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Draft A

Performance Monitoring Plan for the 200-UP-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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Richland, Washington 99352

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APPROVED
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Terms

AWLN	Automated Water Level Network
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
GLS	generalized least-squares
HEIS	Hanford Environmental Information System
HSU	hydrostratigraphic unit
IC	institutional control
MEUK	Multi-Event Universal Kriging
MNA	monitored natural attenuation
NAVD88	*North American Vertical Datum of 1988*
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
PSQ	principal study question
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RAWP	remedial design/remedial action work plan
RDR	remedial design report
ROD	record of decision
SST	single-shell tank
UCL	upper confidence limit

UCL_{95}	95 percent upper confidence limit
UK	Universal Kriging
UPR	unplanned release
WAC	*Washington Administrative Code*
WMA	waste management area

1 Introduction

This performance monitoring plan (PMP) has been prepared to describe groundwater monitoring data collection activities associated with implementation of the 200-UP-1 Operable Unit (OU) remedial action. The selected remedy is described in the record of decision (ROD) (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). This PMP defines the types of data to be collected, well networks to be monitored, frequency of data collection, and analysis of data to satisfy ROD requirements. Specific details of data collection are described in a sampling and analysis plan (Appendix B). A separate operations and maintenance plan will describe monitoring of the treatment process in the treatment plant and compliance monitoring for treated effluent discharge from the treatment plant. Monitoring of remedial activities for the 200-ZP-1 OU is described in DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*, and DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*.

This PMP is intended to be a flexible living document, which will be modified and approved, as needed, based on changing hydraulic and contaminant distribution conditions at the 200-UP-1 OU. Modifications to the network are probable due to changing conditions. Some wells in the PMP monitoring network may go dry as a result of pump and treat (P&T) operations, and improvements will be made to the conceptual site model (CSM), 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 adaptability of the PMP so that it can be used or updated to specify a performance monitoring regime that is appropriate for current site conditions.

The 200-UP-1 Groundwater OU includes several groundwater plumes that span an area approximately 10 km^2 (4 mi^2) underlying the southern portion of the Hanford Site 200 West Area (Figure 1-1). The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities that have been grouped into four process areas: U Plant, Z Plant, S Plant (Reduction-Oxidation Plant), and T Plant. Major waste streams that contributed to 200-UP-1 OU groundwater contamination were associated with plutonium separation and uranium recovery operations at the S Plant and U Plant facilities, where liquid wastes were disposed to the ground via ponds, cribs, ditches, and trenches. As effluent was discharged to these sites in the past, more mobile contaminants migrated through the vadose zone to the groundwater. Some groundwater contamination also resulted from single-shell tank (SST) leaks or unplanned releases (UPRs), particularly associated with Waste Management Area (WMA) S-SX. Groundwater contamination has also migrated from the adjacent 200-ZP-1 OU into the 200-UP-1 OU that originated from liquid waste disposed to the ground at Z Plant plutonium concentration and recovery facilities.

The remedial investigation/feasibility study (DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*) concluded that without remedial action, contaminants in 200-UP-1 groundwater would exceed risk threshold values for future industrial workers and residents who might use the groundwater as a drinking water supply. Existing contaminant concentrations also exceed federal and state maximum contaminant levels and state groundwater cleanup standards for use of groundwater as a drinking water source. As stated in the ROD (EPA et al., 2012), contaminants of concern (COCs) identified for the 200-UP-1 OU are carbon tetrachloride, chromium (total and hexavalent), iodine-129, nitrate, technetium-99, tritium, and uranium. The ROD (EPA et al., 2012) also requires monitoring of final contaminants of potential concern (COPCs), including 1,4-dioxane, chloroform, strontium-90, tetrachloroethene, and trichloroethene.

The ROD (EPA et al., 2012) presents the selected remedial action for restoring the aquifer, as well as cleanup levels for the COCs. The remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*) describes the design and implementation of the remedial actions required by the ROD (EPA et al.,

2012). This PMP describes monitoring activities associated with the remedial action process, remedial action objectives (RAOs), and the preferred remedial action alternative chosen to meet those RAOs.

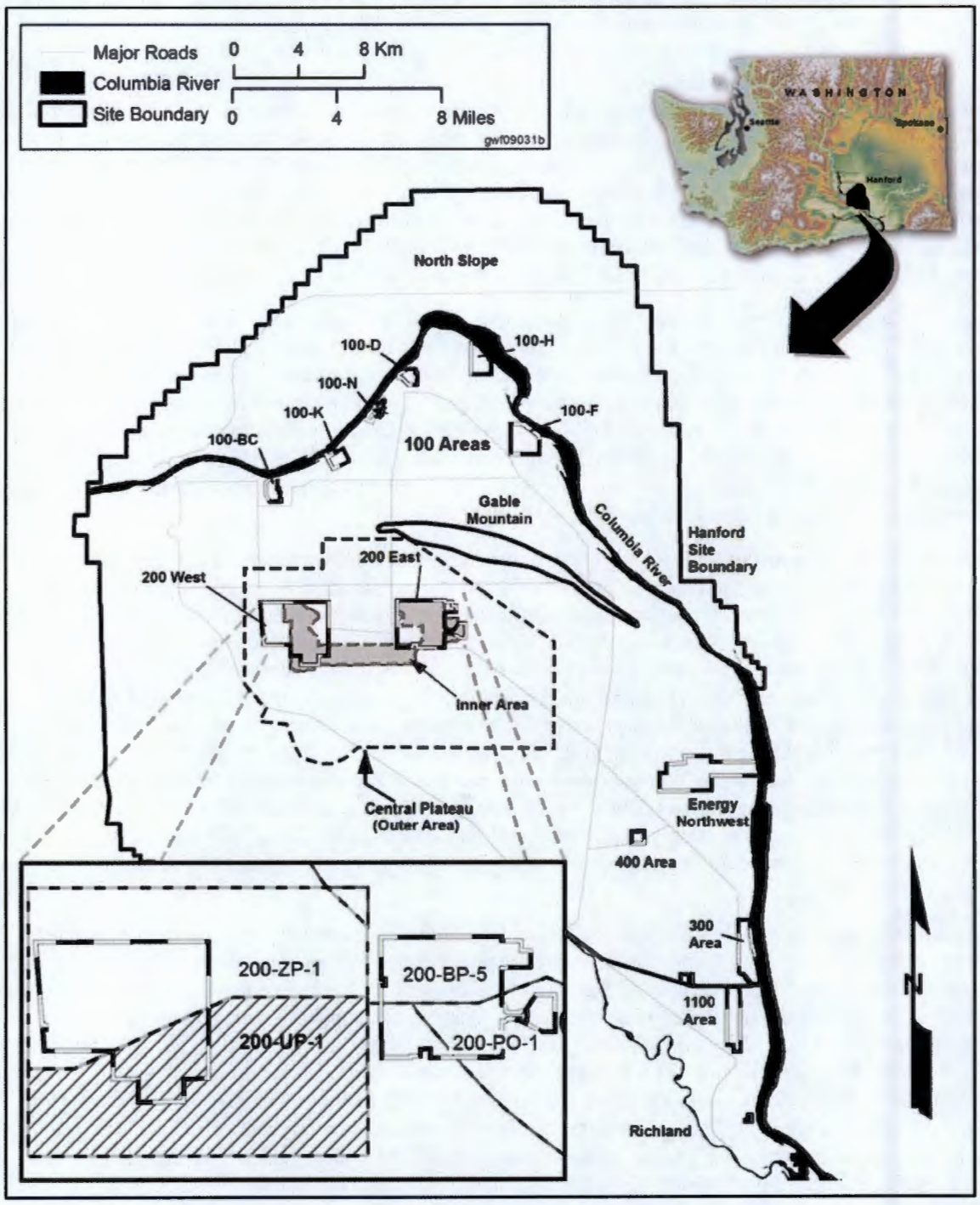

Figure 1-1. Site Location

1.1 Remedial Action Objectives

Through its groundwater protection program, the State of Washington determined that the 200-UP-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, 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 following specific RAOs for remediation of contaminated 200-UP-1 OU groundwater are listed:

- **RAO 1:** Return the 200-UP-1 OU groundwater to beneficial use as a potential drinking water source.
- **RAO 2:** Prevent human exposure to contaminated 200-UP-1 OU groundwater that exceeds acceptable risk levels for drinking water.

Groundwater cleanup levels for COCs identified in the 200-UP-1 ROD (EPA et al., 2012) are listed in Table 1-1. Although listed as a COC for the 200-UP-1 OU, monitoring for carbon tetrachloride within the 200-UP-1, groundwater monitoring for carbon tetrachloride is addressed in the 200-ZP-1 OU PMP (DOE/RL-2009-115).

Table 1-1. Cleanup Levels for 200-UP-1 Operable Unit Groundwater

Contaminant of Concern	Cleanup Level	Units
Carbon Tetrachloride	3.4[a]	µg/L
Chromium (Total)	100	µg/L
Hexavalent Chromium	48	µg/L
Iodine-129	1[b]	pCi/L
Nitrate	10,000[c]	µg/L
Nitrate	45,000[c]	µg/L
Technetium-99	900	pCi/L
Tritium	20,000	pCi/L
Uranium	30	µg/L

a. This cleanup level is a risk-based calculation for carbon tetrachloride. This value represents a cumulative 1×10^{-5} risk in accordance with WAC 173-340-720(7)(a), "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards."

b. Currently identified groundwater treatment technology is insufficient to reach the 1 pCi/L drinking water standard.

c. Nitrate (NO_3) may be expressed as the ion NO_3 (NO_3- NO_3) or as nitrogen (NO_3-N). The federal drinking water standard for nitrate is 10 mg/L expressed as N and 45 mg/L expressed as NO_3-. The state cleanup level is 25.6 mg/L, as nitrogen.

1.2 200-UP-1 Operable Unit Selected Remedy

The selected remedy for the 200-UP-1 OU consists of five components: P&T; monitored natural attenuation (MNA); iodine-129 hydraulic containment and treatment technology evaluation; remedy performance monitoring; and institutional controls (ICs). The first four components, which are the subject of this PMP, require periodic groundwater monitoring and data evaluation to assess remedy performance and determine when the remedial action is complete. The fifth component does not require groundwater monitoring and is addressed separately in the current revision of DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*. Descriptions of the first four components of the selected remedy are presented in the following subsections.

1.2.1 Pump-and-Treat Component

The groundwater extraction and treatment component will use a P&T system, consisting of a network of groundwater extraction wells (Figure 1-2) and conveyance piping (with transfer pump stations), and will use the existing groundwater treatment facility in the 200 West Area, which will be modified to meet the 200-UP-1 OU selected remedy treatment requirements. Extraction wells will be designed and installed to remove contaminated groundwater from the aquifer and reduce or prevent further plume migration. The P&T system will be designed and implemented in combination with MNA to achieve cleanup levels for all COCs in the 200-UP-1 OU, except iodine-129, within the following time frames: 15 years for technetium-99; 25 years for uranium; 25 years for chromium (total and hexavalent) through P&T; 35 years for nitrate through P&T and MNA; 125 years for carbon tetrachloride through P&T and MNA; and 25 years for tritium through MNA. Injection wells will be used to inject treated water back into the aquifer to provide flow path (gradient) control.

1.2.2 Monitored Natural Attenuation Component

The selected remedy relies upon MNA for parts of the nitrate and carbon tetrachloride plumes and for the entire tritium plume. The parts of the nitrate plume that will be addressed through MNA are the diffuse (low concentration) nitrate plume areas not captured by the P&T system. Carbon tetrachloride will require the longest MNA time frame, estimated to be 125 years, which is consistent with the MNA time frame for carbon tetrachloride identified in the ROD for the adjacent 200-ZP-1 OU (EPA, 2008, *Record of Decision, Hanford 200 Area, 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington*). The tritium plume will be addressed through MNA due to its short radioactive half-life (12.3 years) and lack of an effective tritium groundwater treatment technology.

1.2.3 Iodine-129 Hydraulic Containment and Treatment Technology Evaluation Component

The technology evaluation for iodine-129 that was completed as part of the feasibility study determined that no current treatment technology can achieve the federal drinking water standard of 1 pCi/L for iodine-129 concentrations present in the 200-UP-1 OU. The U.S. Department of Energy (DOE) will evaluate potential treatment options for iodine-129 as part of the selected remedy through further technology evaluation. If one or more viable technologies are identified, treatability tests will be conducted for those technologies. Hydraulic containment of the iodine-129 plume will be implemented until a subsequent remedial decision for the iodine-129 plume is made. Hydraulic containment will be performed using injection wells placed at the leading edge of the iodine-129 plume (Figure 1-2).

The selected remedy requires an interim waiver of the federal drinking water standard of 1 pCi/L for iodine-129, which is an applicable or relevant and appropriate requirement. If a viable treatment technology is not available, use of a technical impracticability waiver under 40 CFR 300.430(f)(l)(ii)(c), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy," may need to be considered as part of the final remedy.

1.2.4 Remedy Performance Monitoring Component

Remedy performance monitoring is required to be conducted over the life of the interim remedial action to evaluate and confirm its performance and optimize its effectiveness. Performance monitoring for the extraction and injection well network will include groundwater sampling and analysis for COCs, assessment of extraction well flow rates, and water level measurements. This will allow evaluation of each contaminant's mass removal rate and determine the effectiveness of the injection well network for hydraulically containing the iodine-129 plume.

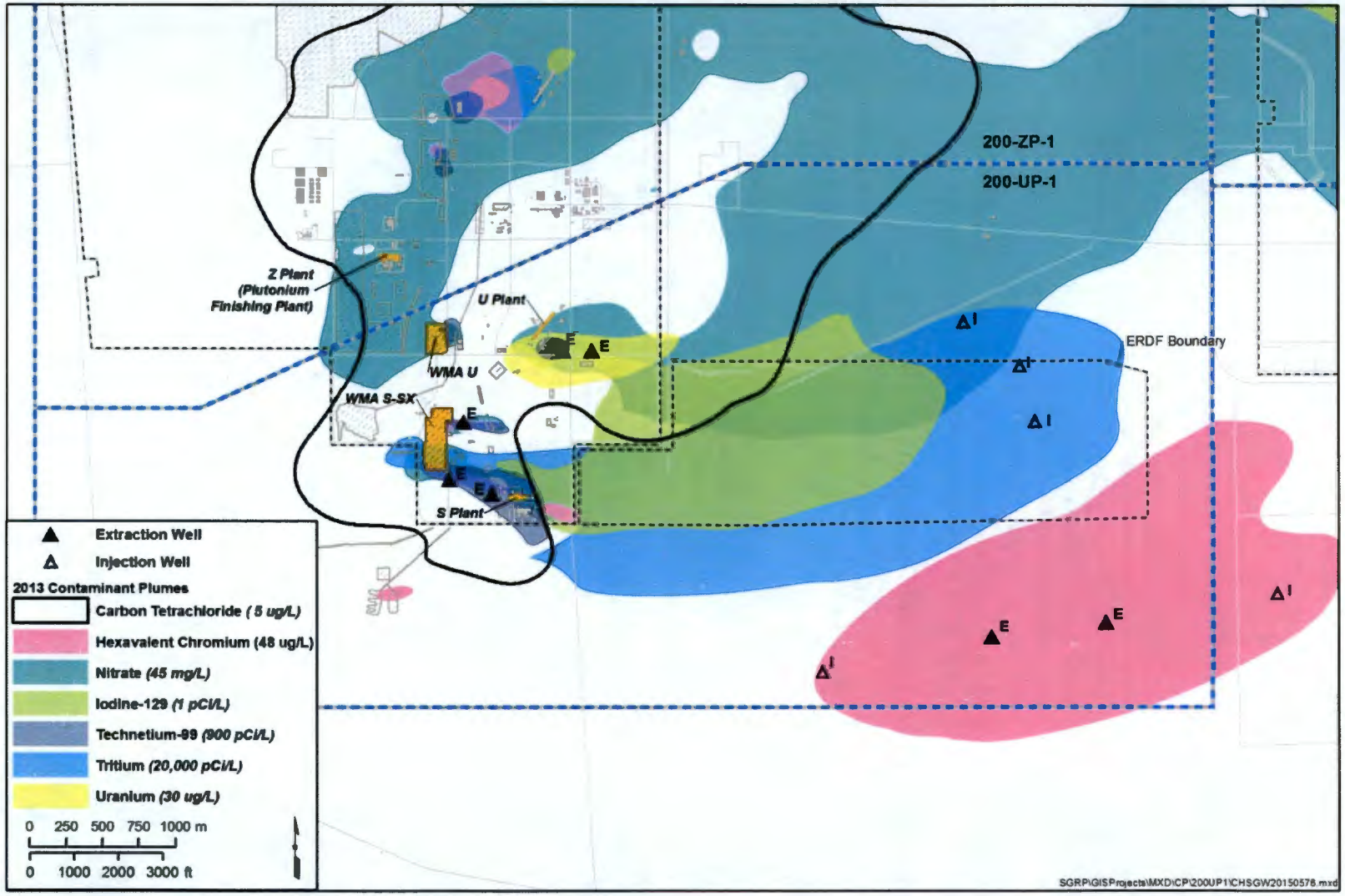

Figure 1-2. Conceptual Layout of Extraction and Injection Wells for the 200-UP-1 Remedy from the RD/RAWP (DOE/RL-2013-07)

Since cleanup decisions for the soil OUs located above the 200-UP-1 OU have not yet been identified, monitoring will also be conducted for the final COPCs, which include: 1,4-dioxane, chloroform, tetrachloroethene, trichloroethene, and strontium-90. Monitoring for the final COPCs will help determine if they are impacting groundwater at concentrations that may pose an unacceptable risk to human health and the environment (EPA et. al, 2012).

1.2.5 Institutional Controls Component

ICs will be required for the 200-UP-1 OU as long as groundwater contamination precludes its use as a potential source of drinking water. ICs include the requirement that DOE control access to groundwater to prevent exposure of humans to contaminated groundwater, except as otherwise authorized by the U.S. Environmental Protection Agency (EPA), and prohibit activities that would damage components of the remedy or disrupt or lessen performance of any component of the remedy, except as otherwise authorized in lead regulatory agency approved documents. DOE is responsible for implementing, maintaining, reporting on, and enforcing ICs required under the ROD (EPA et al., 2012). Although DOE may later transfer these procedural responsibilities to another party by contract, property conveyance agreement, or other means, DOE will retain ultimate responsibility for remedy integrity and ICs.

1.3 Implementation of the Selected Remedy

Implementation of the 200-UP-1 OU remedy will be performed in a sequenced manner. A conceptual layout of the P&T and hydraulic control system is illustrated in Figure 1-2. The P&T component will be implemented by plume area as follows:

- **WMA S-SX plume area:** The primary COC in this area is technetium-99, with emerging chromium and nitrate plumes originating from past UPRs and leaks from WMA S-SX SSTs. The extraction system for this area began operating in 2012. The focus of this extraction system is the capture and removal of two technetium-99 plumes (Figure 1-2), located downgradient of WMA S-SX. Capturing the technetium-99 plumes also effectively captures the emerging chromium and nitrate plumes, as well as a portion of the carbon tetrachloride plume that originates from the 200-ZP-1 OU. The extraction system (three wells) is designed to operate at a total average extraction rate of 303 L/min (80 gpm) and is expected to operate for a period of approximately 15 years, based on current plume conditions. The duration of operations may be extended if WMA S-SX vadose zone contamination continues to contribute to groundwater contamination exceeding cleanup levels.

- **U Plant plume area:** The primary COC in this area is uranium with technetium-99 and nitrate that originated primarily from past releases to the 216-U-1/U-2 Cribs located on the upgradient edge of the uranium plume (Figure 1-2). Beginning in 1985, this area has undergone focused groundwater remediation efforts to remove higher concentrations of uranium (greater than 300 μg/L) and technetium-99 (greater than 9,000 pCi/L), as discussed in Section 2.2 of the 200-UP-1 OU ROD (EPA et al., 2012) and DOE/RL-2013-07. The focus of the new extraction/injection system under this plan is cleanup of the remaining portions of the uranium and technetium-99 plumes. Associated higher levels of nitrate will also be extracted locally, as well as carbon tetrachloride that has migrated into the area from the 200-ZP-1 OU. The system is expected to require approximately two extraction wells, operating at an approximate total average flow rate of 568 L/min (150 gpm) for 25 years, based on current contamination conditions.

- **Southeast chromium plume area:** This area is located in the far southeastern portion of the 200-UP-1 OU that is primarily associated with historic waste discharges to the 216-S-20 Crib and the 216-S-10 Pond and Ditch. The chromium plume is largely isolated in this area and has not been well characterized. As an initial step in implementing the remedy in this area, additional monitoring wells

will need to be installed for further characterization of the vertical and lateral extent of the plume in support of remedial design. The system is expected to require approximately two extraction and two injection wells, operating at an approximate total average flow rate of 757 L/min (200 gpm) for 25 years based on the current interpretation of contamination distribution.

The hydraulic containment component to control migration of the iodine-129 plume is expected to consist of a set of injection wells (approximately three) placed at the leading edge of the plume, with an approximate total average flow rate of 568 L/min (150 gpm). Hydraulic containment of the iodine-129 plume will continue until a subsequent remedial decision for the plume is made. In addition to implementing the hydraulic containment component, a study will be performed for further evaluation of potential treatment options for iodine-129 (to be defined in the iodine-129 technology evaluation plan). The P&T and hydraulic control systems are expected to be implemented by plume area in the following sequence:

- WMA S-SX P&T system
- U Plant P&T system
- Iodine-129 plume hydraulic containment system
- Southeast chromium plume P&T system

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2 Conceptual Site Model

This chapter briefly describes the local geology, hydrogeology, and groundwater within the 200-UP-1 OU area. This information is summarized from the RD/RAWP (DOE/RL-2013-07) and is included to provide a brief overview of the current understanding of the CSM. Additional detail is provided in Appendix A.

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-UP-1 OU underlies the southern portion of the 200 West Area, which is on the western side of the Central Plateau. Surface elevations above the OU range from approximately 183 m (600 ft) to more than 213 m (700 ft) above mean sea level. Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the geology of the 200-UP-1 OU.

The overlying sediments are approximately 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford formation, which are composed primarily of sand and gravel, with some silt layers. Figure 2-1 shows a generalized cross section of the Central Plateau and illustrates the hydrogeologic conditions present at the OU, including the water table.

2.2 Local Hydrogeology

Sedimentary layers are laterally continuous across the majority of the OU and are referred to as hydrostratigraphic units (HSUs). Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the upper Ringold unit), Cold Creek unit (CCU), and Hanford formation. The following geologic units are above the basalt bedrock (in descending sequence):

- Unconsolidated sand and gravel of the Hanford formation (HSU 1)
- Fine- to coarse-grained sediment of the CCU (HSU 3)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 5 (HSU 5)
- Silt and clay of the Ringold Formation lower mud unit 8 (HSU 8)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 9 (HSU 9)

The sediment thickness above the water table (vadose zone) in the 200 West Area ranges from 40 to 75 m (132 to 246 ft). Erosion during cataclysmic flooding removed some of the Ringold Formation and CCU. Perched water (above the water table) has historically been documented above the CCU at locations in the 200 West Area. 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. Natural recharge originates from precipitation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/year (0 to 4 in./year) (PNNL-10285) 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. Artificial recharge in the Central Plateau that continues is largely limited to onsite sanitary sewage treatment and disposal systems; possible 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.

