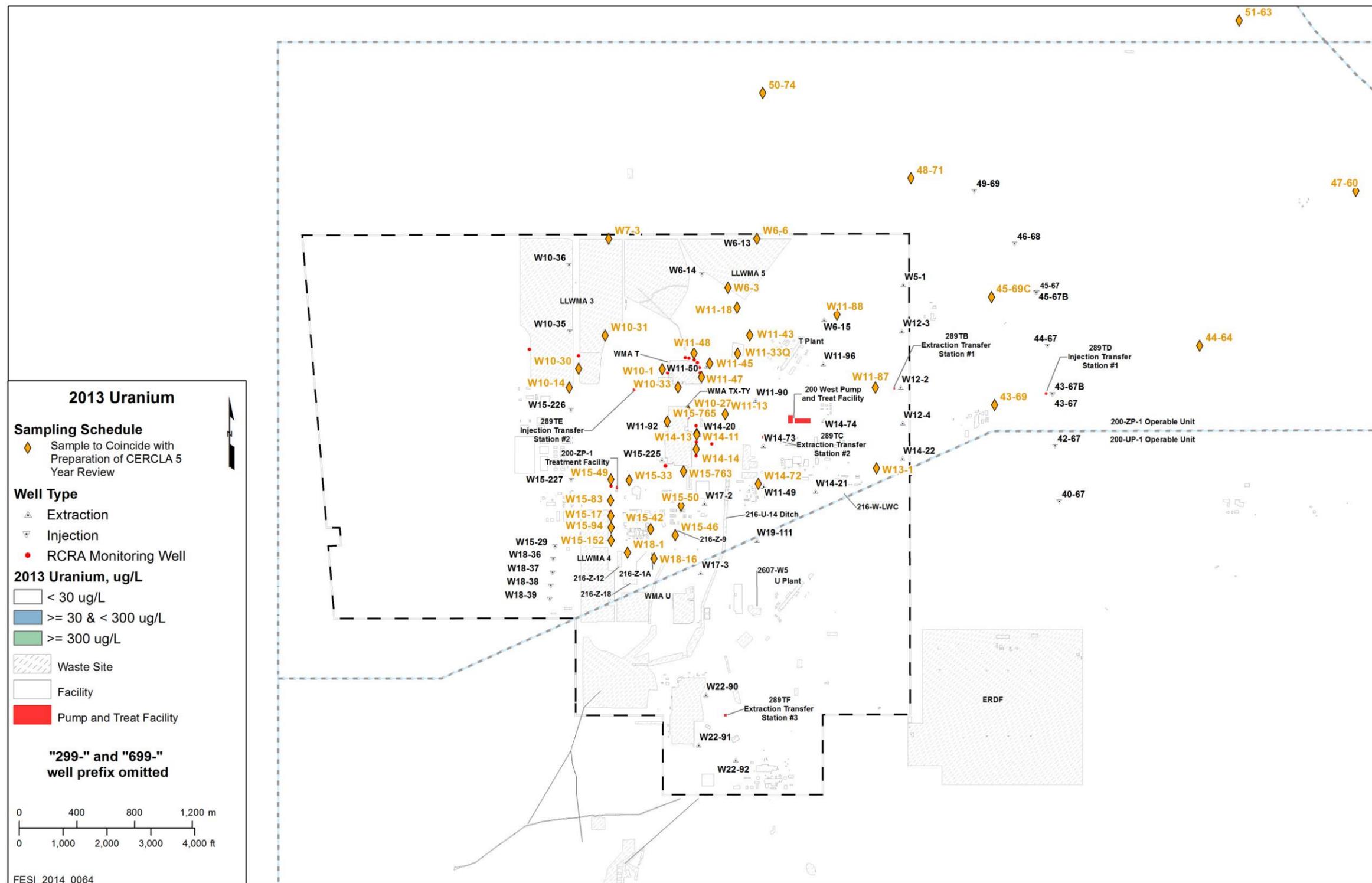


Figure B-14. Contaminant-Specific Monitoring Well Network (Uranium)

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B3.3.2 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Radiological screening will be performed by the RCT or other qualified personnel. The RCT will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the field geologist (for wells) for daily inclusion in the field logbook or operational records, as applicable. The following information will be distributed to personnel performing work in support of this SAP:

- Instructions to RCTs on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.
- Information regarding the portable radiological field instrumentation, including the following: a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments are commonly used on the Hanford Site to obtain measurements of removable surface contamination measurements and direct measurements of the total surface contamination.
- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, “Occupational Radiation Protection.”
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of radiological information.
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related information.
- The requirements associated with preparing and transporting regulated material.
- Daily reports of radiological surveys and measurements collected during conduct of field investigation activities. Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results.

B3.3.3 Water Levels

Groundwater levels are measured annually across the Hanford Site to construct water table maps that are used to determine the direction and rate of groundwater flow in the unconfined aquifer (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Water levels are also measured in wells that are screened in confined or partially confined aquifers to help determine horizontal and vertical hydraulic gradients.

A measurement of depth to water is also recorded in each well prior to sampling using calibrated depth measurement tapes. Two consecutive measurements are taken that agree within 6 mm (0.02 ft), and these are recorded along with the date, time, and measuring tape number. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of casing) to obtain the water-level elevation. The top of casing is a known elevation reference point because it has been surveyed to local reference data.

B3.4 Documentation of Field Activities

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

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

- Purpose of activity
- Day, date, time, and weather conditions
- Names, titles, and organizations of personnel present
- Deviations from the QAPjP
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)
- Details of samples collected (e.g., preparation, SPLIT, DUP, MS, and EB)
- Location and types of samples
- Chain-of-custody details and variances relating to the chain-of-custody
- Field measurements
- Field calibrations testing, inspections, maintenance and surveys, and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to decontamination methods
- Equipment failures or breakdowns and descriptions of any corrective actions
- Telephone calls relating to field activities

B3.4.1 Corrective Actions and Deviations for Sampling Activities

The OU project manager, FWS, appropriate BTR (or designee), and SMR personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The OU project manager, FWS, appropriate BTR (or designee), or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Table B-8.

B3.5 Calibration of Field Equipment

Construction management, the appropriate BTR, or the FWS is responsible for ensuring that field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with manufacturers' operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from all instrument calibration activities are recorded in accordance with HASQARD (DOE/RL-96-68).

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

- Prior to initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or methods, or as required by regulations
- Upon failure to meet specified QC criteria

Calibration of radiological field instruments on the Hanford Site is performed by the Mission Support Alliance prime contractor, as specified by their calibration program.

Daily calibration checks will be performed and documented for each instrument used to characterize areas under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.

Standards used for calibration will be traceable to nationally recognized standard agency source or measurement system.

B3.6 Sample Handling

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

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

B3.6.1 Containers

Pre-cleaned sample containers with certificates of analysis denoting compliance with EPA specifications (EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*) for the intended analyses will be used for samples collected for chemical analysis. Container sizes may vary depending upon laboratory-specific volumes/requirements for meeting analytical detection limits. The Radiological Engineering organization will measure the contamination levels and dose rates associated with the filled sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be

received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the FWS (in consultation with the SMR organization) can send smaller volumes to the laboratory. Container types and sample amounts or volumes are identified in Table B-12.

B3.6.2 Container Labeling

Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- SAF
- HEIS number
- Sample collection date and time
- Analysis required
- Preservation method (if applicable)
- Chain-of-custody number
- Bottle type and size
- Laboratory performing the analyses
- Sample location

Sample records must include the following information:

- Analysis required
- Source of sample
- Matrix (water)
- Field data (pH, temperature, turbidity, and conductivity)
- Radiological readings

B3.6.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record is initiated in the field during sampling and accompanies the sample sets when they are shipped to the laboratory.

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

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

- Project name
- Signature of sampler
- Unique sample number
- Date and time of collection
- Matrix

- Preservatives
- Signatures of individual involved in sample transfer
- Requested analyses (or reference thereto)

Samplers should note any anomalies with the samples that would prevent batching. If anomalies are found, the samplers should inform the SMR organization before adding any information regarding batching on the chain-of-custody form.

B3.6.4 Sample Transportation

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

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be packaged, marked, labeled, and shipped according to the specific instructions for that material.

Materials are classified by DOT/IATA as radioactive when the isotope-specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," are exceeded. Samples shall be screened, or relevant historical data will be used, to determine if these values are exceeded. When screening or historical data indicate that samples are radioactive, the samples shall be properly classified, described, packaged, marked, labeled, and transported in accordance with DOT/IATA requirements.

Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping shall notify the laboratory of the approximate number and radiological levels of the samples. This notification is conducted through the SMR organization's project coordinator. The laboratory is responsible for ensuring that the applicable license limits are not exceeded. The laboratory shall provide the SMR organization with written acceptance for samples with elevated radioactive contamination or dose.

B4 Management of Waste

Waste materials are generated during sample collection, processing, and sub-sampling activities. Waste will be managed in accordance with Appendix B of DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities. Pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the DOE-RL remedial project manager is required before returning unused samples or waste from offsite laboratories.

