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Revision 1

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Revision 1

Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action

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Assistant Secretary for Environmental Management

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Terms

amsl	above mean sea level
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
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
MCL	maximum contaminant level
MNA	monitored natural attenuation
OU	operable unit
PMP	performance monitoring plan
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
ROD	Record of Decision
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDL	Well Information and Document Lookup

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1 Introduction

This revision of the performance monitoring plan (PMP) has been prepared to guide groundwater monitoring data collection activities and reflect necessary changes subsequent to the implementation to date of the 200-ZP-1 Operable Unit (OU) remedial action. The selected remedy is described in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al., 2008), hereafter referred to as the Record of Decision (ROD). This PMP presents recommendations for the types of data that should be collected, the well networks that should be monitored, the frequency of data collection, and the analysis of the data to satisfy the requirements of the ROD. The PMP does not present the more specific aspects of data collection that are typically described in a sampling and analysis plan and/or a quality assurance project plan. Those plans are presented in Appendices D and E of the *200 West Area Pump-and-Treat Facility Operations and Maintenance Plan* (DOE/RL-2009-124). In addition, the PMP is not designed to monitor the treatment process in 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.

This PMP is intended to be 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. Some wells in the PMP monitoring network will go dry as a result of pump-and-treat (P&T) operations, and improvements will be made to the site conceptual model, groundwater flow model, and three-dimensional contaminant distributions based on information from newly drilled extraction and injection wells. Therefore, emphasis must be placed on the PMP being adaptable enough that it can be used and/or updated to specify a performance monitoring regime that makes sense for the current state of the site.

The 200-ZP-1 Groundwater OU includes several groundwater plumes that span an area approximately 13 km^2 (5 mi^2) beneath the Hanford Site's 200 West Area (Figure 1-1). 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 study (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*, respectively) concluded that without remedial action, contaminants in 200-ZP-1 groundwater would exceed risk threshold values for future industrial workers and residents who might use the groundwater as a drinking water supply. The existing contaminant concentrations also exceed federal and state maximum contaminant levels (MCLs) and state groundwater cleanup standards for use of the groundwater as a source of drinking water. As stated in the ROD, the major contaminant of concern (COC) for the 200-ZP-1 OU is carbon tetrachloride. Other 200-ZP-1 COCs include total chromium, hexavalent chromium, nitrate, trichloroethylene, iodine-129, technetium-99, and tritium.

The ROD presents the selected remedial action for restoring the aquifer, as well as the cleanup levels for the COCs. The *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78) (RD/RAWP) describes the design and implementation of the remedial action process required by the ROD. This document describes the monitoring activities associated with the remedial action process, the remedial action objectives (RAOs), and the preferred remedial action alternative chosen to meet those RAOs.

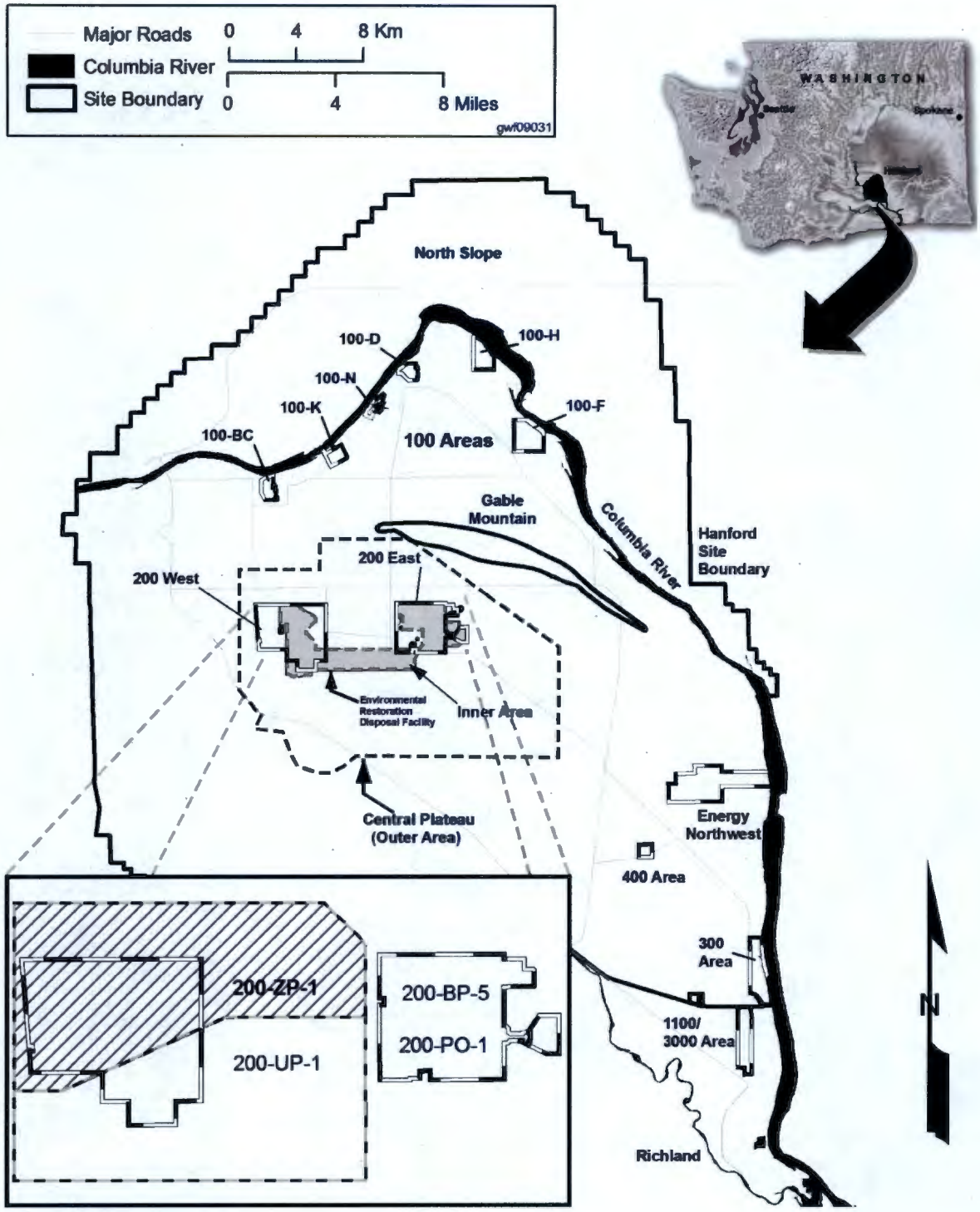

Figure 1-1. Site Location

1.1 Remedial Action Objectives

Through its groundwater protection program, the state of Washington determined that the 200-ZP-1 OU aquifer setting meets the *Washington Administrative Code* (WAC) definition for potable groundwater and has been recognized by the state as a potential source of domestic drinking water. Consistent with the state's beneficial-use determination, the contaminated groundwater must be restored to a level that supports future use as a potential domestic drinking water supply. In accordance with this goal, the specific RAOs for remediation of the contaminated 200-ZP-1 OU groundwater are listed below.

- **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 1-1). This objective is to be achieved within the entire 200-ZP-1 OU groundwater plumes. The estimated time frame to achieve cleanup levels is within 150 years.[1]
- **RAO #2:** Apply institutional controls to prevent the use of groundwater until the cleanup levels (Table 1-1) have been achieved. Within the entire OU groundwater plumes, institutional controls must be maintained and enforced until the 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 contaminants originating from the 200-ZP-1 OU. This final objective is applicable to the entire 200-ZP-1 OU groundwater plume. Protection of the Columbia River from impacts caused by 200-ZP-1 OU contaminants must continue until the cleanup levels are achieved, which is estimated to be within 150 years.[1]

Table 1-1. Cleanup Levels for 200-ZP-1 Operable Unit 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
Trichloroethylene	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 Operable Unit subject to WAC 173-340, "Model Toxics Control Act – Cleanup" (carbon tetrachloride and trichloroethylene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

COC = contaminant of concern

WAC = *Washington Administrative Code*

[1] The RAOs identify the estimated time frame to achieve cleanup levels as 150 years. Further requirements in the ROD identify 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 consists of four components: (1) groundwater P&T, (2) monitored natural attenuation (MNA), (3) flow-path control, and (4) institutional controls. The first three components, which are the subject of this PMP, require periodic groundwater monitoring and data evaluation to assess remedy performance and to determine when the remedial action is complete. The fourth component does not require groundwater monitoring and is addressed separately in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41). Descriptions of the first three components of the selected remedy are presented in the following sections.

1.2.1 Pump-and-Treat Component

The 200 West P&T has been designed, the majority of the wells installed, and is operated to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride, total chromium, hexavalent chromium, nitrate, trichloroethylene, iodine-129, and technetium-99 throughout the 200-ZP-1 OU 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 1-1 for all COCs within 125 years. Modeling performed for the *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24) indicates that carbon tetrachloride concentrations in the groundwater greater than 100 µg/L correspond to approximately 95 percent of the mass of carbon tetrachloride currently residing in the aquifer. The estimated pumping rate required to reduce the mass of carbon tetrachloride by 95 percent within the expected time frame is 7,570 L/min (2,000 gallons per minute [gpm]) using approximately 20 extraction wells and approximately 16 injection wells.

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

The RD/RAWP (DOE/RL-2008-78) considers the need for treatment of other constituents (e.g., uranium) that may be captured by the 200-ZP-1 OU extraction wells. While not COCs for the 200-ZP-1 OU, such 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 the cleanup levels specified in the ROD. 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 200 West P&T operation, natural attenuation plays an increasingly larger role in reducing COC concentrations. Natural attenuation processes expected to contribute to COC concentration reductions include abiotic degradation, volatilization (for trichloroethylene and carbon tetrachloride), dispersion, sorption, and natural radioactive decay (for tritium). As presented in the ROD, it is estimated that natural attenuation processes will reduce COC concentrations to 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 1-1 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 1-2). Injecting the treated water in these locations slows the natural eastward flow of most of the groundwater and, as a result, keeps the COCs for the 200-ZP-1 OU within the hydraulic capture zone of the extraction wells. Injection wells installed to the west (upgradient) are used to 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 ROD was signed in 2008, the 200 West P&T was constructed, including the installation of 21 new extraction wells and 11 new injection wells, and connection to the interim system's five injection wells. There are seven injection wells and four extraction wells remaining to be installed and connected to the 200 West P&T, as identified in Figure 1-2. The 200 West P&T, with a hydraulic capacity of 9,464 L/min (2,500 gpm), began operations in 2012 after operations were ended at the interim facility. The design of the new 200 West extraction, injection, and monitoring well field continues to evolve as a result of data collected and analyzed from drilling, sampling, and testing of new extraction, injection, and monitoring wells. If during drilling of new wells, sampling results indicate that contamination below Ringold Unit 8 (also known as the Ringold lower mud unit) is higher than contaminant levels above Ringold Unit 8, changes to the well design and locations will be made to appropriately address the contamination in order to meet cleanup levels specified in the 200-ZP-1 ROD. These changes may include constructing the extraction well below Ringold Unit 8. Likewise, if high concentrations of contaminants are found below Ringold Unit 8, then changes may include injecting treated water below Ringold Unit 8 to provide a vertical gradient to prevent eastern migration of contaminants above the basalt and protect contamination from penetrating the basalt. If contamination is above levels that are being addressed through MNA in the interval below Ringold Unit 8, then this may warrant construction of extraction and injection wells below Ringold Unit 8 and the addition of drilling monitoring wells below Ringold Unit 8 to monitor the migration and containment of contaminants in that interval.

The new extraction wells are located in areas with carbon tetrachloride concentrations greater than 100 µg/L (Figure 1-2). This design concept concentrates the active treatment portion of the selected remedy on the most contaminated groundwater in a relatively large groundwater plume. The eastern injection wells are located in areas with carbon tetrachloride concentrations less than 100 µg/L but possibly greater than 5 µg/L (Figure 1-2). Any groundwater contaminated above cleanup levels that is located downgradient of the eastern injection well fence will be addressed by natural attenuation. The western injection wells are generally located in groundwater with carbon tetrachloride concentrations around 5 µg/L.

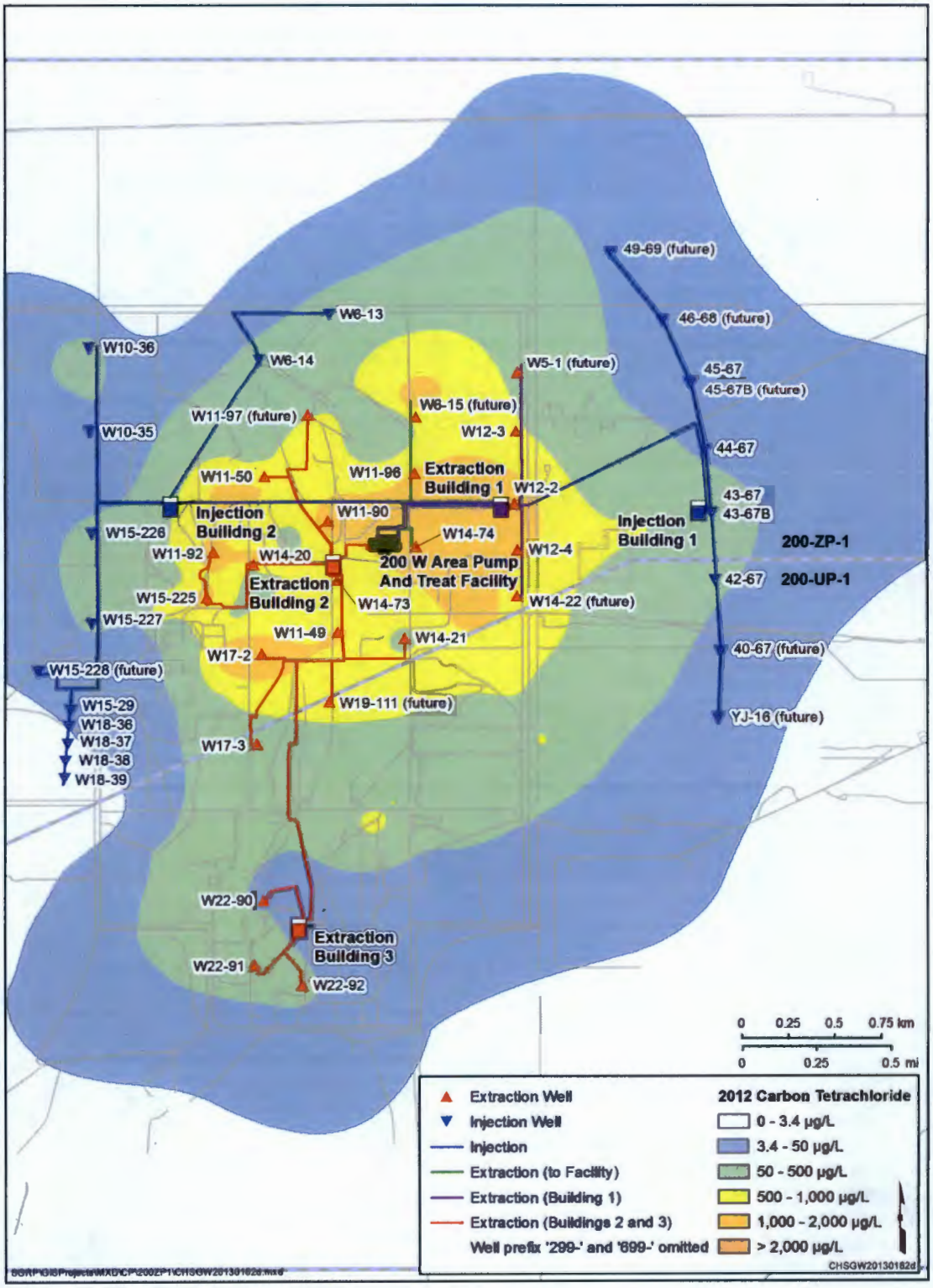

Figure 1-2. 200 West Pump and Treat Well Field and Pipeline Routes Overlying the Carbon Tetrachloride Plume

The 200 West P&T is extracting 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:

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

This PMP is not intended to monitor the performance of any 200-UP-1 remedial activities that are addressed by the *Record of Decision for Interim Remedial Action, Hanford 200 Area Superfund Site, 200-UP-1 Operable Unit* (EPA et al., 2012), which was signed in September 2012.

The carbon tetrachloride plume depicted in Figure 1-2 is from *Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (DOE/RL-2013-14). Figure 1-2 depicts the initial condition of the carbon tetrachloride plume after startup began in 2012. The carbon tetrachloride concentrations in the contaminant transport model are documented in *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY 2012) 200 Areas Pump-and-Treat Report* (ECF-200ZP1-13-0006).

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2 Site Conceptual Model

This chapter briefly describes the local geology, hydrogeology, and groundwater in the 200 West Area. This information is summarized from the ROD and is included to provide a brief overview of the current understanding of the site conceptual model.

2.1 Local Geology

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington (Figure 1-1). The Central Plateau is a relatively flat, prominent terrace near the center of the Hanford Site. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the western end of the Central Plateau. Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. The overlying sediments are approximately 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 2-1, 2-2, and 2-3). Surface elevations range from approximately 200 to 217 m (660 to 712 ft).