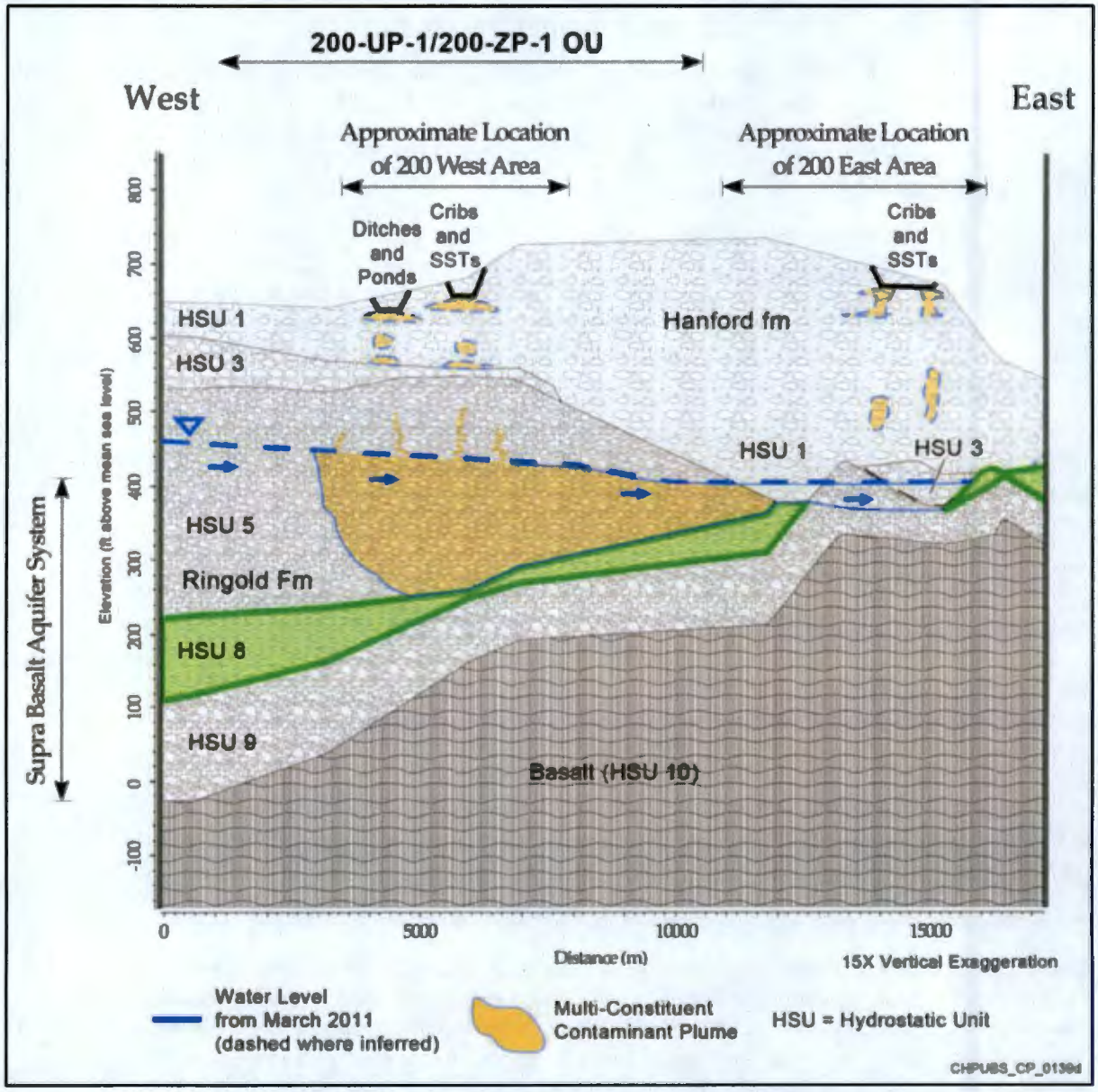


Figure 2-1. Physical Conceptual Site Model for the 200 West Area

2.3 Groundwater

Groundwater beneath the Hanford Site is found in an upper unconfined aquifer and in deeper confined aquifers within the lower Ringold Formation and the basalt. 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 eastward direction from the 200 West Area to the 200 East Area (Figure 2-2).

Historical liquid waste discharges to the ground (e.g., cooling water and process wastewater) during the 1940s through the 1990s greatly altered the groundwater flow regime, especially around the 216-U-10 Pond in the 200 West Area, which created a large water table mound that deflected the

groundwater flow to the northeast. As drainage from these discharges has ceased, the water table has been declining, and groundwater flow direction is returning to a more easterly course through the Central Plateau. There are currently no liquid waste discharges to the ground above the 200-UP-1 OU (with the exception of sanitary drain fields).

The water table is relatively deep within the 200-UP-1 OU, averaging approximately 75 m (250 ft) below ground surface. The uppermost unconfined aquifer, ranges in thickness from approximately 10 to 100 m (33 to 330 ft). The unconfined aquifer controls lateral movement of groundwater contaminants across the OU and is bounded below by the Ringold Formation lower mud unit (HSU 8). This mud layer acts as a hydraulic impediment over the majority of the OU and limits groundwater flow from moving into the confined aquifer below.

Groundwater flow is locally influenced by the 200-ZP-1 OU final remedy P&T system and the WMA S-SX interim remedial measure extraction system.

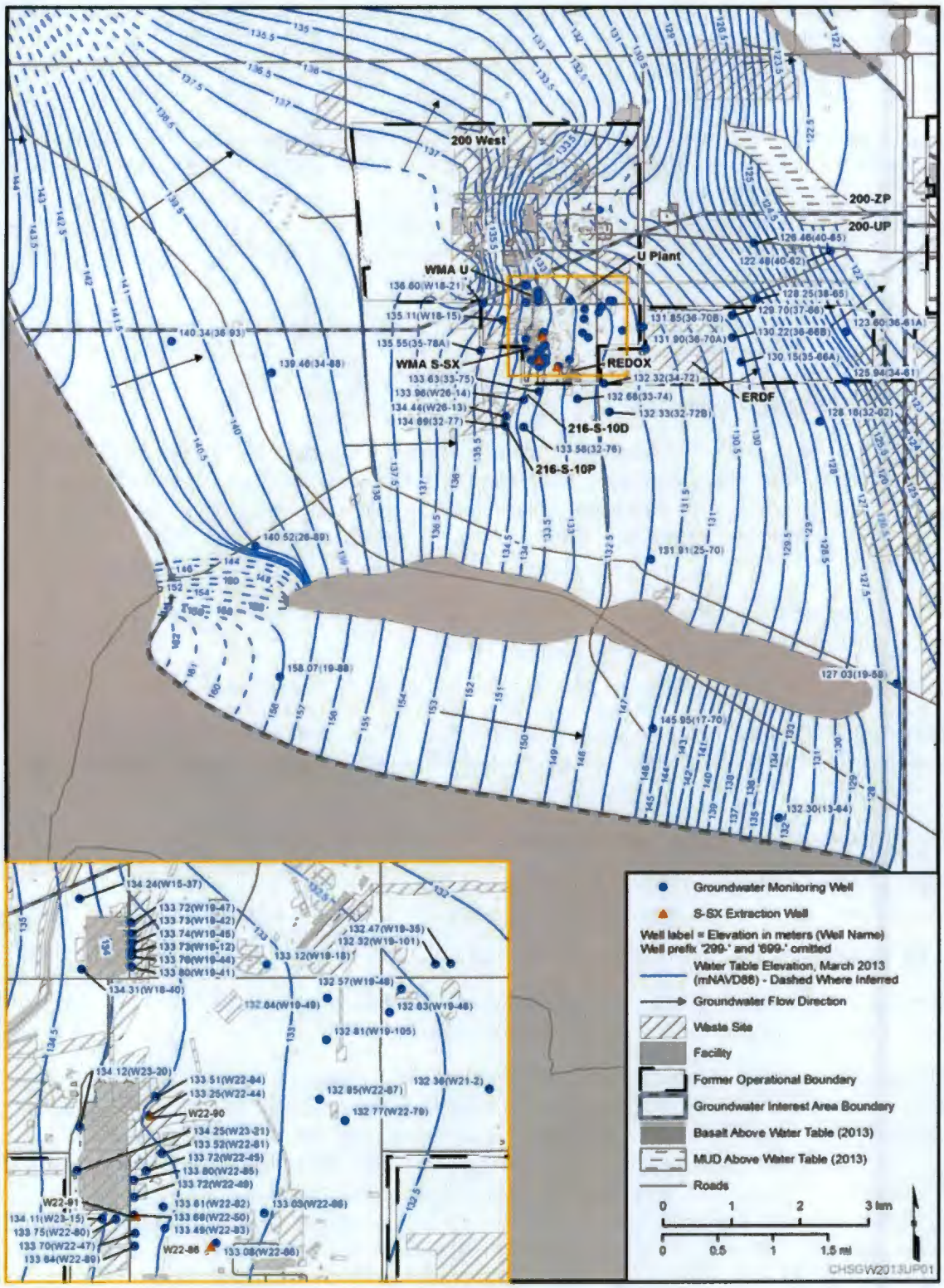
2.4 Contaminant Distribution

Figure 1-2 shows the 200-UP-1 OU groundwater plumes (location and size) based on DOE/RL-2014-32, *Hanford Site Groundwater Monitoring for 2013*. More than 90 groundwater monitoring wells were used to assess the nature and extent of these contaminants within and surrounding the 200-UP-1 OU. The 200-ZP-1 OU plumes to the north are also shown on Figure 1-2. The following plumes originated within the 200-UP-1 OU:

- Uranium plume originating from the U Plant cribs (uranium occurs within the upper 21 m [70 ft] of the unconfined aquifer)
- Widespread nitrate plume originating from U Plant and S Plant cribs and WMA S-SX
- Two chromium plumes: one associated with WMA S-SX, and a second dispersed chromium (total and hexavalent) plume in the southeast corner of the OU that originated from S Plant disposal facilities
- Widespread iodine-129 plume originating from U Plant and S Plant cribs
- Four separate technetium-99 plumes associated with WMA U, U Plant cribs, and WMA S-SX (technetium-99 occurs within the upper 20 m [66 ft] of the unconfined aquifer)
- Widespread tritium plume originating from S Plant cribs

Groundwater contamination associated with these plumes is within the upper 21 m (70 ft) of the unconfined aquifer. Additional details are provided in Appendix A.

In addition to the plumes that formed within the 200-UP-1 OU, a widespread carbon tetrachloride plume exists over a large portion of the 200 West Area that originated from the 200-ZP-1 OU. The carbon tetrachloride plume is present at the water table in the source area and gradually occurs deeper in the aquifer as it migrates downgradient. The downward migration of the plume is stopped by the relatively fine-grained Ringold lower mud, which acts as a hydraulic barrier to vertical groundwater flow. The Ringold lower mud unit, is discontinuous and/or relatively thin in parts of the 200-ZP-1 OU, which allows the carbon tetrachloride plume to migrate vertically downward to the basalt bedrock in those areas where the Ringold lower mud is missing. Discontinuous portions of the lower mud have not been identified within the 200-UP-1 OU. The carbon tetrachloride plume does not extend downward into the basalt bedrock that defines the bottom of the alluvial aquifer system. Groundwater monitoring for carbon tetrachloride is addressed in the 200-ZP-1 OU PMP (DOE/RL-2009-115).



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

Figure 2-2. 2013 Groundwater Table in the 200-UP-1 Operable Unit

3 Design of the Performance Monitoring Program

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

3.1 Contaminant Monitoring

Contaminant monitoring data will be collected over the projected 35-year lifetime of the remedial action to evaluate performance, optimize effectiveness, and determine when the remedial action is complete. Selection of the contaminant monitoring well network, sampling frequency, and analytical parameters is discussed in the following subsections. The contaminant monitoring approach was developed to meet the RAOs described in Section 1.1. Wells were selected based on the ability of the monitoring network to supply sufficient information to monitor cleanup progress, define the extent of the COCs, monitor the plume travel path, and monitor COCs and COPCs in areas not within the footprint of a defined remedy component described in the ROD (EPA et al., 2012).

3.1.1 Assessment of Cleanup Progress

During the performance monitoring time frame, statistical evaluation of monitoring well data will be performed to assess progress in achieving cleanup levels. The process will follow groundwater risk assessment guidance, where the exposure point concentration for each plume within the OU will be continuously evaluated based on available performance monitoring measurements. As presented in the RD/RAWP (DOE/RL-2013-07), the statistical analysis will consist of calculating the upper one-sided 95 percent confidence limit (UCL_{95}) for each COC for comparison to the cleanup levels. The UCL_{95} will be calculated periodically (at least once every 3 years) as new monitoring data are collected to assess progress in achieving cleanup levels and the need for continued active remediation. Following the active remediation period, MNA will be evaluated using an approach consistent with EPA guidance (e.g., EPA/600/R-11/204), and PMP revised at that time, to ensure that cleanup levels have been achieved throughout the contaminated groundwater plumes The active portion of the remedy will be considered complete when UCL_{95} are equal to or less than cleanup levels.

Concentrations of COCs and COPCs vary across the 200-UP-1 OU from no detections and background values to peak values. Contaminant monitoring networks are designed to sample primarily from within the footprint of each plume but extend beyond the plume boundaries in order to capture the full extent of each COC. In order to avoid the UCL_{95} statistic being biased by low concentrations sampled outside of the main plume areas, only wells with detections above one-tenth of the cleanup level are used in calculating the UCL_{95}.

These data are being collected to assess progress toward interim cleanup levels based on mean (average) concentrations. Each mean value has a certain amount of uncertainty associated with it, based on variability and distribution of the data (frequency of each value within the data set). In order to ensure that the mean value used to measure progress is highly likely to be within an acceptable range of uncertainty, UCL_{95} of the mean value is reported. This metric indicates that if the sampling had been repeated many times, 95 percent of the calculated mean values would be no more than the UCL_{95} value. This is a very conservative measure of the mean because the actual mean is likely lower than the calculated UCL_{95} value. For these evaluations, UCL_{95} will be calculated using a student's t-distribution, which is

appropriate when the number of sample locations is relatively small. Using the same approach to calculate the UCL_{95} for each COC will allow consistent comparisons of progress.

UCL_{95} values will be calculated every three years for each COC, based on the current year and previous two years of concentration measurements from wells within or near the boundaries of the plume (extent of cleanup level), using the student's t-statistic (EPA/600/R-07/041, *ProUCL Version 5.0.00 User Guide*). EPA guidance suggests that a group of 20 to 30 results provides a reasonable estimates of the population mean (OSWER Publication 9285.7-08I, *Supplemental Guidance to RAGS: Calculating the Concentration Term*); therefore, wells will be selected to ensure that at least 20 sample results are available for each UCL_{95} calculation for each contaminant.

3.1.2 Contaminant Monitoring Network

When developing the initial list of wells for the monitoring well networks, all available monitoring wells for the 200-UP-1 OU were initially considered, including wells that are sample dry (i.e., well has insufficient water for sampling). Reasonably likely future locations of wells were also considered (e.g., characterization wells to be drilled for the southeast chromium plume). Along with the well locations, the following additional factors were used during selection of the well networks:

- Location of the wells with respect to the plume boundaries as defined by DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*
- Location of wells with respect to the known or suspected plume sources
- Using the existing and planned monitoring wells, which were selected to provide as much spatial coverage for a COC plume as possible
- Well characteristics (e.g., screen type, screen length, and age); in choosing between two wells, preference is given to new construction (e.g., WAC-173-160, "Minimum Standards for Construction and Maintenance of Wells," compliant, screen location, and expected well life) versus older, non-WAC-173-160 compliant wells
- Contaminant concentration trends
- Defining both horizontal and vertical extent of contamination
- Location of wells with respect to groundwater extraction and injection wells

Additional details regarding well selection criteria, along with well construction details and status, are provided in Appendix A.

Contaminant specific monitoring networks were developed for each COC and COPC. Criteria for the selection of monitoring wells are defined in DQOs (Appendix A). Wells were selected based on the following general criteria:

- To calculate UCL_{95}, at least 8 wells over a period of 3 years (or less) are required, providing 20 to 30 sample results for each analyte (OSWER Publication 9285.7-08I).
- Well selection should consider spatial distribution, both horizontal and vertical plume definition. Sample locations should be spaced as evenly as possible throughout each COC plume.
- Boundary wells should be selected to define the plume extent adequately (horizontal and vertical).

- Sample locations will be optimized as much as possible, to allow multiple COCs and/or COPCs to be sampled at a single location, without sacrificing representativeness.

Monitoring well networks for each COC and COPC are listed in Table 3-1, and shown in Figures 3-1 to 3-7. Coordination of sampling efforts between multiple sampling programs (e.g., *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, *Resource Conservation and Recovery Act of 1976*, and *Atomic Energy Act of 1954*) will occur during sample planning in order to reduce redundancy and maximize cost savings, where possible.

Table 3-1. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential Concern Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-E13-14	A	--	--	--	--	--	--	--	--	--	--
299-E13-19	A	--	--	--	--	--	--	--	--	--	--
299-W14-71(d)	--	--	--	--	--	--	--	A	A	A	--
299-W15-37	--	--	A	--	--	--	--	--	--	--	--
299-W18-15	--	--	A	--	--	--	--	--	--	--	--
299-W18-21	--	--	A	--	--	--	--	--	--	--	--
299-W18-40	--	--	A	--	--	--	--	--	--	--	--
299-W19-101	--	T	A	A	--	A	--	--	--	--	--
299-W19-105	--	--	--	--	--	A	--	--	--	--	--
288-W19-107(d)	--	--	A	A	--	A	--	A	A	A	--
299-W19-18*	--	T	A	A	--	A	--	--	--	--	--
299-W19-34A(d)	--	--	A	A	--	T	--	A	A	A	--
299-W19-34B(d)	--	--	--	--	--	--	--	A	A	A	--
299-W19-36	--	--	S	S	--	A	--	--	--	--	--
299-W19-39	--	T	A	--	--	A	--	--	--	--	--
299-W19-4	--	--	A	--	--	--	--	--	--	--	--
299-W19-43	--	--	S	S	--	A	--	--	--	--	--
299-W19-44	--	--	A	A	--	--	--	--	--	--	--
299-W19-45	--	--	A	A	--	--	--	--	--	--	--
299-W19-46	--	--	A	--	--	A	--	--	--	--	--

Table 3-1. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential Concern Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W19-47	--	--	A	A	--	--	--	--	--	--	--
299-W19-48	--	--	A	A	--	A	--	--	--	--	--
299-W19-49	--	T	A	A	--	A	--	--	--	--	--
299-W21-2	--	T	A	--	--	T	--	--	--	--	--
299-W22-113	A	--	A	A	A	--	--	--	--	--	--
299-W22-9 (dry, 299-W22-115)	--	T	--	--	A	--	--	--	--	--	--
299-W22-10	--	--	--	A	--	--	--	--	--	--	A
299-W22-20 (dry)**	A	T	A	A	A	--	A	--	--	--	--
299-W22-44 (dry, 299-W22-93)	A	--	A	A	--	--	--	--	--	--	--
299-W22-45	--	--	A	A	A	--	--	--	--	--	--
299-W22-47	A	--	A	A	--	--	--	--	--	--	--
299-W22-50 (dry, 299-W22-116)	A	--	A	A	--	--	--	--	--	--	--
299-W22-69	A	T	A	A	T	--	--	--	--	--	--
299-W22-72	--	T	A	A	A	--	--	--	--	--	--
299-W22-79	--	T	--	--	--	--	--	--	--	--	--
299-W22-81	--	--	A	A	--	--	--	--	--	--	--
299-W22-82	A	--	--	A	--	--	--	--	--	--	--
299-W22-83	A	--	A	A	T	--	--	--	--	--	--
299-W22-84	A	--	A	A	--	--	--	--	--	--	--
299-W22-85	--	--	--	A	--	--	--	--	--	--	--
299-W22-86	A	T	A	A	A	--	--	--	--	--	--
299-W22-87	--	--	--	--	--	T	--	--	--	--	--
299-W22-88	--	T	--	--	A	--	--	--	--	--	--

Table 3-1. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential Concern Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W22-94	A	--	A	A	--	--	--	--	--	--	--
299-W22-95	A	--	A	A	--	--	--	--	--	--	--
299-W22-96	A	T	A	A	A	--	--	--	--	--	--
299-W23-19	A	T	A	A	A	--	--	--	--	--	--
299-W23-20	A	--	A	A	--	--	--	--	--	--	--
299-W23-21	A	--	A	A	A	T	--	--	--	--	--
299-W23-4	--	--	A	--	A	A	--	--	--	--	--
299-W26-13	A	--	--	--	--	--	--	--	--	--	--
299-W26-14	T	--	--	--	--	--	--	--	--	--	--
699-30-66 (d)	A	--	--	--	--	--	--	--	--	--	--
699-32-70B	T	--	--	--	A	--	--	--	--	--	--
699-32-72A	--	T	--	--	A	--	--	--	--	--	--
699-32-62	A	--	--	--	T	--	--	--	--	--	--
699-32-76	T	--	--	--	--	--	--	--	--	--	--
699-33-56	A	--	--	--	--	--	--	--	--	--	--
699-33-74	--	T	--	T	A	--	--	--	--	--	--
699-34-61	A	--	--	--	A	--	--	--	--	--	--
699-34-72	T	T	T	T	A	--	A	--	--	--	--
699-35-66A	T	A	T	--	A	--	--	--	--	--	--
699-35-70 (dry, 299-W21-3)	--	T	--	--	A	--	--	--	--	--	--
699-35-78A	--	--	--	--	T	--	--	--	--	--	--
699-36-61A	T	--	--	--	A	--	--	--	--	--	--
699-36-66B	--	A	A	--	A	--	--	--	--	--	--
699-36-70A	--	T	T	--	A	--	--	--	--	--	--

Table 3-1. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential Concern Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
699-36-70B	--	T	A	--	B	--	--	--	--	--	--
699-37-66	--	A	A	--	A	--	--	--	--	--	--
699-38-61	--	--	T	--	A	--	--	--	--	--	--
699-38-65	--	A	A	--	A	--	--	--	--	--	--
699-38-68A	--	A	A	--	B	T	--	--	--	--	--
699-38-70 (dry, 299-W19-116)	--	A	A	--	--	A	--	--	--	--	--
699-38-70B (d)	--	--	T	--	--	--	--	A	A	A	--
699-38-70C (d)	--	A	A	--	--	--	--	A	A	A	--
699-40-62	--	--	A	--	T	--	--	--	--	--	--
699-40-65	--	--	A	--	--	--	--	--	--	--	--
699-29-66***	A	--	--	--	--	--	--	--	--	--	--
699-30-57***	A	--	--	--	--	--	--	--	--	--	--
699-31-68***	A	--	--	--	--	--	--	--	--	--	--

A = annual

B = biennial

S = semiannual

T = triennial

(d) = well screened in the deeper portion of unconfined aquifer

(dry, replacement well name) = well currently sample dry (i.e., well has insufficient water for sampling) and to be replaced. Replacement well will be sampled quarterly for the first year, then on sample schedule shown in the table thereafter.

* Well to be replaced by 299-W19-115

** Replacement well number not yet assigned

*** Southeast chromium plume characterization well, not yet installed

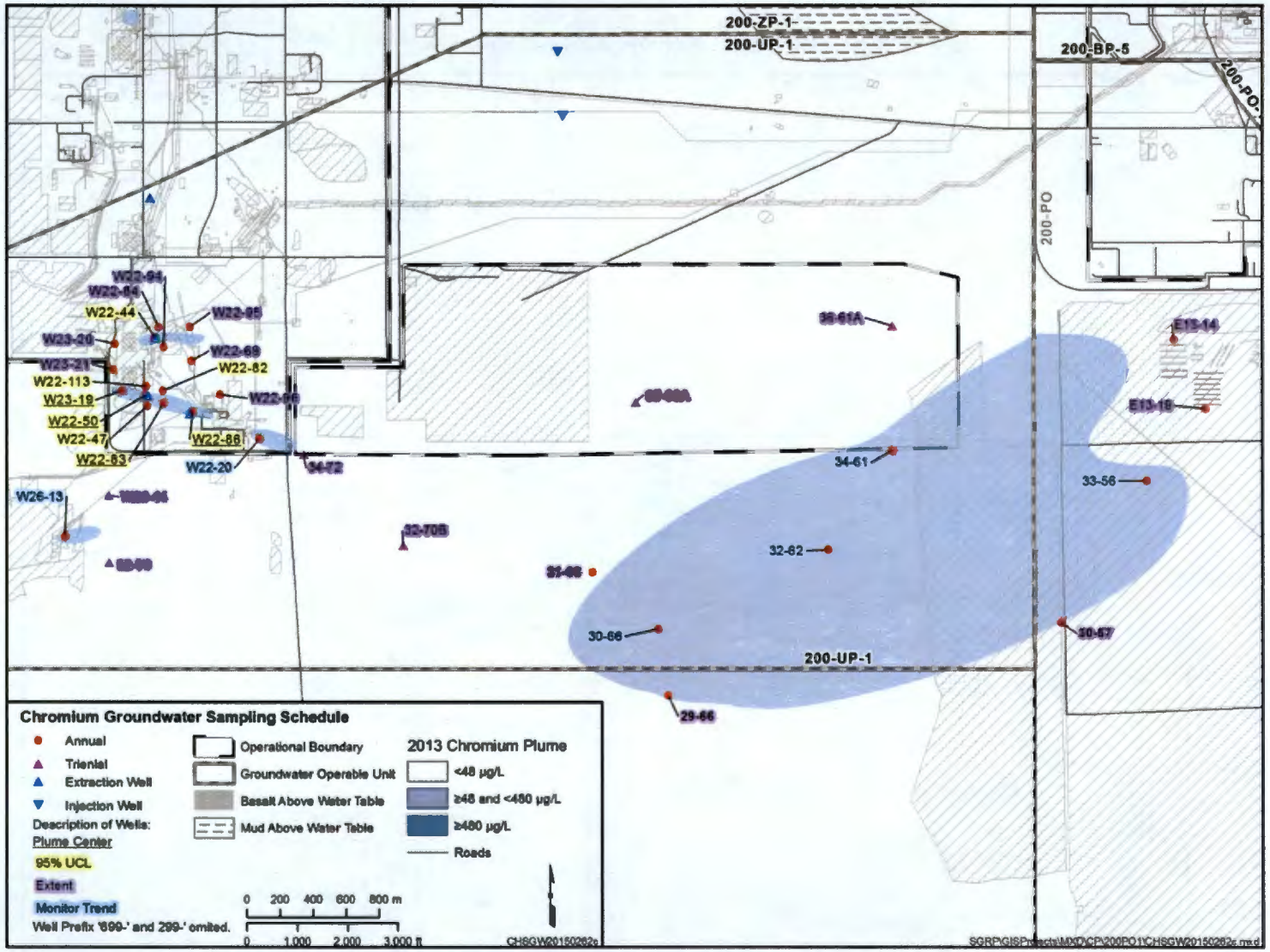


Figure 3-1. Contaminant Monitoring Well Network (Chromium)