B5 Health and Safety

The hazardous waste operations safety and health program was established to ensure the safety and health of workers involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, “Occupational Safety and Health Standards,” “Hazardous Waste Operations and Emergency Response,” and 10 CFR 835. The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for day-to-day work activities on the Hanford Site. The health and safety program governs personal training, control of industrial safety and radiological hazards, personal protective equipment, site control, and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting.

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Appendix C
200-ZP-1 Operable Unit
Contaminant Monitoring Well Network

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C1 200-ZP-1 Operable Unit Contaminant Monitoring Well Network

Table C-1 provides details on the 200-ZP-1 Operable Unit (OU) contaminant monitoring well network for volatile organics, and Table C-2 provides details of the monitoring network for the other contaminants of concern, which are a subset of the volatile organic network. Table C-3 provides the details of the contaminant-specific well networks and their sampling schedules.

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Eastings (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W10-1	566663	136735	207.5	149.5	125.2	8/7/1947	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/1987	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/2001	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/2006	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/2006	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/2007	84.1
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/1961	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/6197	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/1994	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/2005	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/2005	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/2006	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/2006	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/2007	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/2007	80.1
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/2004	99.1
299-W13-2	568833	135819	225.3	128.4	104.3	3/21/2016	116.4
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/2005	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/1998	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/1998	134.0
299-W14-71	567733	135568	219.4	94.2	89.7	7/27/2006	92.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/2006	87.9

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/1968	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/2005	132.6
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/1987	79.5
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/1995	135.2
299-W15-37	566716	135248	203.0	140.3	125.1	5/16/1996	132.7
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/2002	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/2003	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/2004	131.9
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/2005	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/1966	123.2
299-W15-763	566809	136029	202.9	138.4	127.7	1/17/2001	133.1
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/2001	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/2005	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/2005	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/1959	113.8
299-W18-15	566380	134733	202.2	142.8	118.7	4/25/1980	130.7
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/2004	131.8
299-W18-21	566098	134979	204.9	145.3	136.2	7/29/120987	140.7
299-W18-22	566089	134990	204.9	77.9	68.5	9/25/1987	73.2
299-W18-40	566723	134996	203.4	136.9	126.2	9/28/2001	131.6
299-W19-105	567565	134745	213.0	135.2	124.5	12/13/2005	129.8
299-W19-107	567998	135206	217.4	122.8	118.2	3/31/2006	120.5
299-W19-18	567361	135012	214.0	146.9	104.9	12/12/1985	125.9
299-W19-34A	567674	135012	215.3	116.5	111.8	5/18/1994	113.3
299-W19-34B	567663	135011	215.5	90.0	87.1	11/9/1994	87.6
299-W19-36	567635	135017	215.4	140.8	127.1	9/1/1995	133.9
299-W19-4	567950	135351	219.0	141.3	56.0	2/15/1960	98.3

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W19-41	566897	135005	206.5	139.5	128.8	9/23/1998	134.1
299-W19-47	566895	135162	206.3	137.1	126.4	6/1/2004	131.7
299-W19-48	567823	134926	212.9	133.0	122.3	10/5/2004	127.6
299-W19-49	567568	134894	214.2	135.1	124.5	8/30/2005	129.8
299-W19-6	567133	134694	210.3	94.5	85.1	12/13/1968	89.8
299-W21-2	568124	134574	214.9	135.6	124.9	11/22/2004	130.2
299-W22-47	566909	134076	206.3	136.6	125.9	1/19/2005	131.2
299-W22-72	567237	134207	208.0	135.8	125.1	2/22/2006	130.5
299-W22-86	567187	134041	206.4	135.9	125.2	3/10/2006	130.5
299-W22-87	567542	134540	212.0	135.7	125.1	12/14/2005	130.4
299-W22-88	568046	134391	213.9	134.3	123.7	2/6/2008	129.0
299-W23-19	566759	134167	202.5	139.5	136.4	11/17/1999	137.9
299-W23-4	566628	134392	203.0	148.1	111.6	6/18/1957	129.9
299-W26-13	566424	133294	199.8	138.2	127.5	12/28/1999	132.8
299-W27-2	566908	133670	207.4	83.6	80.5	12/18/1992	82.1
299-W5-2	568175	137621	216.9	111.7	87.4	12/1/2015	99.5
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/1991	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/1991	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/1987	66.1
699-30-66	569991	132739	210.5	93.1	90.1	10/13/2004	91.6
699-32-62	571010	133216	216.6	132.7	64.2	4/6/1960	98.5
699-32-72A	567943	133363	204.7	76.7	56.8	7/31/1957	66.7
699-33-75	566908	133662	207.4	135.7	125.1	1/8/2008	130.4
699-34-61	571396	133810	221.8	129.4	123.3	11/29/1993	126.3
699-35-66A	569858	134099	222.5	143.2	124.3	6/13/1957	133.8
699-35-78A	566064	134271	202.4	147.5	117.3	8/17/1950	132.0
699-36-61A	571395	134557	229.0	128.4	110.5	8/12/1948	119.5

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
699-36-66B	569731	134469	221.3	131.7	121.0	12/20/2007	126.4
699-36-70A	568467	134309	216.0	137.6	128.4	12/10/1994	132.2
699-36-70B	568428	134626	215.2	134.7	124.1	6/9/2004	129.4
699-37-66	569730	134797	222.0	131.3	120.6	11/28/2007	126.0
699-38-61	571219	134997	228.2	126.3	120.2	11/16/1993	123.3
699-38-65	570090	135040	230.7	163.7	72.2	12/31/1959	117.9
699-38-68A	569180	134932	218.9	137.3	128.2	6/21/1994	132.0
699-38-70B	568469	135331	222.6	98.6	94.0	2/3/2004	96.3
699-38-70C	569084	135326	226.7	106.1	101.5	2/17/2004	103.8
699-40-62	571164	135764	228.9	126.8	115.0	1/17/1949	120.9
699-40-65	570057	135881	231.0	130.2	119.5	2/3/2004	124.1
699-43-69	568967	136488	227.4	105.4	94.7	12/11/2007	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/1960	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/1948	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/2007	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/1948	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/1956	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/2005	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/1956	123.5

* Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set.

Table C-2. 200-ZP-1 OU Contaminant Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W10-1	566663	136735	207.5	149.5	125.2	8/7/1947	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/1987	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/2001	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/2006	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/2006	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/2007	84.1
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/1961	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/1967	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/1994	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/2005	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/2005	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/2006	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/2006	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/2007	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/2007	80.1
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/2004	99.1
299-W13-2	568833	135819	225.3	128.4	104.3	3/21/2016	116.4
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/2005	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/1998	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/1998	134.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/2006	87.9
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/1968	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/2005	132.6
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/1987	79.5
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/1995	135.2
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/2002	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/2003	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/2004	131.9

Table C-2. 200-ZP-1 OU Contaminant Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/2005	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/1966	123.2
299-W15-763	566809	136029	202.9	138.4	127.7	1/17/2001	133.1
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/2001	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/2005	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/2005	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/1959	113.8
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/2004	131.8
299-W5-2	568175	137621	216.9	111.7	87.4	12/1/2015	99.5
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/1991	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/1991	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/1987	66.1
699-43-69	568967	136488	227.4	105.4	94.7	12/11/2007	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/1960	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/1948	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/2007	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/1948	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/1956	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/2005	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/1956	123.5

* Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set.

Table C-3. 200-ZP-1 OU Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
299-W10-1	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-14	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-27	A	A	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-30	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-31	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-33	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-13	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-18	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-33Q	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-43	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-45	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-47	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-48	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-87	A	A	5	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-88	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W13-1	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W13-2	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-11	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-13	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-14	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-72	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-11	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-152	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-17	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-33	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-42	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A

Table C-3. 200-ZP-1 OU Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential	
299-W15-46	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-49	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-50	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-7	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-763	A	5	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-765	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-83	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W15-94	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W18-1	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W18-16	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W5-2	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W6-3	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W6-6	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
299-W7-3	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-43-69	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-44-64	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-45-69A	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-45-69C	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-47-60	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-48-71	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-50-74	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
699-51-63	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	
VOC Wells in 200-UP-1 OU																														
299-W14-71	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	
299-W15-37	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	
299-W18-15	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	

Table C-3. 200-ZP-1 OU Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
299-W18-21	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W18-22	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W18-40	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-105	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-107	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-18	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-34A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-34B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-36	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-4	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-41	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-47	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-48	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-49	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-6	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W21-2	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-47	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-72	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-86	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-87	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-88	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W23-19	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W23-4	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W26-13	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W27-2	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-30-66	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A

Table C-3. 200-ZP-1 OU Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
699-32-62	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-32-72A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-33-75	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-34-61	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-35-66A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-35-78A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-61A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-66B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-70A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-70B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-37-66	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-61	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-65	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-68A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-70B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-70C	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-40-62	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-40-65	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A

A = sample annually

5 = sample every 5 years to coincide with preparation of the next *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 5-year review

— = not sampled

OU = operable unit

VOC = volatile organic compound

C2 Reference

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

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Appendix D

200-ZP-1 Operable Unit Kriged Carbon Tetrachloride Error Variance Maps

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Figure D-7. Kriged Carbon Tetrachloride Error Variance from 73.5 to 76.5 m amsl D-8