2.2 Local Hydrogeology

The sediment thickness above the water table (the vadose zone) in the 200 West Area 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, and the Hanford Formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and Cold Creek unit. Perched water (water above the water table) has historically been documented above the Cold Creek unit at locations in the 200 Areas. However, since most liquid waste discharges to the area were stopped in 1995, perched water is infrequently encountered in the vadose zone.

Recharge to the unconfined aquifer in the 200 West Area is from artificial and natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in./yr) and are largely dependent on soil texture, as well as 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 were stopped in 1995. The continuing artificial recharge in the Central Plateau is largely limited to onsite sanitary sewage treatment and disposal systems; leaks from potable and raw water lines; two state-approved land disposal structures; and small-volume, uncontaminated, miscellaneous waste streams. A small volume of uncontaminated water may be used for dust and contamination control during construction phases.

2.3 Groundwater

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the Ringold Formation and sedimentary interbeds in the basalt. The Columbia River is the primary discharge area for both the unconfined and confined aquifers. The 200 West Area is located approximately 8 km (5 mi) south of the Columbia River. The unconfined aquifer in the 200-ZP-1 OU area of the Central Plateau 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, groundwater flow through the Central Plateau occurs in a predominantly easterly direction from the 200 West Area to the 200 East Area.

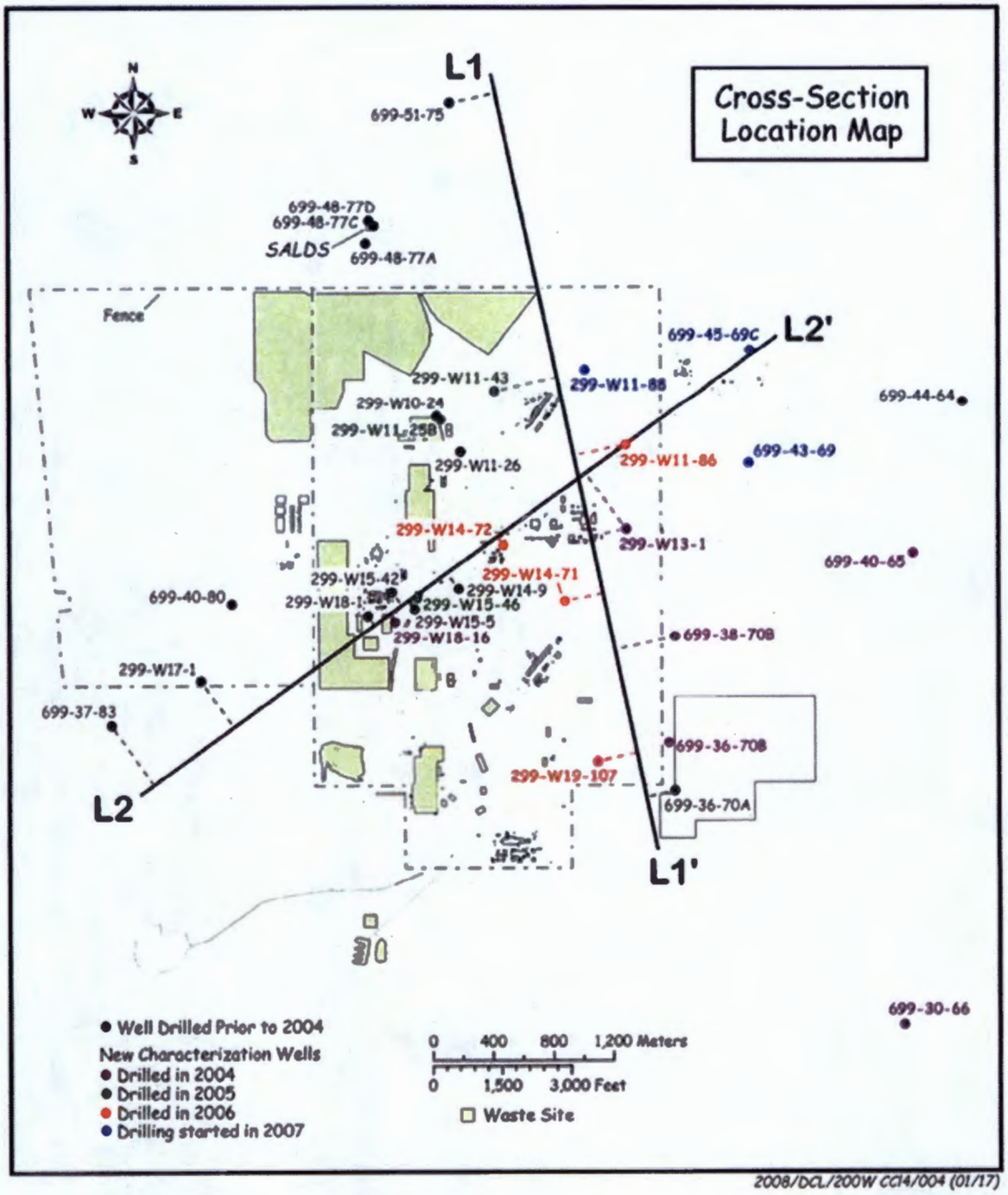
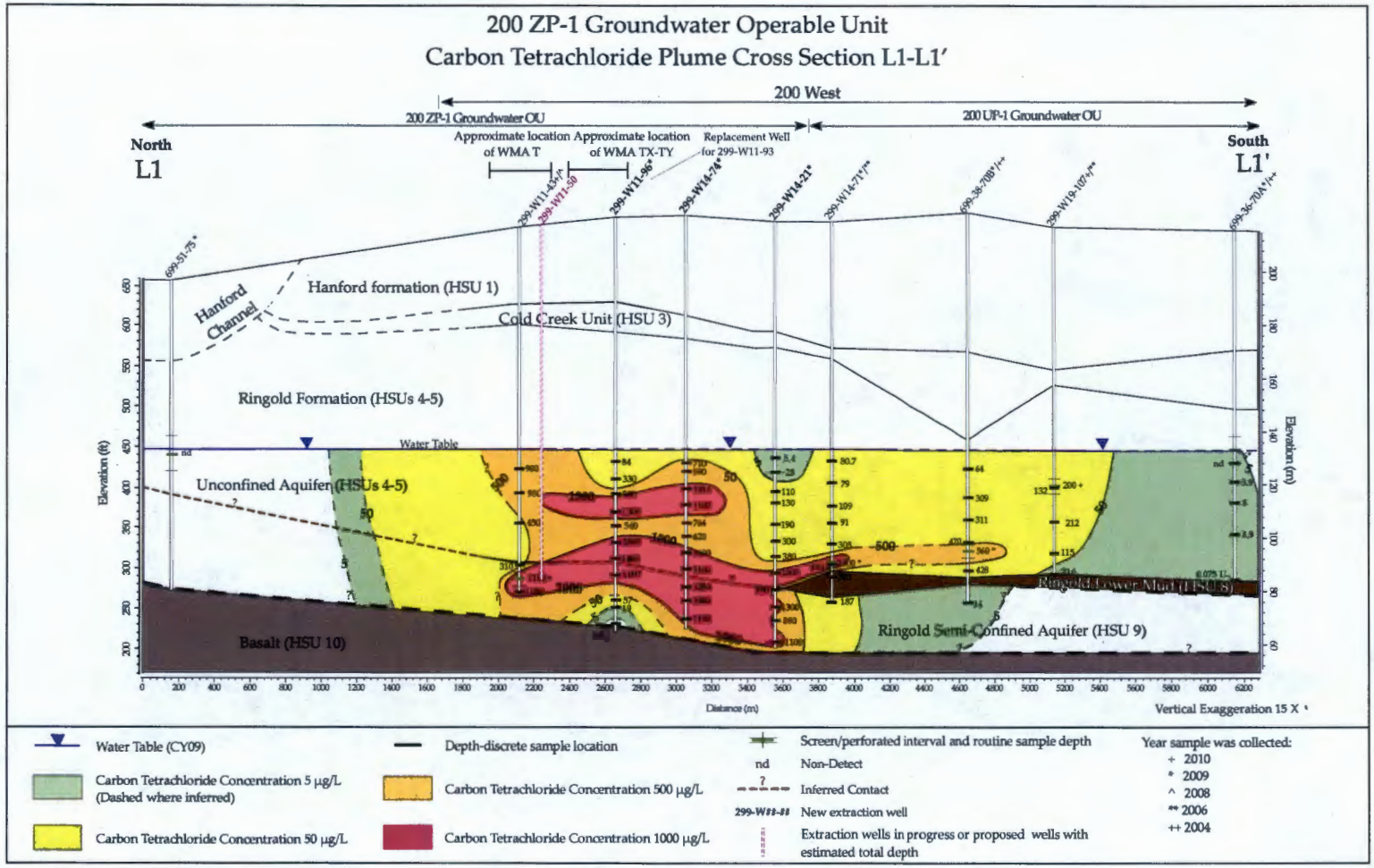
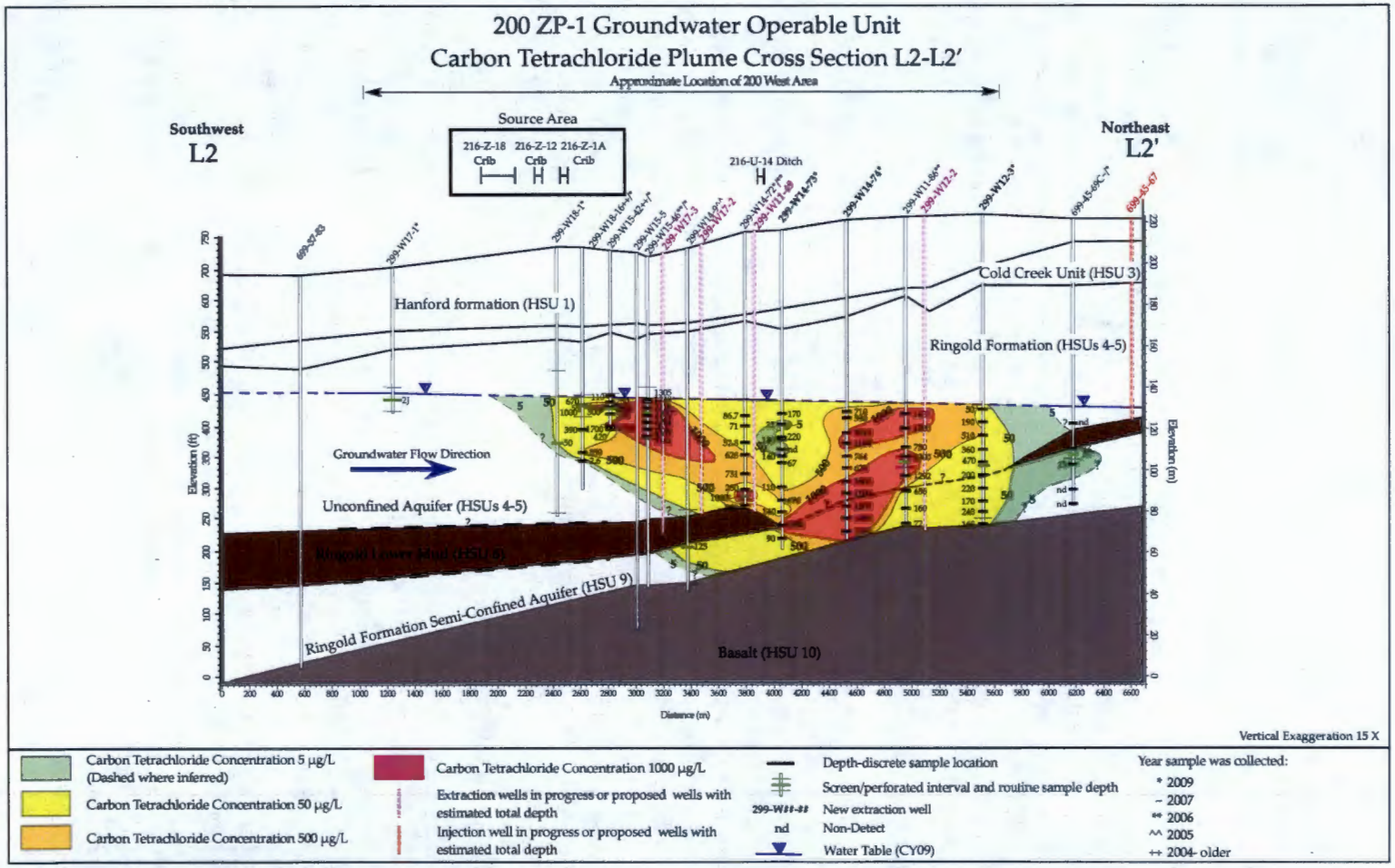


Figure 2-1. Location of Cross Sections, Including Wells Used for Interpretation



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

Figure 2-2. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Northwest to Southeast (L1 to L1′)



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

Figure 2-3. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Southwest to Northeast (L2 to L2')

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 developing in excess of 26 m (85 ft). Discharges to the 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area, deflecting it to the north through Gable Gap, between Gable Mountain and Gable Butte, or to the south of the 216-B-3 Pond (Figure 2-4). As the hydraulic effects of these two discharge sites diminish, groundwater is expected to flow on a more easterly course through the Central Plateau, with some flow possibly 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 at the State-Approved Land Disposal Site. 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 influx of artificial recharge that created the elevated water table was eliminated when production ceased at the Hanford Site.

2.4 Contaminant Distribution

Figures 2-2 and 2-3 show cross sections of the carbon tetrachloride concentrations in the 200 West Area. The figures depict a carbon tetrachloride plume that is present at the water table in the source area and gradually dives into 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, also known as the Ringold lower mud unit, is discontinuous and/or relatively thin in places. This allows the carbon tetrachloride plume to migrate vertically downward to the basalt bedrock in those areas where Ringold Unit 8 is missing. The carbon tetrachloride plume does not extend downward into the basalt bedrock that defines the bottom of the alluvial 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.

2.5 Site Conceptual Model Uncertainties

Several potential uncertainties are associated with the current site conceptual model that could impact the success of the 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) the continuity of Ringold Unit 8, and (3) the thickness of the contaminant plume near the source areas. Near the contaminant source areas, Figures 2-2 and 2-3 depict approximately 60 m (196.9 ft) of saturated aquifer above the confining unit, Ringold Unit 8. Below the confining unit is approximately 15 m (49.2 ft) of saturated aquifer above the basalt bedrock. The continuity of the confining unit and its effectiveness as a hydraulic barrier to the downward migration of contaminants are important to the design of the new extraction well field. If the confining unit is fairly effective as a hydraulic barrier and contaminants have not migrated below the unit, then the extraction wells should only be completed above the confining unit. If the 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 both above and below the confining unit. If contamination has migrated below the confining unit, the possibility of the carbon tetrachloride plume extending into the basalt bedrock may need to be further evaluated.

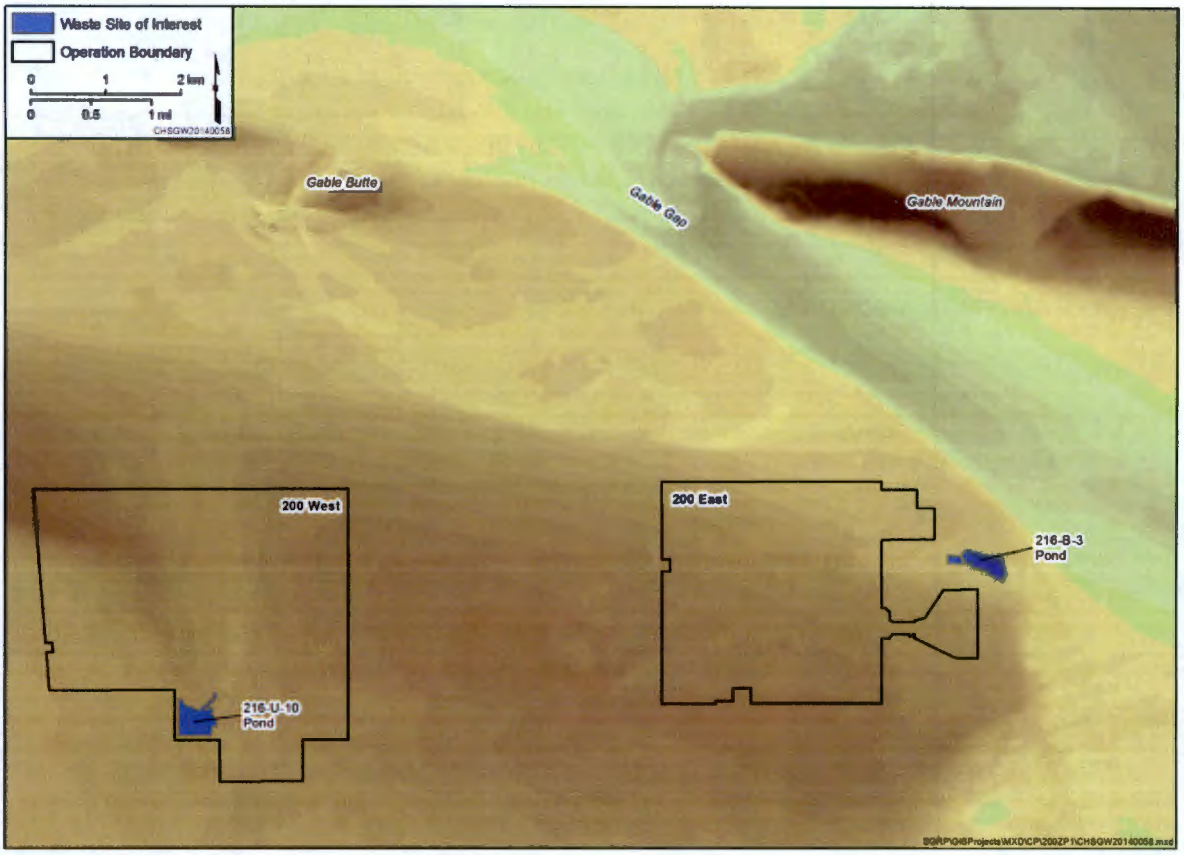


Figure 2-4. Aerial View of Gable Butte, Gable Gap, Gable Mountain, and the 200 Areas, Including U Pond and B Pond

In addition, there are few deep monitoring wells near the source areas that monitor carbon tetrachloride down to the top of the confining unit and below it to the top of the basalt bedrock. Therefore, the thickness of the plume under the source area is relatively uncertain.