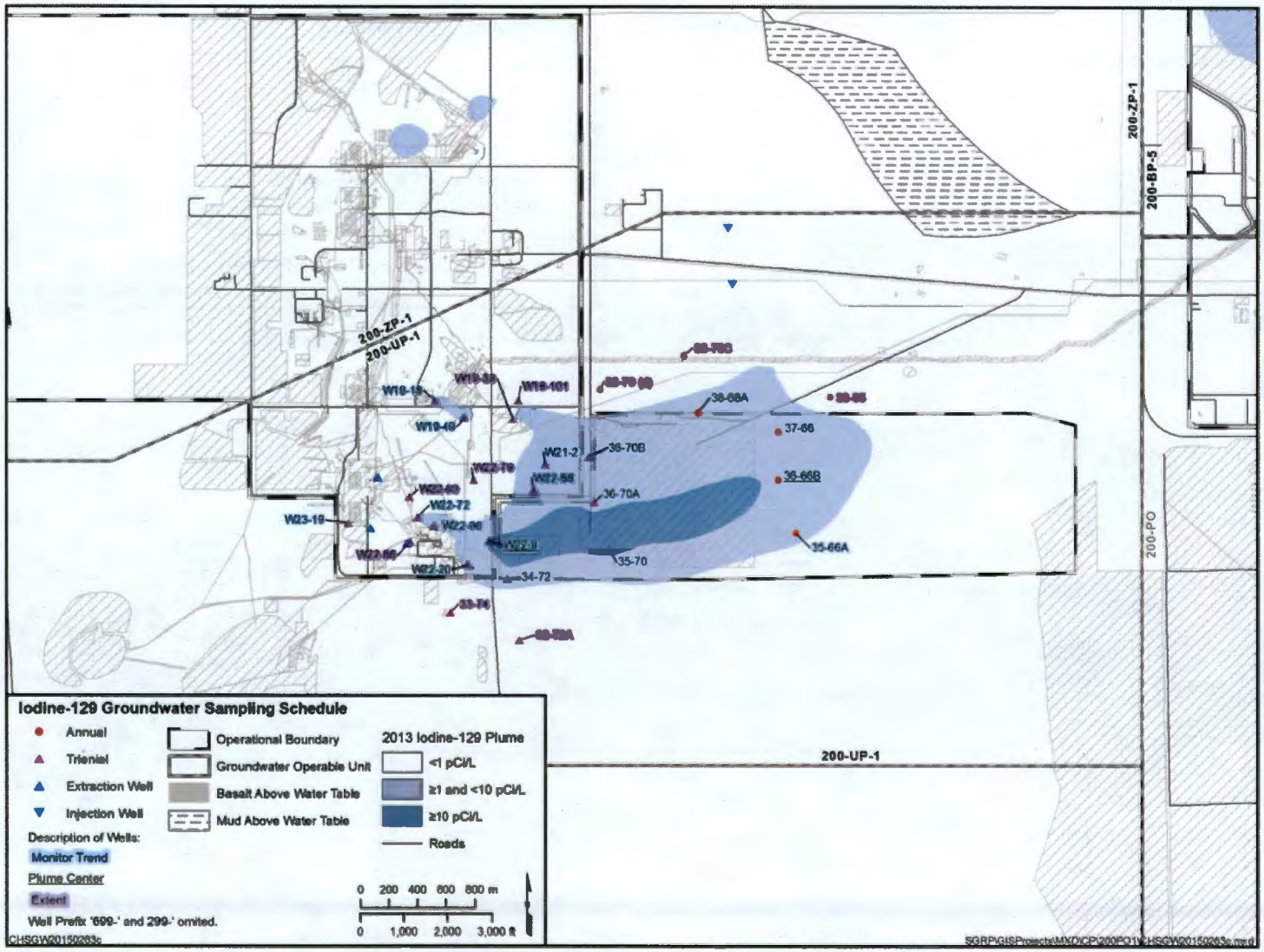


Figure 3-2. Contaminant Specific Monitoring Well Network (Iodine-129)

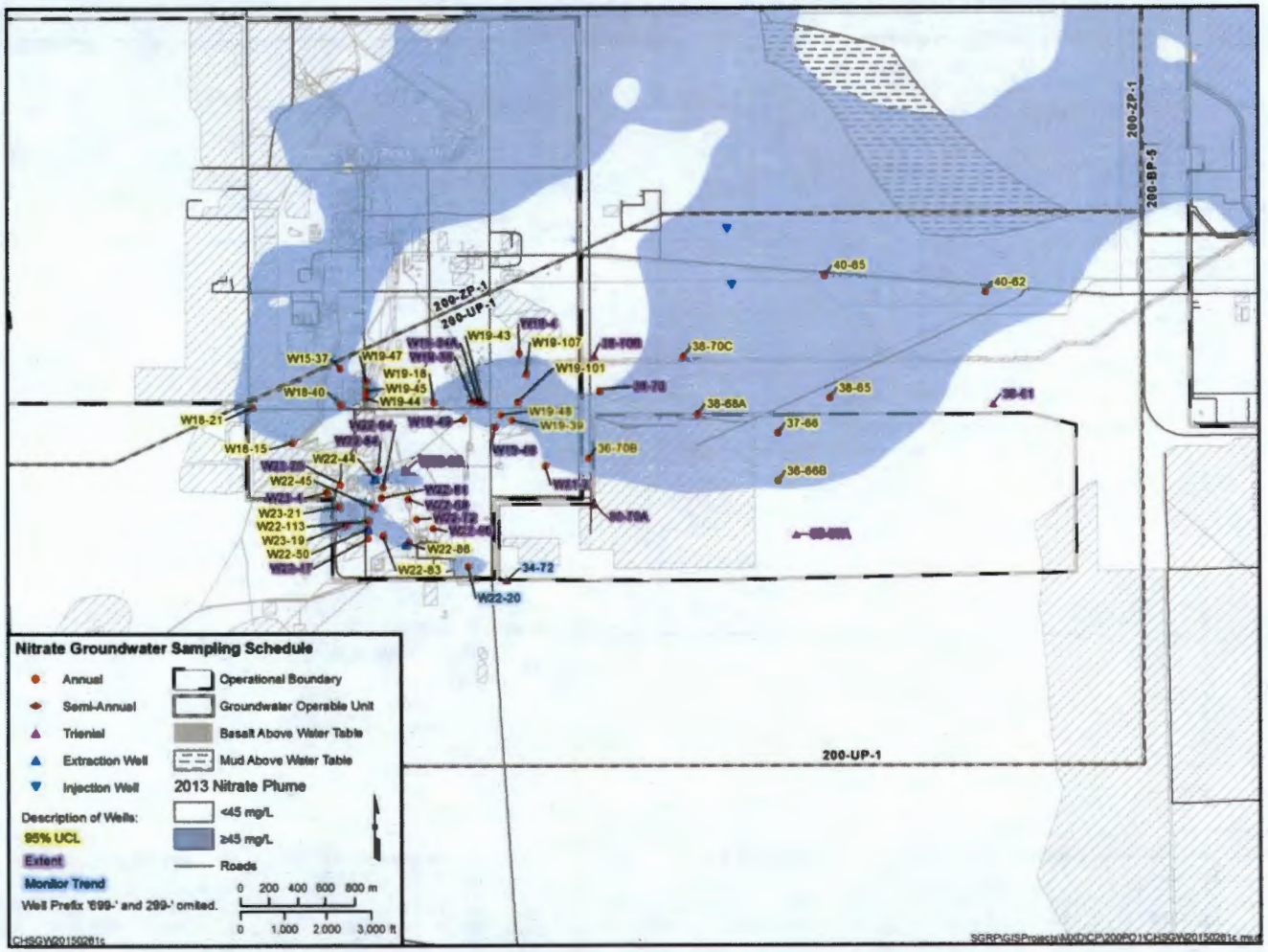


Figure 3-3. Contaminant Specific Monitoring Well Network (Nitrate)

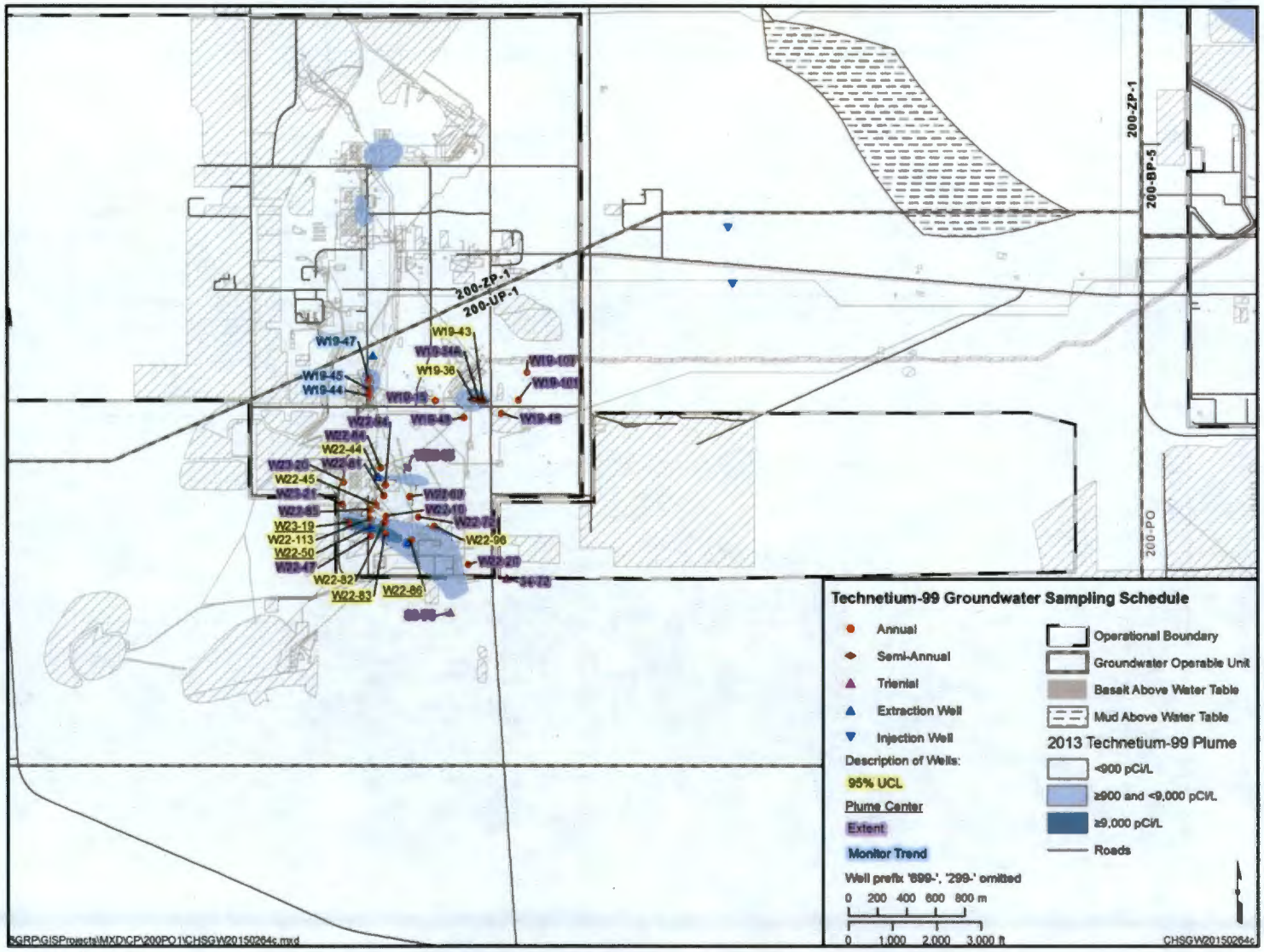


Figure 3-4. Contaminant Specific Well Monitoring Network (Technetium-99)

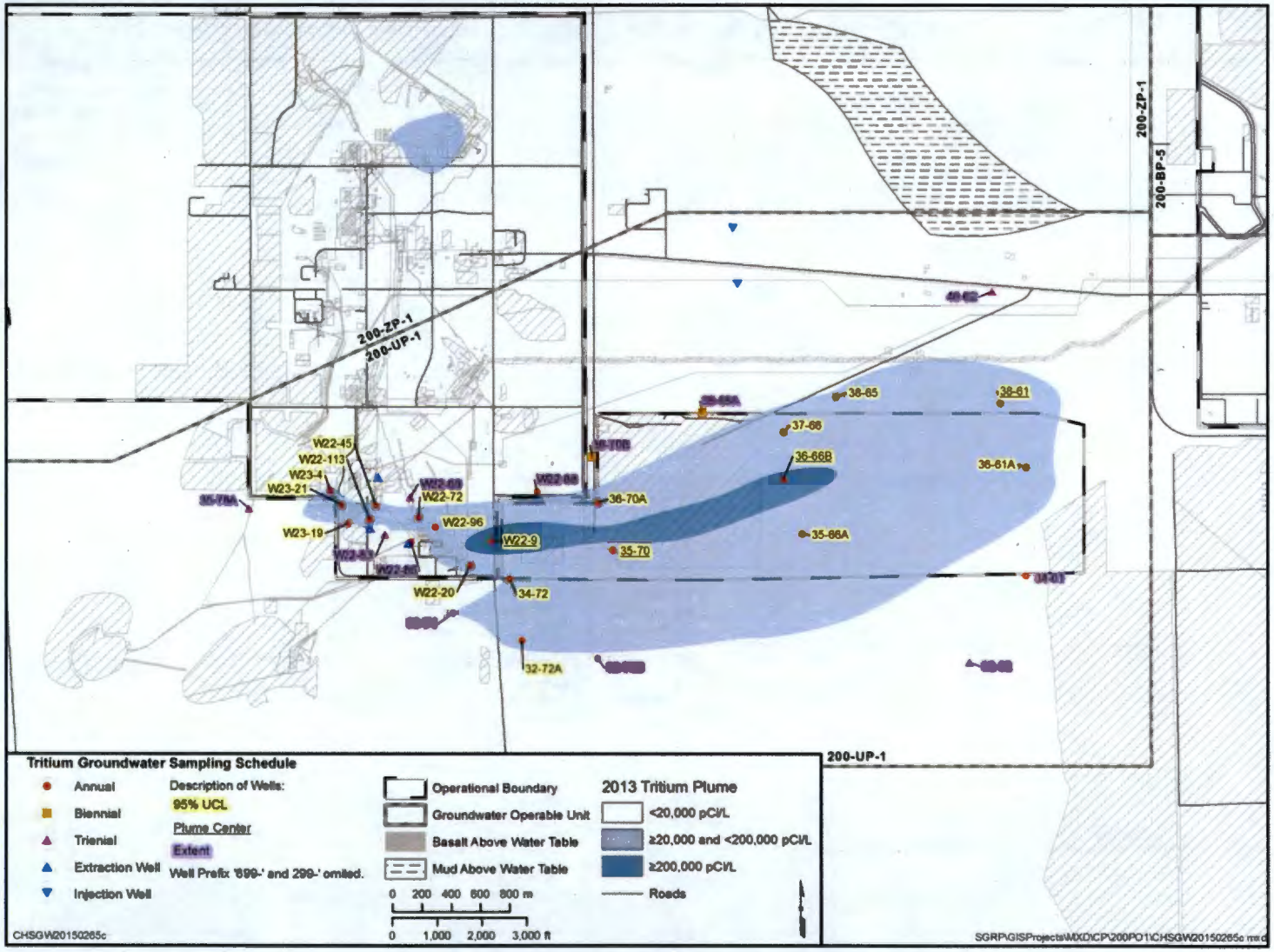


Figure 3-5. Contaminant Specific Monitoring Well Network (Tritium)

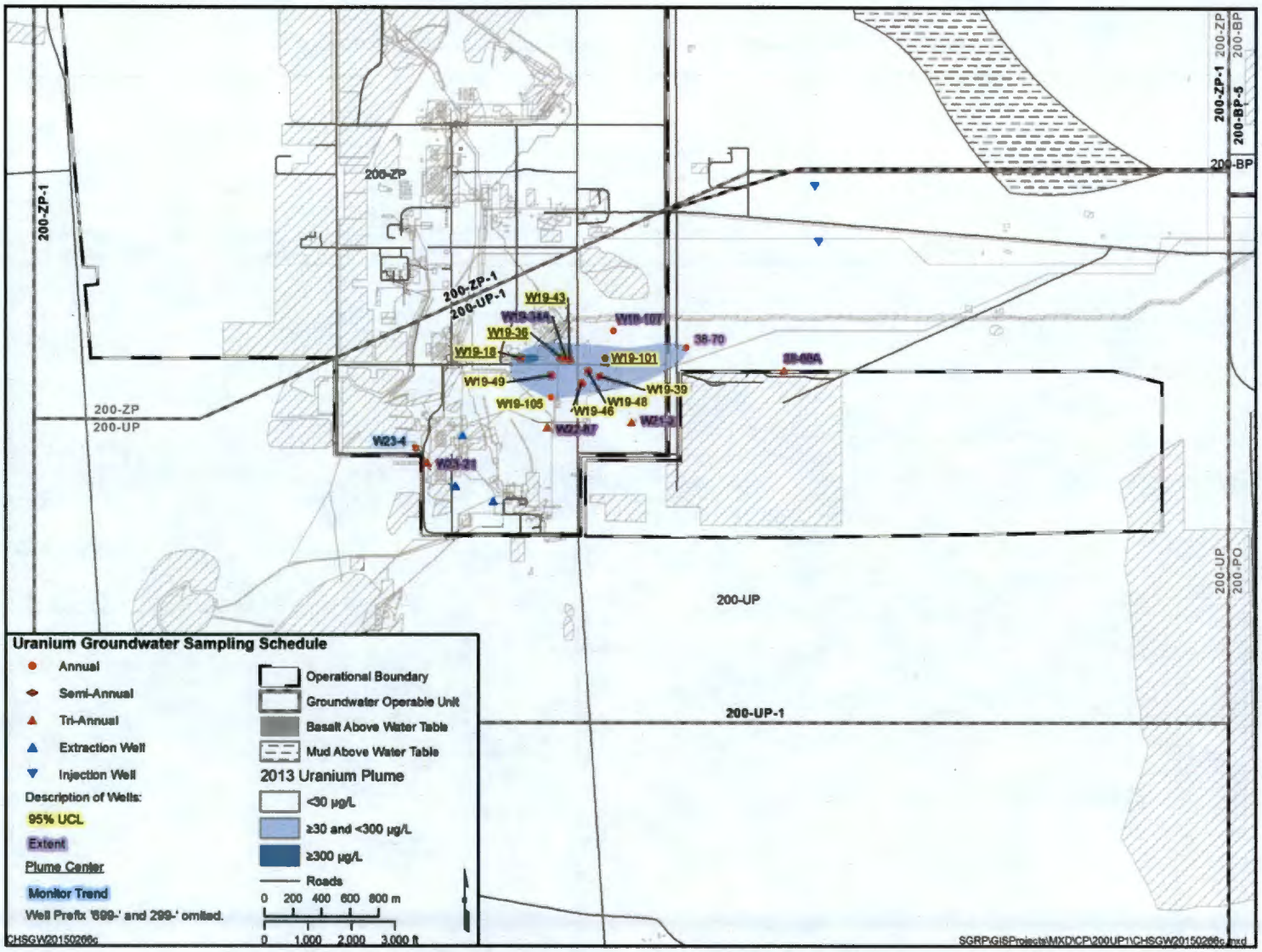


Figure 3-6. Contaminant Specific Monitoring Well Network (Uranium)

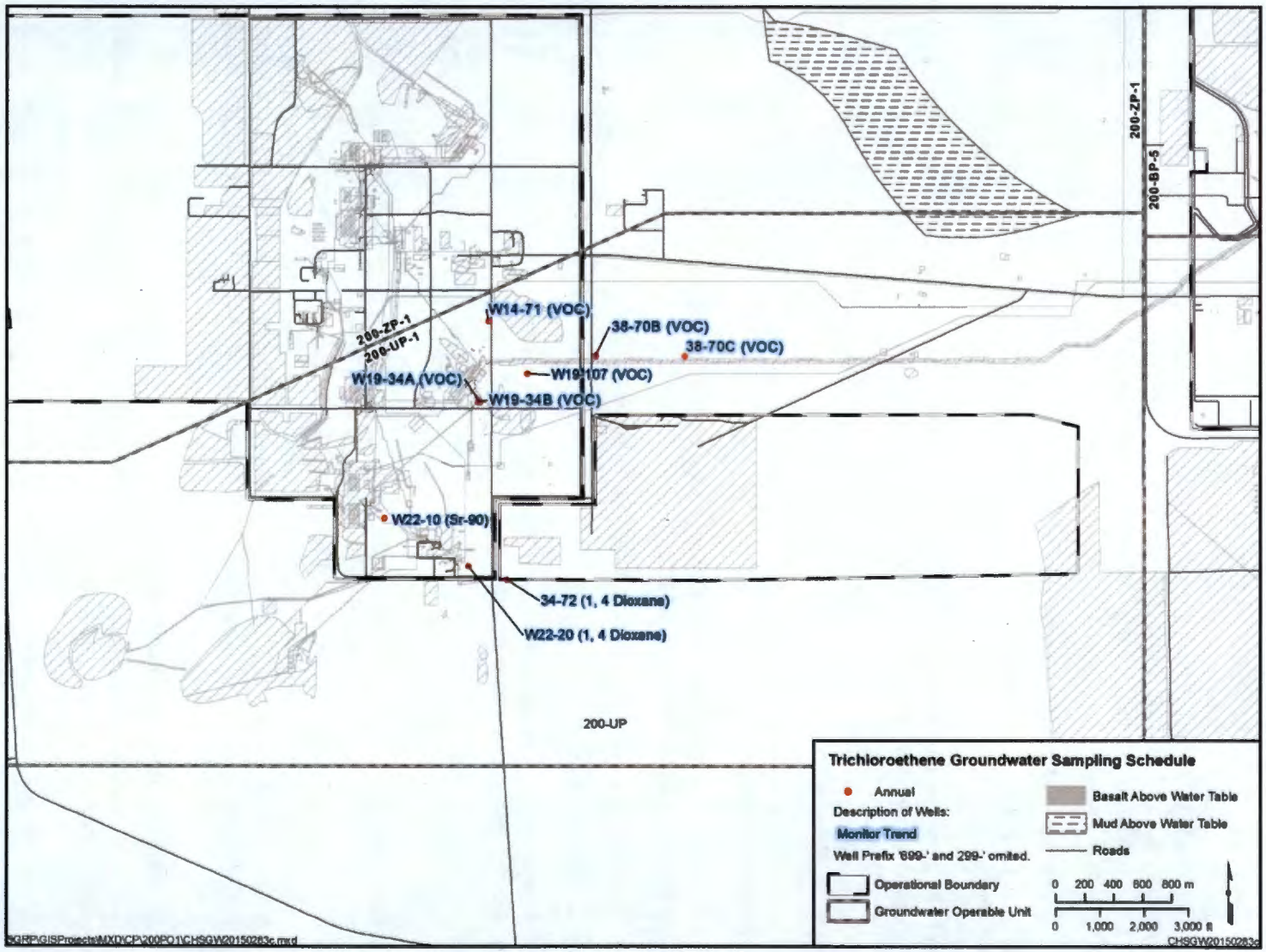


Figure 3-7. Contaminants of Potential Concern Groundwater Monitoring Network

3.1.3 Data Gaps in Monitoring Well Coverage

To fill gaps in monitoring well coverage, up to nine wells are planned to be drilled within the 200-UP-1 OU that will then be sampled for performance monitoring purposes as part of this PMP. Four of the wells are replacements for wells that have either gone dry or are almost dry, and the other three are for additional characterization of the southeast chromium plume. An additional three wells will be installed based on the results of the first three characterization wells for the southeast chromium plume. For wells that sample dry (i.e., do not yield sufficient water to be sampled), one new well will be installed to replace 299-W19-18 (within the uranium plume), and one new well will be drilled to replace 699-35-70 (within the iodine-129 plume).

3.1.4 Contaminant Monitoring Frequency

As shown in Table 3-1, most monitoring wells for the COCs and COPCs will be sampled annually, with the following exceptions:

- Wells in areas where relatively rapid changes in groundwater concentrations are expected (e.g., areas associated with groundwater P&T) will be sampled semiannually.
- Perimeter wells with concentrations that have remained stable for several years will be sampled biennially or triennially.
- Wells in which irregular, decreasing, or increasing trends occur will be sampled on an adjusted frequency, if needed.
- New wells will be sampled as frequently as quarterly for the first year of installation, and as frequently as semiannually the second year.

Sample frequencies for existing monitoring wells will be as follows:

- Active remedy monitoring will be annual.
- MNA monitoring will range from annual in wells in higher concentration areas of the plumes to triennial in wells near the plume margins.
- Iodine-129 sampling to assess hydraulic containment will be annual in wells near plume front and triennial in other wells.

After the second year of sampling a new well, the frequency will be re-evaluated. The frequency of monitoring was chosen for each COC to provide sufficient data to calculate upper confidence limit (UCL) on an annual basis and support evaluation of Principal Study Question (PSQ) 1 (Determine if 200-UP-1 cleanup criteria and RAOs for groundwater are being achieved within the time frames projected in the RDR/RAWP [DOE/RL-2013-07]). The frequency of sampling selected to monitor COPCs is adequate to support PSQ 2 (Determine if COPC concentrations are below action levels over the next 5 year time frame).