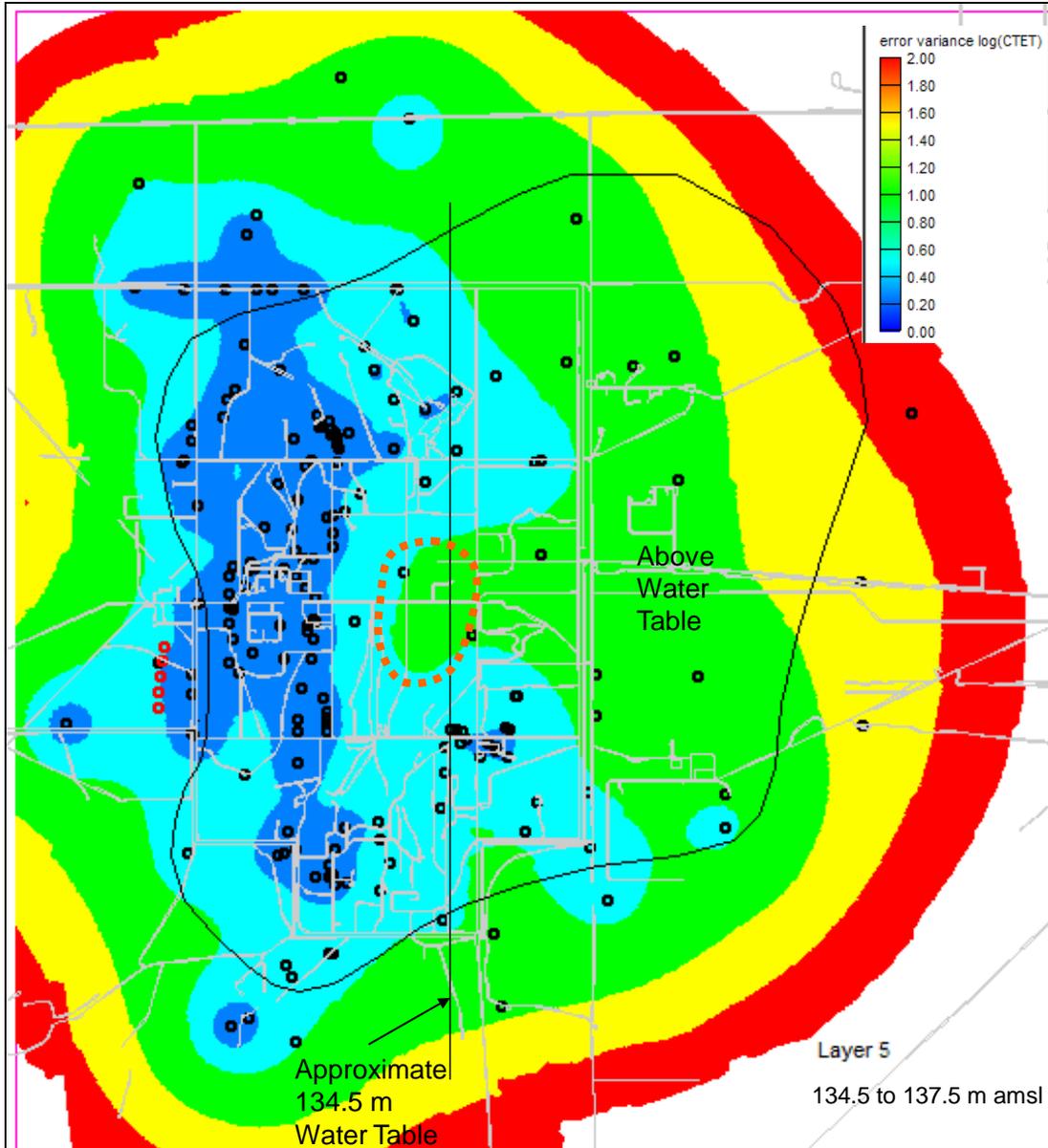
Figure D-8. Kriged Carbon Tetrachloride Error Variance from 67.5 to 70.5 m amsl D-9

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D1 200-ZP-1 Operable Unit Kriged Carbon Tetrachloride Error Variance Maps

The maps provided in this appendix reveal the areas in the kriged three-dimensional carbon tetrachloride plume shell of the 200-ZP-1 Operable Unit that have the greatest error variance or relative uncertainty. While these maps provide visual information concerning uncertainty in the distribution of data, the maps are dependent upon the kriging parameters used to generate them.



Map of Kriged Carbon Tetrachloride Error Variance

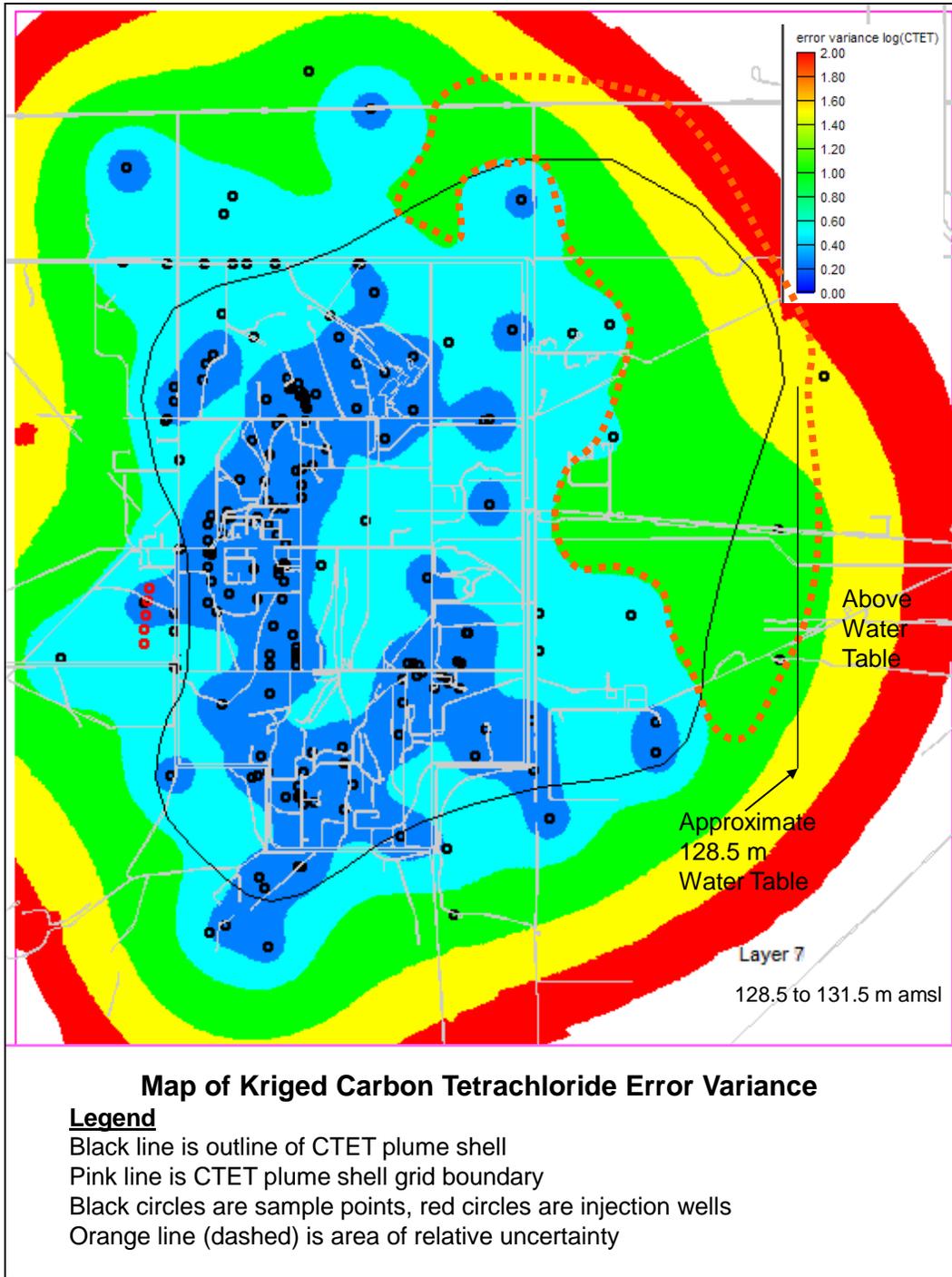
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