3 Design of the Performance Monitoring Program

This chapter presents the groundwater monitoring data collection activities associated with implementation of the 200-ZP-1 OU remedial action. The program for collecting the contaminant and hydraulic performance monitoring data is presented in this discussion, as well as guidance on how the monitoring data will be used to monitor and evaluate the success of the selected remedial action. Appendix A presents the results from the data quality objectives process that were used to develop the sampling approaches identified in this chapter.

3.1 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.

3.1.1 Contaminant Monitoring Network

The 200-ZP-1, VOC, and contaminant-specific networks are presented in this PMP. The VOC and contaminant-specific well networks are currently scheduled to be sampled annually, while the 200-ZP-1 network is currently scheduled to be sampled for each of the COCs in the contaminant-specific well network every 5 years to support the preparation of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) 5-year review. The sampling schedule is shown in detail in Appendix B, Table B-3. Sampling of the VOC and the 200-ZP-1 networks for COCs included in the contaminant-specific network will generate sufficient data for quantitative analysis in support of addressing each of the nine decision statements (DSs). This analysis includes plume shell development (where data sets are used 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 mass of COCs within 25 years and achieve cleanup levels within 125 years. Sampling of the VOC and contaminant-specific well networks will generate sufficient data for more qualitative analysis in support of addressing DSs #1, #2, and #5. This includes determining if any new releases have occurred; evaluating concentration trends in high-concentration areas of the plumes; and determining if contamination is expanding downgradient, laterally, or vertically.

The contaminant monitoring networks shown in Figures 3-1 through 3-7 will evolve over time as the 200 West P&T and natural attenuation remediation processes result in changes in contaminant concentrations and plume sizes. Some areas of the plumes will be cleaned up more quickly than other areas, and the extraction wells will likely be shut down in a staged manner as they become increasingly inefficient to operate. Additionally, many of the shallow monitoring wells may go dry in areas farthest removed from the east and west injection wells. Therefore, while the 200 West P&T is operating, the contaminant monitoring well networks and constituent analyses will be evaluated on an annual basis. The evaluation will determine whether monitoring wells will be dropped from the networks or if other wells should be added to the networks. The evaluation will also determine which constituent analyses are appropriate to those wells. Changes to the well network and/or constituent analyses resulting from the annual review will be made with U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) concurrence.

After the 200 West P&T has been shut down, the contaminant monitoring well networks will be evaluated on a less frequent basis as the plumes change more slowly. At a minimum, the contaminant monitoring networks should be evaluated every 5 years in accordance with the CERCLA 5-year review.

When developing the initial list of wells for the VOC monitoring well network, a master list of available monitoring wells was queried from the Well Information and Document Lookup (WIDL) database for the 200-ZP-1 and 200-UP-1 OUs. This query included data such as well coordinates, well construction information, and historical purposes of the wells. Many of the wells included in the query results had missing information, especially the older historic wells.

The master list of monitoring wells was then reduced by determining whether the well was missing crucial information, was found to be dry, or was located outside the area of interest for performance monitoring. Many wells identified from the WIDL database query were missing top and bottom screen elevation data; however, this information was present in the 2008 carbon tetrachloride plume shell data set. For these wells, the mid-screen elevation was supplied (in Appendix B) from the plume shell data set.

The remaining potential monitoring wells were then imported into the latest carbon tetrachloride plume shell grid and were compared to the three-dimensional carbon tetrachloride distribution to qualitatively evaluate their redundancy. At this stage of the evaluation, there was a relatively dense (i.e., well separation ranging from approximately 40 to 260 m [131.2 to 853.0 ft]) network of shallow monitoring wells in the tank farm areas and a much more widely spaced (i.e., well separation ranges from approximately 500 to 1,900 m [1,640.4 to 6,233.6 ft]) network of monitoring wells further to the east and/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 kept, and the wells that provided little added definition of the three-dimensional carbon tetrachloride distribution were not included. The goal of this evaluation was to improve future carbon tetrachloride plume shell development by providing a more spatially consistent and complete network of monitoring 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 considered. Monitoring wells that defined the high concentrations of other COCs, or that were otherwise important to the definition of the other plumes, were added back into the network. This step added some wells in the tank farm areas and also a number of wells that are potentially downgradient of the leading edge of the carbon tetrachloride plume (because other COCs such as nitrate have plume leading edges that extend further to the east).

Determination of a contaminant monitoring well network occurred during the fiscal year (FY)/calendar year (CY) 2012 baseline sampling (the year prior to startup operations of the 200 West P&T). Some wells initially proposed for the VOC contaminant monitoring well network were rejected due to inaccessibility or lack of water. The VOC network currently includes 96 wells, which are shown in Figure 3-1 and associated construction details are presented in Appendix B. The contaminant-specific well networks include variable numbers of wells and are presented in Figures 3-2 through 3-7. As the monitoring network for VOCs is comprehensive for all of the 200 West Area, 48 of the wells in the contaminant monitoring network are within the 200-UP-1 OU. These 48 wells were not considered for sampling of the other 200-ZP-1 OU COCs. The remaining 48 wells comprise the 200-ZP-1 network. Every effort will be made to coordinate sampling efforts between projects in order to reduce redundancy and maximize cost savings.

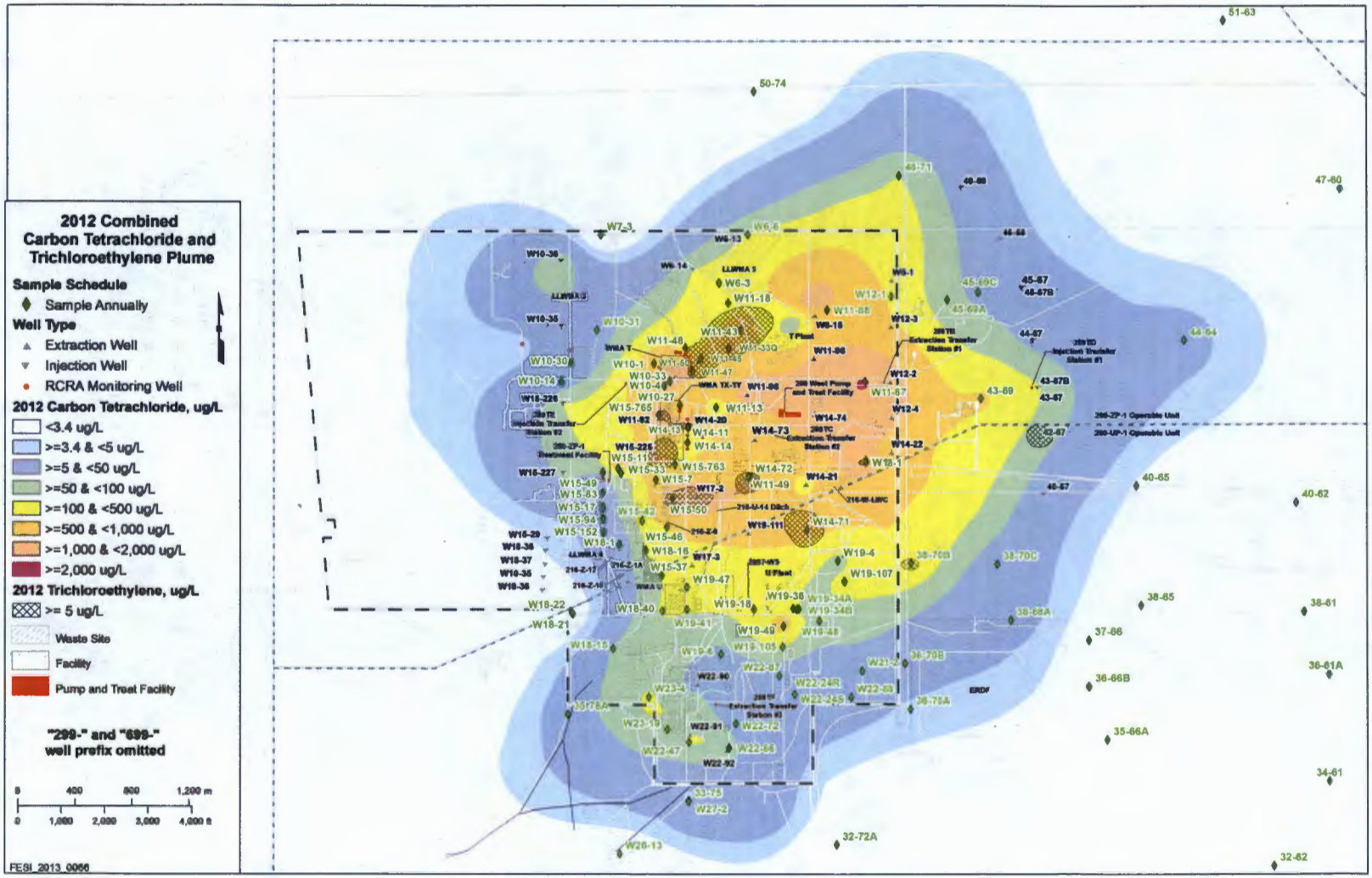


Figure 3-1. Contaminant Monitoring Well Network (VOC)

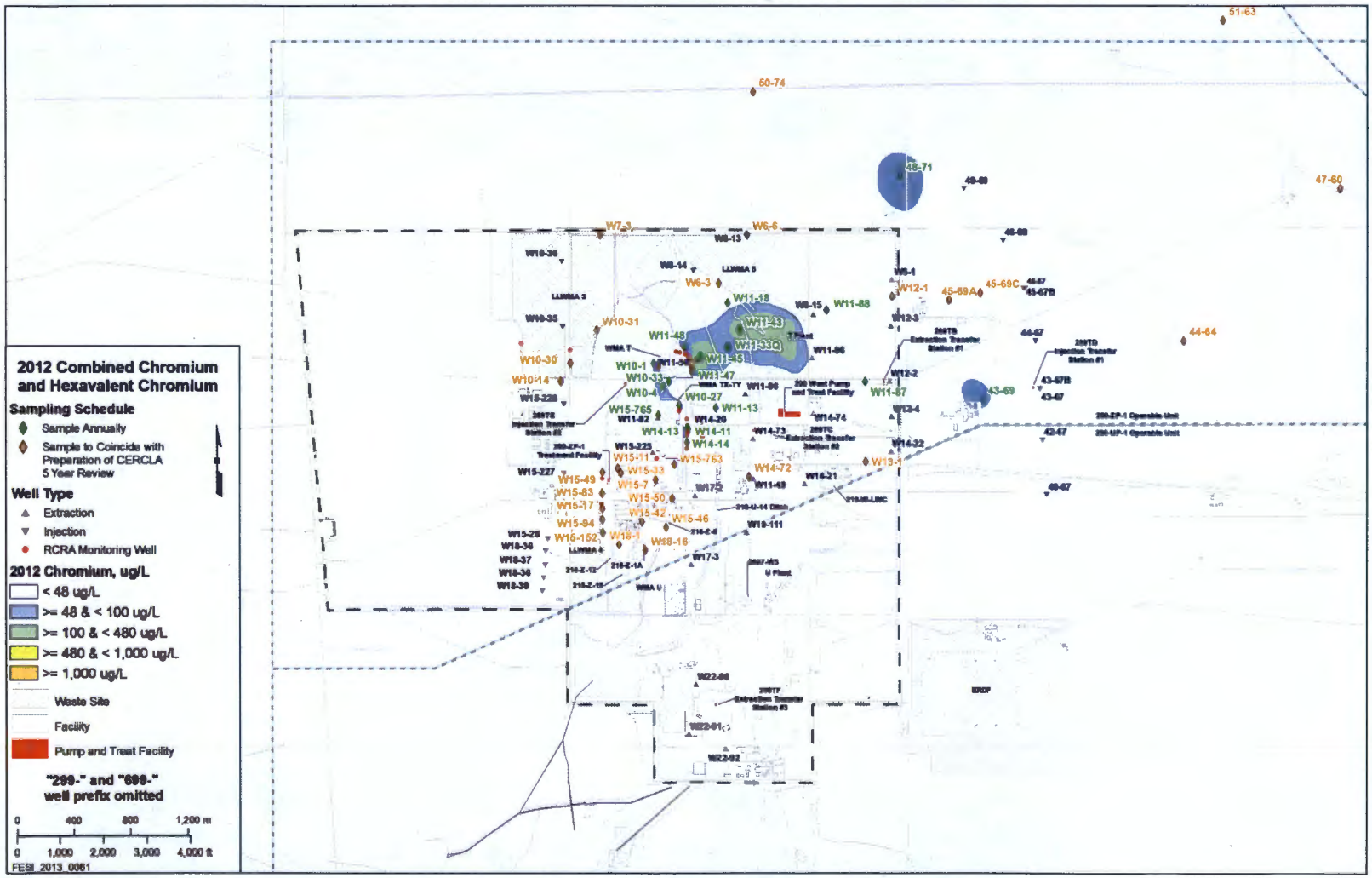


Figure 3-2. Contaminant-Specific Monitoring Well Network (Chromium)

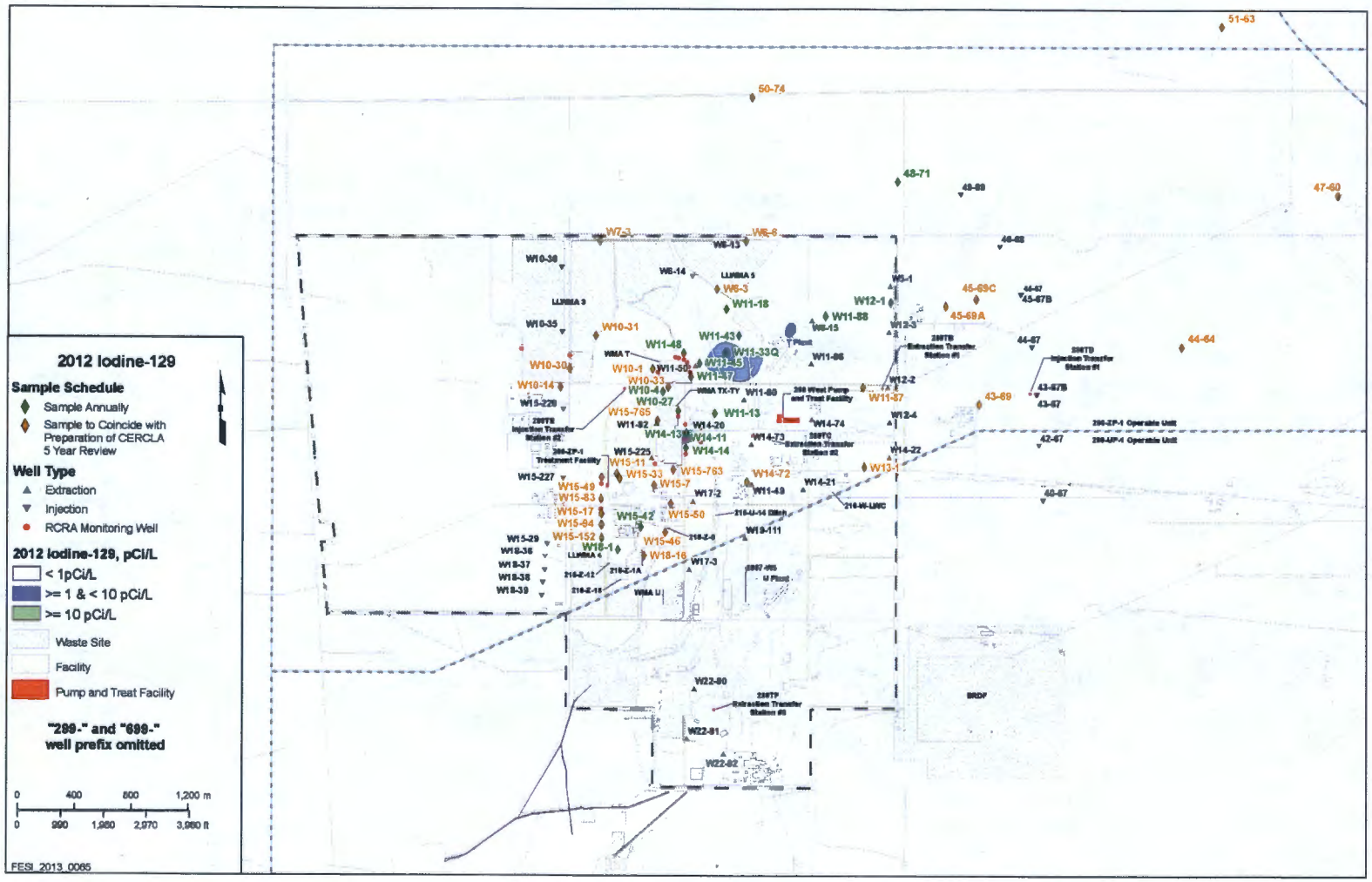


Figure 3-3. Contaminant-Specific Monitoring Well Network (Iodine-129)