3.1.5 Baseline Contaminant Calculations

Numerical fate and transport modeling has been conducted as a design tool for specifying the number, locations, and extraction/injection rates for the P&T system. Predictions produced by this model provide a baseline against which the observations collected in the PMP can be compared. As described in Section 3.3, the remedy will be optimized over time by means of an ongoing process of improvement of the predictive capabilities of the fate and transport model and modification to P&T operations to improve performance.

The fate and transport model represents state variables, such as contaminant concentration throughout the model domain. This comprehensive knowledge is used in the design of the P&T system. However, this is not the best basis for comparison with the PMP observations. Data compiled from the PMP are point observations made at discrete locations and times. The more useful way to compare the model and data is to replicate in the model domain the same sampling scheme used in the field.

Baseline conditions for each remedy component will be calculated in the year prior to remedy startup. Interim groundwater extraction began operating at WMA S-SX in 2012. Therefore, baseline conditions will use 2011 groundwater monitoring data and plume extent information available in DOE/RL-2011-118.

3.2 Hydraulic Monitoring

Water level monitoring is an integral component of remedy performance evaluations. For example, to evaluate the performance of groundwater P&T systems, hydraulic capture must be determined and compared to the area of the aquifer targeted for remediation (EPA 600/R-08/003, *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems*). Groundwater flow models can also be used to assist with the evaluation of remedy performance, particularly MNA, and water level data are needed to calibrate these models.

The need for water level monitoring of the 200-UP-1 OU remedies was established in DQOs (Appendix A). Specifically, water level data are needed to address the following decision statements (DSs):

- **DS 1:** Determine if the 200-UP-1 cleanup criteria and RAOs for groundwater are being achieved within the time frames projected in the RD/RAWP (DOE/RL-2013-07).
- **DS 2:** Determine if COPC concentrations are below action levels based on current/future information (5+ years of data).

To assess the adequacy of the monitoring well network for sampling, information on groundwater flow directions is needed to identify likely future directions of contaminant plume migration. Groundwater flow directions are determined by collecting water level measurements from wells and preparing potentiometric surface maps and/or calculating hydraulic gradients. This needs to be done on a periodic basis during the life of the remedies to detect changes in groundwater flow directions that may occur in order to help interpret groundwater sample results and evaluate the necessity for changes to the sampling well network.

Another use of water level measurements is to establish the current and likely future usability of the wells. Water levels are declining over much of the Hanford Site in response to the curtailment of effluent discharges to the soil column. Water level measurements are used to determine the amount of water that currently remains in a well, and water level trends are used to project when a monitoring well may go dry. This supports the planning and drilling of replacement wells.

To assess progress toward cleanup objectives and determine whether a P&T system will likely achieve cleanup objectives in the predicted time frame, the actual hydraulic capture developed by the system should be consistent with the design capture unless plume configurations have changed (EPA 600/R-08/003). Although calculations of this type can be made using groundwater models, such analyses should always be supported by direct data interpretation. For this reason, water level data in the vicinity of extraction wells are analyzed and used to prepare potentiometric surface maps indicating groundwater flow directions. These maps are then used for particle tracking analyses to estimate the extent of the capture zone developed by the P&T system and migration directions and rates for any contaminants not contained within the capture zone (Section 3.2.1).

The water level monitoring program for the 200-UP-1 OU is described in the following subsections. The water level monitoring program for the 200-UP-1 OU is described in SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*.

Methods of data analysis are described in Section 3.2.1, the water level monitoring network itself is presented in Section 3.2.2, and monitoring frequency is addressed in Section 3.2.3. Sources of uncertainty are described in Section 3.2.4.

3.2.1 Water Level Analytical Methods

This subsection presents methods that are proposed for analysis of water level data to assess the efficacy of implemented groundwater remedial technologies and progress toward the attainment of RAOs. The principal technique proposed for use is the "Multi-Event Universal Kriging (MEUK)" (Tonkin et al., 2013) method of preparing potentiometric surface maps; however, other techniques also will be used, as appropriate. The use of water level data in the context of model calibration is beyond the scope of this PMP, but this topic is addressed in modeling documentation packages.

Water level monitoring at the Hanford Site, including within the 200-UP-1 OU, is composed of the following elements:

- Water levels obtained from monitoring wells by manual (depth-to-water) measurements
- Automated water levels obtained from monitoring wells using data loggers equipped with pressure transducers, with the data retrieval via telemetry (referred to as the Hanford Site Automated Water Level Network [AWLN])
- Automated water levels obtained from extraction and injection wells using pressure transducers, with records stored on the central treatment system's supervisory control and data acquisition system

The location and frequency of manual water level measurements vary over time. For instance, a single sitewide synoptic water level survey, during which water levels are obtained from a large group of wells covering the entire Hanford Site, is scheduled for March of each year (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). This survey includes many wells within the 200-UP-1 OU and the neighboring 200-ZP-1 OU. In addition to the site-wide measurements, synoptic measurements from smaller well groups with smaller geographic coverage are obtained at various locations and times throughout the year, including within the 200-UP-1 OU. The MEUK (Tonkin et al., 2013) method described in this subsection is designed to leverage information from networks that comprise a mix of monitoring locations and frequencies to make use of all available water level information in the vicinity of the 200-UP-1 remedies.

Water level measurements will be reviewed and analyzed using the following six-step process:

1. Data verification
2. Calculation of three-point gradients
3. Organization of measurements into time periods or events
4. Calculation of the (two-dimensional) potentiometric surface
5. Calculation of water level changes over time
6. Calculation of the extent of hydraulic containment (capture) in the vicinity of groundwater P&T systems using particle tracking (flowline) analyses

3.2.1.1 Water Level Measurement Data Verification

Water level data will be tabulated and combined in one or more database tables, so tests can be performed to identify probable outliers. These tests, which will be automated within the R programming environment (R Core Team, 2013, *R: A Language and Environment for Statistical Computing*), will include (but will not be limited to) the following:

- Rolling median test conducted for long time series data (particularly AWLN data)
- Test comparing the mean absolute deviation and time varying median to the water level value
- Comparison of the well casing elevation to the water level value
- Comparison of the screen bottom elevation of the well to the water level value
- Comparison of AWLN data to manual measurements

Hydrographs will be plotted to identify water level patterns and trends visually over time and for visual inspection of possible outliers identified in the previous step. Hydrographs will use symbols that reflect the result of the outlier tests. The scientist will make the final determination to remove data flagged as outliers from subsequent data analyses.

3.2.1.2 Three-Point Gradient Calculations

Using the verified water level data set, three point gradients may be calculated for a network of monitoring wells near active P&T remedies, focusing on areas where the distribution of wells enables the definition of a relatively large group (approximately 20) of well-formed (i.e., limited eccentricity) triangular elements. These three-point gradient calculations will be used to estimate the direction and magnitude of the hydraulic gradient, within the area encompassed by each triangular element for each event on which water levels are available, and to calculate summary statistics such as the average and median gradient magnitude and direction. Results will be presented using rose diagrams and time series plots of the gradient magnitude and direction.

3.2.1.3 Data Organization into Events

The verified water level data set may be organized into time periods or events prior to completing further detailed analyses. An event is composed of an essentially contemporaneous set of measurements, obtained within a sufficiently brief time period, so they can be grouped for the purposes of the intended analyses (e.g., generation of a potentiometric surface). This grouping of data into events is often, but not always, necessary because the water level data are obtained on an infrequent basis and monitoring events do not always coincide to provide contemporaneous spatial coverage. This grouping (if necessary) of the acquired water level data will be based upon, but not limited to, the following information:

- Dates of the defined monitoring events
- Review of the plotted hydrographs and three-point gradients
- Independent knowledge of changes in stresses (such as pumping) that occurred during the monitoring period

As described later in this chapter, the default frequency for further detailed analysis and corresponding grouping of events will initially be monthly, although the frequency will be reviewed following a year of monitoring and analysis (Section 3.2.3).

3.2.1.4 Calculation of Potentiometric Surfaces

Potentiometric surface maps (i.e., groundwater elevation contour maps) will be prepared for each event identified as described in the preceding subsection. Potentiometric surface maps will be interpreted qualitatively for general patterns of groundwater flow and corresponding contaminant migration and will be used quantitatively for particle tracking (flowline) calculations as described in this subsection.

Potentiometric surface maps will be prepared using the procedures and methods described in SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*. These methods have been used to prepare potentiometric surface maps at Hanford and other sites for several years, including the evaluation of the fate of groundwater contaminants and the performance of groundwater P&T and MNA remedies as part of Hanford Site annual reports.

SGW-42305 describes mathematical techniques to interpolate measured groundwater elevation data while incorporating equations that describe the effect of other stressors and features on water levels, including groundwater extraction and injection, and hydraulic barriers (such as basalt subcrops). These techniques combine Universal Kriging (UK) with the analytic element method to construct a spatial, water level "trend" for the area being analyzed. Since the resulting water level map includes information on stressors and other features, it is typically more hydraulically plausible than maps constructed using other methods. Since the number and location of wells for which water levels are available will vary over time within the 200-UP-1 OU, the MEUK (Tonkin et al., 2013) variant of the technique described in SGW-42305 will be used to construct the maps in the vicinity of the active remedies.

MEUK (Tonkin et al., 2013) is designed specifically to create a series of related potentiometric surface maps, each corresponding to a specific event, which exhibit spatial relationships that persist over time. MEUK assumes that multi-event data can be described by a combination of (1) trends that vary over time, (2) trends that are invariant over time, and (3) a spatially and temporally stationary spatial correlation among the residuals from these trends. MEUK provides a geostatistical basis for implementing "wheel-and-axle" monitoring strategies (Ward et al., 1990, *Design of Water Quality Monitoring Systems*), in which a core group of locations is monitored with a high frequency to track conditions over time while a larger group of locations is measured less frequently to provide synoptic depictions of spatial patterns. MEUK leads to improved trend estimates when the spatial distribution of monitoring locations varies greatly from event to event, and when there is an uncertain level of noise present in the data.

MEUK (Tonkin et al., 2013) is comprised of two distinct processes:

1. **Estimation:** use of the generalized least-squares (GLS) regression to obtain the coefficients for the defined trend terms ("calibration")

2. **Prediction:** solution of the kriging system of equations using the coefficients estimated through "1. Estimation" to predict water levels at intermediate locations and/or times, such as when producing a grid suitable for contouring ("mapping")

Prior to undertaking MEUK (Tonkin et al., 2013), an underlying trend must be proposed that is based on independent information about the site. Components of the trend must be specified as either global or local:

- Global trend components are assumed to apply throughout the period represented by the multi-event data set.

- Local trend components are assumed to apply only for individual events (or for groups of events) and to change between different events (or groups of events), based on internal or external stresses.

Using MEUK (Tonkin et al., 2013), all occasions at which water levels are measured are interpolated simultaneously through the solution of a single block-diagonal, multi-event, UK matrix. In doing so, MEUK has the following advantages over other interpolation methods for applications such as at 200-UP-1:

- GLS regression enables the incorporation of numerous physically-based trend terms and estimation and reporting of the coefficients of those trend terms. These coefficients can be reviewed to determine the strength of association between the source feature(s) and the resulting map.
- Water level data from all events are evaluated simultaneously within a single GLS/UK operation, which enables trend coefficients and interpolated maps to be conditioned on the entire data set.
- Single-point cross-validation can be used to evaluate the role of each data point in the prediction, using the underlying trend, when that point is excluded from the estimation process.
- MEUK produces maps that honor measured data, and once reviewed for consistency with independent information, can be used for other subsequent analyses such as evaluating groundwater flow directions and rates, and contaminant fate and transport.

Although global trends apply to the entire data set, the effect of a global trend component can vary between events, through the specification of event specific strengths. For example, aquifer transmissivity may be considered fairly constant over time (i.e., for all events) and, hence, is a candidate for a global trend component; however, the effect of well pumping can vary by specifying that the pumping rate varies between events. SGW-42305 presents the general form of the trend equations that are solved when constructing potentiometric surface maps using these techniques: the specific form of the trend equation used to prepare potentiometric maps for 200-UP-1 performance monitoring using MEUK (Tonkin et al., 2013) will be detailed in corresponding reports and calculation packages.

The MEUK (Tonkin et al., 2013) technique is programmed in the R language (R Core Team, 2013), uses the gstat package (Pebesma, 2004, "Multivariable geostatistics in S: the gstat package"), and can be supplemented or validated using KT3D_H2O (Karanovic et al., 2009, "KT3D_H2O: A Program for Kriging Water Level Data Using Hydrologic Drift Terms").

3.2.1.5 Calculation of Water Level Trends

Changes in water levels over time will be evaluated to understand (1) the continuing water table recession following cessation of large-scale waste-water disposal at the site; (2) the potential for wells to become dry, impacting the integrity of the monitoring network; and (3) the magnitude and extent of drawdown and mounding in response to extraction and injection in the vicinity of groundwater P&T systems. Water level changes will first be evaluated qualitatively through review of the hydrographs prepared as described in Section 3.2.1.1. Although this will reveal some patterns of change, such a review will not always enable the causes of the changes to be elucidated. The association between water level changes and probable causes will be determined through evaluation of the trend coefficients obtained from the MEUK (Tonkin et al., 2013) estimation (GLS) procedure. The MEUK GLS estimation procedure will be used to help estimate and apportion the rates of change at each well due to (1) water table recession from past waste-water disposal activities versus, (2) nearby groundwater extraction and injection versus, (3) any other activities that could result in a sustained change in groundwater levels over time. Estimates of drawdown and mounding in the vicinity of groundwater P&T remedies will then be made either by subtracting potentiometric surfaces constructed using MEUK, as described, with an adjustment to account

for the background rate of water table decline, or by using the MEUK technique directly to interpolate drawdown and mounding values computed for each individual well that have already been adjusted for the background water table decline.

3.2.1.6 Calculation of Hydraulic Capture

The extent of hydraulic containment developed by extraction and injection at groundwater P&T systems will be estimated by particle tracking on the potentiometric surfaces computed using the MEUK (Tonkin et al., 2013) method, as described in this report and detailed in SGW-42305. The extent of hydraulic containment may be depicted using flowlines (i.e., particle tracks), that depict the approximate path of individual parcels of groundwater, or color flooded images to distinguish and contrast those areas that will eventually be captured by the extraction wells from those areas that will not.

3.2.2 Water Level Monitoring Network

To provide the data needed to implement MEUK (Tonkin et al., 2013) methodology, as well as to provide the data needed for regional mapping of the 200-UP-1 OU water table, a three-tiered approach to water level monitoring will be used. First, automated water levels will be collected using pressure transducers and data loggers installed in selected monitoring wells near groundwater extraction systems. These areas are expected to exhibit the most dynamic water level changes that will occur within the OU, and these changes can best be monitored by collecting automated measurements. The automated water level stations will be part of AWLN.

Second, manual water level measurements will be collected several times each year from a network of wells in the vicinity of groundwater extraction systems. This information, combined with the automated measurements, will be analyzed by MEUK (Tonkin et al., 2013) (Section 3.2.1.4) to develop a series of potentiometric surfaces representative of water level conditions during the year. The potentiometric surfaces will be used in particle track analyses to delineate hydraulic capture. This combination of high-frequency automated measurements from a small well network and lower frequency manual measurements from a larger well network constitutes the "wheel-and-axle" strategy suited to the MEUK (Tonkin et al., 2013) method (Section 3.2.1.4).

The well network for monitoring the groundwater extraction systems within the 200-UP-1 OU is shown in Figure 3-8. Initially, the network is designed to support WMA S-SX and U Plant area groundwater extraction systems. This network will be expanded in the future as other active remedies are designed (e.g., hydraulic control of the iodine-129 plume and groundwater extraction of the southeast chromium plume).

Third, a set of manual water level measurements are collected in March of each year across the entire 200-UP-1 OU as part of Hanford Site water level monitoring (SGW-38815). The sitewide measurements are used to construct annual water table maps for the Hanford Site which support the annual groundwater monitoring report (e.g., DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). Such maps provide information on regional groundwater flow directions and will be used to (1) evaluate the adequacy of the sampling well network, (2) monitor for changes in groundwater flow directions that may impact the efficacy of active or passive remedies, and (3) to support groundwater model calibration. The wells used for the regional water table map within the 200-UP-1 OU are shown in Figure 3-9.

The water level monitoring network for the 200-UP-1 OU is listed in Table 3-2.

3.2.3 Water Level Monitoring Frequency

Manual measurements in support of the groundwater extraction systems will be collected monthly for one year after the start of operations in the U Plant area (the WMA S-SX system has been operating since

2012). The data will be analyzed by the MEUK (Tonkin et al., 2013) method described in Section 3.2.1.4. After one year, the frequency of the manual measurements may be reduced to quarterly if the results of the analysis indicate that groundwater conditions are stable enough to allow for reliable determinations of groundwater flow and hydraulic capture using lower frequency measurements. The automated water level measurements will be collected on an hourly frequency.

The manual measurements supporting regional water level monitoring are collected annually during March (SGW-38815). These measurements have been collected for many years, and an annual frequency has proven sufficient to monitor changes to the regional water table.

3.2.4 Sources of Uncertainty

The potentiometric surface maps are constructed using a technique that incorporates the effects of drawdown and mounding due to groundwater extraction and injection, respectively (SGW-42305). The resulting maps respect the values of water levels measured at each well and provide a plausible interpretation of groundwater levels and hydraulic gradients between measured locations. However, the accuracy of the contours is influenced by, but not limited to, the following:

- Accuracy of the measured (or recorded) water levels (described in SGW-38815 and SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*)
- Number and distribution of monitoring locations
- Relationship between the open interval of the monitoring wells and those of the extraction and injection wells
- Verticality of the monitored wells and impact of any deviations from vertical on calculated groundwater elevations
- Degree of adherence to, or violation of, assumptions that underlie the mapping method (as outlined in SGW-42305)

The water level monitoring network presented in Section 3.2.2 has good spatial coverage near the active remedies at WMA S-SX and the U Plant area. However, there is a lack of monitoring wells to the north of U Plant and the water table in this region is substantially affected by the 200-ZP-1 P&T system. Because this limitation is mitigated to some extent by the incorporation of extraction well flow rates into the UK mapping methodology (Section 3.2.1.4), there is no need to install monitoring wells solely for the purpose of water level monitoring. However, the potentiometric surface maps have more uncertainty in this area than would be the case if monitoring wells were available. If monitoring wells were to be installed north of U Plant for another purpose, they would be added to the hydraulic monitoring network.

The net effect of the potential sources of error listed above is that the potentiometric surface maps only approximate actual conditions. However, the water level and hydraulic capture maps are interpreted as reasonable approximations that provide value when determining the likely directions and rates of groundwater movement, and the likely extents of convergent hydraulic gradients consistent with capture.

3.3 Performance Monitoring Analysis and Reporting

Performance monitoring will be analyzed and reported on an annual basis. The monitoring will be reported in calendar year annual summary reports (e.g., DOE/RL-2014-26, *Calendar Year Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*).

Table 3-2. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
299-W14-71	C5102	LU			X
299-W15-37	B2753	UU	X		X
299-W18-15	A4932	TU		X	X
299-W18-21	A4933	TU			X
299-W18-22	A4934	LU			X
299-W18-40	C3395	TU			X
299-W19-101	C4966	TU	X	X	X
299-W19-105	C4968	TU		X	X
299-W19-107	C5193	UU	X		X
299-W19-12	A4945	TU			X
299-W19-18	A7743	TU		X	X
299-W19-34A	A9517	MU		X	X
299-W19-34B	A9513	MU		X	X
299-W19-35	A9515	TU			X
299-W19-36	B2461	TU	X	X	X
299-W19-39	B2460	TU		X	X
299-W19-41	B8551	TU			X
299-W19-42	B8553	TU			X
299-W19-43	C3381	TU		X	X
299-W19-44	C3393	TU			X
299-W19-45	C3394	TU			X
299-W19-46	C3958	TU		X	X
299-W19-47	C4258	TU			X
299-W19-48	C4300	TU	X	X	X
299-W19-49	C4695	TU		X	X
299-W21-2	C4639	TU			X
299-W22-24R	A9570	LU			X
299-W22-24S	A9571	MU			X
299-W22-24T	A9572	MU			X
299-W22-44	A4975	TU			X

Table 3-2. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
299-W22-45	A4976	TU		X	X
299-W22-47	C4667	TU		X	X
299-W22-49	B8813	TU		X	X
299-W22-50	B8814	TU	X	X	X
299-W22-69	C4969	TU		X	X
299-W22-72	C4970	TU		X	X
299-W22-79	B8552	TU			X
299-W22-80	C3115	TU		X	X
299-W22-81	C3123	TU		X	X
299-W22-82	C3124	TU		X	X
299-W22-83	C3126	TU	X		X
299-W22-84	C3398	TU	X	X	X
299-W22-85	C3399	TU	X	X	X
299-W22-86	C4971	TU	X	X	X
299-W22-87	C4977	TU		X	X
299-W22-88	C4978	TU	X		X
299-W22-89	C7664	TU		X	X
299-W22-94	C8203	TU	X	X	X
299-W22-95	C8240	UU		X	X
299-W22-96	C8241	TU		X	X
299-W23-15	A4984	TU		X	X
299-W23-20	C3112	TU		X	X
299-W23-21	C3113	TU		X	X
299-W26-13	B8817	TU			X
299-W26-14	B8828	TU			X
299-W27-2	A5410	LU			X
699-30-66	C4298	LU			X
699-32-62	A5128	TU			X
699-32-72B	A9525	TU			X
699-32-76	C4975	TU			X

Table 3-2. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
699-32-77	A5131	TU			X
699-33-74	C4973	TU			X
699-33-75	C4974	TU		X	X
699-33-76	C4976	TU			X
699-34-61	A5463	TU			X
699-34-72	C4972	TU		X	X
699-35-66A	A5139	TU			X
699-35-78A	A5141	TU	X		X
699-36-61A	A5144	TU			X
699-36-66B	C6219	TU			X
699-36-70A	A9901	TU			X
699-36-70B	C4299	TU		X	X
699-37-66	C5704	TU			X
699-38-65	A5148	TU			X
699-38-70B	C4236	MU			X
699-38-70C	C4256	LU			X
699-40-62	A5158	TU			X
699-40-65	C4235	TU			X

a. Identifies the relative position of the screened interval in the aquifer, as follows:

- TU (top of unconfined): Screened across or within 1.5 m (5 ft) of the water table with less than 10.7 m (35 ft) of the open interval extending below the water table.
- UU (upper unconfined): Screened across or within 1.5 m (5 ft) of the water table with more than 10.7 m (35 ft) but no more than 15.2 m (50 ft) of the open interval extending below the water table, or screened deeper than 1.5 m (5 ft) below the water table and open interval extends no more than 15.2 m (50 ft) below the water table.
- MU (middle unconfined): Open interval begins at greater than 15.2 m (50 ft) below the water table and does not extend below the middle coarse of the Ringold Formation (unit 7) or to within 15.2 m (50 ft) of the top of basalt.
- LU (lower unconfined): Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse of the Ringold Formation (unit 7) or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.

b. Monthly for one year, then evaluate if a quarterly frequency is acceptable thereafter.

c. Collected annually in March.