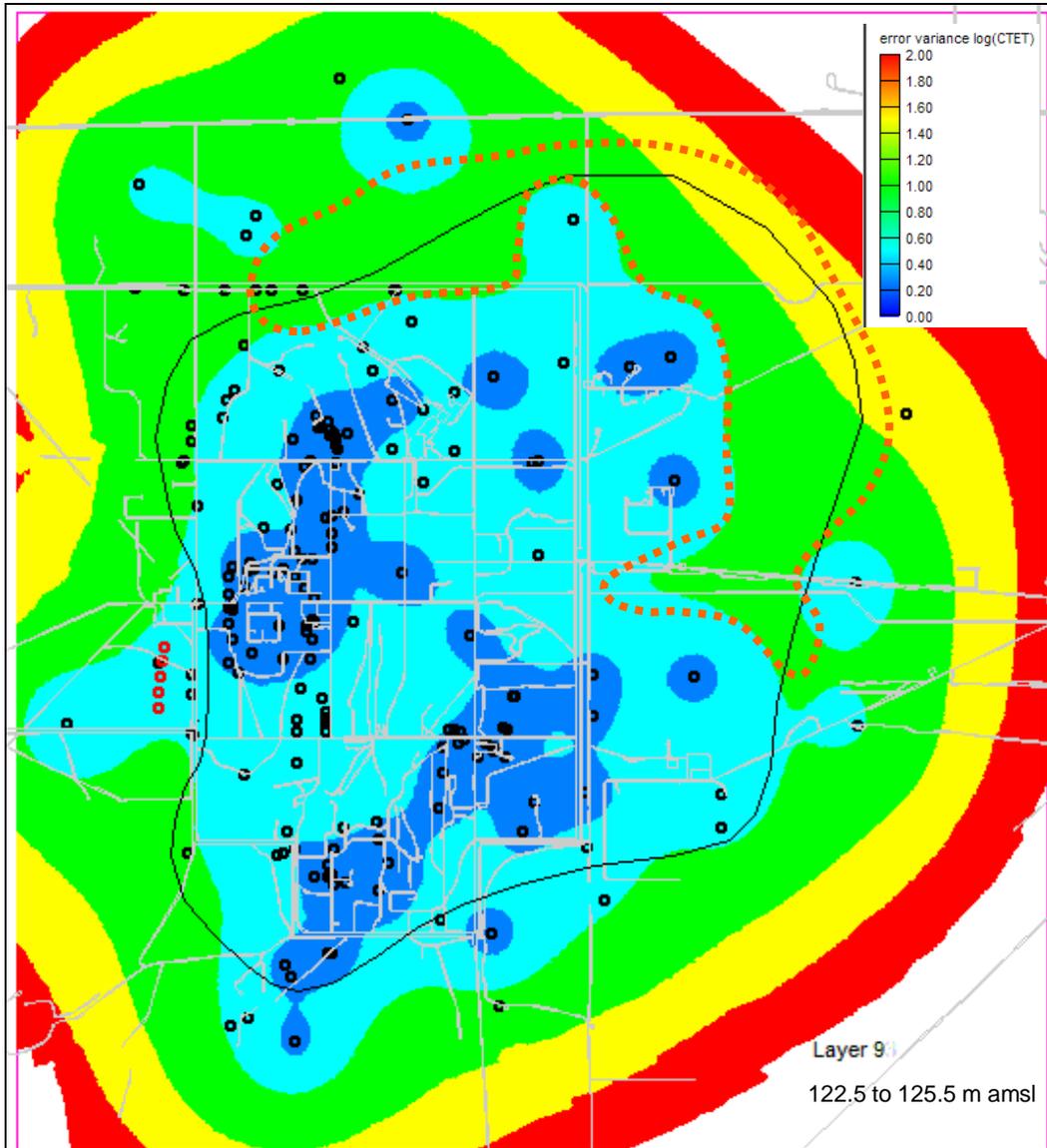
Figure D-1. Kriged Carbon Tetrachloride Error Variance from 134.5 to 137.5 m amsl



amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-2. Kriged Carbon Tetrachloride Error Variance from 128.5 to 131.5 m amsl



Map of Kriged Carbon Tetrachloride Error Variance

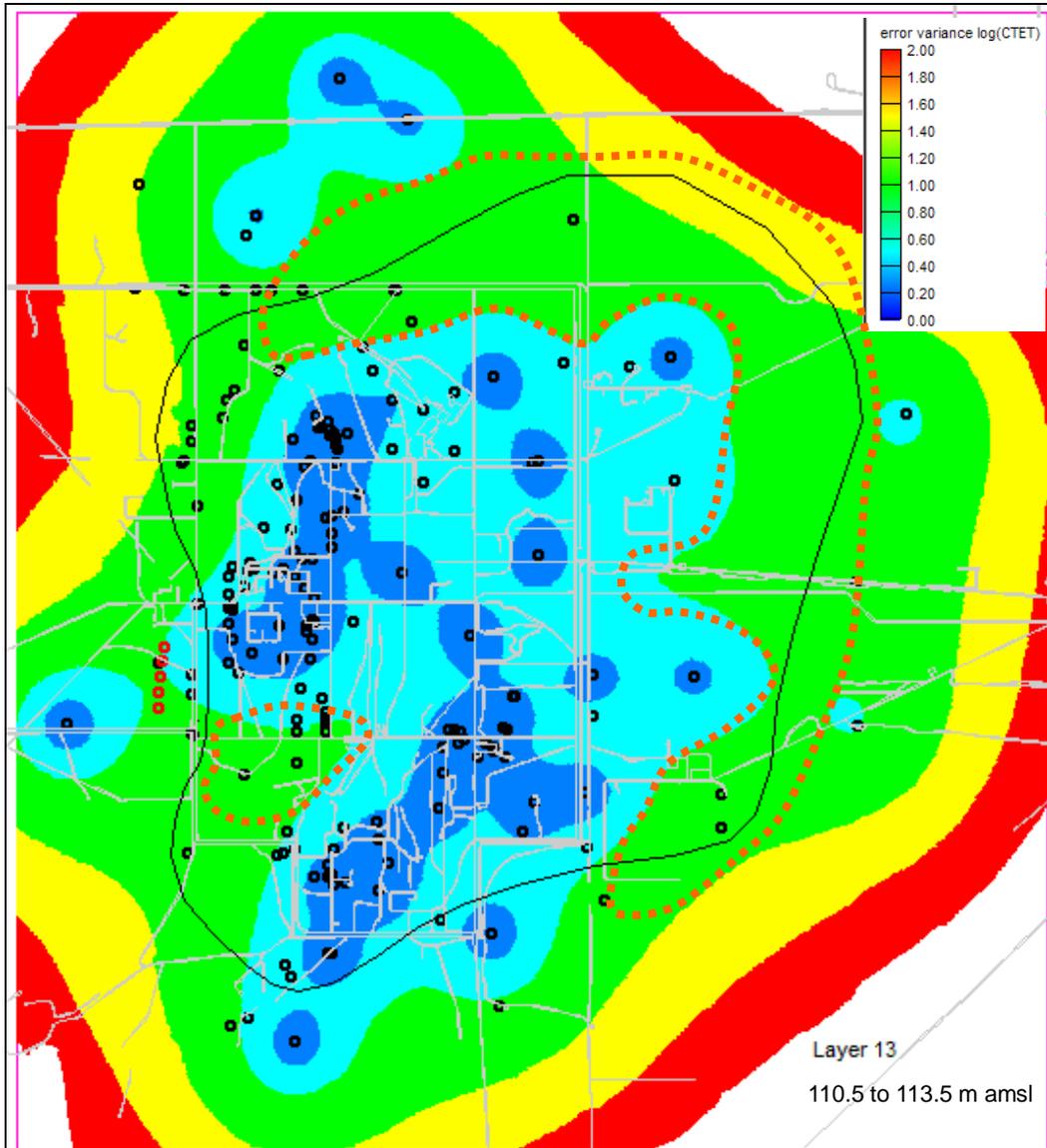
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-3. Kriged Carbon Tetrachloride Error Variance from 122.5 to 125.5 m amsl



Map of Kriged Carbon Tetrachloride Error Variance

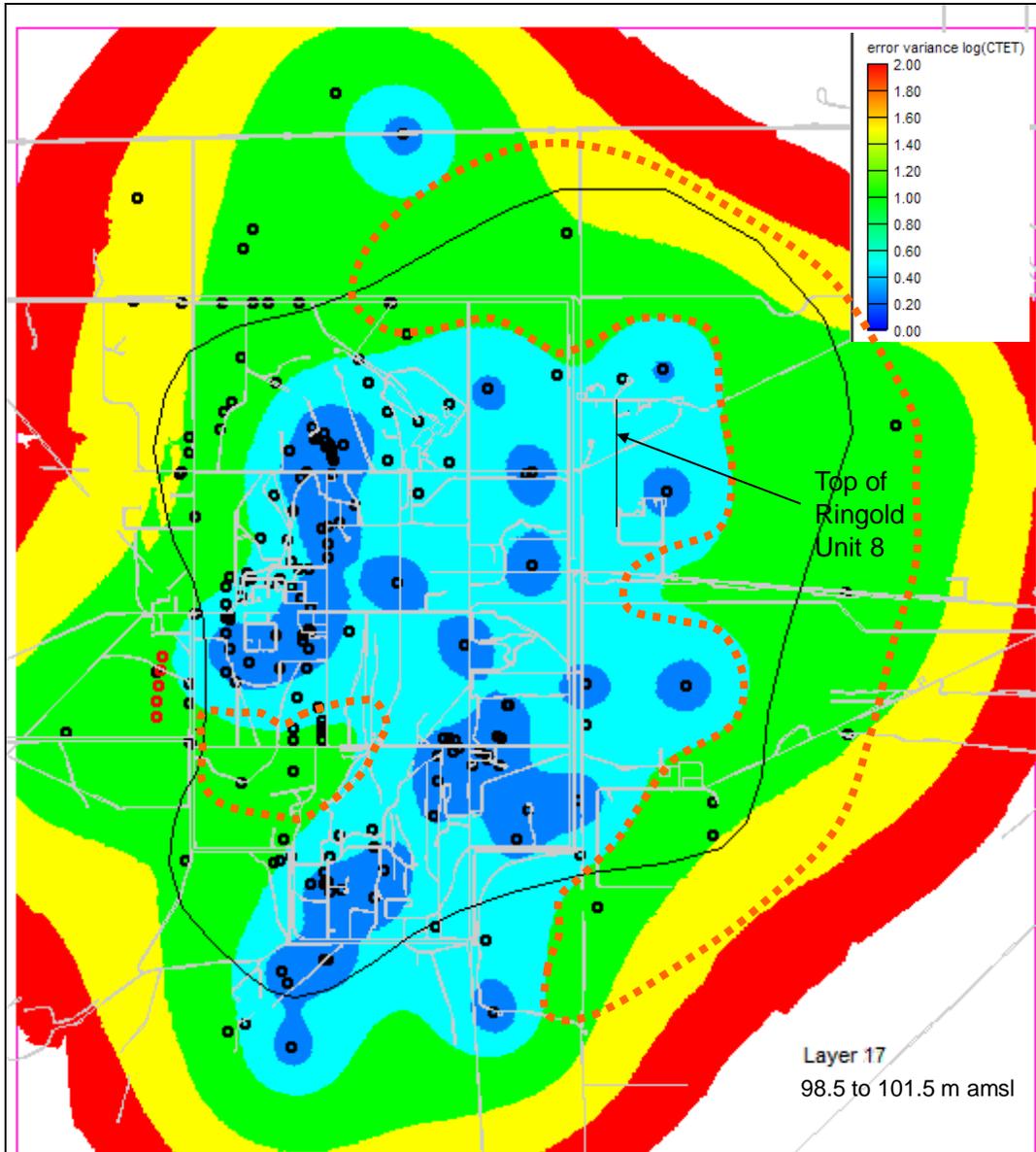
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-4. Kriged Carbon Tetrachloride Error Variance from 110.5 to 113.5 m amsl