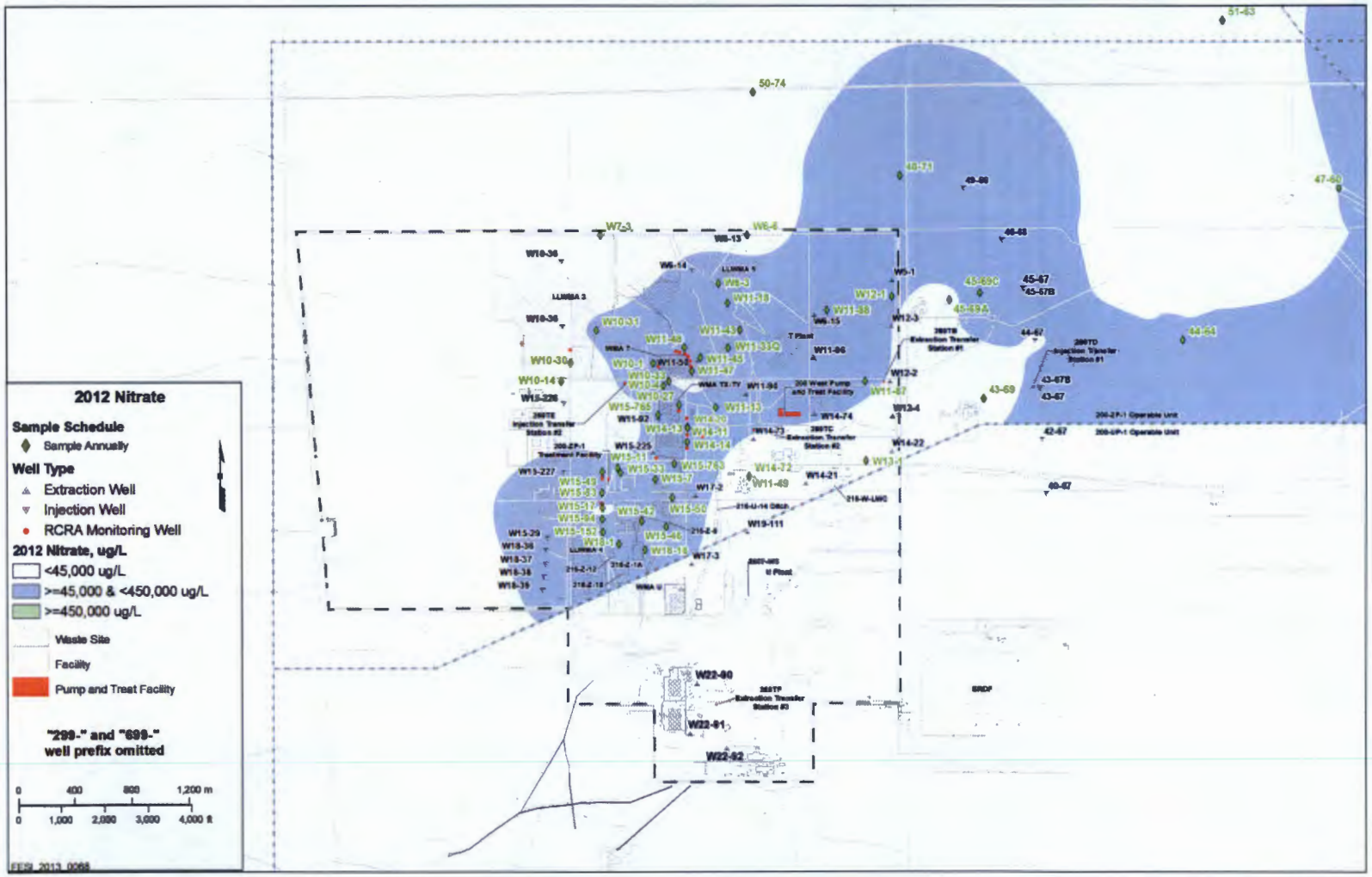


Figure 3-4. Contaminant-Specific Well Monitoring Network (Nitrate)

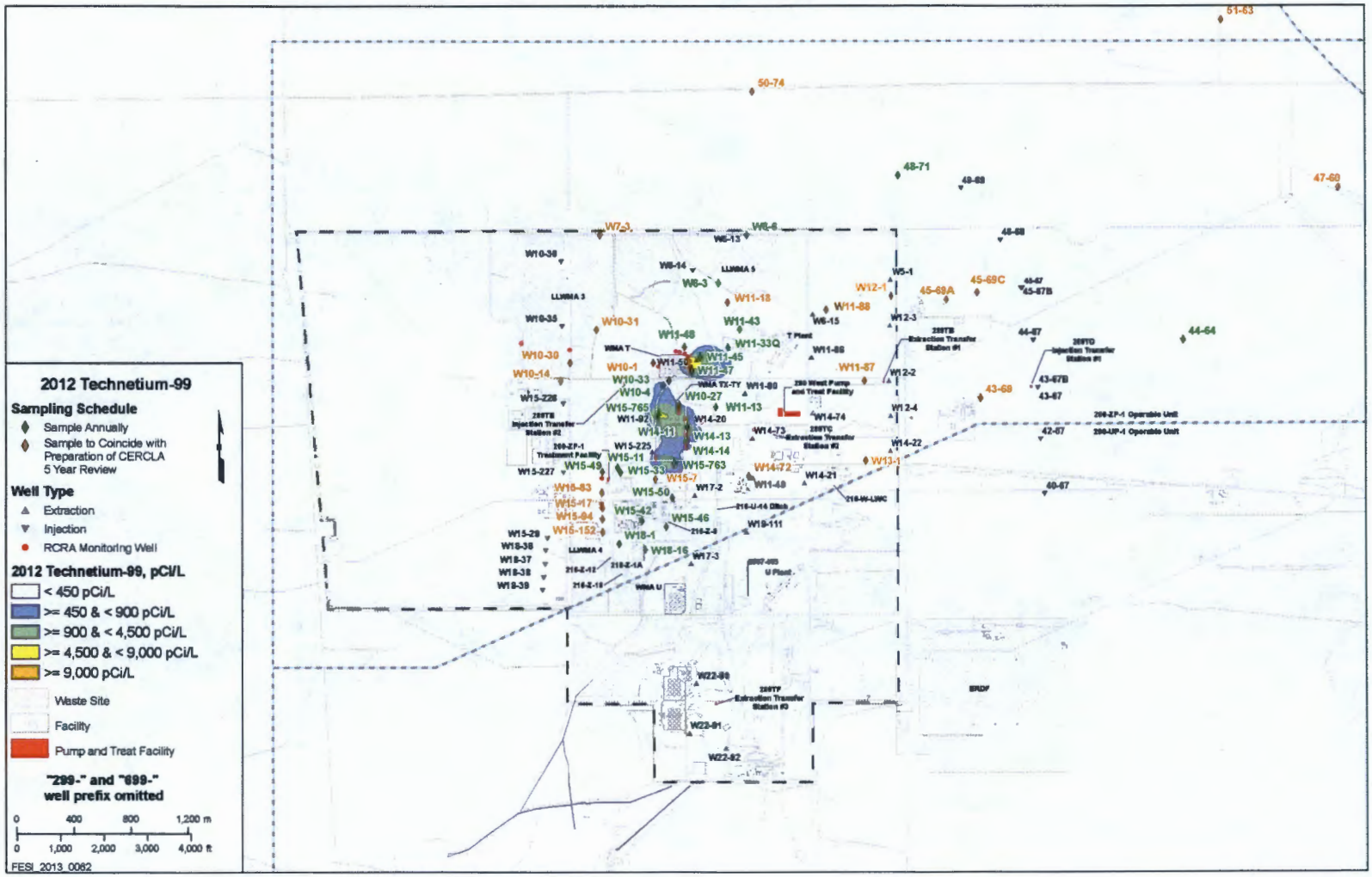


Figure 3-5. Contaminant-Specific Monitoring Well Network (Technetium-99)

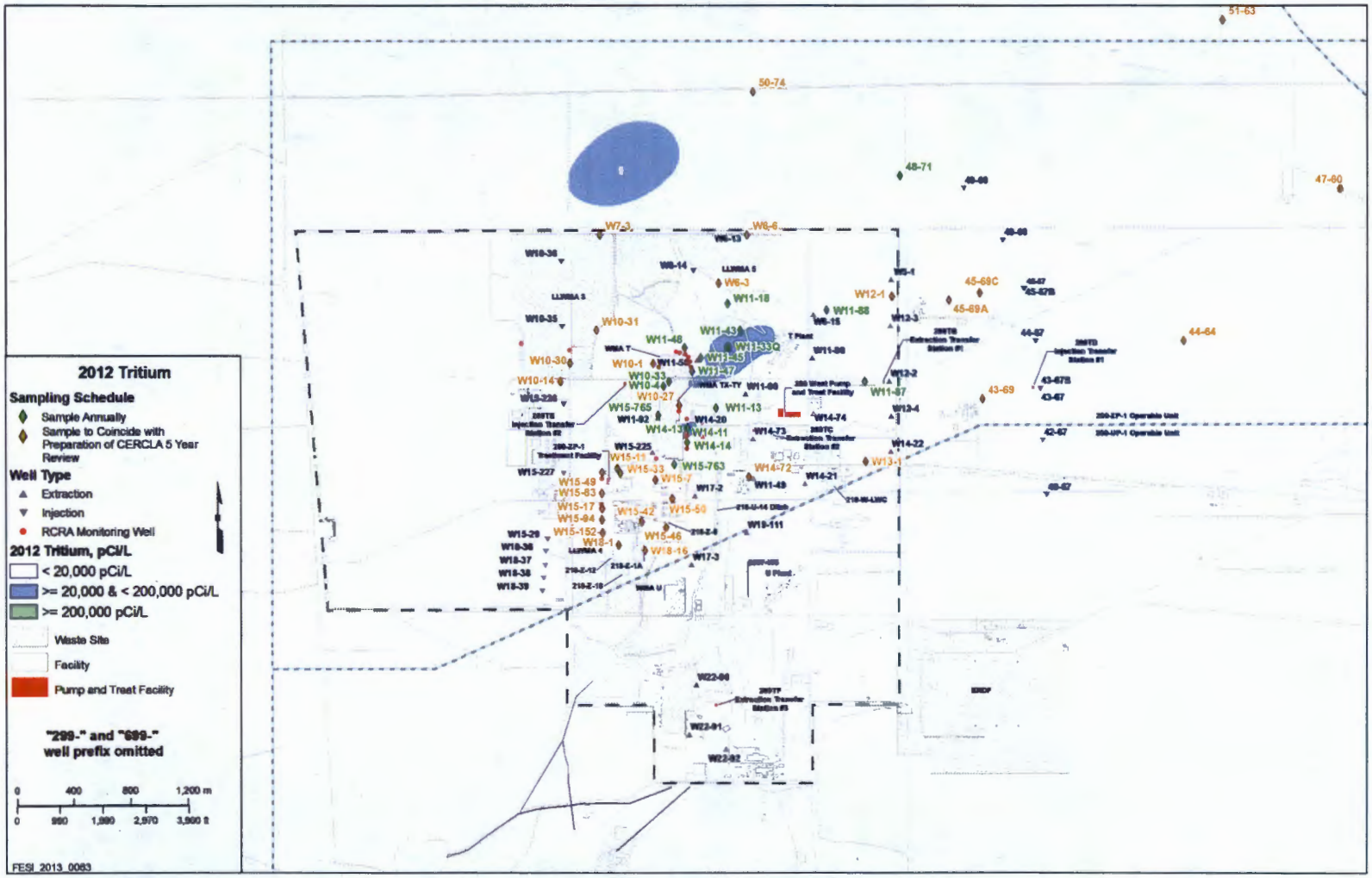


Figure 3-6. Contaminant-Specific Monitoring Well Network (Tritium)

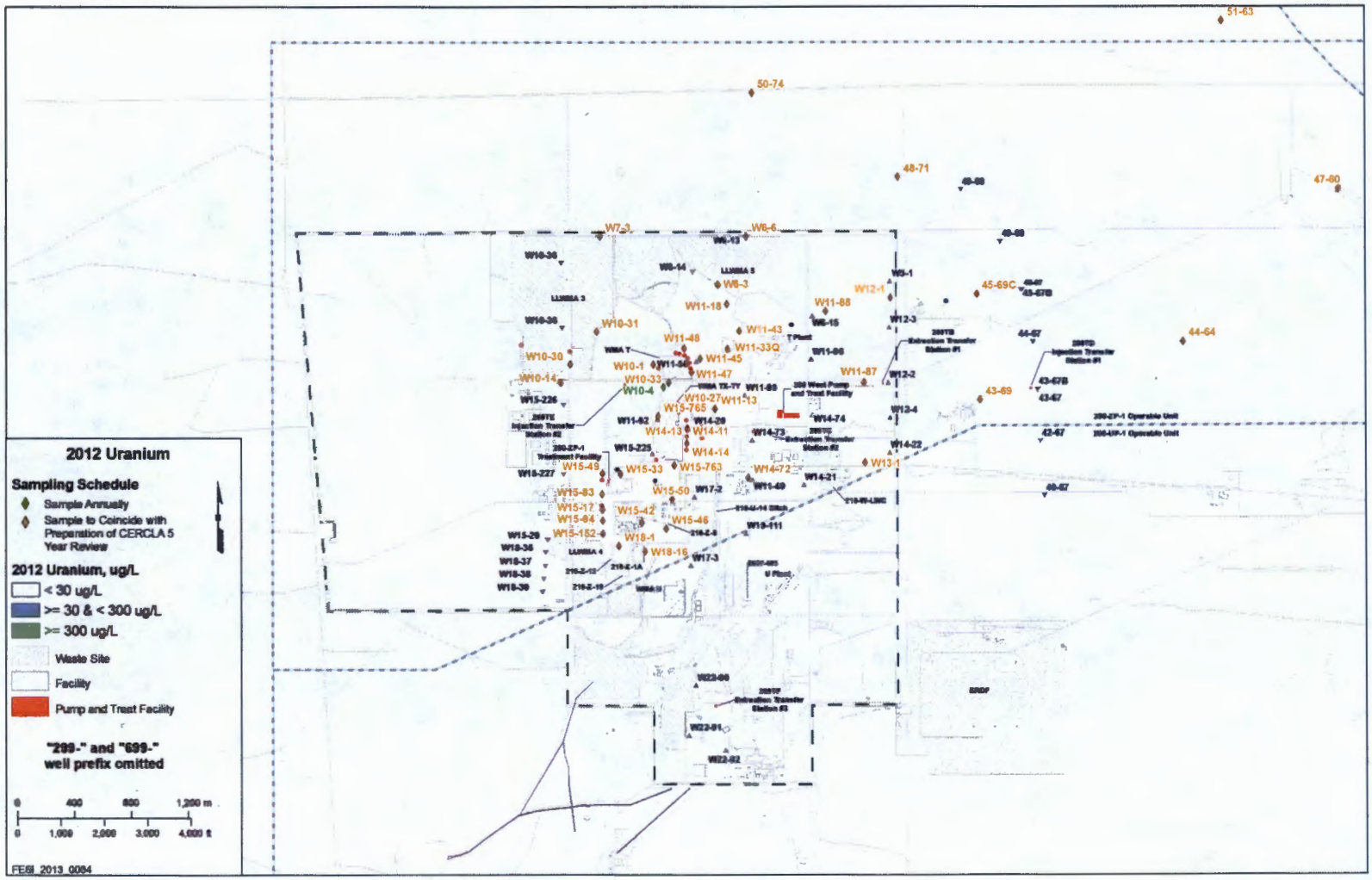


Figure 3-7. Contaminant-Specific Well Monitoring Network (Uranium)

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3.1.2 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 monitoring well coverage. These data gap areas resulted in areas of relatively large uncertainty in the carbon tetrachloride plume shell. In support of the data gap investigation, maps of kriged carbon tetrachloride error variance were also produced for several elevation intervals in the aquifer. These maps, which are presented in Appendix C, reveal the areas in the kriged three-dimensional carbon tetrachloride plume shell with the greatest error variance or relative uncertainty. While these maps provide visual information concerning uncertainty in the distribution of data, the maps are dependent on the kriging parameters used to generate them.

In order to reduce some of the more significant uncertainty in the carbon tetrachloride plume delineation, several new monitoring wells are proposed. Table 3-1 lists the locations and estimated mid-screen elevations of proposed new monitoring wells that, if constructed and routinely sampled, could significantly reduce this uncertainty. Priority ranking (highest priority is ranked as 1, lowest priority is ranked as 8) was also assigned to each well based on the well's potential to reduce the uncertainty in the carbon tetrachloride distribution. While some of these data gaps may be temporarily filled by one-time sampling data collected during drilling of the proposed new extraction wells, the data gaps will remain and add uncertainty to future plume shells and transport simulations. If the new monitoring wells are not installed, these data gaps may ultimately hinder the 200 West P&T system optimization.