AWLN = Automated Water Level Network

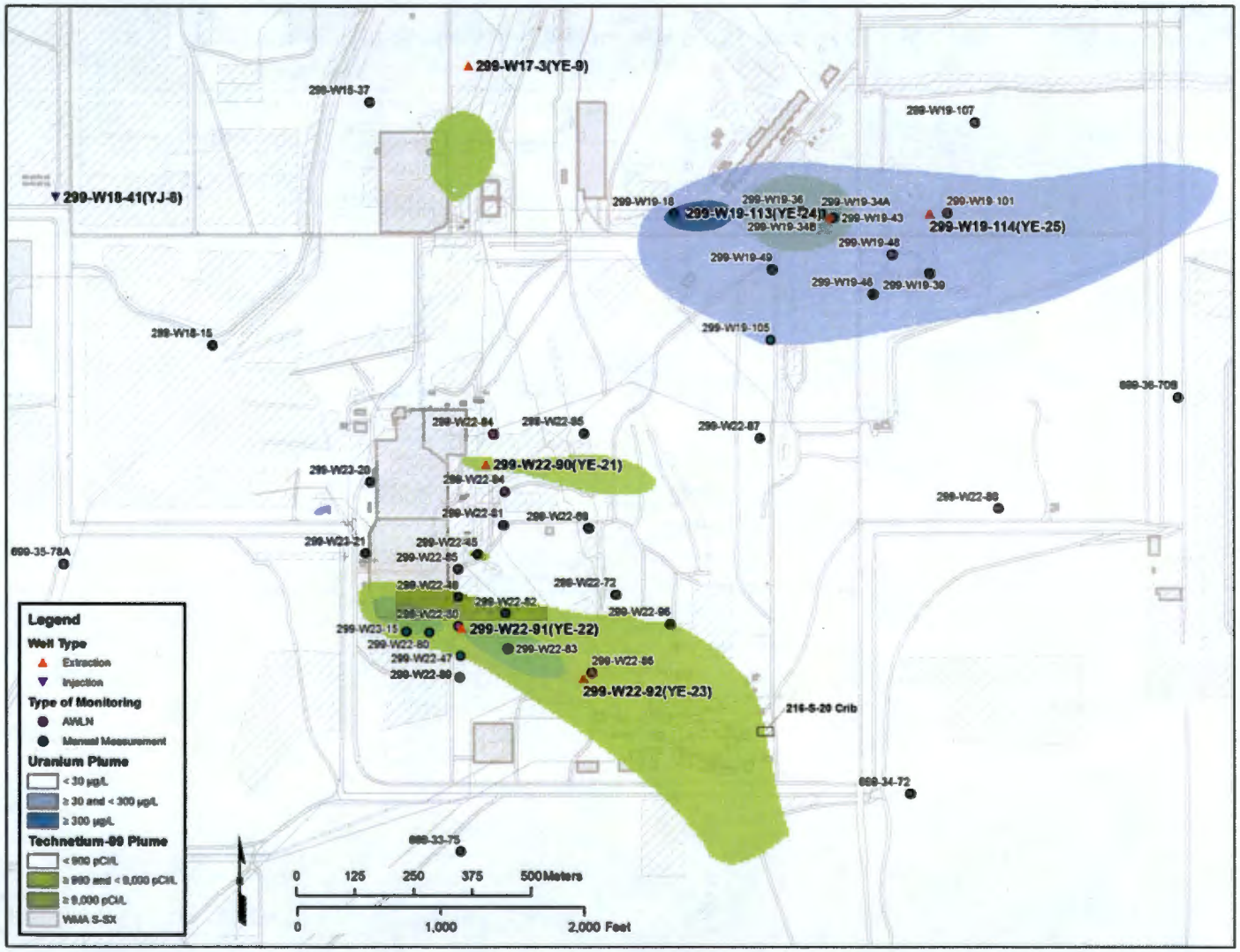
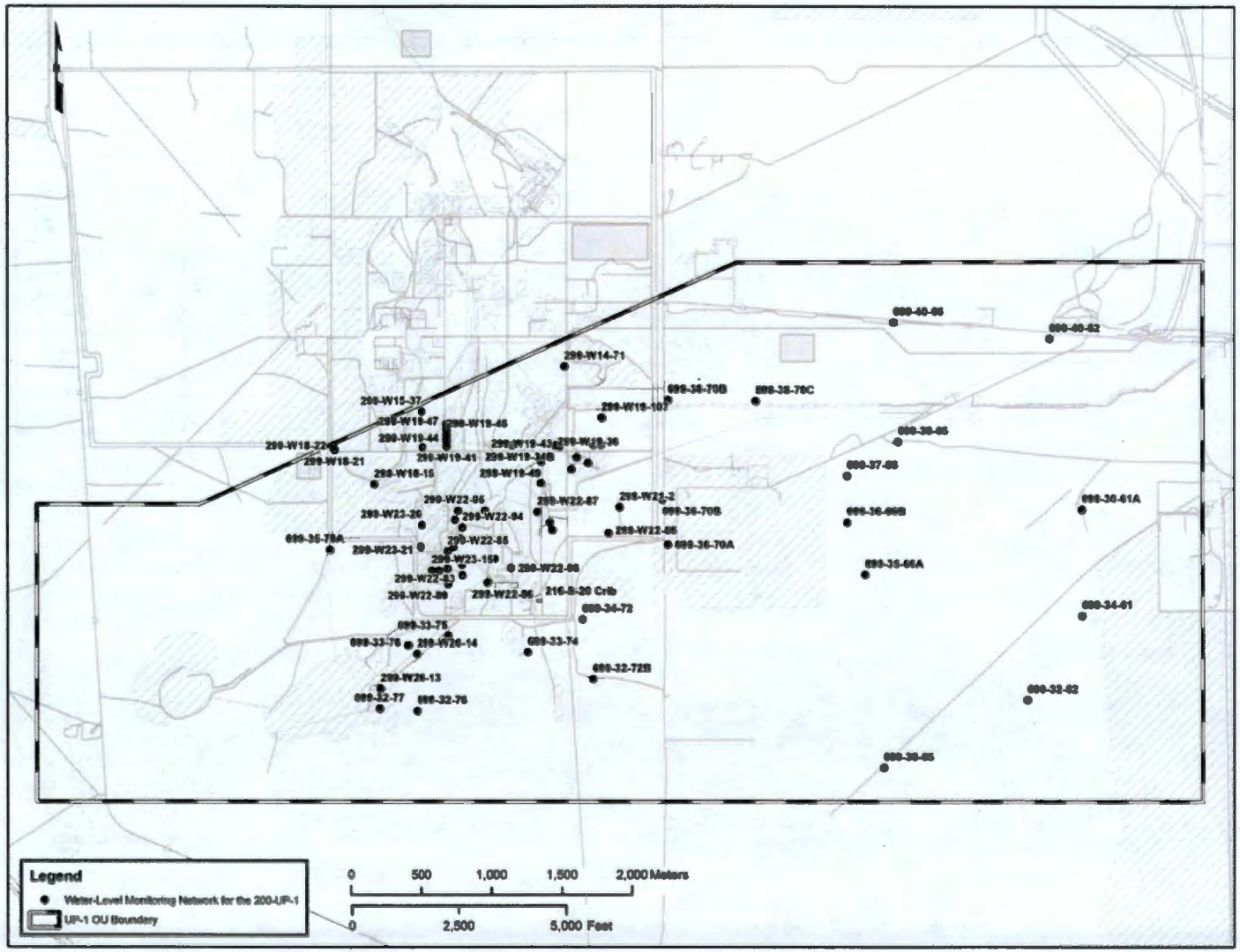


Figure 3-8. Water Level Network for Waste Management Area S-SX and U Plant Area Groundwater Extraction Systems


299-W14-71
299-W15-37
299-W18-22
299-W18-21
299-W18-15
299-W19-47
299-W19-44
299-W19-45
299-W19-41
299-W19-43
299-W19-36
299-W19-40
299-W22-95
299-W22-94
299-W22-87
299-W22-85
299-W23-20
299-W23-21
299-W23-159
299-W22-83
299-W22-89
299-W22-86
216-B-20 Crib
299-W26-14
299-W26-13
299-W21-2
299-W22-88
299-W19-107
299-W19-46
299-W19-34B
299-W19-39
299-W19-42
299-W19-36
299-W19-40
299-W19-41
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Appendix A

Data Quality Objectives

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Terms

AWLN	Automated Water Level Network
bgs	below ground surface
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DQO	data quality objective
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
HSU	hydrostratigraphic unit
IC	institutional control
MNA	monitored natural attenuation
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
PQL	practical quantitation limit
PSQ	principal study question
QA	quality assurance
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RAWP	remedial design/remedial action work plan
REDOX	Reduction-Oxidation (Plant)
RI/FS	remedial investigation/feasibility study

ROD	record of decision
SAP	sampling and analysis plan
TCE	Trichloroethene
UCL_{95}	95 percent upper confidence limit
WMA	waste management area

A1 Introduction

The purpose of this data quality objective (DQO) process is to support the development and design of the environmental data and information collection activities needed to develop a performance monitoring plan (PMP) and associated sampling and analysis plan (SAP) for the 200-UP-1 Groundwater Operable Unit (OU) (Figure A-1). Monitoring objectives for the OU are for groundwater sampling through active remedy implementation and do not include attainment monitoring for long term monitored natural attenuation (MNA).

This document follows DQO guidance identified in EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objective Process*. The following steps are used for DQO development:

1. State the problem
2. Identify the goal of the study
3. Identify 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

The environmental data needed to evaluate groundwater remedy performance, guide remedy optimization, measure the progress toward final cleanup level and remedial action objective (RAO) achievement, and characterize the southeast chromium plume in the 200-UP-1 OU have been identified, using the U.S. Environmental Protection Agency (EPA) seven-step process .

The current contaminants of concern (COCs) are identified are shown in Table A-1. In addition, five contaminant of potential concern (COPC) were identified (1,4-dioxane, chloroform, strontium-90, tetracholoroethene, and trichloroethene)

Although chromium is listed in the record of decision (ROD) (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*) as two COCs (total chromium and hexavalent chromium [Cr(VI)]), it occurs in Hanford Site groundwater only in the mobile hexavalent form. Total chromium and Cr(VI) have different cleanup levels (100 and 48 µg/L, respectively) specified in the ROD (EPA et al., 2012). In this DQO, sample results for total chromium and Cr(VI) will typically be referred to simply as chromium, and the effective cleanup level is 48 µg/L because it is more restrictive.

A1.1 State the Problem

A series of individual problem statements has been developed to focus the scope of data collection. Each problem statement identifies a condition, or conditions, that require measurement and observation data to meet specific data needs. In some instances, the same data may fill data needs for more than one problem statement.

The problem statement is created to define the issues that require new environmental data, so the focus of the study will be clear and unambiguous. Pertinent information from similar studies and assumptions should be organized, reviewed, identified, evaluated, and documented.

A PMP that defines the requirements for groundwater performance monitoring is required for the 200-UP-1 OU. Remedy performance monitoring will be conducted over the lifetime of the interim remedial action described in the 200-UP-1 ROD (EPA et al., 2012) to evaluate its performance and optimize

effectiveness. The PMP will include water level measurements and groundwater sampling and analysis of analytical data from monitoring wells to assess changes in contaminant plume geometry, active and monitored natural attenuation (MNA) remedy performance, and hydraulic control of iodine-129. Additional groundwater sampling will be performed to monitor trends of COPCs at select locations.

During the performance monitoring time frame, statistical evaluation of monitoring well data will be performed to assess progress in achieving cleanup levels. The process will follow groundwater risk assessment guidance, where the exposure point concentration for each plume within the OU will be continuously evaluated based on available performance monitoring measurements. As presented in the remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*), the statistical analysis will consist of calculating the upper one-sided 95 percent confidence limit (UCL_{95}) for each COC for comparison to the cleanup levels. The UCL_{95} will be calculated periodically (at least once every 3 years) as new monitoring data are collected to assess progress in achieving cleanup levels and the need for continued active remediation. The active portion of the remedy will be considered complete when the UCL_{95} is less than or equal to cleanup levels. Following the active remediation period, MNA will be evaluated to ensure that cleanup levels have been achieved throughout the contaminated groundwater plumes.

Taken from the RD/RAWP (DOE/RL-2013-07), Table A-2 provides a conceptual list of pump and treat (P&T) and hydraulic containment components by plume area, and Figure A-2 illustrates expected temporal changes in aquifer concentrations for COCs actively pumped (expressed as UCL_{95}). The remedy is expected to achieve cleanup levels for technetium-99 within 15 years, uranium within 25 years, chromium within 25 years, and nitrate within 35 years through P&T and MNA. MNA is the selected remedy for the tritium plume, which is expected to achieve cleanup levels within 25 years.

Groundwater concentrations shown in Figure A-3 illustrate a conceptual response timeline for groundwater remediation progress. Remediation activities within the 200-UP-1 OU are expected to follow a similar pattern. Two aspects of particular concern in this timeline are (1) determining when to end active remediation, and (2) determining when RAOs can be demonstrated to be attained. This PMP will focus on step 2: "active and passive remediation with performance monitoring."

Data are also required to characterize the southeast 200-UP-1 chromium plume. However, relatively few monitoring wells are available in the area to define the vertical and horizontal extent of this plume at this time, so additional characterization will be performed to refine the plume geometry and optimize the remedial design. Data collection and well installation activities for the characterization in the southeast chromium plume is described in DOE/RL-2014-27, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*. Groundwater sampling for wells installed for the southeast chromium characterization is included in this DQO.

To help identify the data quality objectives required to develop a successful 200-UP-1 PMP, the following three problem statements were developed:

- Problem Statement #1: Remedy performance monitoring is required over the lifetime of the interim remedial action described in the 200-UP-1 ROD to evaluate its performance and optimize effectiveness.
- Problem Statement #2: Sampling is required to monitor groundwater concentration trends of COPCs at limited 200-UP-1 locations.

Table A-1. Cleanup Levels for 200-UP-1 OU COCs

COCs	Units	90th Percentile Groundwater Concentrations	Federal DWS	MTCA Method B Cleanup Levels		Cleanup Level
				Non-carcinogens at HQ = 1	Carcinogens at 1×10^{-6} Risk Level	
Iodine-129	pCi/L	3.5	1	—	—	1[d]
Technetium-99	pCi/L	4,150	900	—	—	900
Tritium	pCi/L	51,150	20,000	—	—	20,000
Uranium	µg/L	206	30	—	—	30
Nitrate[b] (as NO_3)	mg/L	133	45	113.6	—	45
Nitrate[b] (as N)	mg/L	30.1	10	25.6	—	10
Total chromium	µg/L	99	100	24,000	—	100
Hexavalent chromium	µg/L	52	—	48	—	48
Carbon tetrachloride	µg/L	189	5	5.6	0.34[e]	3.4[f]

Source: Table 14 of the *Record of Decision for Interim Remedial Action, Hanford 200 Area Superfund Site, 200-UP-1 Operable Unit* (EPA et al., 2012).

a. Federal DWS from 40 CFR 141, "National Primary Drinking Water Regulations," with iodine-129 and technetium-99 values from EPA 816-F-00-002, *Implementation Guide for Radionuclides*.

b. Nitrate (NO_3) may be expressed as the ion NO_3 (NO_3- NO_3) or as nitrogen (NO_3-N). The federal DWS for nitrate is 10 mg/L expressed as N, and 45 mg/L expressed as NO_3-. The Washington State cleanup level is 25.6 mg/L, as nitrogen.

c. There is no federal DWS for hexavalent chromium.

d. Currently identified groundwater treatment technology is insufficient to reach the 1 pCi/L DWS.

e. This value is represents estimated risk from an individual contaminant, at 1×10^{-6} risk level.

f. This cleanup level is a risk-based calculation for carbon tetrachloride. This value represents a cumulative 1×10^{-5} risk in accordance with WAC 173-340-720(7)(a).

COC = contaminant of concern
DWS = drinking water standard
HQ = hazard quotient
MTCA = *Model Toxics Control Act*

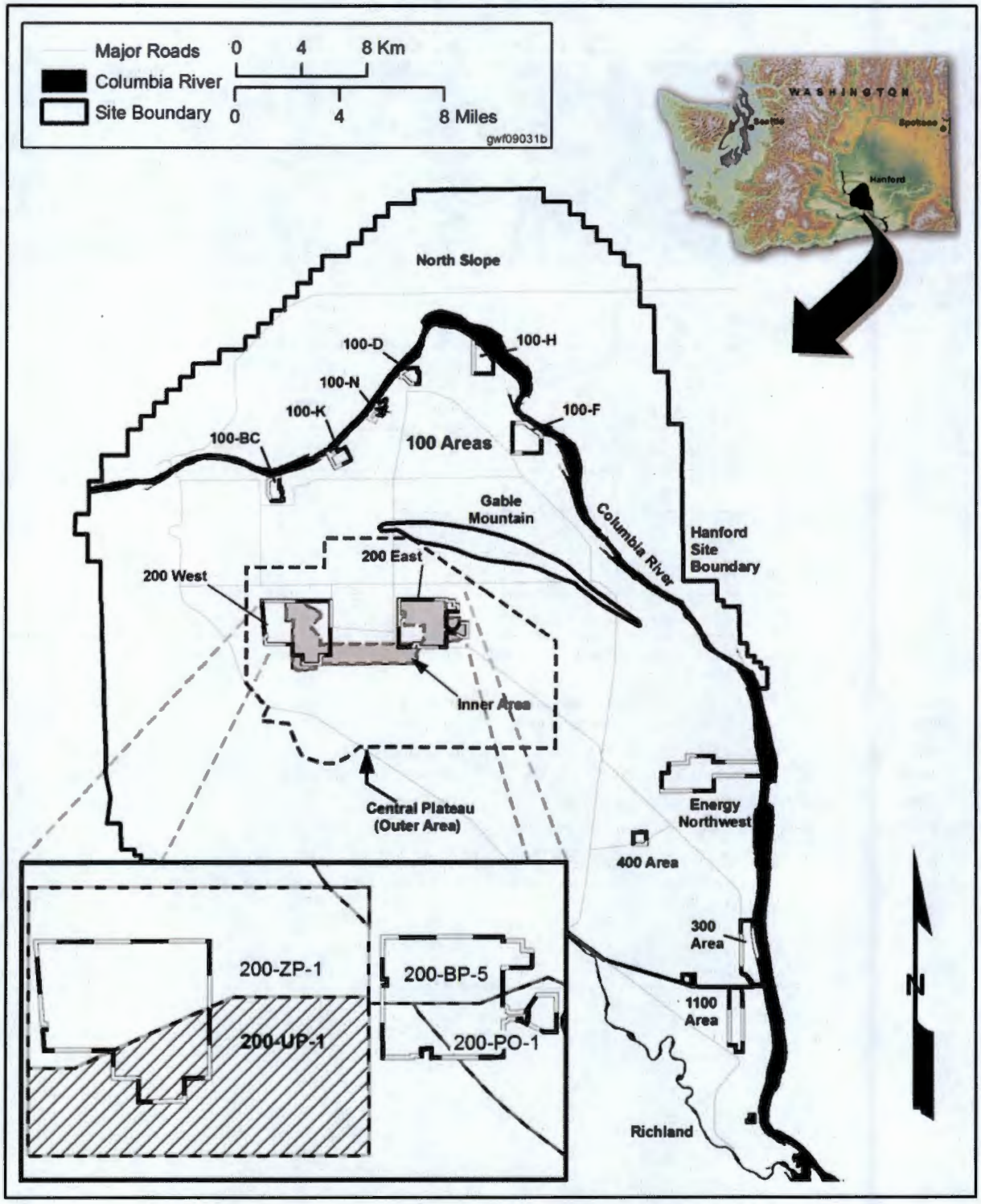

Figure A-1. Location of the 200-UP-1 Operable Unit

Table A-2. 200-UP-1 Operable Unit Pump-and-Treat Components (modified from Table 3-4 of DOE/RL-2013-07)

Location	Contaminants of Concern	Expected Well Field	200 West Groundwater Treatment Facility
Waste Management Area S-SX	Technetium-99, nitrate, chromium, and carbon tetrachloride	Three extraction wells, total flow of 80 gpm for 15 years	Currently being treated at the P&T flowing through Tc-99 ion exchange and biological processes followed by air stripping
U Plant Area	Uranium, technetium-99, nitrate, and carbon tetrachloride	Two extraction wells, average flow of 150 gpm for 25 years	Will be treated in sequence through the following processes: uranium ion exchange, technetium-99 ion exchange, and biological process followed by air stripping
Southeast Chromium Plume Area	Chromium	Two extraction wells and two injection wells, average flow of 200 gpm for 25 years	Will be treated through the biological treatment process
Iodine-129 Hydraulic Containment	Iodine-129 (no treatment)	Three injection wells for hydraulic control, 50 gpm per well	200 West P&T will return 150 gpm of treated water for hydraulic control

gpm = gallons per minute P&T = pump-and-treat

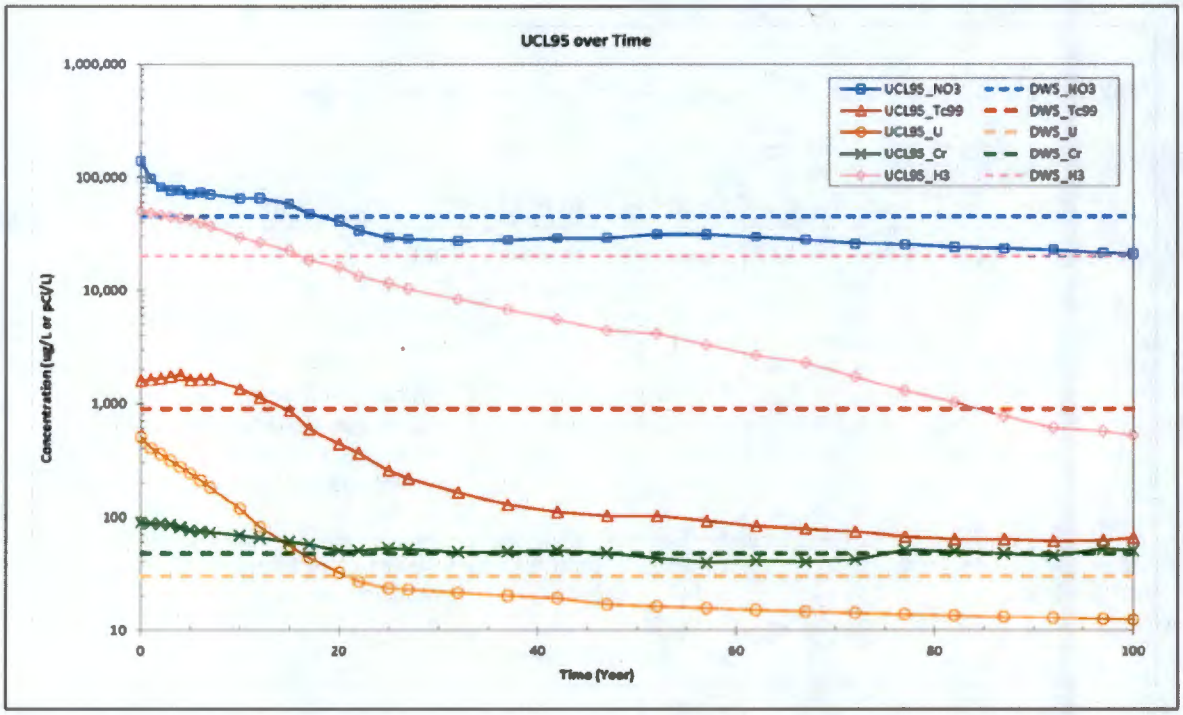

Figure A-2. Estimated Reduction in Contaminant of Concern Exposure Point Concentrations (UCL_{95}) over Time

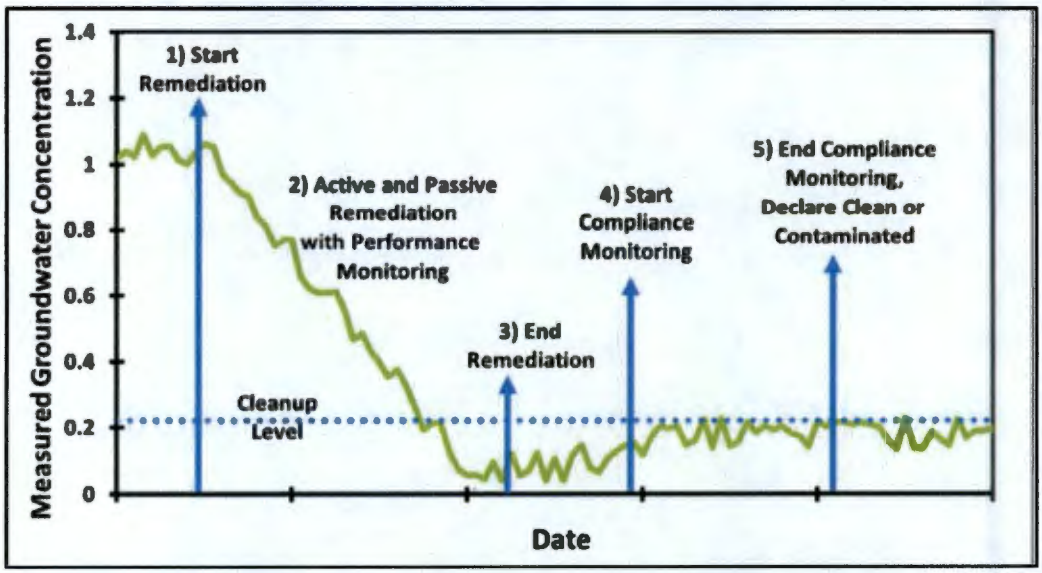

Figure A-3. Conceptual Response Timeline for Groundwater Remediation Progress

A1.1.1 Planning Team

The planning team that participated in the 200-UP-1 DQO process is show in Table A-3.

Table A-3. 200-UP-1 Planning Team

Name	Organization	Role
Curt Wittreich	CHPRC	200-UP-1 Project Delivery Manager
Craig Arola	CHPRC	Task Lead
John McDonald	CHPRC	Subject Matter Expert
Alaa Aly	CHPRC	Risk and Modeling Integration
Justin Jayne	INTERA	Risk and Modeling Support
Roger Ovink	WCH	DQO Facilitator and Document Author
John Morse	DOE-RL	DOE-RL Groundwater Lead
Naomi Jaschke	DOE-RL	DOE-RL Project Manager
Emerald Laija	EPA	EPA Project Lead
Ken Moser	Kurion	DQO Panel
Kevin Kytola	Sapere	DQO Panel
Rob Mackley	PNNL	DQO Panel

CHPRC = CH2M HILL Plateau Remediation Company
DOE-RL = U.S. Department of Energy, Richland Operations Office
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
PNNL = Pacific Northwest National Laboratory
WCH = Washington Closure Hanford

A1.1.2 Conceptual Site Model

The Hanford Site lies within the semiarid, shrub-steppe Pasco Basin of the Columbia Plateau in southeastern Washington State. The 200 West and 200 East Areas are located on a broad, relatively flat area that constitutes a local topographic high near the center of the Hanford Site. The 200-UP-1 OU underlies the southern portion of the 200 West Area, which is on the western end of the Central Plateau. Figure A-4 presents the location of the 200-UP-1 OU and the groundwater plumes associated with it.