Map of Kriged Carbon Tetrachloride Error Variance

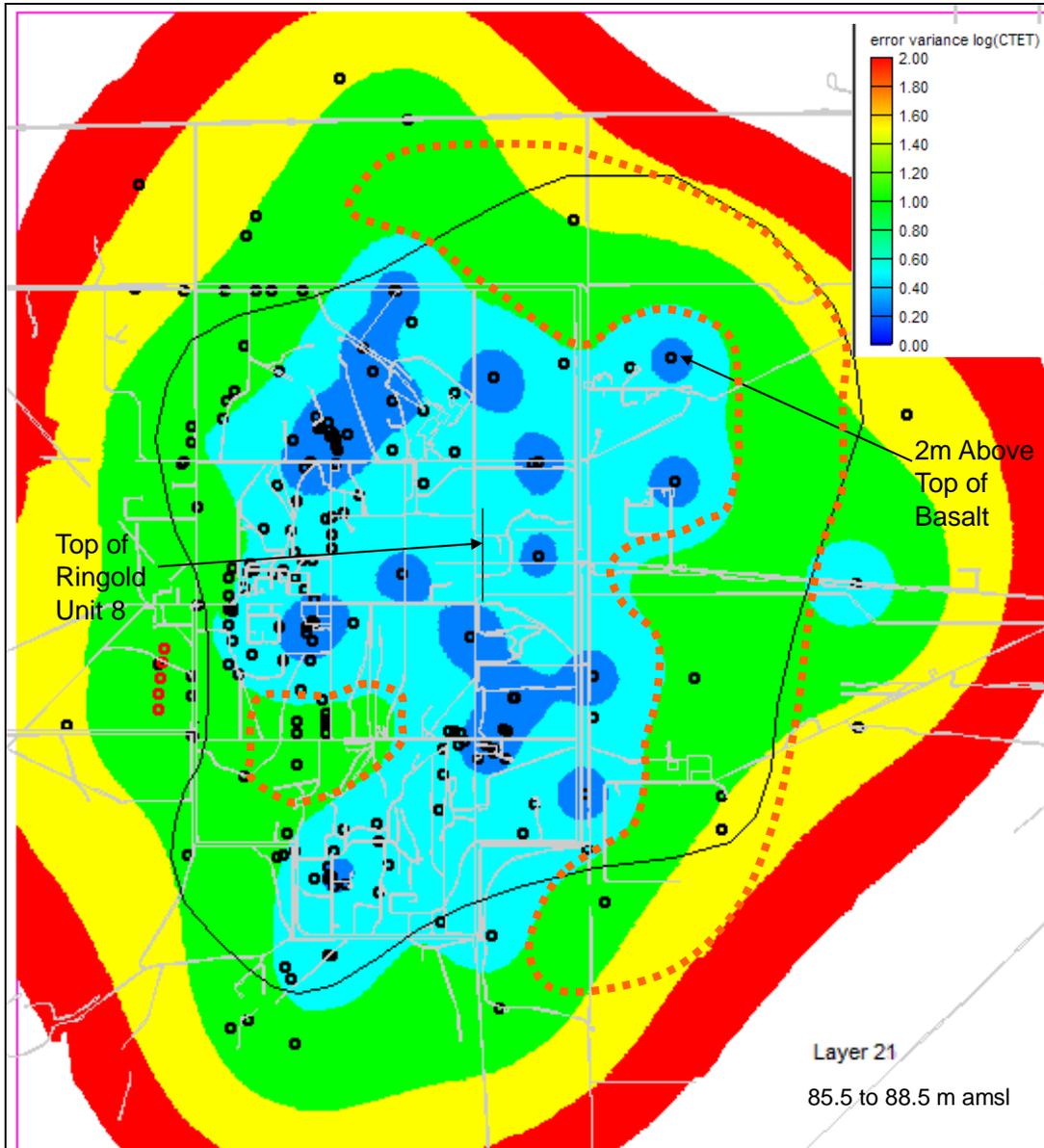
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-5. Kriged Carbon Tetrachloride Error Variance from 98.5 to 101.5 m amsl



Map of Kriged Carbon Tetrachloride Error Variance

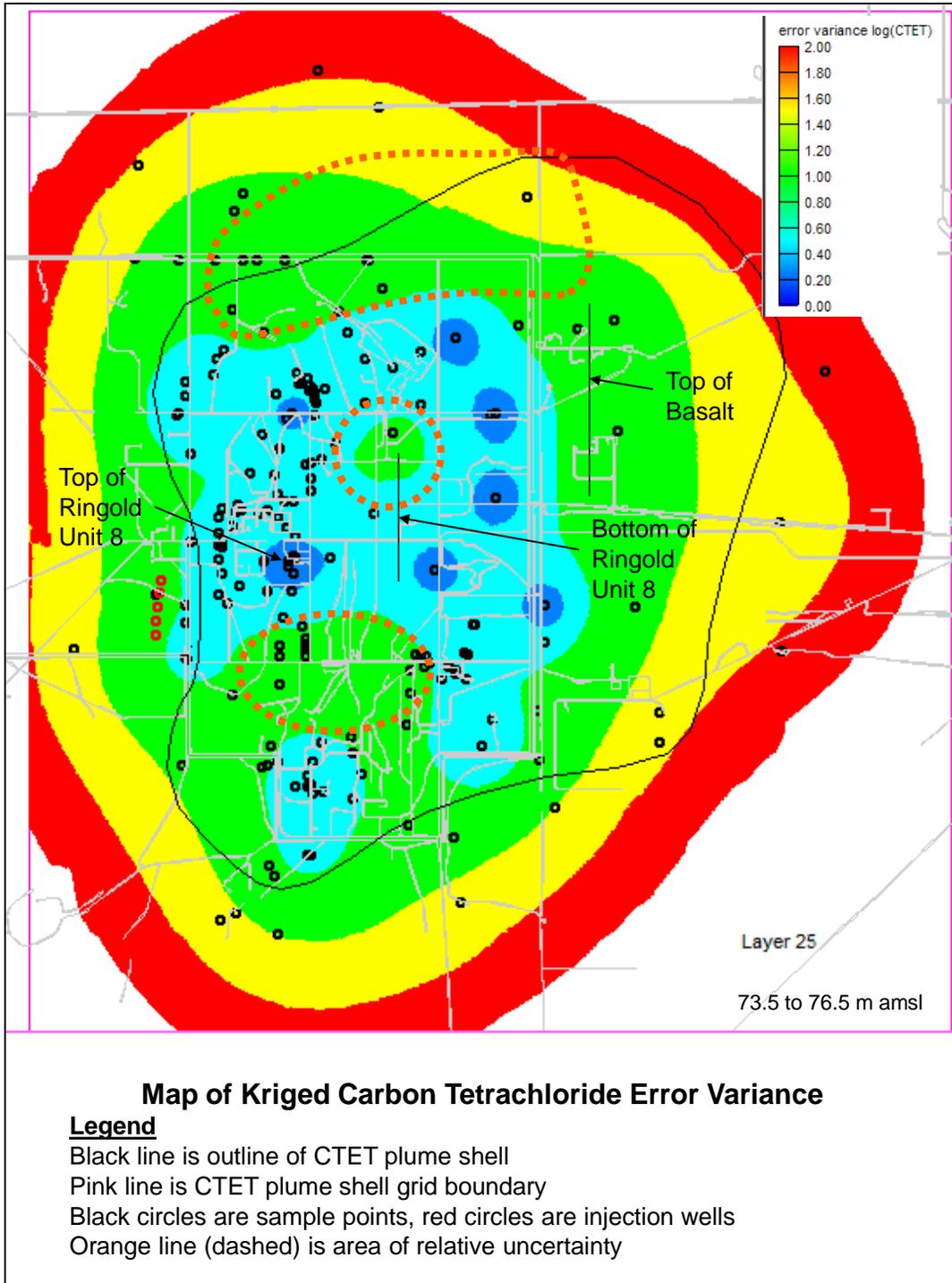
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