Proposed new monitoring wells MW1A, MW1B, and MW2 are intended to help delineate the northern and northeastern boundaries of the carbon tetrachloride plume. Sampling at location 299-W11-88 has carbon tetrachloride concentrations of 1,700 µg/L at 103 m (337.9 ft) above mean sea level (amsl) and 850 µg/L at 94 m (308.4 ft) amsl. Currently, there are no available monitoring wells screened at appropriate elevations to delineate the northern and northeastern extent of these high concentrations. These proposed new monitoring wells are also positioned in locations between the western and eastern injection well fences, within the area of groundwater extraction.

Proposed new monitoring wells MW3A, MW3B, and MW3C are intended to fill in a gap in the monitoring well network between upgradient monitoring wells (e.g., 299-W10-33 and 299-W14-11) and downgradient monitoring wells (e.g., 299-W11-86 and 299-W11-87). This data gap is approximately 1,325 m (4,347.1 ft) in the middle of the new 200 West P&T extraction well field with significant carbon tetrachloride concentrations (greater than 1,000 µg/L), both upgradient and downgradient. Well screen A should be completed below Ringold Unit 8 to help delineate the northern extent of the deep carbon tetrachloride found at well 299-W13-1. Well screens B and C shall be completed above Ringold Unit 8.

Proposed new monitoring wells MW4A and MW4B are intended to provide deep monitoring coverage near the source areas just west of the TX/TY Tank Farms, as this area has little deep monitoring coverage. The proposed new monitoring wells are also intended to provide deep monitoring coverage close to the first new 200 West P&T extraction well installed in 2009. Well screens A and B shall both be completed above Ringold Unit 8.

Proposed new monitoring wells MW5A and MW5B are intended to provide monitoring coverage above and below the existing monitoring well screen at 299-W14-72 (mid-screen elevation of 88 m [288.7 ft] amsl). As with proposed new monitoring wells MW3A, B, and C, these proposed new monitoring wells are located in the middle of the new 200 West P&T extraction well field, upgradient of sampling location 299-W13-1 that monitors carbon tetrachloride concentrations greater than 500 µg/L deep in the aquifer. Screen A is intended to be completed below Ringold Unit 8, and screen B shall be completed above Ringold Unit 8.

Table 3-1. Proposed New Monitoring Wells

Well Priority	Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)
1	MW7B	568900	135945	120
	MW7A	568900	135945	100
2	MW1A	568369	137743	90
	MW1B	568369	137743	110
3	MW3A	567578	136476	73
	MW3B	567578	136476	92
	MW3C	567578	136476	112
4	MW5A	567374	135941	70
	MW5B	567374	135941	110
5	MW2	567591	137577	111
6	MW4A	566638	136251	80
	MW4B	566638	136251	100
7	MW6A	566941	135175	80
	MW6B	566941	135175	106
8	MW8A	568670	136810	98
	MW8B	568670	136810	120

amsl = above mean sea level

Proposed new monitoring wells MW6A and MW6B are intended to provide deep (mid-screen elevations of 80 and 106 m [262.5 and 347.8 ft] amsl) monitoring coverage just northeast of the U Tank Farm in the vicinity of the carbon tetrachloride source areas. These wells shall help delineate the southern boundary of the high-concentration area of the carbon tetrachloride plume under the source areas. Well screen A shall be completed below Ringold Unit 8, and well screen B shall be completed above Ringold Unit 8.

Proposed new monitoring wells MW7A and MW7B shall help delineate the downgradient extent of the contamination found at sampling location 299-W13-1 and to fill in the gap in monitoring coverage between monitoring wells 299-W13-1 and 699-40-65. Proposed new monitoring wells MW8A and MW8B shall help delineate the downgradient extent of the contamination found at sampling location 299-W11-87 and help fill in the gap in monitoring coverage between monitoring wells 299-W11-87 and 699-44-64. This is a gap in coverage of approximately 1,880 m (6,168.0 ft). Well screen B shall be completed above Ringold Unit 8 (if there is sufficient saturated thickness). Well screen A shall be completed below Ringold Unit 8. The proposed new monitoring wells are located upgradient of the new 200 West P&T system's eastern injection well fence and downgradient of the new extraction wells.

3.1.3 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 generating data from the first year of system operation. The data collected from this sampling event, in addition to the data collected from the drilling and sampling of the new extraction and injection wells, were used to construct baseline three-dimensional contaminant plume shells for each COC. The data set is the most comprehensive set of sampling data available and will generate the most accurate starting contaminant masses and plume volumes for each COC (DOE/RL-2013-14). These initial contaminant masses will be used to calculate the mass removal statistics for each COC over the life of the remedial system operation in support of DS #4.

During the early operation of the 200 West P&T, groundwater samples will be collected from the VOC and contaminant-specific monitoring well networks on an annual basis. As stated previously, 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. The upper-bound value of 0.5 m/d (1.64 ft/d) corresponds to a maximum groundwater flow rate of approximately 180 m/yr (590.6 ft/yr). For the relatively closely spaced, shallow monitoring wells in the tank farm areas (with well separation ranging from approximately 40 to 260 m [131.2 to 853.0 ft]), the minimum time for groundwater at one well to reach the next downgradient well could range from 0.2 to 1.4 years. For the more widely spaced monitoring locations (with well separation ranging from approximately 500 to 1,900 m [1,640.4 to 6,233.6 ft]), the minimum time for groundwater at one well to reach the next downgradient well could range from 2.7 to 10.5 years. There is little to no 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 the well spacing of the available monitoring well network.

Sampling of the contaminant monitoring network will coincide with the preparation of the CERCLA 5-year review in order to provide a more comprehensive data set with which 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 later 200 West P&T operations, when contaminant concentrations change less rapidly, the frequency of monitoring well sampling will be evaluated.

After the P&T system is shut down, the frequency of contaminant monitoring will be evaluated based on the observed rate of change of the contaminant plumes. The contaminant monitoring frequency for those monitoring wells near the last extraction wells to be shut down should be adequate to monitor for possible rebound of contaminant concentrations in the early years after the wells are shut down. At a minimum, contaminant monitoring samples will be collected every 5 years in accordance with the CERCLA 5-year review.

Each extraction well is currently sampled on a quarterly basis. The sampling data collected from each extraction well 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 for plume shell calibration purposes, it is generally advisable to monitor extraction well concentrations more frequently. The pumping rates and effective screen intervals of each extraction well may need to be optimized, especially during the first few years of operation, in order to maximize the mass removed per volume of produced groundwater. The sampling data are also needed to help track contaminant mass removal during the remedial action. Some COCs may be detectable above the cleanup levels in samples collected from individual extraction wells but may not be detectable in the combined treatment plant influent samples. Therefore, without the extraction well

sampling results, the mass removal for such COCs could not be tracked by using only the combined treatment plant influent samples.

Once contaminant distributions and system operation have stabilized, the extraction well sampling frequency or list of analytical constituents will be evaluated and may be changed with DOE and EPA concurrence.

Treatment plant influent and effluent sampling is currently performed on a monthly basis. Any reduction in sampling frequency or constituent analysis will be made with DOE and EPA concurrence.

3.1.4 Contaminant Monitoring Analytical Parameters

During the initial baseline sampling, contaminant monitoring samples collected from the monitoring wells were analyzed for the COCs and other potential contaminants listed in Table A-1, as well as the biogeochemical and field screening parameters in Table A-2 (see Appendix A). Subsequently, the constituents monitored at each monitoring well have been reviewed, and a reduced list of constituents has been 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 every 5 years to coincide with preparation of the CERCLA 5-year review. The review assessed the data trends in the Hanford Environmental Information System (HEIS) database from 1990 through 2013 for each well and considered constituents for reduction with respect to the baseline plumes prepared for DOE/RL-2013-14. The review determined that the analytical parameters analyzed for in each monitoring well will be sufficient to delineate each contaminant plume in three-dimensional space, with sub-cleanup 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 uranium[2] in monitoring wells in the 200-ZP-1 OU only. Carbon tetrachloride, trichloroethylene, and nitrate were not considered for any reduction in analyses as they are ubiquitous throughout the 200-ZP-1 OU. Data with specific laboratory and review qualifiers were omitted from the data set, along with in-process data and vertical profile data. Data were also omitted if they were considered inconclusive. Inconclusive data were data points whose minimum detection level or minimum detectable activity was greater than the cleanup levels given in the ROD. Additionally, undetected qualified data for radiological constituents were replaced with one-half of the minimum detectable activity.

The data for each constituent was assembled to show the number of samples collected within the 1990 through 2013 time frame, with sub-data 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 individually evaluated against the appropriate plume map to determine whether or not 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 (therefore warranting further monitoring), 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 majority of wells that were considered for reduction did not have detections above the cleanup level and were stable or downward-trending below the cleanup level.

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

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 (Appendix A).

Beginning in FY14, the biogeochemical parameters tracking natural attenuation processes will be analyzed for every 5 years in conjunction with the CERCLA 5-year review. Two years of sampling including the full suite of parameters listed in Table A-2 (Appendix A) were collected as part of the project baseline sampling. The frequency is being reduced, as the remedy is currently in the midst of active P&T operations. When the 200 West P&T operations cease, the frequency of sampling these parameters will be evaluated.

3.2 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 monitoring well network and measurement frequency are described in the following subsections.

3.2.1 Hydraulic Monitoring Network

The hydraulic monitoring well network is shown in Figure 3-8, and the available well construction details are listed in Appendix D. Hydraulic monitoring will be conducted for the duration of the 200 West P&T operation. The hydraulic monitoring well network was derived using a procedure similar to that used for selecting contaminant monitoring locations. The starting point used the same master list of available monitoring wells previously described for the contaminant monitoring network. The list was then reduced to provide a more consistently spaced network of well screens, covering elevations ranging from the basalt bedrock to the water table interface. Since hydraulic stresses are more homogeneous than contaminant concentrations, this monitoring well network is less dense and more regularly spaced than the contaminant monitoring network. A few monitoring wells located in close proximity to new 200 West P&T extraction wells were then added to the network to provide monitoring points in close proximity to several of the extraction wells. 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 sets.

Many of the hydraulic monitoring wells are instrumented with transducers and data loggers to measure semi-continuous groundwater elevations. These wells are shown on Figure 3-8 and are listed in Appendix D. The hydraulic monitoring wells were chosen for the following reasons:

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

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

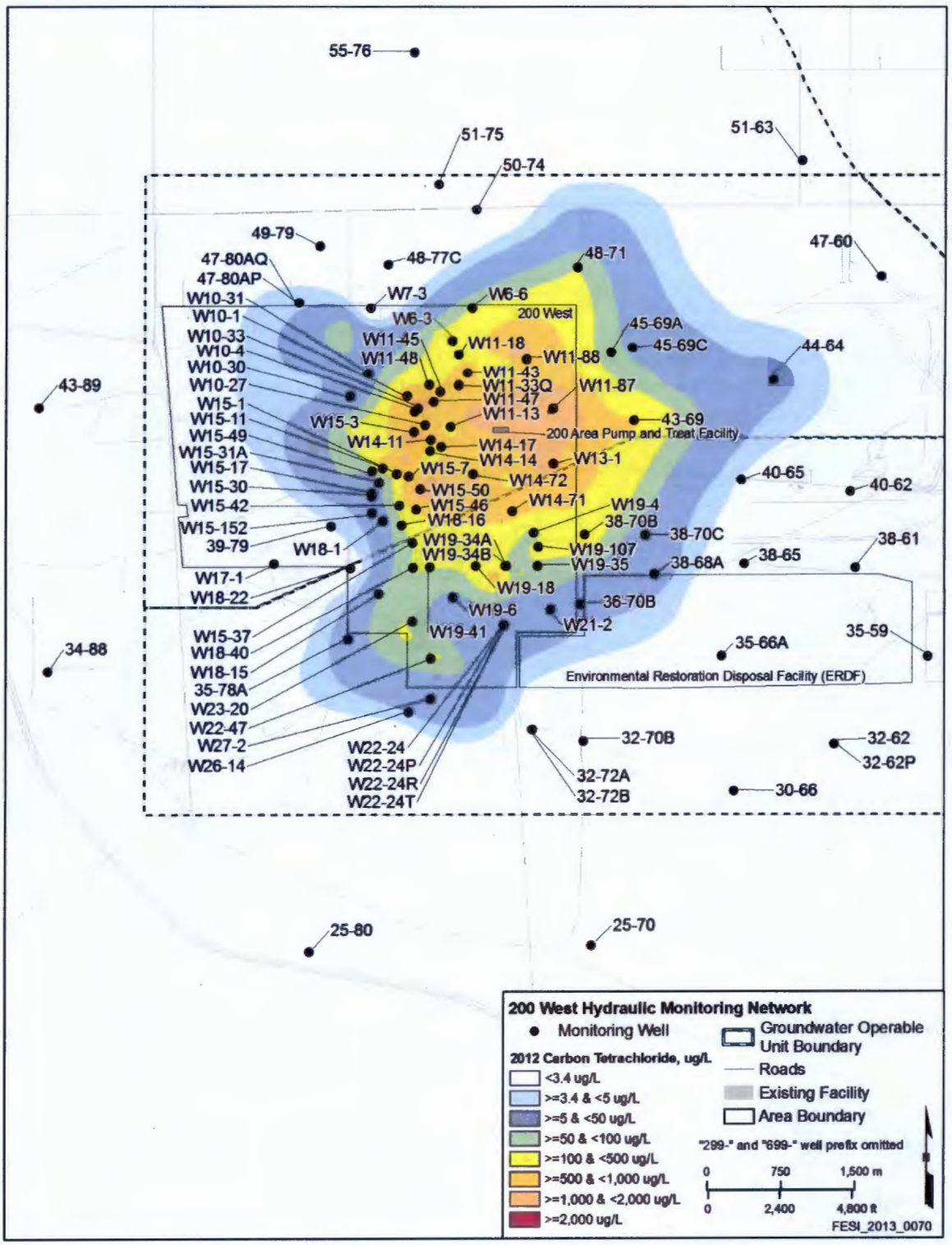

Figure 3-8. Hydraulic Monitoring Well Network

3.2.2 Hydraulic Monitoring Frequency

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

While the 200 West P&T is operating, the need for semi-continuously measured groundwater elevations from transducer-equipped hydraulic monitoring wells will be evaluated and the wells equipped as needed. 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 re-balancing upgradient and downgradient injection to ensure that a sustainable remedy is implemented.

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

After the 200 West P&T has been 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 in accordance with the CERCLA 5-year review.

3.3 Performance Monitoring Analysis and Reporting

Results of performance monitoring will be analyzed and reported annually during the early years of 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

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
- 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

Suggested Performance Monitoring Report Outline (cont'd.)

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 Site Conceptual 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
NTU	nephelometric turbidity unit
OU	operable unit
PMP	performance monitoring plan
RAM	residual analysis method
ROD	Record of Decision
USGS	U.S. Geological Survey
WAC	*Washington Administrative Code*

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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 the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA/240/B-06/001). The DQO process involves a series of logical steps that guide managers or staff to 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. In the case of the 200-ZP-1 OU, sufficient monitoring data must be collected to optimally operate the groundwater pump-and-treat system and to verify that the contaminated groundwater is being remediated to the level specified in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (Ecology et al., 2008).

A3 Identify the Goal(s) of the Study

The second step of the DQO process identifies the key decisions and/or goals that must be addressed to achieve the final solution to the problem. As stated in the Record of Decision (ROD) (Ecology et al., 2008), the selected remedy combines pump-and-treat, monitored natural attenuation, 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 the 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/or PMP; otherwise, continue with the current remedial action and PMP.

- **DS #2:** Determine if potentially toxic and/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 pump-and-treat system, natural attenuation processes, and the flow-path control actions, thereby necessitating changes to the remedial action and/or PMP; otherwise, continue with the current remedial action and PMP.
- **DS #4:** Determine if the pump-and-treat system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the pump-and-treat phase of the remedy; otherwise, evaluate modifications to the pump-and-treat system that could achieve the stated goal for the pump-and-treat phase of the remedy.
- **DS #5:** Determine if contamination is expanding downgradient, laterally or vertically after the pump-and-treat 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 impractability waiver should be invoked.
- **DS #8:** Determine if certain areas of the contaminant plumes are not responding to pump-and-treat 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 have been removed, determine if there is rebound in COC concentrations, which would require the pump-and-treat system to be turned back on; otherwise, leave the pump-and-treat system off and continue with monitor natural attenuation.

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 summarized 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 in its coverage, as well as to 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 are equal to or less than the cleanup levels listed in Table 1-1 in the main text. 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	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
Trichloroethylene	1[a]	µg/L	Delineate trichloroethylene 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 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	NA[c]	NA	Evaluate carbon tetrachloride natural attenuation
cis-1,2-Dichloroethene	70[b]	µg/L	Evaluate TCE natural attenuation
Vinyl chloride	2[b]	µg/L	Evaluate TCE 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 trichloroethylene) 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.

NA = not available

TCE = trichloroethylene

WAC = *Washington Administrative Code*

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 "National Field Manual for the Collection of Water-Quality Data"	mV	Evaluate natural attenuation

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

"National Field Manual for the Collection of Water-Quality Data," U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapters A1 through A9.