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 primarily of sand and gravel, with some silt layers. Sediments in the vadose zone are the Ringold Formation, the Cold Creek unit (CCU), and the Hanford formation. Geologic units above the basalt bedrock are laterally continuous across the majority of the OU and (in descending sequence) are as follows:

- Unconsolidated sand and gravel of the Hanford formation (hydrostratigraphic unit [HSU] 1)
- Fine-to-coarse grained sediment of the CCU (HSU 3)

- Semi-consolidated silt, sand, and gravel of the Ringold Formation unit E (HSU 5)
- Silt and clay of the Ringold Formation lower mud unit (HSU 8)
- Semi-consolidated silt, sand, and gravel of the Ringold Formation unit A (HSU 9)

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the lower Ringold Formation and the basalt. In general, Central Plateau groundwater flows in a predominantly easterly direction from the 200 West Area to the 200 East Area (Figure A-4). Historical liquid waste discharges to the ground (e.g., cooling water and process wastewater) during the 1940s through the 1990s greatly altered the groundwater flow regime, especially around the 216-U-10 Pond in the 200 West Area, which created a large water table mound that deflected the groundwater flow to the northeast. As drainage from these discharges has ceased, the water table has been declining, and groundwater flow direction is returning to a more easterly course through the Central Plateau. There are currently no liquid waste discharges to the ground above the 200-UP-1 OU (with the exception of sanitary drain fields).

The water table is relatively deep within the 200-UP-1 OU, averaging approximately 75 m (250 ft) below ground surface (bgs). Groundwater contamination is largely contained within the uppermost-unconfined aquifer, which ranges in thickness from approximately 10 to 100 m (33 to 330 ft). The unconfined aquifer controls the lateral movement of groundwater contaminants across the OU and is bounded below by the Ringold Formation lower mud unit (HSU 8). This mud layer acts as a hydraulic impediment over the majority of the OU and limits groundwater flow from moving into the confined aquifer below. Groundwater flow is locally influenced by the 200-ZP-1 OU final remedy P&T system and the Waste Management Area (WMA) S-SX interim remedial measure extraction system.

Figure A-4 shows the 200-UP-1 OU groundwater plumes (location and size) based on DOE/RL-2014-32, *Hanford Site Groundwater Monitoring for 2013*. More than 90 groundwater monitoring wells were used to assess the nature and extent of these contaminants within and surrounding the 200-UP-1 OU. The 200-ZP-1 OU plumes to the north are also shown on Figure A-4. The plumes originating within the 200-UP-1 OU include the following:

- A uranium plume originating from the U Plant cribs
- A nitrate plume originating from U Plant and S Plant cribs and WMA S-SX
- Three chromium plumes: two associated with WMA S-SX and a third dispersed chromium plume in the southeast corner of the OU that originated from the Reduction-Oxidation (REDOX) Plant disposal facilities
- An iodine-129 plume originating from U Plant and S Plant cribs
- Four separate technetium-99 plumes associated with WMA U, U Plant cribs, and WMA S-SX
- A tritium plume originating from S Plant cribs

In addition to the plumes that formed within the 200-UP-1 OU, a carbon tetrachloride plume exists over a large portion of the 200 West Area that originated from the 200-ZP-1 OU. Groundwater monitoring for this plume is addressed in the PMP for the 200-ZP-1 OU (DOE/RL-2009-115) and associated SAP (Appendix A of DOE/RL-2009-124).

A1.1.3 Resources

The various organizations participating in this DQO process have provided the DQO planning team members (Table A-3) and their administrative support staff. Should additional technical support be required (beyond the planning team members noted above), additional resources will be identified.

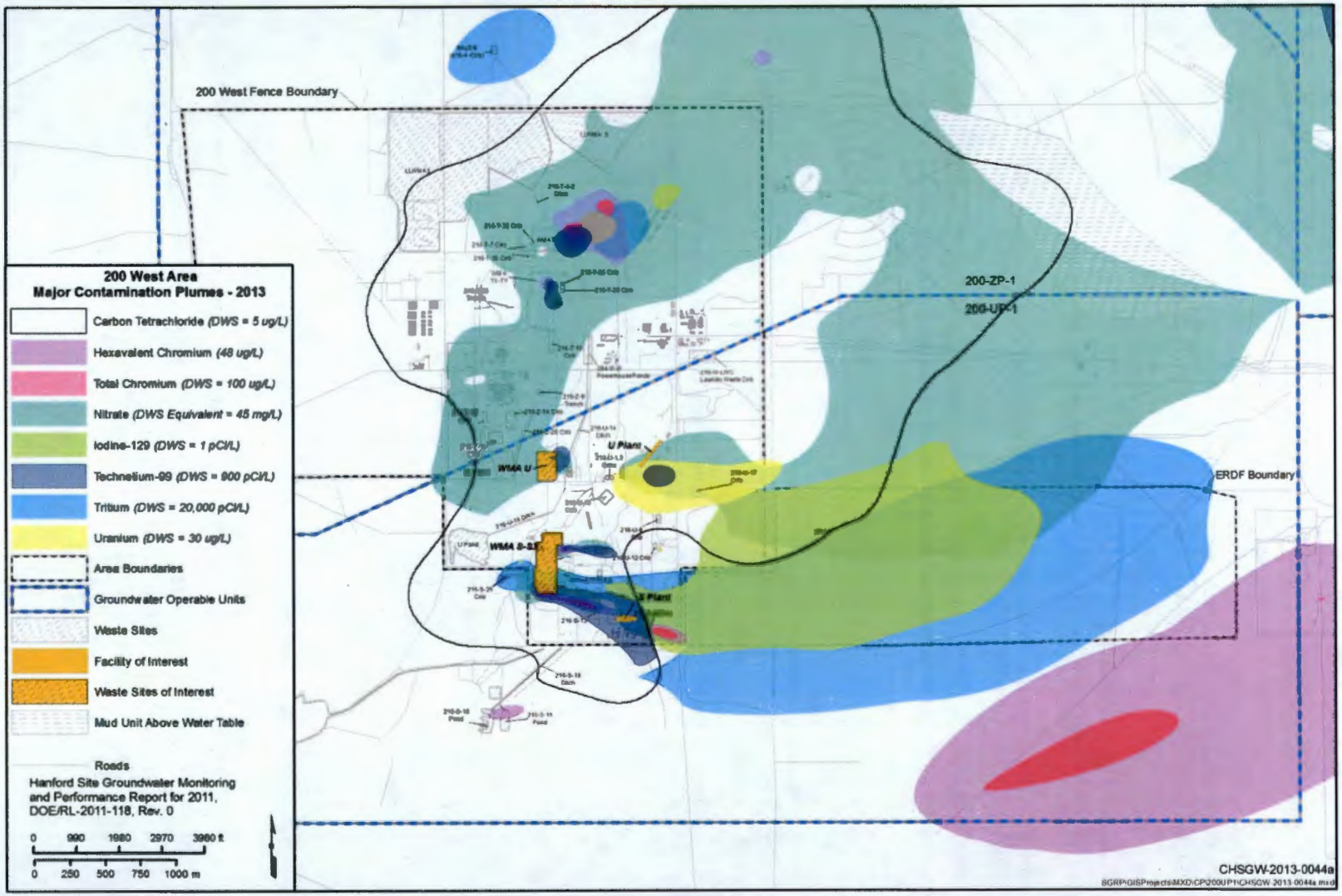

Figure A-4. Location Map of 200-UP-1 Operable Unit and Contaminant of Concern Plumes

A1.2 Step 2: Identify the Goal of the Study

The purpose of the groundwater-monitoring plan is to identify groundwater monitoring sufficient to collect data to track the progress of cleanup actions in the 200-UP-1 OU. Step 2 of the DQO process involves identification of key principal study questions (PSQs) that the study attempts to address. Each PSQ corresponds to a problem statement identified in Step 1. This DQO step identifies the question(s) that the study will address and alternative actions or outcomes that may result based on the results.

A1.2.1 Principal Study Questions

The following two PSQs have been identified for resolution in this DQO:

1. Are the 200-UP-1 cleanup criteria and RAO for groundwater being achieved within the time frames projected in the RD/RAWP (DOE/RL-2013-07)?
    a. RAO 1: Return the 200-UP-1 OU groundwater to beneficial use as a potential drinking water source (i.e., COC concentrations < cleanup levels [CULs]).
        i. P&T Component
            1. Uranium: 25 years
            2. Technetium-99: 15 years
            3. Nitrate (groundwater hot spot removal): 25 years
            4. Chromium (total and hexavalent): 25 years
            5. For all P&T contaminants:
                a. Are the P&T systems performing as intended?
                b. Is there evidence of COC plume concentration, area, or location changes?
                i. Are groundwater contaminant concentrations declining?
                ii. Are plume areas declining?
                iii. Is there evidence of plume migration?
        ii. MNA Component
            1. Nitrate: plume tracking over ~25 years until hot spot removal action is complete; MNA as a secondary remedy (~10 more years for MNA)
            2. Carbon tetrachloride: 200-ZP-1 is source and will treat; MNA is secondary remedy that starts in ~20 years; ~125 years anticipated until cleanup level is achieved (addressed in the 200-ZP-1 OU PMP [DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*]).
            3. Tritium: MNA (25 years) is a primary remedy that starts immediately
            4. Technetium-99 (15 years): S-SX is the main source
            5. For all MNA contaminants:
                a. Is natural attenuation proceeding as predicted?
                b. Is there evidence of COC plume concentration, area, or location changes?
                i. Are groundwater contaminant concentrations declining or stable?
                ii. Are plume areas declining or stable?
                iii. Is there evidence of plume migration?

iii. Hydraulic containment component for iodine-129

1. Is hydraulic containment proceeding as predicted?

a. Are plume areas being contained?
b. Is there evidence of plume migration?

b. RAO 2: Prevent human exposure to contaminated 200-UP-1 OU groundwater that exceeds acceptable risk levels for drinking water. This RAO will be achieved through institutional controls (ICs); no environmental data are needed.

2. Are concentrations of COPCs below action levels over the next 5 year time frame?

a. 1,4-dioxane: only identified in two wells (34-72 and historically in 299-W22-20 [now dry])
b. Trichloroethene: only identified in a limited area (Figure A-17)
c. Strontium-90: only identified in one well (299-W22-10)
d. Tetrachloroethene: generally identified in the same area as trichloroethene
e. Chloroform: identified as breakdown product of carbon tetrachloride.
3. For all the COPCs identified.

A1.2.2 Alternative Outcomes

The following alternative outcomes could result from addressing PSQs:

- Performance is as predicted, continue current monitoring program with no change.
- The conceptual model has changed, but performance is still consistent with expectations, modify monitoring program (e.g., new or different wells and sampling frequencies).
- The IRA is not predicted to meet objectives, reconsider groundwater remediation alternatives.

A1.2.3 Decision Statements

The following statements address PSQs:

1. Determine if the 200-UP-1 cleanup criteria and RAOs for groundwater are being achieved within the time frames projected in the RD/RAWP (DOE/RL-2013-07).

2. Determine if COPC concentrations are below action levels based on current/future information (5+ years of data).

A1.2.4 Key Assumptions

Assumptions used in the DQO process for the 200-UP-1 PMP include the following:

1. The PMP and SAP developed through this DQO will address only *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater monitoring requirements. Monitoring requirements for other regulatory programs (e.g., *Resource Conservation and Recovery Act of 1976* [RCRA]) for 200-UP-1 are identified in separate sampling plans.

2. Given the overlapping nature of several of the groundwater plumes, some monitoring wells may serve multiple needs. Wells historically used for monitoring the various 200-UP-1 groundwater plumes and general groundwater quality are included in this DQO.

3. The following groundwater contaminants will be addressed in this DQO:

a. COCs are uranium, technetium-99, tritium, iodine-129, Cr(VI), total chromium, carbon tetrachloride, and nitrate.

i. Sampling for carbon tetrachloride is covered in the 200-ZP-1 PMP.

b. COPCs are 1,4-dioxane, chloroform, trichloroethene, strontium-90, and tetrachloroethene.

4. Some of the existing 200-UP-1 groundwater monitoring wells may not be suitable in their construction and/or locations to support the various monitoring needs identified in the project objectives. New wells will be constructed to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," specifications.

5. Monitoring well locations, construction, sampling frequency, and target analytes will require approval from the U.S. Department of Energy (DOE)-Richland Operations Office (RL) and EPA (200-UP-1 SAP signatories).

6. This DQO will not address re-injection water quality criteria for treated groundwater used for iodine-129 hydraulic control. These requirements are discussed in DOE/RL-2009-124.

7. Statistical evaluations of data collected for the PSQs will be required to support future decisions associated with RAO achievement through P&T and MNA remedies (as evaluated by comparison of UCL_{95} concentrations to cleanup levels).

8. Within the 200 West Area, a carbon tetrachloride plume originated in the 200-ZP-1 OU and has spread into the 200-UP-1 OU. The final 200-ZP-1 ROD (EPA, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*) and associated PMP (DOE/RL-2009-115) address the carbon tetrachloride plume in its entirety.

9. Chromium groundwater data from U.S. Ecology groundwater monitoring wells will continue to be provided to the 200-UP-1 project.

10. Groundwater data for the southeast chromium plume will only be collected to monitor the plume location and migration; these data will not be used for UCL_{95} calculations. After drilling of the additional characterization wells, a well network for UCL_{95} calculations will be selected.

A1.3 Step 3: Identify Information Inputs

The third step of the DQO process is to identify information inputs (e.g., position of well with respect to the contaminant plume and contaminant concentration trends at each well) needed to resolve each of the PSQs developed in Step 2. Data may already exist or may be derived from computational or sampling and analysis methods. The information presented in Step 3 was derived from DOE/RL-2013-07; DOE/RL-2009-124; DOE/RL-2009-115; and DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*.

Information included constituent concentrations (both vertically and spatially), water level, flow direction, and transport characteristics for the aquifers underlying the 200-UP-1 OU.

Problem statements and respective PSQs are associated with specific data needs. Table A-4 identifies the data needs, measurement or observation needed, and data uses for each problem statement and PSQ.

Table A-4. Specific Data Needs to Address the Problem Statements and Principle Study Questions

Data Need	Measurement or Observation	Data Use
Problem Statement 1: Remedy performance monitoring is required over the lifetime of the interim remedial action described in the 200-UP-1 ROD to evaluate its performance and optimize effectiveness. **PSQ 1: Are the 200-UP-1 cleanup criteria and remedial action objectives for groundwater being achieved within the time frames projected in the remedial design/remedial action work plan?**		
Current monitoring well network (Figures A-5 to A-10)	Locations of current groundwater wells and contaminants sampled from each well	Definition of monitoring network
New or replacement wells needed to characterize 200-UP-1 areas of interest	Location and expected drilling date	Addresses potential data gaps in well coverage
Identification of representativeness of groundwater samples	Field parameters for all wells (e.g., anions and pH) as specified in CHPRC procedures	Indicates representativeness of groundwater samples
Strategy to select monitoring wells for each COC monitoring network	Monitoring wells locations with respect to known groundwater impacts, concentration trends of target contaminants, and/or well locations with respect to high concentration plume areas.	Definition of monitoring well frequency
Problem Statement 2: Monitoring of specific COPCs is required by the 200-UP-1 OU ROD. **PSQ 2: Are concentrations of COPCs below action levels over the next 5 year time frame?**		
Current monitoring wells with exceedances of risk based comparison levels (Section A.1.4.1.7)	Locations of current groundwater wells and contaminants sampled from each well	Definition of monitoring network
New or replacement wells needed to characterize 200-UP-1 areas of interest	Location and expected drilling date	Addresses potential data gaps in well coverage
Identification of representativeness of groundwater samples	Field parameters for all wells (e.g., anions and pH) as specified in CHPRC procedures	Indicates representativeness of groundwater samples
Strategy to select monitoring wells for each COPC monitoring network	Monitoring wells locations with respect to known groundwater impacts	Definition of monitoring well frequency

Sources: DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan.*

EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit.*

CHPRC = CH2M HILL Plateau Remediation Company

COC = contaminant of concern

COPC = contaminant of potential concern

OU = operable unit

PSQ = principal study question

ROD = record of decision

A1.4 Types and Sources of Information Needed to Resolve Decision Statements

The 200-UP-1 OU boundary is shown in Figure A-4. Plumes originating within the 200-UP-1 OU include the following:

- P&T component
  - A uranium plume originating from the U Plant cribs
  - A nitrate plume originating from U Plant and S Plant cribs and WMA S-SX
  - Two areas with chromium plumes: one associated with WMA S-SX, and a second dispersed plume in the southeast corner of the OU that originated from an S Plant crib
- Hydraulic containment component
  - An iodine-129 plume originating from U Plant and S Plant cribs
- MNA component
  - Four separate technetium-99 plumes associated with WMA U, U Plant cribs, and WMA S-SX
  - A tritium plume originating from S Plant cribs
  - Nitrate plume originating from U Plant and S Plant cribs and WMA S-SX

Annual groundwater reports provide updated descriptions of conditions in the 200-UP-1 OU. The following subsections present plume figures and summaries of what is known about the 200-UP-1 COC plumes.

A1.4.1.1 Technetium-99 Plume

Concentrations of technetium-99 are above the 900 pCi/L cleanup level downgradient (east) from the 216-U-1 and 216-U-2 Cribs near U Plant, at RCRA WMA S-SX, and at WMA U (Figure A-5). The technetium-99 plume near U Plant originated from the 216-U-1 and 216-U-2 Cribs, which received nearly 16 million L (4.2 million gal) of effluent between 1951 and 1961 (ARH-CD-745, *Input and Decayed Values of Radioactive Liquid Wastes Discharged to the Ground in the 200 Areas through 1975*). Additional contaminant mass was added to the plume when effluent disposed to the nearby 216-U-16 Crib in 1984 and 1985 migrated north along the CCU as perched water and mobilized technetium-99 and uranium in the soil column beneath the 216-U-1 and 216-U-2 Cribs (DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit*).

A P&T system operated in the 216-U-1 and 216-U-2 Cribs plume near U Plant from 1994 until the system was shut down during March 2011. This system was effective at reducing technetium-99 concentrations in the aquifer and reducing the areal extent of the plume. The technetium-99 concentration has rebounded substantially at a former extraction well (299-W19-36) from 6,300 pCi/L during June 2010 to 86,500 pCi/L during August 2014. Between 2012 and 2014, no sample results from wells east of the 200 West Area exceeded the 900 pCi/L cleanup level.

The groundwater flow direction in the U Plant area has changed due to operation of the 200-ZP-1 OU P&T system. Formerly, the flow direction was toward the east, but it is now north-northeast toward the 200-ZP-1 extraction wells. A new groundwater extraction system to address the remaining technetium-99 (and uranium) contamination is being installed in the U Plant area. Drilling of a new extraction well (299-W19-114) indicated that the technetium-99 plume occurs above cleanup levels to a depth of 27 m (90 ft) below the water table.

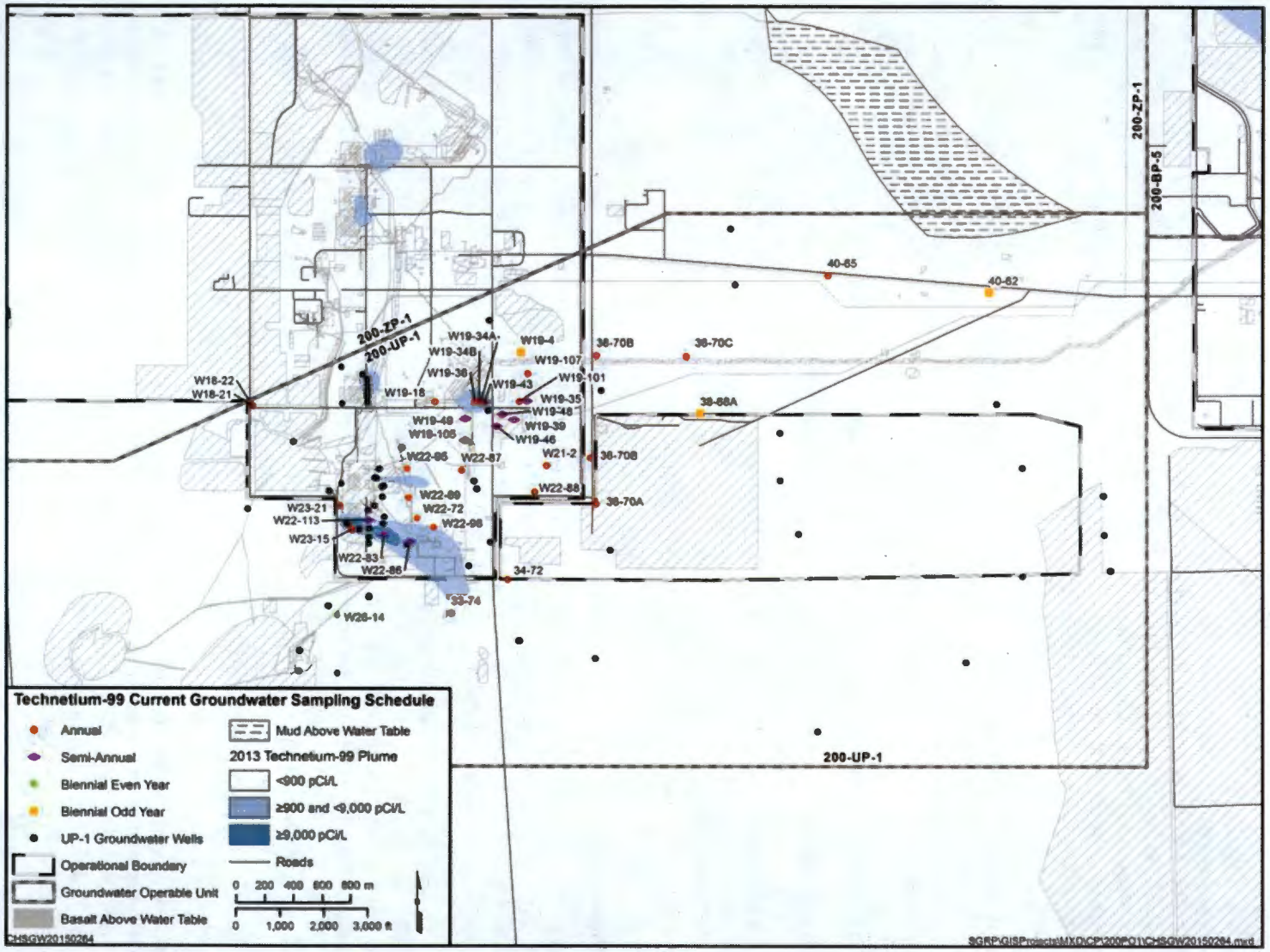

Figure A-5. Technetium Plume and Current Monitoring Well Network

At WMA S-SX, a technetium-99 plume originates from the SX Tank Farm in the southwestern corner of the WMA, and another plume originates from the S Tank Farm in the northern part of the WMA. The plume from the SX Tank Farm is attributed primarily to a leak of 190,000 L (50,000 gal) from Tank SX-115 during 1965 (Section 4.5 of RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*). Historical concentrations at Well 299-W23-19 located within the SX Tank Farm have been as high as 188,000 pCi/L (January 2003), but recent concentrations have been much lower ranging from 10,100 to 22,000 pCi/L during 2014. This plume is being remediated by a groundwater extraction system (Wells 299-W22-91 and 299-W22-92). Concentrations in many of the downgradient wells from the SX Tank Farm are near steady-state conditions, although concentrations are declining in some wells due to the groundwater extraction system. Sampling during well drilling has indicated that this plume occurs within the upper 20 m (66 ft) of the aquifer at concentrations above the cleanup level (DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*).

In the S Tank Farm, an estimated 91,000 L (24,000 gal) was released from Tank S-104 in an overfill event between 1966 and 1970 (RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*). This has resulted in a technetium-99 plume extending east from the tank farm. Historical concentrations in this plume were as high as 20,000 pCi/L. A groundwater extraction well (299-W22-90) is currently operating in the western portion of this plume. Sampling during drilling of the extraction well indicated that the plume extends to a depth of 10 m (33 ft) below the water table at concentrations above the cleanup level.

WMA U is a source of technetium-99 groundwater contamination (PNNL-13282, *Groundwater Quality Assessment for Waste Management Area U: First Determination*). Concentrations exceed the cleanup level in five of the seven downgradient monitoring wells. The highest concentration during 2014 was 4,430 pCi/L in 299-W19-45. The contamination is within the capture zone of 299-W17-3, an extraction well for the 200 West P&T system located 150 m (500 ft) north-northeast of the tank farm. Sampling during drilling of a replacement monitoring well (299-W18-260) indicated that the plume occurs in the upper 8.5 m (28 ft) of the aquifer at concentrations above the cleanup level.