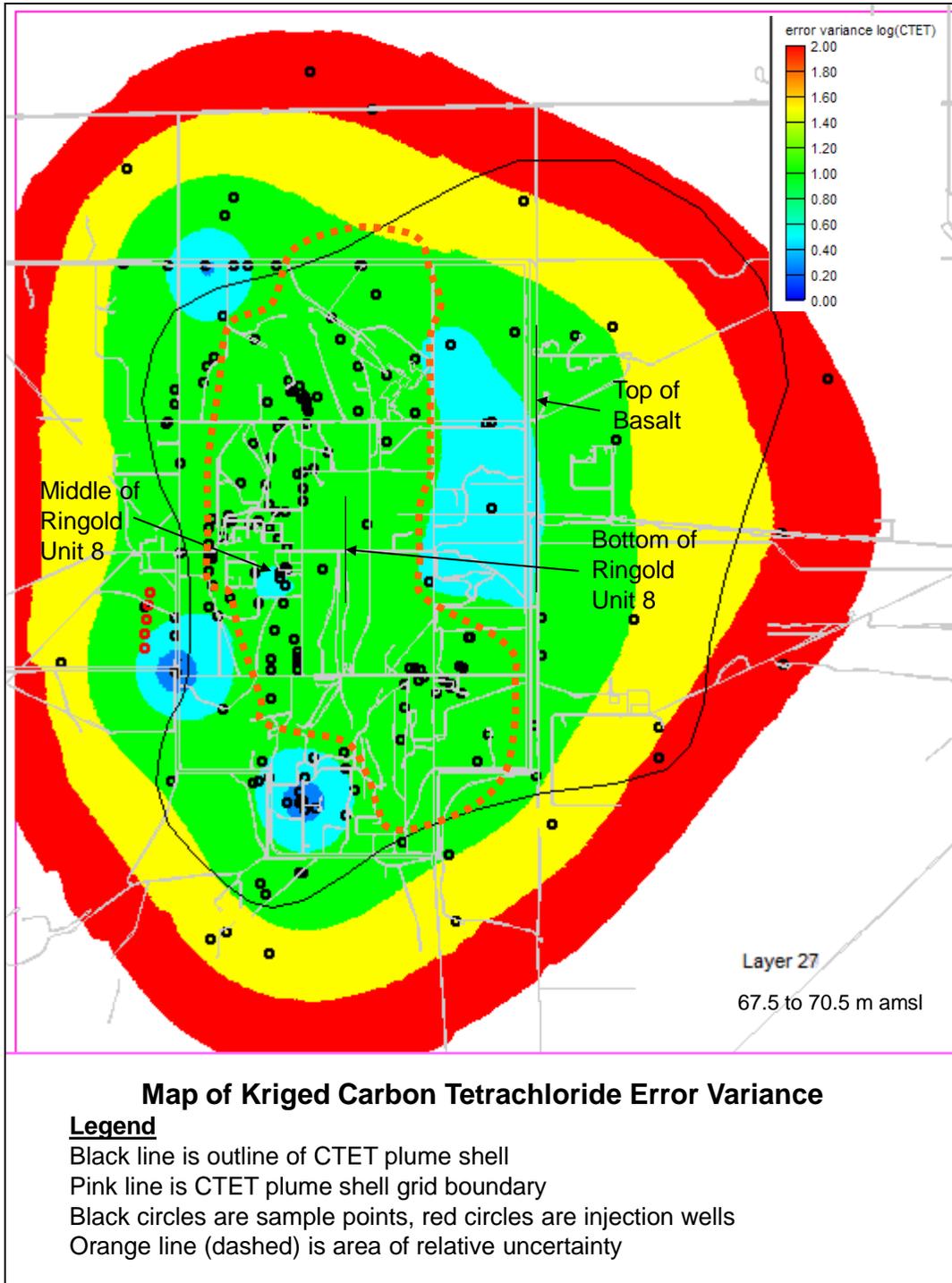
Figure D-6. Kriged Carbon Tetrachloride Error Variance from 85.5 to 88.5 m amsl



amsl = above mean sea level

CTET = carbon tetrachloride

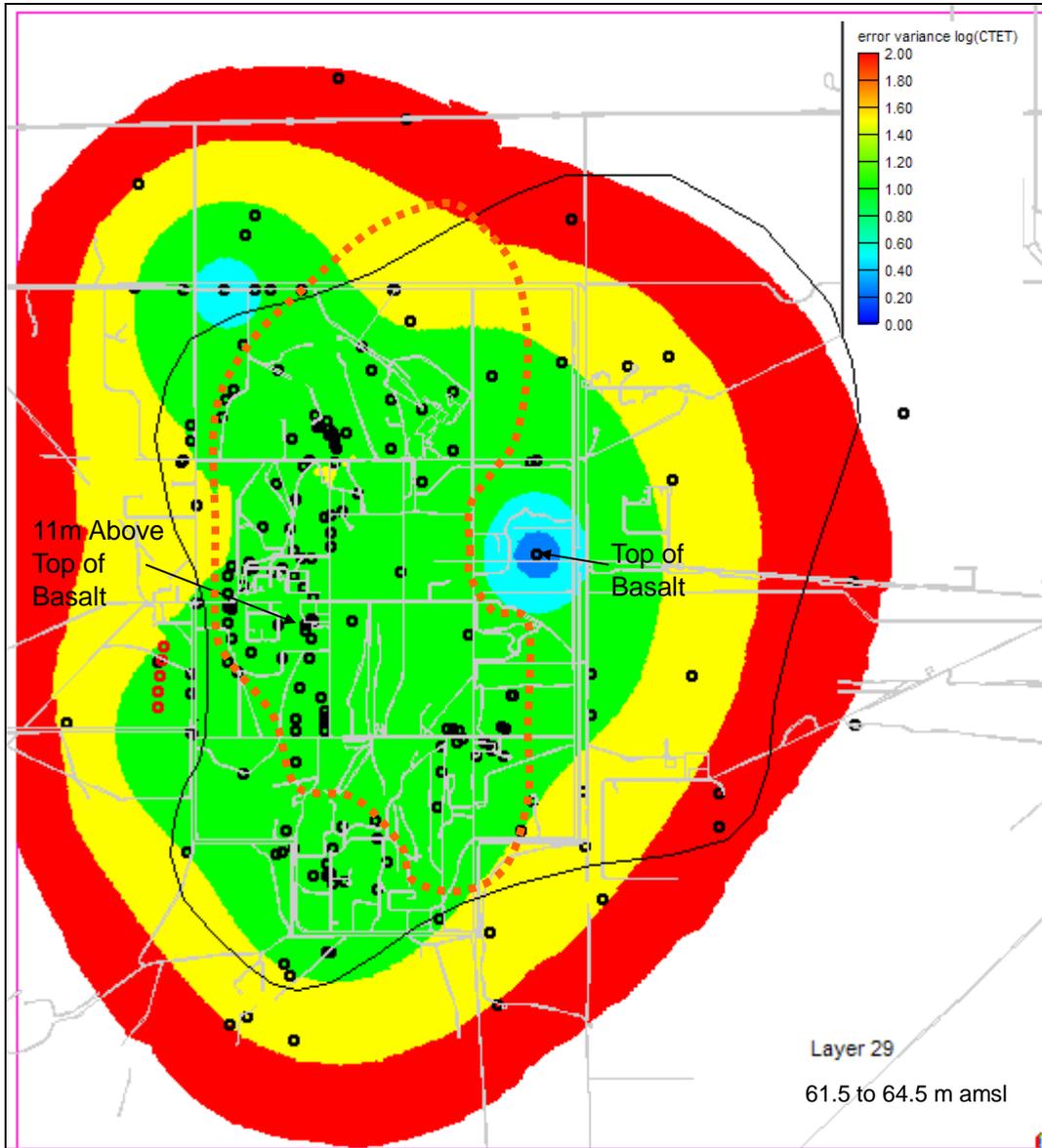
Figure D-7. Kriged Carbon Tetrachloride Error Variance from 73.5 to 76.5 m amsl



amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-8. Krige Carbon Tetrachloride Error Variance from 67.5 to 70.5 m amsl



Map of Kriged Carbon Tetrachloride Error Variance

Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

Figure D-9. Kriged Carbon Tetrachloride Error Variance from 61.5 to 64.5 m amsl

Appendix E

200-ZP-1 Operable Unit Hydraulic Monitoring Well Network

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- 1 **E1 200-ZP-1 Operable Unit Hydraulic Monitoring Well Network**
- 2 Table E-1 provides details for the 200-ZP-1 Operable Unit (OU) hydraulic monitoring well network.