EPA = U.S. Environmental Protection Agency

NTU = nephelometric turbidity unit

USGS = U.S. Geological Survey

- **Hydraulic monitoring network data:** The hydraulic monitoring well network spatially covers an area larger than the area covered by the pump-and-treat 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 1-2 [see main text]). 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/or transducer-measured groundwater elevations collected semi-continuously. 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 semi-continuous 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 1-1 (see main text), and the analytical method detection limits are equal to or less than the cleanup levels listed in Table 1-1 (main text). 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 1-1, and the analytical method detection limits are equal to or less than the cleanup levels listed in Table 1-1.

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 releases of COCs occur. The sampling data are used to establish concentration trends in monitor 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 releases of COCs could impact the effectiveness of the remedy. 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 pump-and-treat system. Extraction and injection well flow rates are needed for model input. The contaminant transport model is used to predict if any new releases of COCs will impact either the goal of 95 percent mass removal within 25 years and/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 releases of COCs 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/or 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 method detection limits 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/or 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 pump-and treat 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 pump-and-treat 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 pump-and-treat system. Monitoring of the 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/or predict if the pump-and-treat 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 used to predict if the pump-and-treat 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 *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38), 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 pump-and-treat 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 pump-and-treat system has been shut down. Plots of measured contaminant concentration trends in downgradient monitoring wells may be needed to evaluate the expansion and/or 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 used to predict if the pump-and-treat 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 pump-and-treat 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 pump-and-treat 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 contaminant plumes after 95 percent of the mass of COCs have been removed and the pump-and-treat 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 interface. The current 200-ZP-1 site conceptual model does not include any COC concentrations greater than cleanup levels in the basalt bedrock. Performance monitoring is expected to continue temporally 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 analytic 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 are and will be evaluated to determine if any new releases of COCs have occurred. Monitoring well concentration trends are and will be evaluated, and the sampling data are and will be used to update the three-dimensional plume shell for each contaminant. If contaminant concentrations in a monitoring well are stable and/or increasing, and there is no known upgradient dissolved-phase contaminant mass to support these stable and/or increasing concentrations, then there may be a new release. Dissolved-phase contaminant mass may also be present in a low-conductivity zone and/or contaminant mass 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 pump-and-treat system, then that area should be evaluated as a possible new release of COCs. Understanding the three-dimensional distribution of the contaminant concentrations as the contaminant plumes evolve is essential to 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 (*An Introduction to Applied Geostatistics* [Isaaks and Srivastava, 1989]). 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 extrapolation 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 the cleanup level. Outside the plan view mask boundary, interpolated contaminant concentrations are set to 0 µg/L. The use of 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/or 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 can be large enough to 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. These 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 pump-and-treat 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. Superpositioning the three-dimensional capture zones over the three-dimensional plume shells reveals whether each COC is being captured by the pump-and-treat 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 bifurcate 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/or the PMP.

Several potential changes can be made to the remedial action to accommodate any new releases. Individual extraction well pumping rates and/or production intervals can be adjusted so the combined treatment plant influent concentrations remain within design limits. Individual extraction well pumping rates and/or 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 and/or conversion of existing monitoring wells to extraction wells. Additional treatment capacity can be added to the treatment plant to handle the higher contaminant concentrations caused by the new release.

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

A6.2 Approach to Resolve Decision Statement #2

Groundwater sampling data are evaluated to determine if potentially toxic and/or 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, in the case of the 200-ZP-1 OU, includes carbon tetrachloride, trichloroethylene, and nitrate. The rates of decline in the parent compound and the formation of the degradation product 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 the ROD.

If potentially toxic and/or mobile transformation products are generated at large enough concentrations, it is possible that these products 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 any toxic and/or 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. The *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24) and the *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28) can be reviewed to determine if the potential risks posed by the 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/or mobile transformation products should be included in the list of COCs, then the PMP should be modified to include the applicable transformation products as COCs.

A6.3 Approach to Resolve Decision Statement #3

Groundwater elevation data is necessary to determine if changes are occurring in environmental conditions that may reduce the efficacy of the pump-and treat system and the flow-path control actions. The data includes 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 pump-and-treat system extraction well field. The decreases in groundwater elevation may cause monitoring wells to go dry, resulting in removal of the wells from the monitoring well 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 ("Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift" [Tonkin and Larson, 2002]). 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.

In order to evaluate remediation by natural attenuation, it needs to 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 concentrations can be directly correlated to increases in daughter compounds. The simplest way to accomplish this is by mapping of 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 these 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.

A6.4 Approach to Resolve Decision Statement #4

The groundwater contaminant transport model is used to predict if the pump-and-treat 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 in the model and transporting 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, then modifications to the pump-and-treat system should be evaluated. Improvements in mass removal may be achieved through pump-and-treat system optimization. This usually involves using the model to evaluate changes to extraction and injection well flow rates and production intervals (by packering 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 operating more extraction wells, increasing the capacity of the treatment plant and pumping the existing extraction well harder, and/or evaluating other technologies for a more focused or "hot spot" 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 pump-and-treat 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.

While the ROD 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 approximately 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 of the extraction wells, 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. Most likely, the pump-and-treat system shutdown will 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 pump-and-treat system has been shut down. The pump-and-treat system is designed to capture carbon tetrachloride concentrations above 100 µg/L, and some carbon tetrachloride contamination may likely be present downgradient of the pump-and-treat 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/or 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 and the remedial system is still operating, several courses of action may be taken. Extraction and injection well flow rates and/or 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 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 migrates over time. If the simulated contaminant concentrations remain significantly above the cleanup level during the 125-year period, the remedy goal may not be achieved within the desired remedial timeframe.

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 pump-and-treat 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 pump-and-treat 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 on an annual basis to determine if any areas of the contaminant plumes are not responding to pump-and-treat 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 specified to the nearest 0.3 cm (0.01 ft), and depth-to-water measurements are typically specified 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. Also, a groundwater elevation data set can 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 conservatively 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 have the potential for significant uncertainty. However, well screen elevation errors are likely not a significant 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 significant 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 semi-continuous 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 an approximately 2 kg/year error in calculated contaminant mass extracted. If the carbon tetrachloride plume is assumed to have a dissolved-phase mass above the cleanup level of approximately 1,221 kg, then this error is approximately 0.2 percent of the plume mass. To put this in perspective, under current Hanford Site laboratory contracts using *Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods* (SW-846) 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 approximately 40 kg/year. 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 significant 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 a successful cleanup. 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 and/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 site conceptual 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 on an annual basis, 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 significant decisions. Surveyed northing and easting coordinates typically are provided to the nearest 0.03 m (0.10 ft). Errors of 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 likely 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 site conceptual 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/or reaction pathways within the reactive zones of the plumes. Errors in the measurement of these parameters would usually have little impact on any significant decisions regarding natural attenuation processes.

Key groundwater parameters typically 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 purgewater has been withdrawn from a well and that a representative sample of the groundwater can be collected. These parameters are also important for monitoring natural attenuation processes. Errors in the field measurement of these parameters would usually have little impact on any significant 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; however, increasing the number of monitoring wells is expensive. 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. Also, the outer plume boundaries (both horizontal and vertical) can be controlled during kriging by using control points and masking to ensure that the plume boundaries do not extend above the water table (into bedrock) and, in general, agree with the site conceptual model and professional judgment. Use of these methods ensures that all available lines of evidence are being used to construct the 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 selected 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 all available lines of evidence are 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 generate 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 3 in the main text of this PMP and in Appendix E of the *200 West Pump and Treat Operations and Maintenance Plan* (DOE/RL-2009-124).

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Appendix B

200-ZP-1 Operable Unit Contaminant Monitoring Well Network

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B1 200-ZP-1 Operable Unit Contaminant Monitoring Well Network

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

Table B-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[a] (m)
299-W10-1	566663	136735	207.5	149.5	125.2	8/7/47	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/87	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/01	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/06	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/06	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/07	84.1
299-W10-4	566735	136578	205.5	147.6	130.8	11/10/52	139.0
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/61	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/67	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/94	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/05	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/05	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/06	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/07	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/07	80.1
299-W12-1	568331	137206	222.4	138.9	128.3	5/9/56	133.6
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/04	99.1
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/05	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/98	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/98	134.0
299-W14-71	567733	135568	219.4	94.2	89.7	7/27/06	92.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/06	87.9
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/68	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/05	132.6

Table B-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[a] (m)
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/87	79.5
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/95	135.2
299-W15-37	566716	135248	203.0	140.3	125.1	5/16/96	132.7
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/02	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/03	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/04	131.9
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/05	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/66	123.2
299-W15-763	566809	136029	202.9	138.4	127.7	1/17/01	133.1
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/01	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/05	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/05	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/59	113.8
299-W18-15	566380	134733	202.2	142.8	118.7	4/25/80	130.7
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
299-W18-21	566098	134979	204.9	145.3	136.2	7/29/87	140.7
299-W18-22	566089	134990	204.9	77.9	68.5	9/25/87	73.2
299-W18-40	566723	134996	203.4	136.9	126.2	9/28/01	131.6
299-W19-105	567565	134745	213.0	135.2	124.5	12/13/05	129.8
299-W19-107	567998	135206	217.4	122.8	118.2	3/31/06	120.5
299-W19-18	567361	135012	214.0	146.9	104.9	12/12/85	125.9
299-W19-34A	567674	135012	215.3	116.5	111.8	5/18/94	113.3
299-W19-34B	567663	135011	215.5	90.0	87.1	11/9/94	87.6
299-W19-36	567635	135017	215.4	140.8	127.1	9/1/95	133.9
299-W19-4	567950	135351	219.0	141.3	56.0	2/15/60	98.3
299-W19-41	566897	135005	206.5	139.5	128.8	9/23/98	134.1
299-W19-47	566895	135162	206.3	137.1	126.4	6/1/04	131.7
299-W19-48	567823	134926	212.9	133.0	122.3	10/5/04	127.6
299-W19-49	567568	134894	214.2	135.1	124.5	8/30/05	129.8
299-W19-6	567133	134694	210.3	94.5	85.1	12/13/68	89.8
299-W21-2	568124	134574	214.9	135.6	124.9	11/22/04	130.2

Table B-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[a] (m)
299-W22-24S[b]	567648	134411	212.2	104.9	97.3	9/8/60	101.1
299-W22-47	566909	134076	206.3	136.6	125.9	1/19/05	131.2
299-W22-72	567237	134207	208.0	135.8	125.1	2/22/06	130.5
299-W22-86	567187	134041	206.4	135.9	125.2	3/10/06	130.5
299-W22-87	567542	134540	212.0	135.7	125.1	12/14/05	130.4
299-W22-88	568046	134391	213.9	134.3	123.7	2/6/08	129.0
299-W23-19	566759	134167	202.5	139.5	136.4	11/17/99	137.9
299-W23-4	566628	134392	203.0	148.1	111.6	6/18/57	129.9
299-W26-13	566424	133294	199.8	138.2	127.5	12/28/99	132.8
299-W27-2	566908	133670	207.4	83.6	80.5	12/18/92	82.1
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/91	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/91	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/87	66.1
699-30-66	569991	132739	210.5	93.1	90.1	10/13/04	91.6
699-32-62	571010	133216	216.6	132.7	64.2	4/6/60	98.5
699-32-72A	567943	133363	204.7	76.7	56.8	7/31/57	66.7
699-33-75	566908	133662	207.4	135.7	125.1	1/8/08	130.4
699-34-61	571396	133810	221.8	129.4	123.3	11/29/93	126.3
699-35-66A	569858	134099	222.5	143.2	124.3	6/13/57	133.8
699-35-78A	566064	134271	202.4	147.5	117.3	8/17/50	132.0
699-36-61A	571395	134557	229.0	128.4	110.5	8/12/48	119.5
699-36-66B	569731	134469	221.3	131.7	121.0	12/20/07	126.4
699-36-70A	568467	134309	216.0	137.6	128.4	12/10/94	132.2
699-36-70B	568428	134626	215.2	134.7	124.1	6/9/04	129.4
699-37-66	569730	134797	222.0	131.3	120.6	11/28/07	126.0
699-38-61	571219	134997	228.2	126.3	120.2	11/16/93	123.3
699-38-65	570090	135040	230.7	163.7	72.2	12/31/59	117.9
699-38-68A	569180	134932	218.9	137.3	128.2	6/21/94	132.0
699-38-70B	568469	135331	222.6	98.6	94.0	2/3/04	96.3
699-38-70C	569084	135326	226.7	106.1	101.5	2/17/04	103.8
699-40-62	571164	135764	228.9	126.8	115.0	1/17/49	120.9

Table B-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[a] (m)
699-40-65	570057	135881	231.0	130.2	119.5	2/3/04	124.1
699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/60	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/48	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/07	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/48	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/56	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/05	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/56	123.5

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

b. Require maintenance prior to sampling.

Table B-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	8/7/47	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/87	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/01	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/06	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/06	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/07	84.1
299-W10-4	566735	136578	205.5	147.6	130.8	11/10/52	139.0
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/61	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/67	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/94	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/05	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/05	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/06	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/07	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/07	80.1
299-W12-1	568331	137206	222.4	138.9	128.3	5/9/56	133.6
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/04	99.1
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/05	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/98	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/98	134.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/06	87.9
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/68	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/05	132.6
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/87	79.5
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/95	135.2
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/02	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/03	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/04	131.9
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/05	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/66	123.2

Table B-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-W15-763	566809	136029	202.9	138.4	127.7	1/17/01	133.1
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/01	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/05	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/05	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/59	113.8
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/91	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/91	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/87	66.1
699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/60	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/48	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/07	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/48	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/56	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/05	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/56	123.5

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

Table B-3. 200-ZP-1 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-W10-4	A	A	A	A	A	A	A	A	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-W12-1	A	5	A	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-W13-1	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-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
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

Table B-3. 200-ZP-1 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-W15-765	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-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																													
299-W14-71	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W15-37	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W18-15	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W18-21	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W18-22	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W18-40	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-105	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-107	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-18	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-34A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-34B	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-36	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-4	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-41	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-47	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B-3. 200-ZP-1 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-W19-48	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-49	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W19-6	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W21-2	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-24S	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-47	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-72	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-86	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-87	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W22-88	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W23-19	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W23-4	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W26-13	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
299-W27-2	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-30-66	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-32-62	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-32-72A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-33-75	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-34-61	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-35-66A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-35-78A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-36-61A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-36-66B	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-36-70A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-36-70B	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-37-66	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-38-61	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-38-65	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-38-68A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-38-70B	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B-3. 200-ZP-1 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
699-38-70C	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-40-62	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
699-40-65	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* (CERCLA) 5-year review

- = not sampled

Appendix C

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

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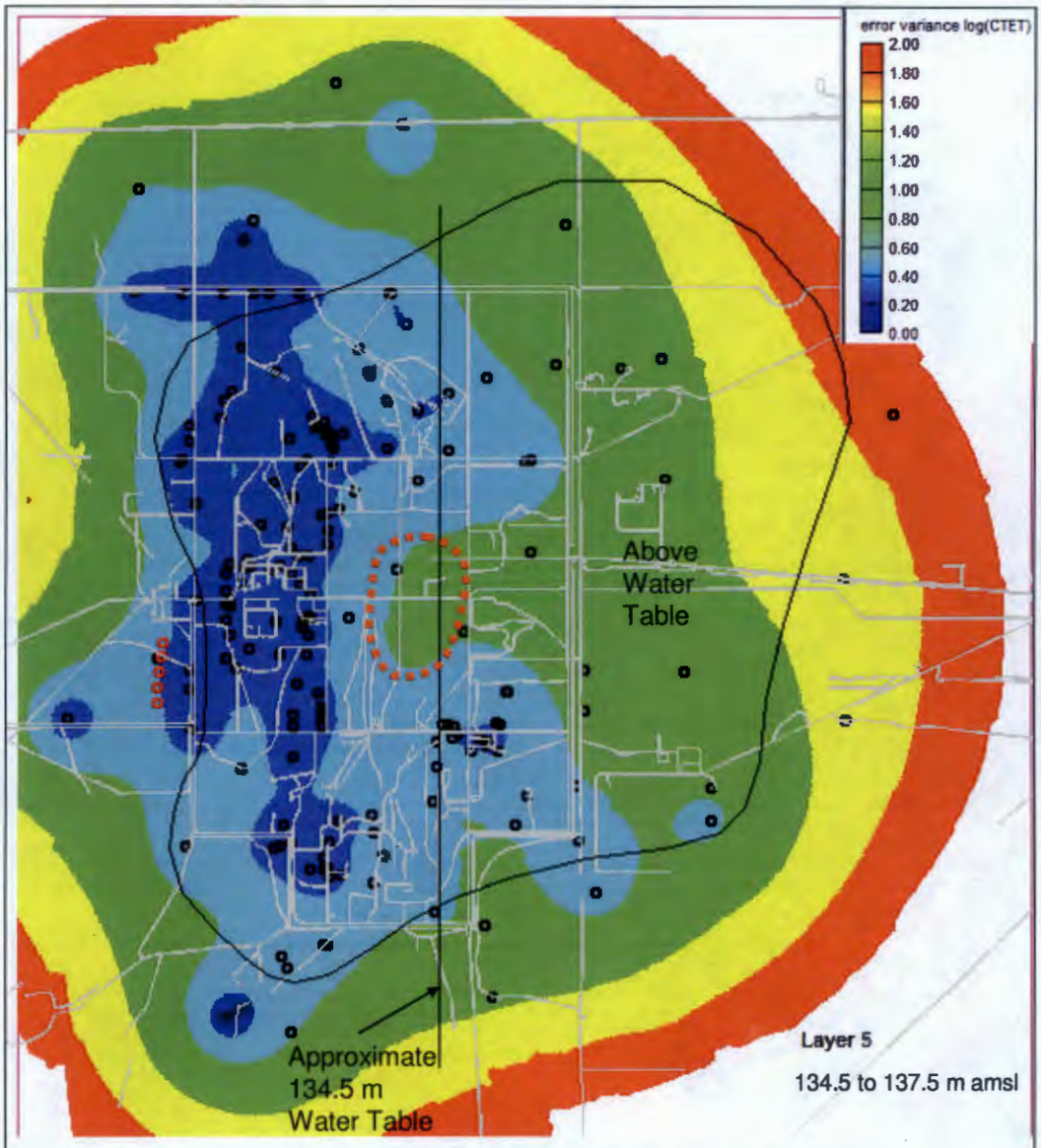
C1 200-ZP-1 Operable Unit Kriged Carbon Tetrachloride Error Variance Maps

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, they are dependent on the kriging parameters used to generate them.