A1.4.1.2 Nitrate Plume

Nitrate in the 200-UP-1 OU originated from U Plant and REDOX Plant disposal facilities, although U Plant sources were more substantial (Appendix C, "SIM Production Output Files" in RPP-26744, *Hanford Soil Inventory Model, Rev. 1*). Nitrate plumes from multiple sources in the OU have merged into a single plume extending east from the 200 West Area and into the 200 East Area (Figure A-6).

In the U Plant area, a region of high nitrate concentration occurs in the vicinity of the two former extraction wells (299-W19-36 and 299-W19-43). Maximum concentrations during 2014 were 1,010 mg/L in Well 299-W19-36 and 2,270 mg/L in Well 299-W19-43. A groundwater extraction system is being installed in this area. Extraction Well 299-W19-113 (drilled during 2014) is located between Wells 299-W19-36 and 299-W19-43. The highest concentration in samples collected during drilling of Well 299-W19-113 was 1,250 mg/L, and the plume occurs to a depth of 21 m (70 ft) below the water table at concentrations above the 45 mg/L nitrate cleanup level (10 mg/L as nitrogen). Farther east at extraction Well 299-W19-114, sampling during drilling indicated nitrate occurs above the cleanup level to a depth of 35 m (115 ft) below the water table.

A nitrate plume originates from the 216-S-25 Crib and merges with a nitrate plume from the SX Tank Farm. The highest concentration in this plume during 2014 was 199 mg/L in Well 299-W23-19, located with the SX Tank Farm. Nitrate from the WMA has been attributed primarily to a 190,000 L (50,000 gal) leak from Tank SX-115 that occurred during 1965 (RPP-ENV-39658). Two operating groundwater extraction wells (299-W22-91 and 299-W22-92) are located within this plume.

A nitrate plume also originates from the overfill event that occurred between 1966 and 1970 at Tank S-104 in the S Tank Farm (RPP-RPT-48589). Historical concentrations in this plume were as high as 280 mg/L. A groundwater extraction well (299-W22-90) is currently operating in the western portion of this plume.

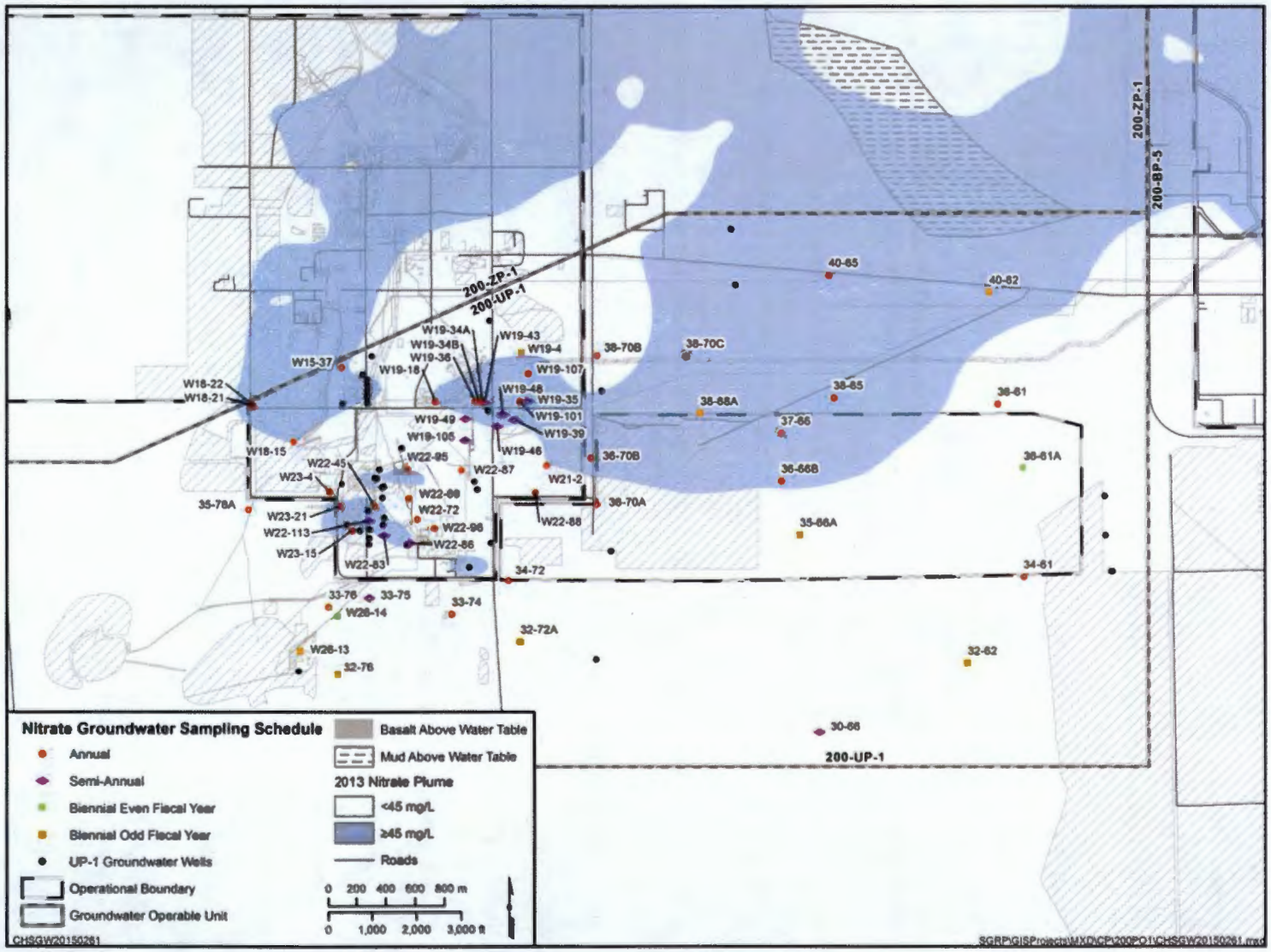

Figure A-6. Nitrate Plume and Current Monitoring Well Network

Sampling during drilling of the extraction well indicated that the plume extends to a depth of 10 m (33 ft) below the water table at concentrations above the cleanup level.

A1.4.1.3 Tritium Plume

Disposal facilities associated with the REDOX Plant, which operated from 1952 until 1967, were the primary sources of tritium in the 200-UP-1 OU. The most substantial sources were the 216-S-1, 216-S-2, 216-S-7, 216-S-21, and 216-S-25 Cribs (RPP-26744). A large tritium plume from the REDOX Plant cribs extends 5 km (3 mi) toward the east and northeast at concentrations above the 20,000 pCi/L cleanup level (Figure A-7).

The highest tritium concentration measured in the OU during 2014 was 280,000 pCi/L in Well 699-36-66B, a downgradient well for the Environmental Restoration Disposal Facility. High tritium concentrations historically occurred at now dry wells (699-35-70 and 299-W22-9). The concentration was 240,000 pCi/L in Well 699-35-70 when it was last sampled in 2008; the concentration was 1,020,000 pCi/L in Well 299-W22-9 when it was last sampled in 2005. Together, these three wells define a high concentration portion of the tritium plume (i.e., greater than 200,000 pCi/L) extending 2.5 km (1.5 mi) east and northeast from the southern 200 West Area (Figure A-7). Replacement wells for Wells 699-35-70 and 299-W22-9 are planned to be drilled during 2015.

Tritium concentrations continue to occur above the cleanup level in wells near the source cribs. Maximum concentrations during 2014 were 69,400 pCi/L in Well 299-W22-49 downgradient from the 216-S-25 Crib; 63,000 pCi/L in Well 299-W23-4 near the 216-S-21 Crib; and 55,000 pCi/L in Well 299-W22-72 near the 216-S-7 Crib. High concentrations also occurred historically in Well 299-W22-20 downgradient from the 216-S-20 Crib. This well is now dry, but the tritium concentration was 270,000 pCi/L when it was last sampled in 2009. The 216-S-3 Crib, located east of the S Tank Farm, has also been interpreted to be a source of tritium to groundwater. Before Well 299-W22-44 became dry, concentrations were 25,000 pCi/L in 2012 and 15,000 pCi/L in 2013. Tritium in this well does not trend the same as contaminants from the S Tank Farm (i.e., chromium, nitrate, and technetium-99), so the 216-S-3 Crib is the interpreted source. This crib received an estimated 122 Ci of tritium between 1953 and 1956 (RPP-26744).

A1.4.1.4 Uranium Plume

Uranium occurs at concentrations above the 30 µg/L cleanup level within two regions of 200-UP-1 (Figure A-8): downgradient of the 216-U-1 and 216-U-2 Cribs, and near the 216-U-10 Pond (U Pond). The uranium plume near U Plant originated from the 216-U-1 and 216-U-2 Cribs, which received nearly 16 million L (4.2 million gal) of effluent between 1951 and 1961 (ARH-CD-745). Additional contaminant mass was added to the plume when effluent disposed to the nearby 216-U-16 Crib in 1984 and 1985 migrated north along the CCU as perched water and mobilized technetium-99 and uranium in the soil column beneath the 216-U-1 and 216-U-2 Cribs (DOE/RL-92-76). The uranium plume is interpreted to extend 1.5 km (0.9 mi) to the east of the cribs at levels above the 30 µg/L cleanup level. The eastern extent of this plume is denoted by Well 699-38-70, which is now dry. When it was last sampled in 2007, the uranium concentration was 42 µg/L. A replacement well is planned to be drilled during 2015.

The former U Plant P&T system operated in the central portion of the U Plant area plume from 1994 until the system was shut down in March 2011. Concentrations were reduced to below the former 300 µg/L RAO at all wells within the area targeted for remediation, but concentrations at most wells remained above the current 30 µg/L cleanup level. The maximum concentration in this plume during 2014 was 734 µg/L in 299-W19-18. This plume is limited to the upper 20 m (66 ft) of the aquifer (DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*). A new groundwater extraction system to address the remaining uranium (and technetium-99) contamination is being installed in this plume.

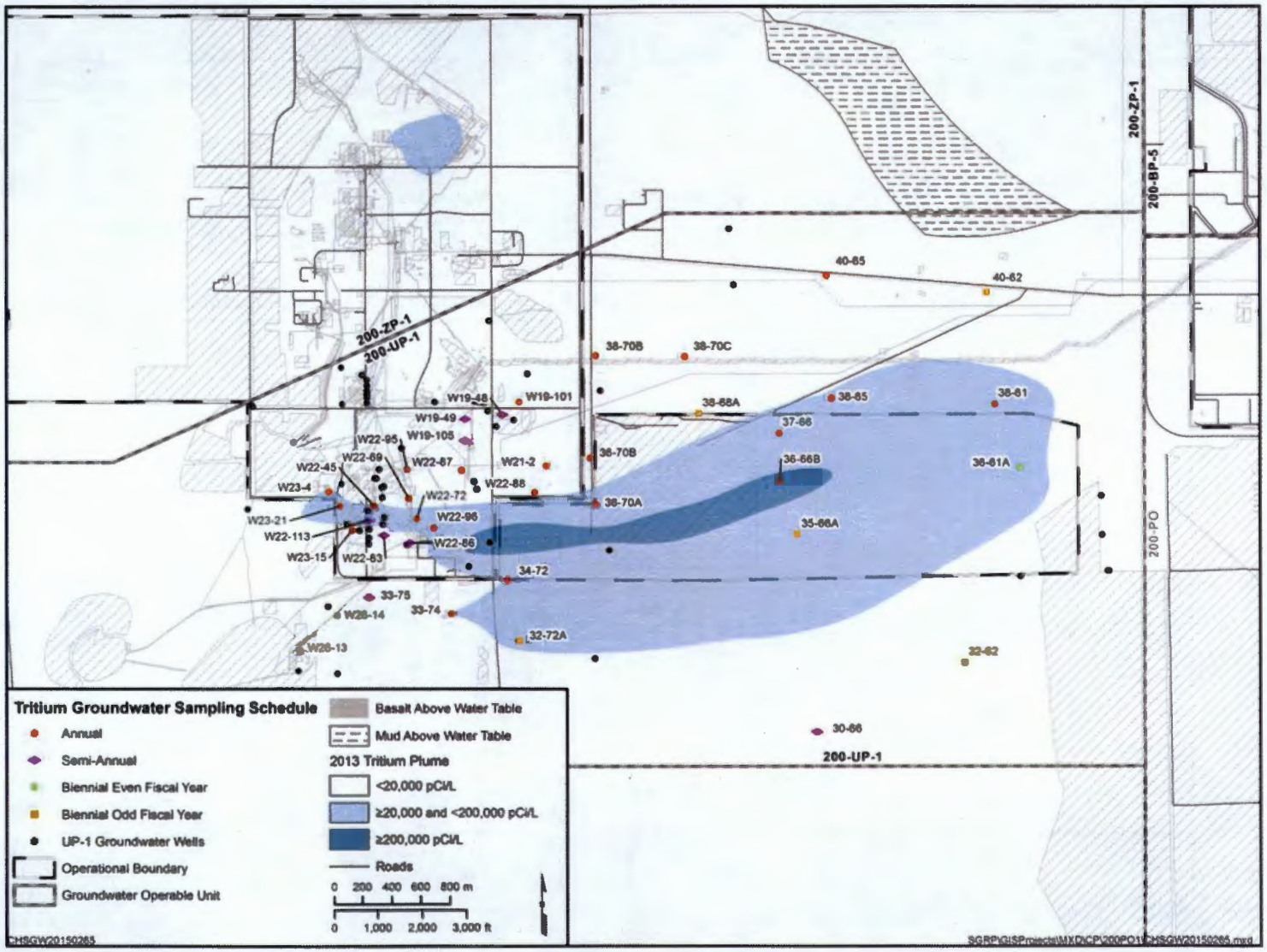

Figure A-7. Tritium Plume and Current Monitoring Well Network

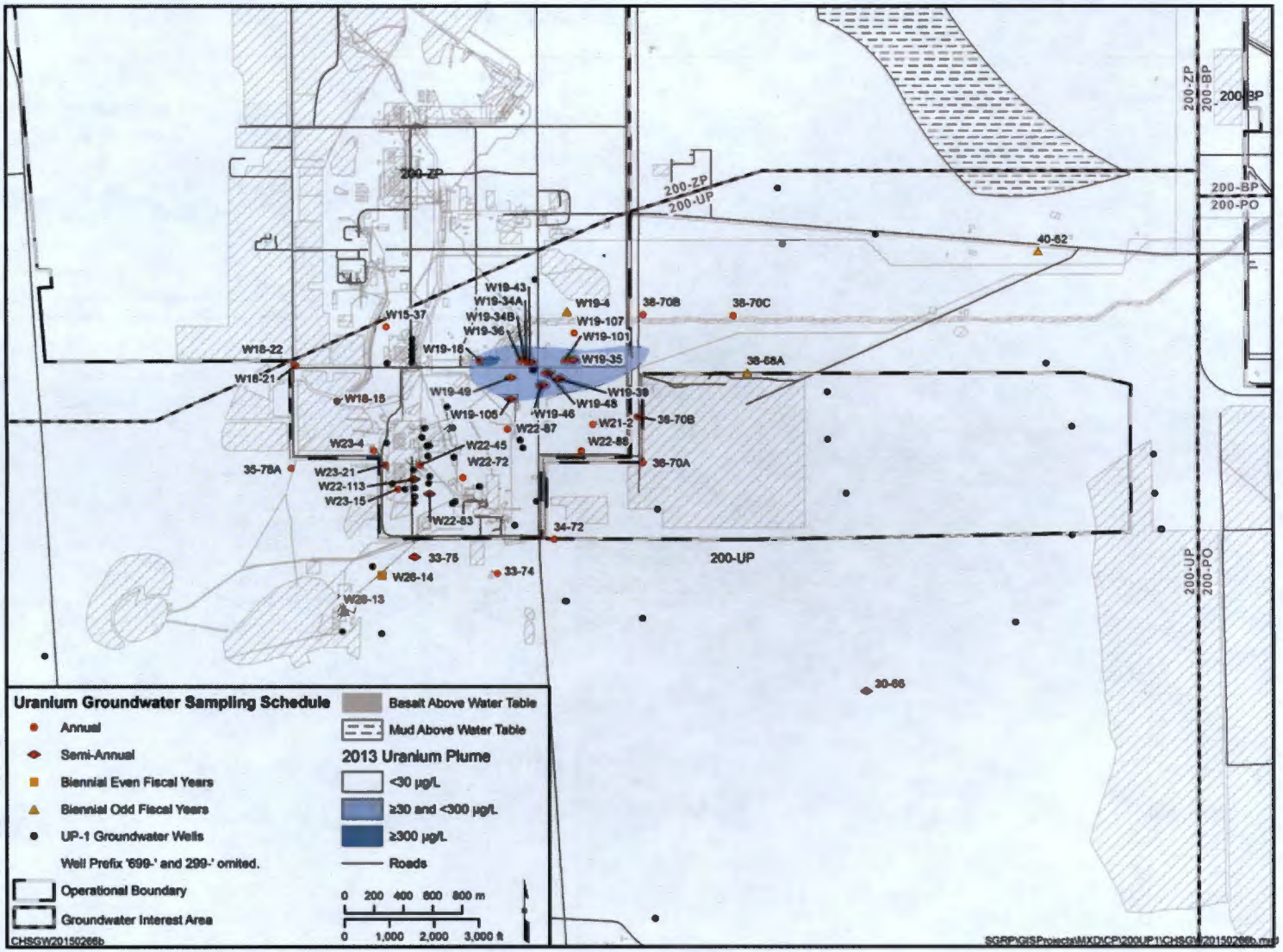

Figure A-8. Uranium Plume and Current Monitoring Well Network

U Pond received an estimated 2,100 kg uranium (Appendix C of RPP-26744) and is a source of uranium to the groundwater. Concentrations are above the cleanup level in Well 299-W23-4 on the east side of U Pond downgradient from the 216-S-20 Crib. The 2014 sample result in this well was 31 µg/L. The next highest concentration during 2014 occurred in Well 299-W18-15 at 23 µg/L.

A1.4.1.5 Iodine-129 Plume

The iodine-129 plumes originated from both U Plant and REDOX Plant waste sites, although the latter were the primary sources. Iodine-129 occurs as two plumes; one from the 216-U-1 and 216-U-2 cribs near U Plant and a second from the REDOX Plant waste sites in the southern portion of the 200 West Area. These plumes merge downgradient and become indistinguishable (Figure A-9).

The highest concentrations of iodine-129, greater than 10 times the 1 pCi/L cleanup level, originate from the REDOX Plant waste sites and occur in a region extending 2 km (1 mi) east The maximum concentration in this plume during 2014 was 11 pCi/L in Well 699-36-70A. However, higher concentrations occurred in Wells 299-W22-9 and 699-35-70 before they became dry. In Well 299-W22-9, the iodine-129 concentration was 30 pCi/L in 2005, and the concentration was 37.1 pCi/L in Well 699-35-70 during 2008. Replacements for both of these wells are planned to be drilled during 2015.

The maximum iodine-129 sample result, downgradient from the 216-U-1 and 216-U-2 Cribs during 2014, was 2.81 pCi/L in Well 299-W19-49. This plume occurs at a shallow depth near the source but deepens as the plume extends eastward. The plume is fully mixed vertically throughout the aquifer at Well 699-38-70C, located 1.8 km (1.1 mi) east of the cribs. The 2014 sample result in this well was 1.09 pCi/L.

Iodine-129 occurs above the 1 pCi/L cleanup level in a single well (299-W23-19), in the vicinity of the SX Tank Farm, which is located inside the farm. The December 2013 sample result for this well was 1.04 pCi/L. During 2011, the iodine-129 concentration was 2.8 pCi/L in Well 299-W22-26 before this well became dry. The source is the 216-S-9 Crib.

A1.4.1.6 Chromium Plumes

Although chromium is listed in the ROD (EPA et al., 2012) as two COCs (Cr(VI) and total chromium), it occurs in Hanford Site groundwater only in the mobile hexavalent form. Chromium is analyzed in groundwater samples using two different methods: (1) inductively coupled plasma, which yields a result for total chromium (i.e., trivalent chromium and Cr(VI) combined); and (2) a colorimetric method (ultraviolet/visible light absorption), which yields a result for only the hexavalent form. Therefore, the Hanford Environmental Information System database includes results for both total chromium and Cr(VI), even though both have similar concentrations within any given well and represent the same constituent in groundwater. Total chromium and Cr(VI) have different cleanup levels specified in the ROD (100 and 48 µg/L, respectively). In this section, sample results for total chromium and Cr(VI) will be referred to together simply as chromium, and the effective cleanup level is 48 µg/L because it is more restrictive.

Substantial chromium plumes are found in two regions of 200-UP-1: a larger plume in the southeast rea of 200 West, and in two plumes at WMA S-SX (Figure A-10). Concentrations above the 48 µg/L cleanup level for Cr(VI) also occur near the 216-S-20 Crib and 216-S-10 Pond and Ditch, which are sources of the southeast chromium plume.