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W10-1	566663	136735	207.5	57.91	82.3	08/07/1947	No	137.4
299-W10-27	566844	136442	205.6	67.36	78.02	03/23/2001	No	132.9
299-W10-30	566083	136739	211.6	73.86	84.53	03/14/2006	No	132.4
299-W10-31	566266	136968	210.4	73.13	83.82	04/20/2006	No	131.9
299-W10-33	566773	136610	206.0	118.87	124.96	06/15/2007	No	84.1
299-W11-13	567099	136424	211.9	66.45	143.86	07/31/1961	No	106.7
299-W11-18	567182	137161	216.5	69.19	89.916	03/01/1967	No	136.9
299-W11-33Q	567185	136844	217.2	74.41	91.17	09/09/1994	No	134.4
299-W11-43	567270	136971	217.5	129.44	134.01	05/23/2005	Yes	85.8
299-W11-45	566993	136776	213.6	85.73	90.18	09/02/2005	No	125.7
299-W11-47	566934	136681	210.4	83.58	92.89	01/06/2006	Yes	122.2
299-W11-48	566882	136846	209.7	84.56	112.01	11/29/2006	Yes	111.4
299-W11-87	568141	136609	223.6	116.36	120.94	03/01/2007	Yes	105.0
299-W11-88	567875	137113	221.9	135.66	147.85	10/03/2007	Yes	80.1
299-W13-1	568149	136049	223.5	119.15	129.81	02/10/2004	Yes	99.1
299-W14-11	566902	136288	205.1	79.77	82.81	04/26/2005	No	123.8
299-W14-14	566898	136181	205.4	66.13	76.81	11/12/1998	Yes	134.0
299-W14-17	567007	136218	205.9	67.64	78.32	10/24/2000	No	132.9
299-W14-71	567733	135568	219.4	125.17	129.74	07/27/2006	Yes	92.0
299-W14-72	567328	135941	216.3	126.18	130.76	08/15/2006	Yes	87.9
299-W15-1	566554	135943	207.0	57.91	82.3	05/02/1947	No	136.9
299-W15-11	566412	136001	208.3	55.78	90.53	03/08/1968	Yes	135.1
299-W15-152	566309	135550	209.9	71.94	82.61	09/15/2005	No	132.6
299-W15-17	566307	135719	209.8	128.77	131.82	10/28/1987	No	79.5

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W15-3	566729	136371	205.4	60.96	71.93	09/30/1952	No	139.0
299-W15-30	566305	135749	210.2	66.47	78.63	05/05/1995	Yes	137.7
299-W15-31A	566377	135856	208.5	64.76	76.93	05/26/1995	No	137.7
299-W15-37	566716	135248	203.0	64.74	77.98	05/16/1996	No	131.68
299-W15-42	566582	135627	207.4	69.50	84.74	02/26/2002	No	130.3
299-W15-46	566752	135587	204.2	63.86	88.23	10/03/2003	No	128.2
299-W15-49	566307	135973	209.1	71.86	82.52	11/01/2004	No	131.9
299-W15-50	566793	135791	203.2	74.19	84.85	02/28/2005	No	123.7
299-W15-7	566676	135920	204.2	55.47	106.68	03/30/1966	Yes	123.1
299-W17-1	565311	135039	199.2	58.99	69.67	12/17/2003	No	134.9
299-W18-1	566422	135465	209.1	59.44	111.89	01/12/1959	No	123.4
299-W18-15	566380	134733	202.2	51.82	74.07	04/25/1980	No	139.3
299-W18-16	566605	135426	208.5	71.47	82.13	10/20/2004	No	131.8
299-W18-22	566089	134990	204.9	126.94	136.39	09/25/1987	No	73.2
299-W18-40	566723	134996	203.4	66.53	77.20	09/28/2001	No	131.6
299-W19-107	567998	135206	217.4	94.65	99.22	03/31/2006	Yes	120.5
299-W19-18	567361	135012	214.0	67.06	109.12	12/12/1985	No	125.90
299-W19-34A	567674	135012	215.1	98.82	103.51	05/18/1994	No	113.9
299-W19-34B	567663	135011	215.5	125.46	128.41	12/12/1985	No	88.6
299-W19-35	567992	135015	213.6	73.13	82.3	04/20/1994	No	135.9
299-W19-4	567950	135351	219.0	77.72	135.03	02/15/1960	No	112.3
299-W19-41	566897	135005	206.5	67.07	77.76	09/23/1998	No	134.1
299-W19-6	567133	134694	210.3	115.82	125.27	12/13/1968	No	89.79
299-W21-2	568124	134574	214.9	79.29	89.96	11/22/2004	No	130.2
299-W22-47	566909	134076	206.3	69.70	80.37	01/19/2005	No	131.3
299-W23-20	566718	134446	203.8	65.68	76.35	08/21/2000	No	132.8
299-W26-14	566683	133539	205.4	68.08	78.75	04/03/2003	No	132.0

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W27-2	566908	133670	207.4	123.79	126.87	12/18/1992	No	82.1
299-W6-3	567118	137299	214.4	124.82	127.95	10/15/1991	No	87.9
299-W6-6	567319	137639	217.5	127.58	130.84	10/24/1991	No	88.3
299-W7-3	566292	137639	207.2	136.85	145.29	11/23/1987	No	66.1
699-25-70	568545	131172	193.0	53.34	134.11	08/31/1948	No	99.24
699-25-80	565676	131106	189.0	273.41	370.03	11/30/1948	No	-132.7
699-30-66	569991	132739	210.5	117.35	120.4	10/13/2004	No	91.6
699-32-62	571010	133216	216.6	83.82	103.63	04/06/1960	No	122.9
699-32-62P	571010	133216	216.6	83.82	146.3	04/06/1960	No	101.5
699-32-70B	568462	133242	204.2	63.09	100.58	08/09/1957	No	122.37
699-32-72A	567943	133363	204.7	65.42	74.56	07/31/1957	No	134.7
699-32-72B	567935	133362	205.1	65.41	74.56	05/18/1994	No	135.1
699-34-88	563012	133950	194.0	146.0	127.02	12/20/1948	No	136.5
699-35-59	571956	134096	222.1	94.48	106.67	10/31/1985	No	121.5
699-35-66A	569858	134099	222.5	79.25	98.15	06/13/1957	No	133.76
699-35-78A	566064	134271	202.4	54.86	85.04	08/17/1950	Yes	132.02
699-36-70B	568428	134626	215.2	80.51	91.17	06/09/2004	No	129.4
699-38-61	571219	134997	228.2	101.83	107.92	11/16/1993	No	123.3
699-38-65	570090	135040	230.7	152.4	155.45	12/31/1959	Yes	76.8
699-38-68A	569180	134932	219.0	81.59	90.74	06/21/1994	No	132.8
699-38-70B	568469	135331	222.6	123.96	128.53	02/03/2004	No	96.3
699-38-70C	569084	135326	226.7	120.60	125.18	02/17/2004	No	103.8
699-39-79	565891	135412	206.5	54.44	73.152	09/07/1948	Yes	142.7
699-40-62	571164	135764	228.9	102.11	114.0	01/17/1949	No	120.8
699-40-65	570057	135881	231.0	100.0	111.5	02/03/2004	Yes	125.3
699-43-69	568967	136488	227.4	121.98	132.64	12/11/2007	Yes	100.1
699-43-89	562917	136620	197.7	43.28	60.35	01/16/1951	No	145.9

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
699-44-64	570391	136897	222.2	96.32	134.72	01/31/1960	Yes	106.67
699-45-69A	568729	137183	222.1	83.52	111.56	06/22/1948	No	124.6
699-45-69C	568947	137234	222.6	111.86	116.43	07/13/2007	Yes	108.4
699-47-60	571474	137969	199.6	71.63	84.43	07/20/1948	No	121.6
699-47-80AP	565562	137693	218.26	198.12	204.83	11/30/1983	No	16.8
699-47-80AQ	565562	137693	218.26	153.31	156.36	11/30/1983	No	63.4
699-48-71	568388	138057	210.9	138	156.36	09/26/1956	Yes	63.7
699-48-77C	566469	138087	206.6	88.39	94.49	04/01/1994	No	115.42
699-49-79	565771	138271	211.1	65.58	80.77	07/03/1948	Yes	137.9
699-50-74	567360	138647	201.4	68.07	78.74	07/12/2005	No	128.0
699-51-63	570664	139148	175.3	47.85	55.78	11/06/1956	No	123.49
699-51-75	566978	138906	196.6	57.91	68.58	10/31/1957	No	133.4
699-55-76	566723	140226	178.7	42.98	67.36	01/18/1959	No	123.5

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Appendix F
Sampling Interval Depth Information
for 200-ZP-1 Groundwater Operable Unit Wells

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F1 Introduction

This appendix provides the following information for the 200-ZP-1 Groundwater Operable Unit (OU) wells:

- Well name
- Hydrogeologic unit to be monitored – the portion of the aquifer that is located at the well screen or perforated casing (Table F-1)
- The following sampling interval depth information for wells within the 200-ZP-1 OU area (Table F-2):
 - Elevation at top of the screen or perforated interval
 - Elevation at the bottom of the screen or perforated interval
 - Open interval length (the difference between elevations of top and bottom of the screen or perforated interval)
 - Water-level elevation (the most recent water-level elevation in the well)
 - Water-level date (date of most recent water-level elevation measured in the well)

Table F-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
CR	Confined Ringold: Wells for which the open interval does not extend more than a approximately 3 m (10 ft) below the top of basalt. Typically open to the lower mud (unit 8) and basal gravel (unit 9) of the Ringold Formation. This classification is not used for wells completed in the Ringold upper mud.
LU	Lower unconfined: Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse hydrogeologic unit or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
MU	Middle unconfined: Open interval begins at greater than 15.2 m (50 ft) below the water table and does not extend below the middle coarse hydrogeologic unit or to within 15.2 m (50 ft) of the top of basalt.
TU	Top of unconfined: Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.
U	Undifferentiated unconfined: Open to more than 15.2 m (50 ft) of the unconfined aquifer system, or the open/monitoring interval depth is not documented but is known to be within the unconfined aquifer system.
UU	Upper unconfined: The top of the open interval is more than 1.5 m (5 ft) below the water table and the bottom of the open interval is no more than 15.2 m (50 ft) below the water table.