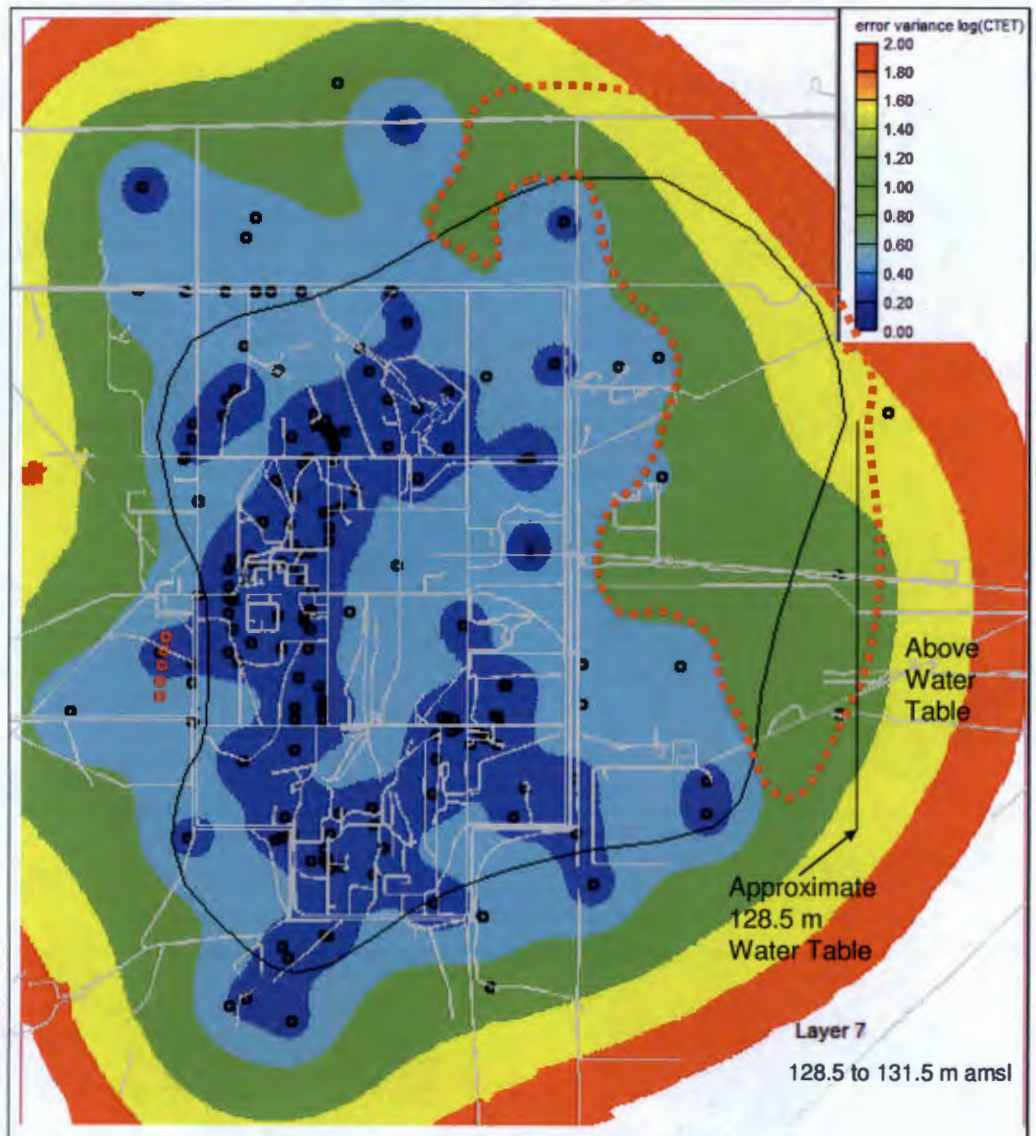
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-1. Kriged Carbon Tetrachloride Error Variance from 134.5 to 137.5 m Above Mean Sea Level



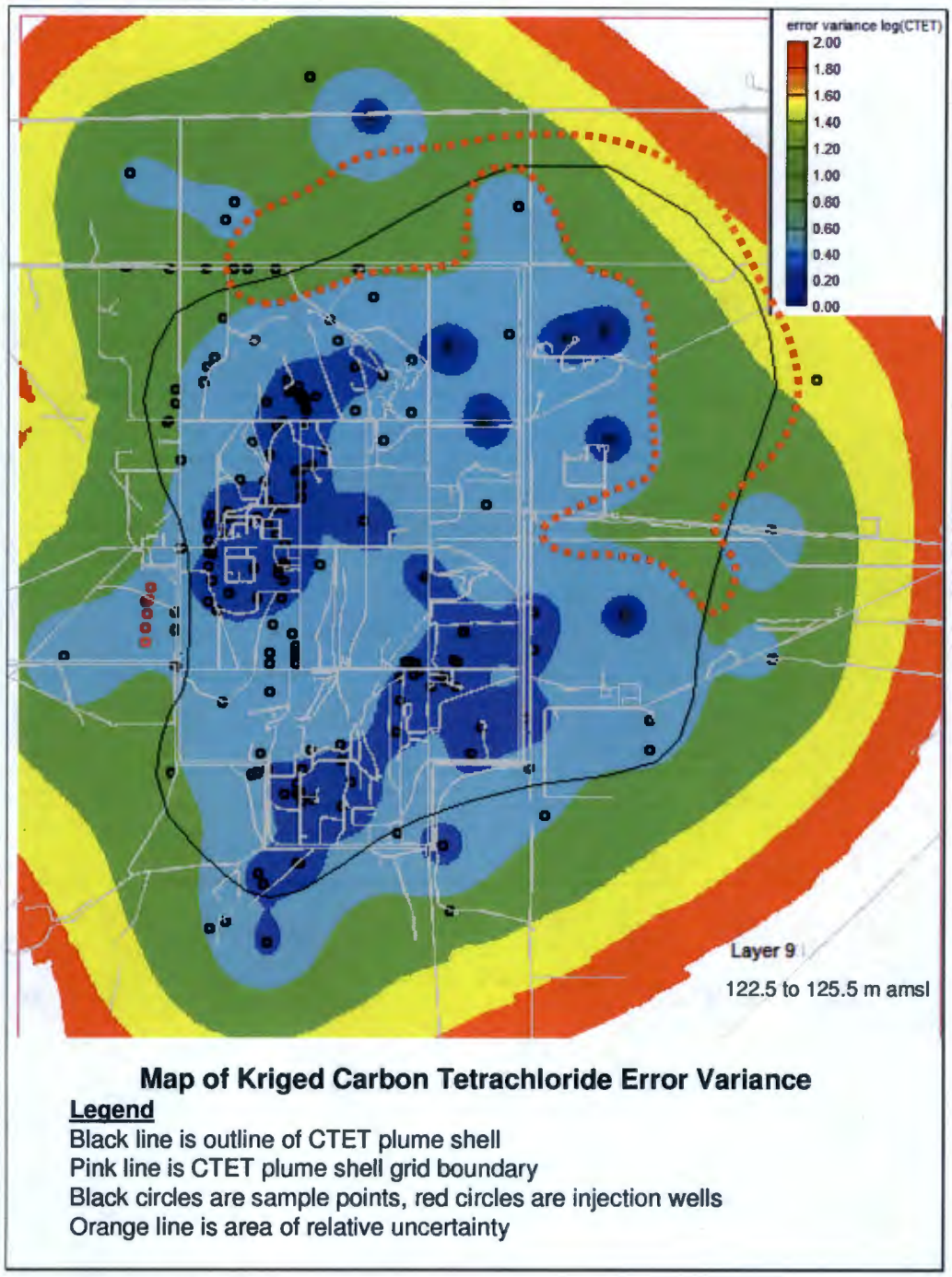
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

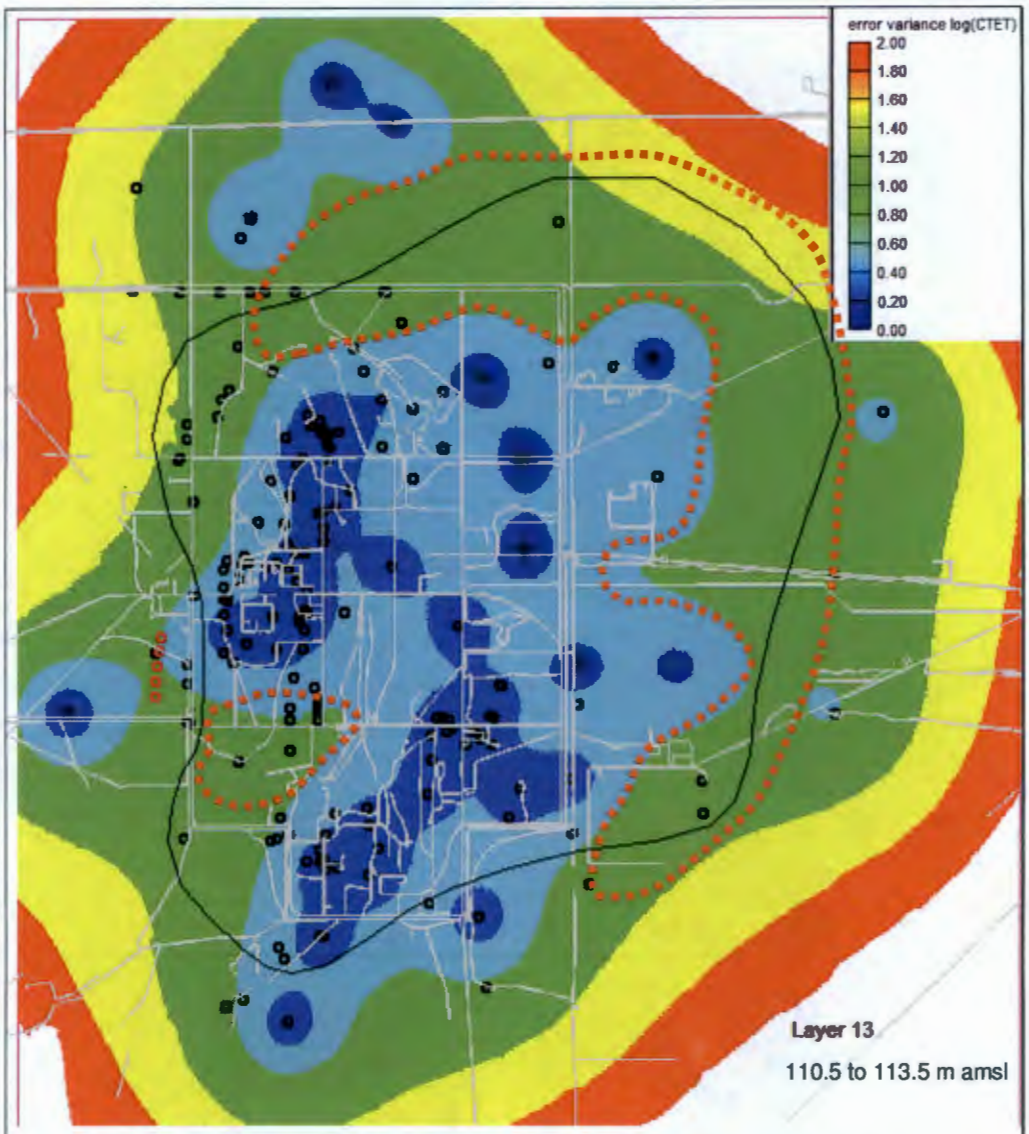
amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-2. Kriged Carbon Tetrachloride Error Variance from 128.5 to 131.5 m Above Mean Sea Level



amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-3. Kriged Carbon Tetrachloride Error Variance from 122.5 to 125.5 m Above Mean Sea Level



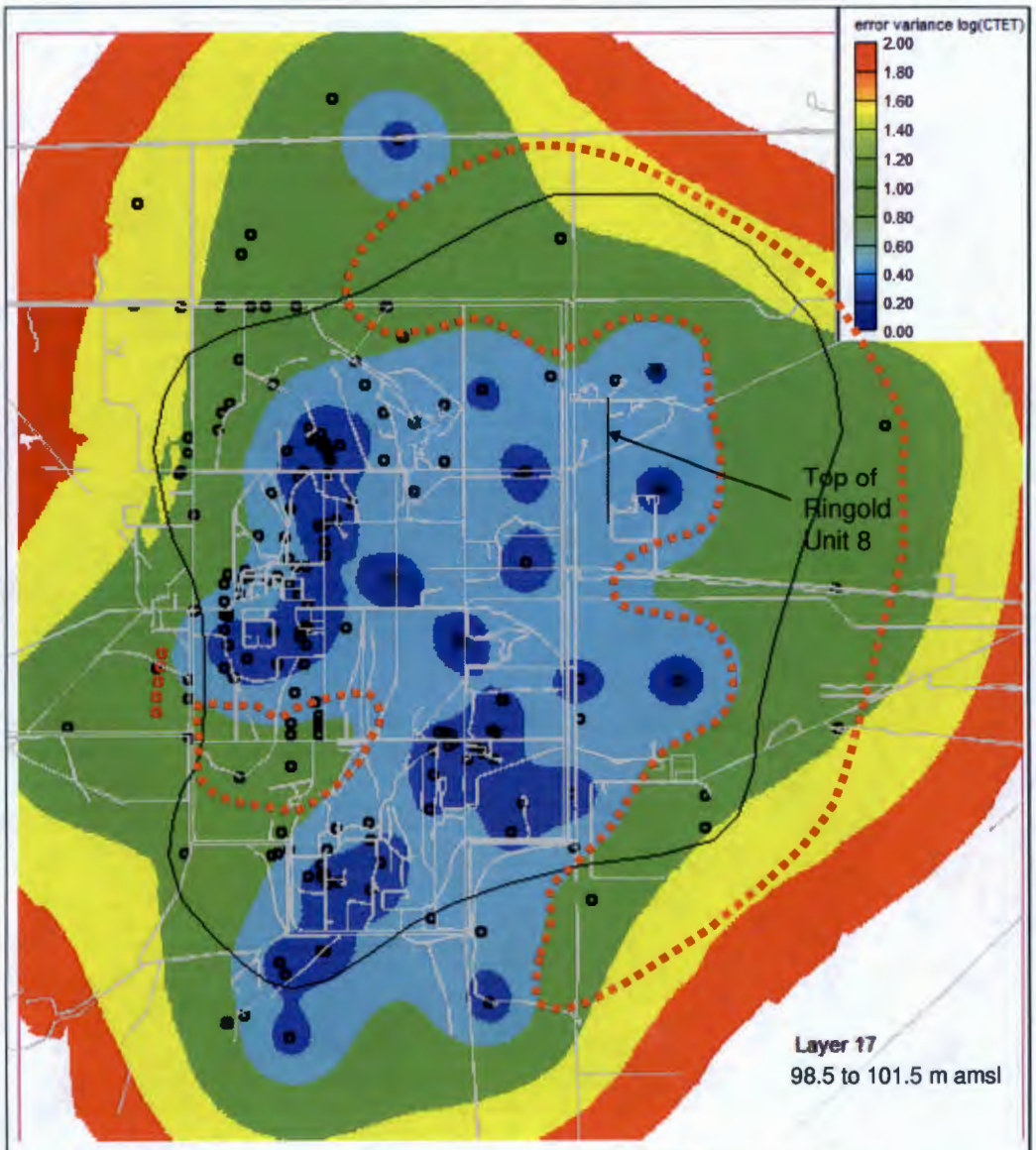
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-4. Kriged Carbon Tetrachloride Error Variance from 110.5 to 113.5 m Above Mean Sea Level



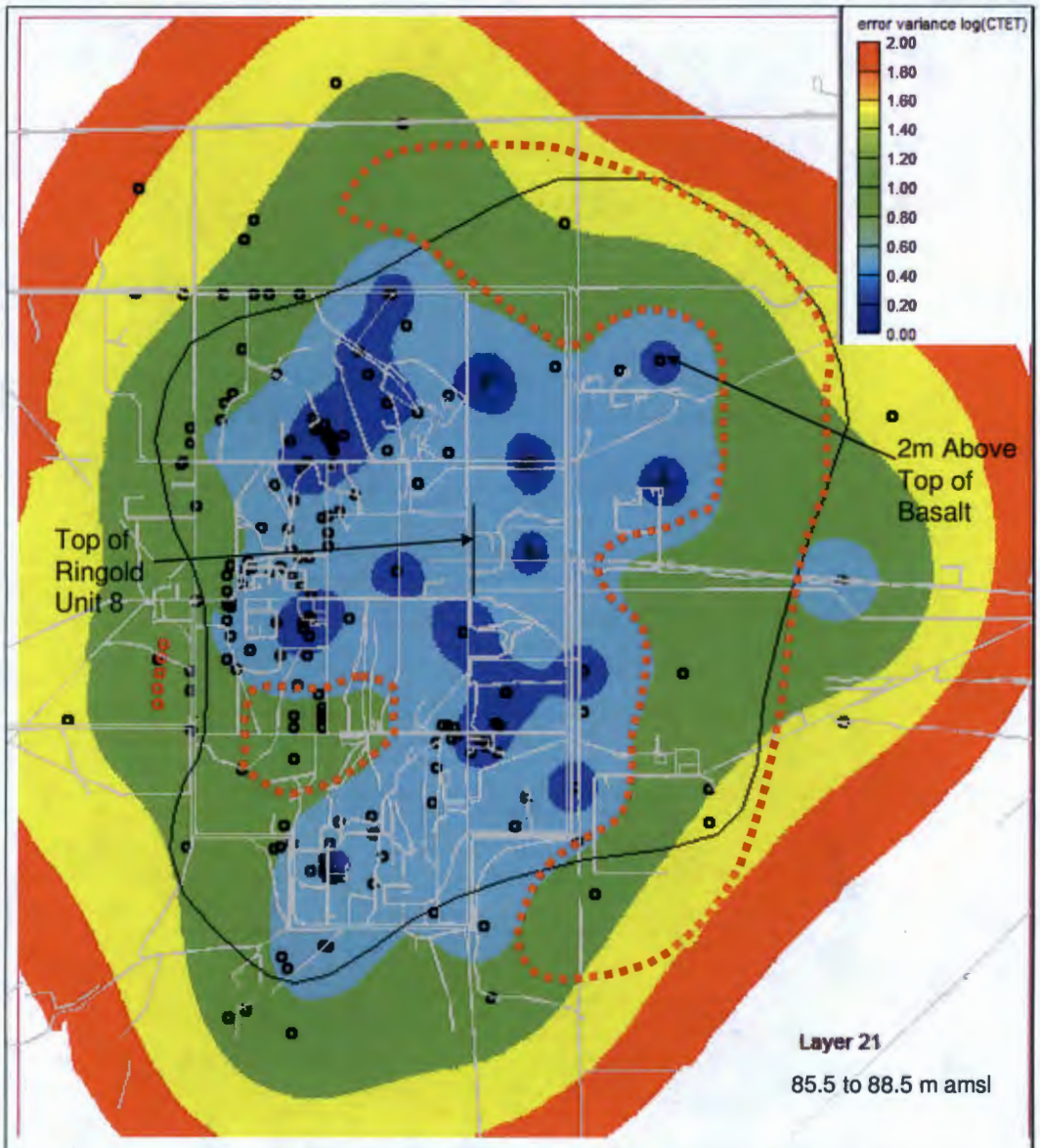
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-5. Kriged Carbon Tetrachloride Error Variance from 98.5 to 101.5 m Above Mean Sea Level



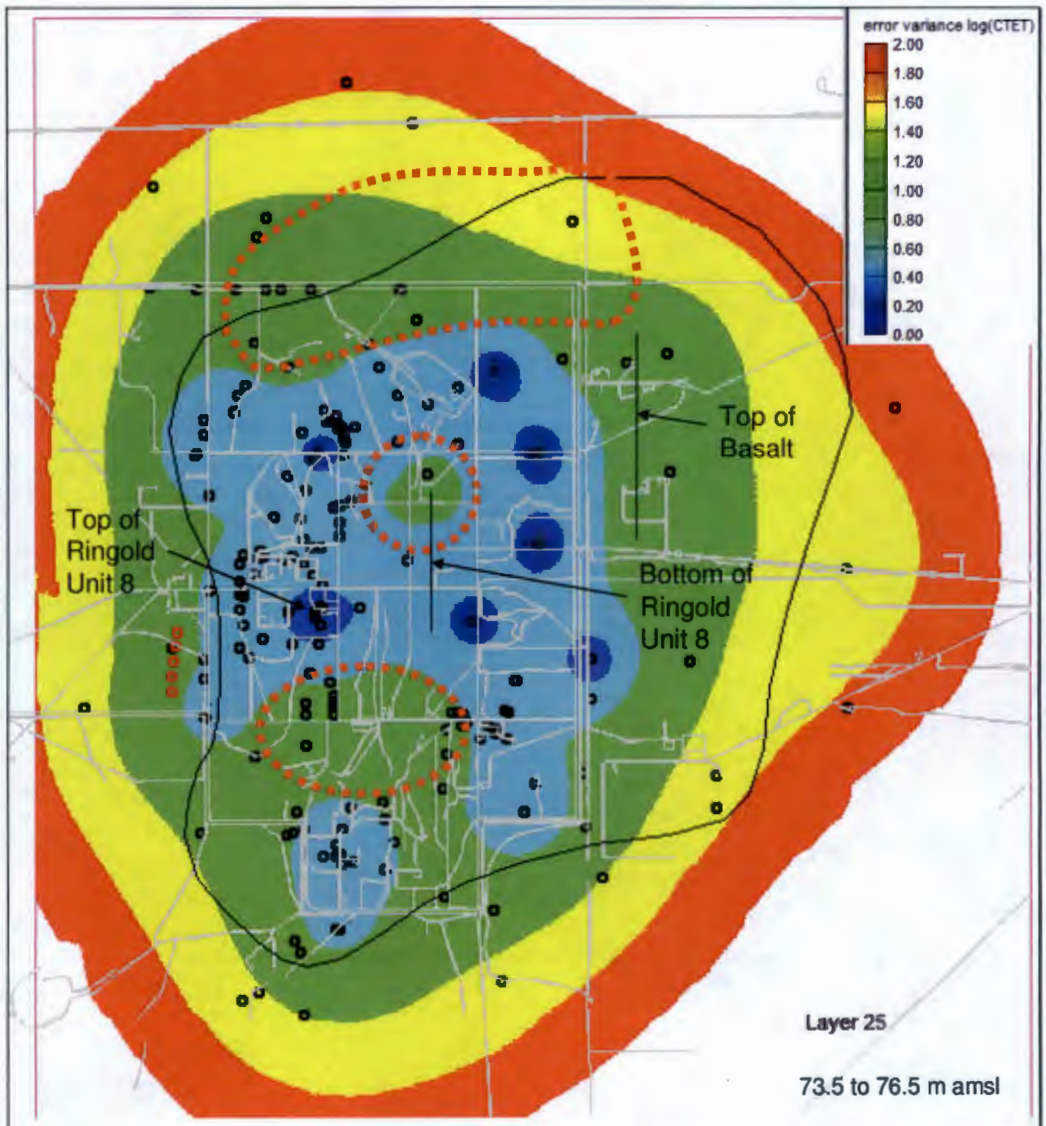
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-6. Kriged Carbon Tetrachloride Error Variance from 85.5 to 88.5 m Above Mean Sea Level



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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-7. Kriged Carbon Tetrachloride Error Variance from 73.5 to 76.5 m Above Mean Sea Level

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-8. Kriged Carbon Tetrachloride Error Variance from 67.5 to 70.5 m Above Mean Sea Level

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

Figure C-9. Kriged Carbon Tetrachloride Error Variance from 61.5 to 64.5 m Above Mean Sea Level

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Appendix D

200-ZP-1 Operable Unit Hydraulic Monitoring Well Network

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D1 200-ZP-1 Operable Unit Hydraulic Monitoring Well Network

Table D-1 provides details for the 200-ZP-1 Operable Unit hydraulic monitoring well network.

Table D-1. 200-ZP-1 Operable Unit 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	08/07/47	No	137.4
299-W10-27	566844	136442	205.6	67.36	78.02	03/23/01	No	132.9
299-W10-30	566083	136739	211.6	73.86	84.53	03/14/06	No	132.4
299-W10-31	566266	136968	210.4	73.13	83.82	04/20/06	No	131.9
299-W10-33	566773	136610	206.0	118.87	124.96	06/15/07	No	84.1
299-W10-4	566735	136578	205.5	57.91	74.68	11/10/52	Yes	139.2
299-W11-13	567099	136424	211.9	66.45	143.86	07/31/61	No	106.7
299-W11-18	567182	137161	216.5	69.19	89.916	03/01/67	No	136.9
299-W11-33Q	567185	136844	217.2	74.41	91.17	09/09/94	No	134.4
299-W11-43	567270	136971	217.5	129.44	134.01	05/23/05	Yes	85.8
299-W11-45	566993	136776	213.6	85.73	90.18	09/02/05	No	125.7
299-W11-47	566934	136681	210.4	83.58	92.89	01/06/06	Yes	122.2
299-W11-48	566882	136846	209.7	84.56	112.01	11/29/06	Yes	111.4
299-W11-87	568141	136609	223.6	116.36	120.94	03/01/07	Yes	105.0
299-W11-88	567875	137113	221.9	135.66	147.85	10/03/07	Yes	80.1
299-W13-1	568149	136049	223.5	119.15	129.81	02/10/04	Yes	99.1
299-W14-11	566902	136288	205.1	79.77	82.81	04/26/05	No	123.8
299-W14-14	566898	136181	205.4	66.13	76.81	11/12/98	Yes	134.0
299-W14-17	567007	136218	205.9	67.64	78.32	10/24/00	No	132.9
299-W14-71	567733	135568	219.4	125.17	129.74	07/27/06	Yes	92.0
299-W14-72	567328	135941	216.3	126.18	130.76	08/15/06	Yes	87.9
299-W15-1	566554	135943	207.0	57.91	82.3	05/02/47	No	136.9
299-W15-11	566412	136001	208.3	55.78	90.53	03/08/68	Yes	135.1
299-W15-152	566309	135550	209.9	71.94	82.61	09/15/05	No	132.6
299-W15-17	566307	135719	209.8	128.77	131.82	10/28/87	No	79.5

Table D-1. 200-ZP-1 Operable Unit 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	09/30/52	No	139.0
299-W15-30	566305	135749	210.2	66.47	78.63	05/05/95	Yes	137.7
299-W15-31A	566377	135856	208.5	64.76	76.93	05/26/95	No	137.7
299-W15-37	566716	135248	203.0	64.74	77.98	05/16/96	No	131.68
299-W15-42	566582	135627	207.4	69.50	84.74	02/26/02	No	130.3
299-W15-46	566752	135587	204.2	63.86	88.23	10/03/03	No	128.2
299-W15-49	566307	135973	209.1	71.86	82.52	11/01/04	No	131.9
299-W15-50	566793	135791	203.2	74.19	84.85	02/28/05	No	123.7
299-W15-7	566676	135920	204.2	55.47	106.68	03/30/66	Yes	123.1
299-W17-1	565311	135039	199.2	58.99	69.67	12/17/03	No	134.9
299-W18-1	566422	135465	209.1	59.44	111.89	01/12/59	No	123.4
299-W18-15	566380	134733	202.2	51.82	74.07	04/25/80	No	139.3
299-W18-16	566605	135426	208.5	71.47	82.13	10/20/04	No	131.8
299-W18-22	566089	134990	204.9	126.94	136.39	09/25/87	No	73.2
299-W18-40	566723	134996	203.4	66.53	77.20	09/28/01	No	131.6
299-W19-107	567998	135206	217.4	94.65	99.22	03/31/06	Yes	120.5
299-W19-18	567361	135012	214.0	67.06	109.12	12/12/85	No	125.90
299-W19-34A	567674	135012	215.1	98.82	103.51	05/18/94	No	113.9
299-W19-34B	567663	135011	215.5	125.46	128.41	12/12/85	No	88.6
299-W19-35	567992	135015	213.6	73.13	82.3	04/20/94	No	135.9
299-W19-4	567950	135351	219.0	77.72	135.03	02/15/60	No	112.3
299-W19-41	566897	135005	206.5	67.07	77.76	09/23/98	No	134.1
299-W19-6	567133	134694	210.3	115.82	125.27	12/13/68	No	89.79
299-W21-2	568124	134574	214.9	79.29	89.96	11/22/04	No	130.2
299-W22-24	567648	134411	212.2	67.06	163.07	09/08/60	No	97.1
299-W22-47	566909	134076	206.3	69.70	80.37	01/19/05	No	131.3
299-W23-20	566718	134446	203.8	65.68	76.35	08/21/00	No	132.8
299-W26-14	566683	133539	205.4	68.08	78.75	04/03/03	No	132.0
299-W27-2	566908	133670	207.4	123.79	126.87	12/18/92	No	82.1
299-W6-3	567118	137299	214.4	124.82	127.95	10/15/91	No	87.9

Table D-1. 200-ZP-1 Operable Unit 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-W6-6	567319	137639	217.5	127.58	130.84	10/24/91	No	88.3
299-W7-3	566292	137639	207.2	136.85	145.29	11/23/87	No	66.1
699-25-70	568545	131172	193.0	53.34	134.11	08/31/48	No	99.24
699-25-80	565676	131106	189.0	273.41	370.03	11/30/48	No	-132.7
699-30-66	569991	132739	210.5	117.35	120.4	10/13/04	No	91.6
699-32-62	571010	133216	216.6	83.82	103.63	04/06/60	No	122.9
699-32-62P	571010	133216	216.6	83.82	146.3	04/06/60	No	101.5
699-32-70B	568462	133242	204.2	63.09	100.58	08/09/57	No	122.37
699-32-72A	567943	133363	204.7	65.42	74.56	07/31/57	No	134.7
699-32-72B	567935	133362	205.1	65.41	74.56	05/18/94	No	135.1
699-34-88	563012	133950	194.0	146.0	127.02	12/20/48	No	136.5
699-35-59	571956	134096	222.1	94.48	106.67	10/31/85	No	121.5
699-35-66A	569858	134099	222.5	79.25	98.15	06/13/57	No	133.76
699-35-78A	566064	134271	202.4	54.86	85.04	08/17/50	Yes	132.02
699-36-70B	568428	134626	215.2	80.51	91.17	06/09/04	No	129.4
699-38-61	571219	134997	228.2	101.83	107.92	11/16/93	No	123.3
699-38-65	570090	135040	230.7	152.4	155.45	12/31/59	Yes	76.8
699-38-68A	569180	134932	219.0	81.59	90.74	06/21/94	No	132.8
699-38-70B	568469	135331	222.6	123.96	128.53	02/03/04	No	96.3
699-38-70C	569084	135326	226.7	120.60	125.18	02/17/04	No	103.8
699-39-79	565891	135412	206.5	54.44	73.152	09/07/48	Yes	142.7
699-40-62	571164	135764	228.9	102.11	114.0	01/17/49	No	120.8
699-40-65	570057	135881	231.0	100.0	111.5	02/03/04	Yes	125.3
699-43-69	568967	136488	227.4	121.98	132.64	12/11/07	Yes	100.1
699-43-89	562917	136620	197.7	43.28	60.35	01/16/51	No	145.9
699-44-64	570391	136897	222.2	96.32	134.72	01/31/60	Yes	106.67
699-45-69A	568729	137183	222.1	83.52	111.56	06/22/48	No	124.6
699-45-69C	568947	137234	222.6	111.86	116.43	07/13/07	Yes	108.4
699-47-60	571474	137969	199.6	71.63	84.43	07/20/48	No	121.6
699-47-80AP	565562	137693	218.26	198.12	204.83	11/30/83	No	16.8

Table D-1. 200-ZP-1 Operable Unit 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)
699-47-80AQ	565562	137693	218.26	153.31	156.36	11/30/83	No	63.4
699-48-71	568388	138057	210.9	138	156.36	09/26/56	Yes	63.7
699-48-77C	566469	138087	206.6	88.39	94.49	04/01/94	No	115.42
699-49-79	565771	138271	211.1	65.58	80.77	07/03/48	Yes	137.9
699-50-74	567360	138647	201.4	68.07	78.74	07/12/05	No	128.0
699-51-63	570664	139148	175.3	47.85	55.78	11/06/56	No	123.49
699-51-75	566978	138906	196.6	57.91	68.58	10/31/57	No	133.4
699-55-76	566723	140226	178.7	42.98	67.36	01/18/59	No	123.5

amsl = above mean sea level
NA = not available

Distribution

	MS	Quantity
U.S. Department of Energy, Richland Operations Office Electronic Dist.		
J.G. Morse	A5-11	1
N.M. Jaschke	A5-11	1
DOE Public Reading Room	H2-53	1
CH2M HILL Plateau Remediation Company - Electronic Distribution		
M.E. Byrnes	R3-50	
W. Faught	R3-50	
R.W. Oldham	R3-60	
J. Riddelle	R3-20	
S.A. Simmons	R3-50	
C. Sutton	R3-50	
Administrative Record	H6-08	1
Document Clearance	H6-08	1

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