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored*	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water-Level Elevation (m NAVD88)	Water-Level Date
299-W10-1	U	149.5	125.2	14.3	133.19	11/12/2014
299-W10-14	LU	84.1	78.0	6.1	137.40	11/14/2014
299-W10-27	TU	138.3	127.6	10.7	131.12	11/5/2014
299-W10-30	TU	137.8	127.1	10.7	136.91	9/5/2014
299-W10-31	TU	137.3	126.6	10.7	135.45	9/5/2014
299-W10-33	LU	87.1	81.0	6.1	132.91	9/2/2014
299-W11-13	U	145.5	68.4	77.1	130.88	3/14/2014
299-W11-18	TU	147.3	126.6	20.7	132.96	3/14/2014
299-W11-33Q	TU	142.8	126.1	16.5	131.43	12/16/2014
299-W11-43	LU	88.1	83.5	4.6	131.40	3/14/2014
299-W11-45	UU	127.9	123.4	4.5	130.78	3/24/2015
299-W11-47	U	126.8	117.5	9.3	131.20	11/7/2014
299-W11-48	LU	125.1	97.7	27.4	132.30	2/6/2014
299-W11-87	LU	107.3	102.7	4.6	128.42	3/14/2014
299-W11-88	LU	86.2	74.0	12.2	130.02	3/14/2014
299-W13-1	MU	104.4	93.7	10.7	129.39	3/14/2014
299-W13-2	LU	128.4	104.3	12.2	128.80	1/5/2016
299-W14-11	UU	125.3	122.3	3.0	129.67	11/11/2014
299-W14-13	TU	138.7	128.7	10.0	129.40	11/11/2014
299-W14-14	TU	139.3	128.6	10.7	130.57	11/18/2014
299-W14-71	LU	94.2	89.7	4.5	129.91	8/15/2014
299-W14-72	LU	90.2	85.6	4.6	129.53	3/14/2014
299-W15-11	TU	152.5	117.8	34.7	135.06	12/30/2013
299-W15-152	TU	137.9	127.3	10.6	133.17	7/22/2014
299-W15-17	LU	81.0	78.0	3.0	135.07	11/14/2014
299-W15-33	UU	142.4	127.9	14.5	134.27	11/14/2014
299-W15-37	UU	140.3	125.1	15.2	133.46	12/10/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored*	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water-Level Elevation (m NAVD88)	Water-Level Date
299-W15-42	UU	137.9	122.7	15.2	133.90	11/14/2014
299-W15-46	UU	140.4	116.0	24.4	133.20	1/20/2014
299-W15-49	UU	137.3	126.6	10.7	136.08	3/14/2014
299-W15-50	MU	129.0	118.4	10.6	132.71	3/14/2014
299-W15-7	TU	148.8	97.6	51.2	133.06	5/6/2014
299-W15-763	TU	138.4	127.7	10.7	132.12	5/20/2014
299-W15-765	TU	138.2	127.6	10.6	131.20	11/7/2014
299-W15-83	TU	137.7	127.0	10.7	135.51	7/9/2014
299-W15-94	TU	137.9	127.2	10.7	135.33	7/9/2014
299-W18-1	U	149.6	79.5	70.1	209.07	11/14/2014
299-W18-15	TU	142.8	118.7	24.1	135.07	2/7/2014
299-W18-16	TU	137.1	126.4	10.7	134.49	3/14/2014
299-W18-21	TU	145.3	136.2	9.1	136.29	11/18/2014
299-W18-22	LU	77.9	68.5	9.4	135.81	11/18/2014
299-W18-40	TU	136.9	126.2	10.7	134.31	12/10/2014
299-W19-105	TU	135.2	124.5	10.7	131.83	9/5/2014
299-W19-107	UU	122.8	118.2	4.6	130.95	3/14/2014
299-W19-18	TU	146.9	104.9	42.0	132.25	7/18/2014
299-W19-34A	MU	116.5	111.8	4.7	131.64	7/18/2014
299-W19-34B	MU	90.0	87.1	2.9	131.85	3/14/2014
299-W19-36	UU	140.8	127.1	13.7	131.86	8/4/2014
299-W19-4	U	141.3	56.0	85.3	131.25	1/2/2014
299-W19-41	TU	139.5	128.8	10.7	132.90	12/10/2014
299-W19-47	TU	137.1	126.4	10.7	136.78	12/10/2014
299-W19-48	UU	133.0	122.3	10.7	131.60	8/12/2014
299-W19-49	TU	135.1	124.5	10.6	131.92	8/12/2014
299-W19-6	MU	94.5	85.1	9.4	132.86	1/20/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored*	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water-Level Elevation (m NAVD88)	Water-Level Date
299-W21-2	TU	135.6	124.9	10.7	131.61	6/19/2014
299-W22-47	UU	136.6	125.9	10.7	132.98	12/10/2014
299-W22-72	TU	135.8	125.1	10.7	132.37	12/19/2014
299-W22-86	TU	135.9	125.2	10.7	132.22	12/19/2014
299-W22-87	TU	135.7	125.1	10.6	132.26	3/14/2014
299-W22-88	TU	134.3	123.7	10.6	131.96	11/4/2014
299-W23-19	TU	139.5	136.4	3.1	Not Available	Not Available
299-W23-4	U	148.1	111.6	36.5	134.30	2/7/2014
299-W26-13	TU	138.2	127.5	10.7	134.10	11/4/2014
299-W27-2	LU	83.6	80.5	3.1	133.29	5/20/2014
299-W5-2	LU	111.7	87.4	12.2	129.50	12/1/2015
299-W6-3	LU	89.5	86.4	3.1	133.99	3/14/2014
299-W6-6	LU	89.9	86.6	3.3	135.01	3/14/2014
299-W7-3	LU	70.3	61.9	8.4	135.23	3/14/2014
699-30-66	LU	93.1	90.1	3.0	130.07	11/3/2014
699-32-62	TU	132.7	64.2	68.5	128.02	3/18/2014
699-32-72A	U	76.7	56.8	19.9	131.97	4/11/2014
699-33-75	TU	135.7	125.1	10.6	133.06	11/3/2014
699-34-61	TU	129.4	123.3	6.1	125.94	3/24/2014
699-35-66A	TU	143.2	124.3	8.9	129.89	9/8/2014
699-35-78A	TU	147.5	117.3	30.2	135.26	11/18/2014
699-36-61A	TU	128.4	110.5	17.9	123.65	6/23/2014
699-36-66B	TU	131.7	121.0	10.7	129.93	9/8/2014
699-36-70A	TU	137.6	128.4	9.2	131.19	9/9/2014
699-36-70B	TU	134.7	124.1	10.6	131.45	2/14/2014
699-37-66	TU	131.3	120.6	10.7	129.40	9/8/2014
699-38-61	TU	126.3	120.2	6.1	123.18	2/10/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored*	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water-Level Elevation (m NAVD88)	Water-Level Date
699-38-65	TU	163.7	72.2	91.5	128.16	6/23/2014
699-38-68A	TU	137.3	128.2	9.1	130.66	2/4/2014
699-38-70B	MU	98.6	94.0	4.6	130.26	5/12/2014
699-38-70C	LU	106.1	101.5	4.6	130.27	5/12/2014
699-40-62	TU	126.8	115.0	11.8	122.44	3/21/2014
699-40-65	TU	130.2	119.5	10.7	126.33	5/13/2014
699-43-69	CR	105.4	94.7	10.7	129.51	3/21/2014
699-44-64	TU	125.9	87.5	38.4	123.03	11/12/2014
699-45-69A	TU	138.6	110.6	28.0	129.58	4/2/2014
699-45-69C	MU	110.7	106.1	4.6	129.57	4/16/2014
699-47-60	TU	123.4	115.1	8.3	121.86	7/21/2014
699-48-71	TU	138.0	118.8	19.2	130.53	8/27/2014
699-50-74	TU	133.3	122.7	10.6	132.33	6/23/2014
699-51-63	TU	127.4	119.5	7.9	122.59	11/14/2014

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

* The hydrogeologic units are defined in Table F-1.

F2 Reference

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

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