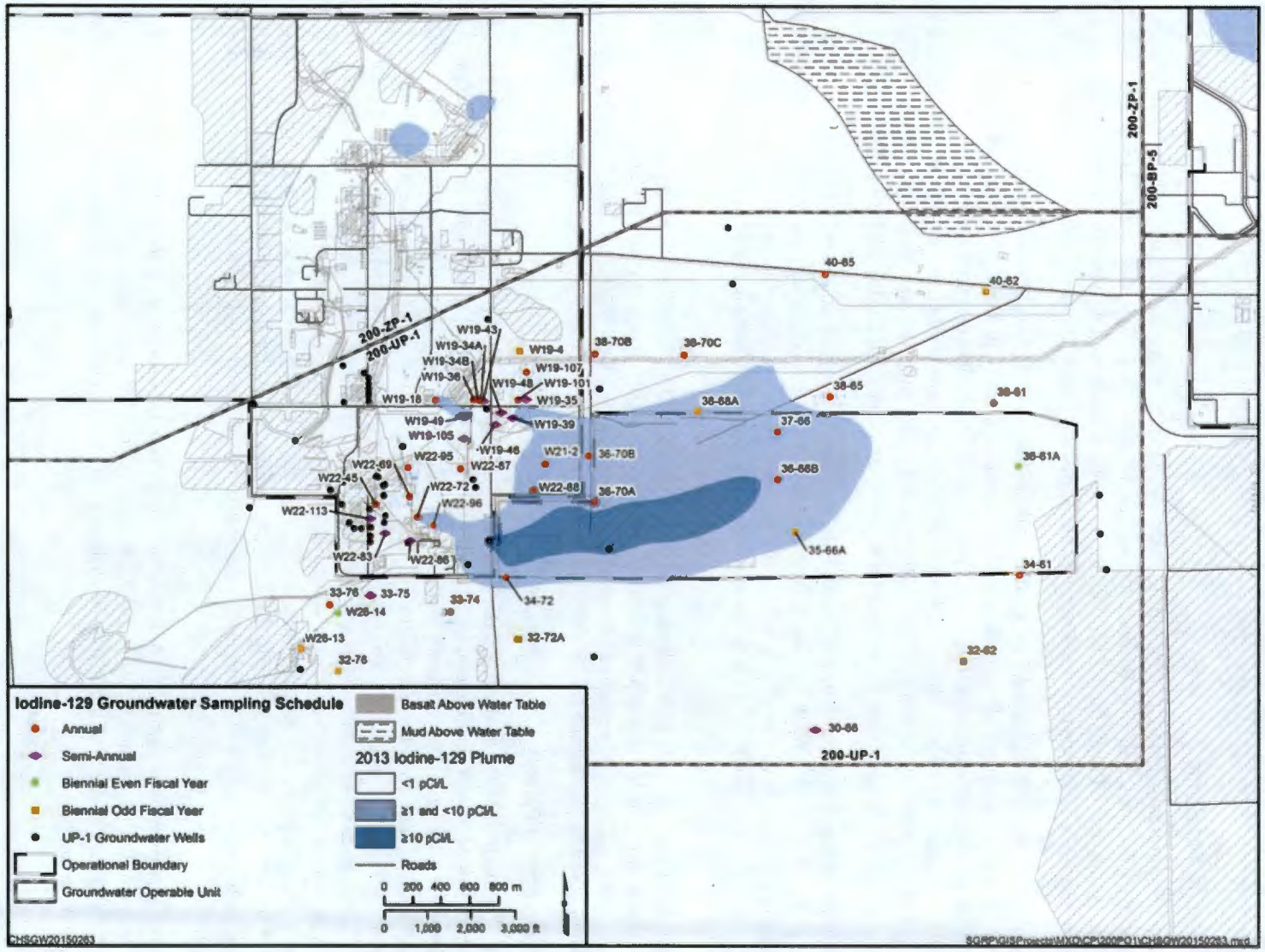

Figure A-9. Iodine Plume and Current Monitoring Well Network

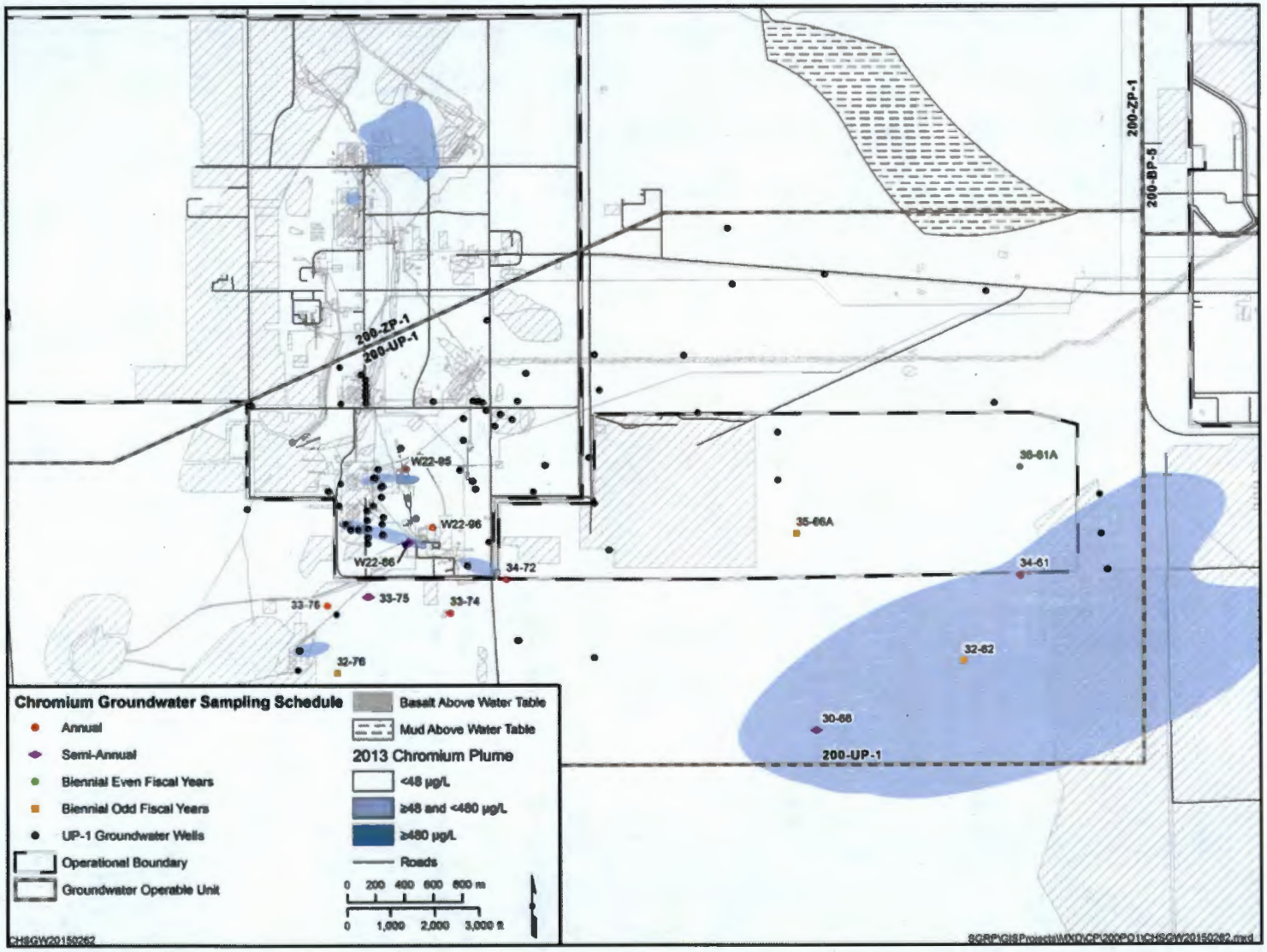

Figure A-10. Chromium Plume and Current Monitoring Well Network

Within the southeast chromium plume, concentrations in Well 699-32-62 have gradually declined from 254 µg/L in 1992 to 134 µg/L in 2012. The reduction in concentration at this location likely results from the continued downgradient migration of the dissolved chromium plume. Chromium is also elevated at Well 699-30-66 (results between 117 and 127 µg/L during 2014), which is completed deep in the aquifer just above the Ringold Formation lower mud unit. These data indicate that chromium is present throughout the aquifer thickness in this region due to dispersion as the plume migrated east from the source sites. The southeast chromium plume originated primarily from effluent disposal to the 216-S-20 Crib during the 1950s, although the REDOX Plant ponds and ditches south of the 200 West Area were also sources (DOE/RL-2009-122). An estimated 5,900 kg of chromium were disposed to the 216-S-20 Crib, and an estimated 3,000 kg were disposed to 216-S-10 Pond and Ditch (RPP-26744). Chromium concentrations continue to be observed in groundwater near both of these source locations. In Well 699-34-72, downgradient from the 216-S-20 Crib, total chromium was detected at 32.7 µg/L in a filtered sample collected during February 2014 (42 µg/L in the unfiltered sample). In Well 299-W26-13 at the 216-S-10-Pond and Ditch, chromium averaged 116 µg/L during 2014 (Cr(VI) and total chromium results combined), and the trend has been generally increasing.

Chromium concentrations in seven wells at WMA S-SX exceeded the 48 µg/L cleanup level in at least one sample during 2014, and form one chromium plume . The highest concentrations occurred at Well 299-W23-19, where the average concentration during 2014 was 439 µg/L. The plume from the SX Tank Farm has been attributed primarily to a 190,000 L (50,000 gal) leak from Tank SX-115 that occurred during 1965 (RPP-ENV-39658). Two groundwater extraction wells (299-W22-91 and 299-W22-92) are operating in this plume.

Thesecond chromium plume at WMA S-SX is downgradient from the S Tank Farm. This plume originated from the Tank S-104 overfill event between 1966 and 1970 (RPP-RPT-48589). At a near-field downgradient well (299-W22-44), the chromium concentration was 404 µg/L in a filtered sample collected during March 2013. This well has become dry because of operation of a nearby extraction well (299-W22-90). A replacement well is planned to be drilled during 2015. The concentration in the extraction well during 2014 averaged 65 µg/L.

A1.4.1.7 Contaminants of Potential Concern

Trichloroethene (TCE) is found within the northern portion of the 200-UP-1 OU. Sampling during drilling indicates that trichloroethene concentrations tend to increase with depth in the aquifer. Since 2012, trichloroethene has been detected in routine groundwater samples above the 4 µg/L risk-based comparison value in five wells: 299-W14-71, 299-W19-107, 299-W19-34B, 699-38-70B, and 699-38-70C. The highest concentration was 8.7 µg/L in 299-W14-71, which is completed deep in the aquifer just above the Ringold Formation lower mud unit. Concentrations of TCE in these wells have been relatively stable or declining since 2008.

Chloroform is a breakdown product of carbon tetrachloride and trichloroethene. Chloroform has been detected above risk based comparison level of 14 µg/L in only one well (299-W14-71) since 2012. The concentration trend of chloroform in this well since 2008 has been declining, and has been detected below 14 µg/L since 2013. Tetrachloroethene is sporadically detected in other 200-UP-1 OU monitoring wells. The most recent detections were in 2012, with a maximum concentration of 0.46 µg/L in Well 299-W14-71. This is below the 5 µg/L risk based comparison level. There were no detections in 2013 and 2014.

1,4-Dioxane has been detected in two wells near the 216-S-20 Crib: 299-W22-20 and 699-34-72. This constituent was detected in Well 299-W22-20 starting in 2002 at 110 µg/L. The peak concentration was 160 µg/L in 2003. This well is now dry, but the last sample collected from this well (in 2009) had 1,4-dioxane at 39 µg/L. Farther downgradient, 1,4-dioxane has been detected in Well 699-34-72 at concentrations ranging from 2.9 to 8.4 µg/L. The 216-S-20 Crib is the most likely source. From 1952

through 1972, this crib received waste from laboratory hoods and decontamination sinks in the 222-S Building, along with laboratory waste from the 300 Area.

Since 2000, detections of strontium-90 at concentrations above the 8 pCi/L drinking water standard (DWS) have occurred in only a single well (299-W22-10), located near the 216-S-1 and 216-S-2 Cribs. The maximum concentration during this time was 76.2 pCi/L in 2001, but concentrations have declined since. This well was last sampled in 2005, and strontium-90 was detected at 26.8 pCi/L. The 216-S-1 and 216-S-2 Cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of an adjacent monitoring well (299-W22-3, located 25 m [80 ft] west-northwest of 299-W22-10), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater. This is the postulated pathway by which strontium-90 reached groundwater at this location.

A1.4.2 Information Needed to Support Choices to Be Made in Step 7

To support selection of wells and sampling frequencies, additional data and information is needed during the DQO. The following is a list of additional data and information that will support the DQO process.

- Current monitoring well construction (adequate for monitoring purposes)
- New or replacement wells needed to characterize 200-UP-1 areas of interest
- Identification of groundwater field parameters for all wells (e.g., specific conductance and pH), as specified in CH2M HILL Plateau Remediation Company (CHPRC) procedures to indicate that groundwater samples are representative
- Automated and manual water level measurements
- Monitoring well selection strategy
  - General well selection criteria:
    1. To calculate UCL_{95}: greater than or equal to eight wells over a period of 3 years (or less) are required with 20 to 30 sample results for each analyte (OSWER Publication 9285.7-081, *Supplemental Guidance to RAGS: Calculating the Concentration Term*).
    2. For less mobile constituents (e.g., uranium), less frequent sampling could be acceptable.
    3. Well selection should consider spatial distribution for both horizontal and vertical plume definition.
    4. Boundary wells should be selected to adequately define the plume extent (horizontal and vertical).
    5. Wells should be selected to adequately track the travel path of the plume.
    6. In choosing between two wells, preference is given to newer well construction (e.g., WAC 173-160 compliant, screen location, and expected well life) versus older, non-WAC 173-160 compliant wells.
  - Well selection for plume boundary tracking and UCL_{95} calculations
    1. Choose wells for calculating UCL_{95}.
    2. Select "boundary" wells to define plume extent (consider spatial distribution plus horizontal and vertical extent).

3. Select wells to track the plume travel path.
4. Select wells to monitor COCs above cleanup standards, as necessary, at other locations not within remedy areas.
5. Select wells that have concentrations above the practical quantitation limit (PQL) and greater than or equal to 10 percent of the cleanup level (except iodine-129, which is still under evaluation).

- Well sampling frequency considerations
  1. Less mobile constituents (e.g., uranium) migrate slowly; therefore, sampling frequency may be reduced.
  2. For well clusters, rotate sampling if possible (e.g., for a three-well cluster, sample each well annually on a rotating basis so each well is sampled once every 3 years).
  3. If the COC trend is stable or decreasing, monitor less frequently except in areas that monitor active remedy performance.
  4. If the COC trend is increasing, monitor more frequently.
- COPC monitoring wells
  1. Select well if concentration trend is above risk based comparison level or increasing toward comparison level.
  2. Do not select well if decreasing or stable concentration trend and concentration are below the comparison level.
  3. For chloroform, tetrachloroethene, and trichloroethene, sample all three constituents in wells where sampling for one or more of the three constituents is identified.

A1.5 Step 4: Define the Boundaries of the Study

Step 4 of the DQO process identifies the target population of interest and the spatial and temporal features pertinent for decision making. Specific spatial and temporal boundaries are identified for groundwater monitoring at the 200-UP-1 OU.

Spatial Boundaries of the Study. The monitoring program physical boundaries constrain the data collection in three dimensions. The areal limits include the 200-UP-1 OU area of interest (Figure A-4), and plumes emanating from the OU that migrate beyond the OU boundary (e.g., southeast chromium plume). The 200-UP-1 OU includes several groundwater plumes that span an area approximately 10 km^2 (4 mi^2) underlying the southern portion of the Hanford Site's 200 West Area (Figure A-4), shown in the previous Step 3 individual plume figures. The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities that have been grouped into four process areas: U Plant, Z Plant, S Plant (REDOX Plant), and T Plant. The major waste streams that contributed to 200-UP-1 OU groundwater contamination were associated with the plutonium-separation and uranium recovery operations at the S Plant and U Plant facilities, where liquid wastes were disposed to the ground via ponds, cribs, ditches, and trenches. As effluent was discharged to these sites in the past, the more mobile contaminants migrated through the vadose zone to the groundwater. Some groundwater contamination also resulted from single-shell tank (SST) leaks or unplanned releases, particularly associated with WMA S-SX. Groundwater

contamination has also migrated from the adjacent 200-ZP-1 OU into the 200-UP-1 OU that originated from liquid waste disposed to the ground at Z Plant plutonium concentration and recovery facilities. The working hypothesis is that groundwater contaminant migration follows groundwater flow paths toward discharge boundaries. The study domain for this DQO includes contaminated groundwater originating within the 200-UP-1 OU boundary.

One distinct vertical boundary for 200-UP-1, the unconfined aquifer, extends from the water table to the Ringold Formation lower mud unit. The 200-UP-1 PMP is designed to gather data that will be used to continue evaluating contaminants within the unconfined aquifer. Monitoring decisions will be made on respective plume monitoring wells having persistent COC concentrations greater than CULs identified in Table A-1.

Temporal Boundaries of the Study. Temporal boundaries are related to physical characteristics and behaviors of the contaminants being monitored and the aquifer flow system (i.e., defined by the timing, frequency, and duration of measurements and observations). Timing is driven by changes in groundwater flow direction and flow velocity. Frequency is the number of times per year a sample is collected from a monitoring location. Historical trends should be evaluated to identify changes in conditions that are related to seasonal changes in order to provide an understanding of how any particular measurement may be affected. Time series plots of concentrations and groundwater elevations were used to identify relationships, with the purpose of developing measurement schedules to satisfy data needs on a well-by-well and/or plume-by-plume basis.

The temporal boundaries of the study are through remedy implementation and do not include attainment monitoring. The PMP will be revised to collect data sufficient to demonstrate attainment and will use an approach consistent with OSWER 9283.1 -44 (*Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*). Based on the remedial components identified by plume, the following times are expected for 200-UP-1 COCs to achieve cleanup levels (expressed as UCL_{95}):

- Technetium-99 within 15 years (P&T and MNA)
- Uranium within 25 years (P&T and MNA)
- Chromium (total and hexavalent) within 25 years (P&T and MNA)
- Nitrate within 35 years (P&T and MNA)
- Tritium within 25 years (MNA only)
- Carbon tetrachloride (active restoration and MNA) within 125 years (consistent with 200-ZP-1)

Water levels are measured manually during well sampling efforts. A network of wells may be incorporated into an Automated Water Level Network (AWLN) for hourly measurements. Water level data will be used to improve interpretations and models of groundwater flow in the 200-UP-1 OU.

Resource Limitations and Constraints. A number of known and potential constraints may interfere with implementation of the groundwater monitoring program. The following constraints are identified at this time:

- DOE baseline budget priorities and available funding, the number and type of new wells to be installed, and extent of testing to be conducted at new and existing wells
- Project and field operation personnel availability limitations
- Further remedial actions (i.e., waste site excavation) near wells that may result in removal of a well included in the monitoring plan

- PQLs (low enough to support cleanup level achievement)
- Cultural and ecological constraints on new well location access
- Additional wells becoming sample dry (i.e., insufficient water for sampling) or changes in groundwater flow due to operations of P&T systems for 200-ZP-1 and 200-UP-1.

A2 Step 5: Develop the Analytic Approach

Step 5 of the DQO process involves developing an analytic approach that will guide analysis of the study results. This is accomplished by developing a decision rule for each PSQ. This step integrates outputs from the previous steps into statements that describe the logical basis to select among the alternative actions. This includes specifying the population parameter (e.g., mean and percentile), determining the action level, and constructing the decision rule. Decision rules can be formed as "If-Then" statements. Table A-5 presents decision rules for each of the PSQs.

The following parameters of interest were used in forming the decision rules:

- Concentrations and trends for COCs expressed by statistical parameters (e.g., UCL_{95} trend analyses) within the time frames projected in the remedial investigation (RI)/feasibility study (FS) (DOE/RL-2009-122)
- Plume areas or masses for each COC (temporal changes [e.g., annual])
- Comparison of empirical observations to previously modeled conditions
- Concentrations and trend analyses for COPCs over the next 5-year time frame

Table A-5. Decision Rules

Decision Rule	
PSQ 1: Are the 200-UP-1 cleanup criteria and remedial action objectives for groundwater being achieved within the time frames projected in the RI/FS?	**If** monitoring well results indicate unexpected changes in COC plume concentrations (e.g., higher or lower than CUL) or locations (e.g., evidence of tritium and iodine-129 plume migration) within the time frames projected in the RI/FS (see Section 4.2 for COC time frames), **then** re-evaluate the monitoring plan (e.g., well addition/removal for plume tracking); **otherwise**, continue monitoring.
PSQ 2: Are concentrations of COPCs (1,4-dioxane, chloroform, strontium-90, tetrachloroethene, and trichloroethene) below action levels or standards over the next five years?	**If** monitoring well results indicate that COPC concentrations are not trending down toward their action levels or are increasing in an unexpected manner over the next 5-year time frame, **then** continue monitoring and refine the monitoring requirements; **otherwise**, maintain their COPC status and evaluate the need to continue monitoring.

Source: DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan.*

COC = contaminant of concern

COPC= contaminant of potential concern

DWS = drinking water standard

PSQ = principal study question

RI/FS= remedial investigation/feasibility study

A3 Step 6: Specify Performance or Acceptance Criteria

This step is intended to specify performance or acceptance criteria that the collected data will need to achieve in order to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in decisions to within acceptable levels. The primary decisions for monitoring DQOs involve the adequacy of spatial and temporal coverage of the monitoring network. Analytical data and field measurements can only estimate the true condition of the site under investigation, and decisions that are made based on measurement data could potentially be in error (i.e., decision error).

Resolving the PSQs is dependent on evaluating historical and current analytical data plus field measurements. These data will be used for scientific calculations (COC UCL_{95} values) and COPC trend analyses. The limits on analytical data are specified within the analytical method quality assurance (QA)/quality control (QC) criteria, as identified in the quality assurance project plan within a SAP.

Traditional statistical sampling designs were not identified for 200-UP-1 groundwater monitoring. Thus, tables defining the null hypothesis, alpha and beta error, and width of the gray region have been excluded from this DQO process. Although statistical sampling designs are not proposed, statistical evaluations of the data collected for PSQs will be required to support future decisions associated with them (e.g., RAO achievement as evaluated by comparison of COC UCL_{95} concentrations to the cleanup levels and trend analyses to determine if COPC concentrations are trending down toward their action levels).

Table A-6 summarizes the potential decision errors associated with the 200-UP-1 PSQs, the decision error consequences, and actions that could avoid or mitigate the decision errors. The UCL_{95} is the statistical decision parameter of interest for 200-UP-1 groundwater COCs. For this parameter, there is 95 percent certainty that the sample mean is not greater than the UCL_{95} value. For COPC groundwater sampling, the "maximum confirmed detected" concentration (based on quality assurance/quality control data) is the parameter of interest.

Table A-6. Potential Consequences of Decision Error.

Type of Decision Error	Consequences	How to avoid (or mitigate) Decision Errors
PSQ #1 (False positive): Erroneously conclude that UP-1 groundwater COC UCL_{95} values exceed the action level (i.e., CUL) requiring further treatment and monitoring.	Groundwater COCs would be treated and monitored unnecessarily.	1. Select monitoring well networks that are representative of the COC concentration ranges within the plumes. 2. Collect sufficient samples (15-20) during typical Plateau groundwater conditions to calculate the least uncertain COC UCL_{95} estimate). 3. Where possible, select analytical methods with MDLs well below the COC CUL. 4. Conduct data quality assurance evaluations on all analytical results to ensure the data is a sufficient quality to support PSQ#1 decisions. If the data quality requirements are not met, additional sampling should be considered. 5. Insist on robust QA/QC analytical programs to ensure analytical uncertainties are minimized or eliminated.
PSQ #1 (False negative): Erroneously conclude that UP-1 groundwater COC UCL_{95} values do not exceed action levels (i.e., CUL) and do not require further treatment or monitoring.	Groundwater COCs would not be treated or monitored when they should be.	

Table A-6. Potential Consequences of Decision Error.

Type of Decision Error	Consequences	How to avoid (or mitigate) Decision Errors
PSQ #2 (False positive): Erroneously conclude that UP-1 groundwater COPCs are not trending down toward their action levels (i.e., CUL) and require further monitoring (and possibly remediation).	Groundwater COPCs would be further monitored (and possibly treated) unnecessarily.	1. Select wells for COPC monitoring with a history of sporadic or inconsistent DWS exceedances. 2. Collect sufficient samples during typical Plateau groundwater conditions to show COPC concentration trends (at least 5-years of data) 3. Where possible, select analytical methods with MDLs well below the COPC CUL. 4. Conduct data quality assurance evaluations on all analytical results to ensure the data is a sufficient quality to support PSQ#1 decisions. If the data quality requirements are not met, additional sampling should be considered. 5. Insist on robust QA/QC analytical programs to ensure analytical uncertainties are minimized or eliminated.
PSQ #2 (False negative): Erroneously conclude that UP-1 groundwater COPCs are trending down toward their action levels (i.e., CUL) and do not require further monitoring (or possibly remediation).	Groundwater COPCs would not be further monitored (and possibly treated) when they should be.	

The data collected will also be used to support future decisions regarding treatment performance, groundwater quality criteria compliance (e.g., UCL_{95} achieves CUL), groundwater conceptual site model (CSM) verification, groundwater contaminant status (e.g., COC or COPC), and plume migration tracking. The consequences of inadequate sampling design may affect the time it takes to achieve cleanup approval, or affect the ability to convincingly demonstrate remedial action goal achievement. All of the monitoring wells are expected to be accessible for resampling, but resampling times will differ and may introduce data set variability.

A4 Step 7: Develop the Plan for Obtaining Data

The goal of step 7 is to develop a resource-effective design for collecting data to address the identified problems. Monitoring locations and frequencies were selected to address the PSQs. This DQO step provides the methodology used to select the final list of groundwater monitoring locations and sampling frequencies that adequately meet the data needs associated with the PSQs.

Inputs to Step 7 include all information and outputs generated in Steps 1 through 6. Outputs from Step 7 include the following:

- As appropriate, identify alternative sampling and analysis designs
- Select a design that will best achieve performance or acceptance criteria
  - Detail how the design should be implemented together with contingency plans for unexpected events
  - Consider QA/QC procedures that would be performed to detect and correct problems and so ensure defensible results (these would be documented in a SAP)
- Full documentation of the final sampling and analysis design, along with a discussion of the key assumptions underlying this design.

A4.1 Monitoring Networks for 200-UP-1 Contaminants of Concern

The monitoring well selection strategy presented in DQO Step 3 (Section A1.4.2) was followed in developing the COC and COPC monitoring well networks. The groundwater monitoring networks recommended for plume tracking and treatment performance monitoring, including network-specific assumptions and general monitoring well inclusion/exclusion criteria follow.

A4.1.1 General Criteria for Monitoring Well Retention and Exclusion

Retention Criteria

- Wells define groundwater contaminant plumes and concentration variations over time.
- Wells monitor the inferred migration pathway of contaminant plume.

Exclusion Criteria

- Wells that are close to other monitoring locations and do not provide supplemental or definitive input to a data need
- Wells that do not provide representative measurements (e.g., wells with poor seals or wells with undefined open intervals, nonconventional well constructions)
- Wells that have not exhibited historical detections of contaminants of interest and do not provide useful bounding condition measurements.

The following subsections present the COC and COPC monitoring networks developed using the above retention/exclusion criteria.

A4.1.2 Technetium-99 Plume

Figure A-11 presents the monitoring well locations for the technetium-99 groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.3 Nitrate Plume

Figure A-12 presents the monitoring well locations for the nitrate groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.4 Tritium Plume

Figure A-13 presents the monitoring well locations for the tritium groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.5 Uranium Plumes

Figure A-14 presents the monitoring well locations for the uranium groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.6 Iodine-129 Plume

Figure A-15 presents the monitoring well locations for the iodine-129 groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.7 Chromium Plume

Figure A-16 presents the monitoring well locations for the chromium groundwater monitoring network for the 200-UP-1 OU. A summary of all the COC well network information is presented in Table A-7.

A4.1.8 COPC Monitoring

Figure A-17 presents the monitoring wells and their locations for the 200-UP-1 OU 1,4-dioxane, chloroform, strontium-90, trichloroethene, and tetrachloroethene groundwater monitoring network.

A4.1.9 Use of Existing Monitoring Wells

Existing wells will be evaluated as follows to help determine their suitability for use:

- Evaluate existing monitoring wells for suitability (e.g., review documentation where available and perform camera surveys, borehole geophysics, and field inspections).
- Rehabilitate existing monitoring wells, as appropriate.

A4.1.10 Sampling Frequency

Proposed sampling frequencies for the various monitoring networks are presented in Table A-7. The frequencies noted will be re-evaluated annually.

Generally, new wells will be sampled as follows:

- Replacement wells will be sampled at the same frequency as the well being replaced.
- Characterization wells for chromium will be sampled quarterly for the first year, and annually thereafter, if the trend is steady. If the trend is not stable, reevaluate the sampling frequency.
- Monitoring wells added to the network: the frequency of sampling will be chosen for consistency with other nearby wells in the network.

Sample frequencies for existing monitoring wells will be as follows:

- Active remedy monitoring will be annual.
- MNA monitoring will range from annual in wells in higher concentration areas of the plumes to triennial in wells near the plume margins.
- Iodine-129 sampling to assess hydraulic containment will be annual in wells near plume front and triennial in other wells.

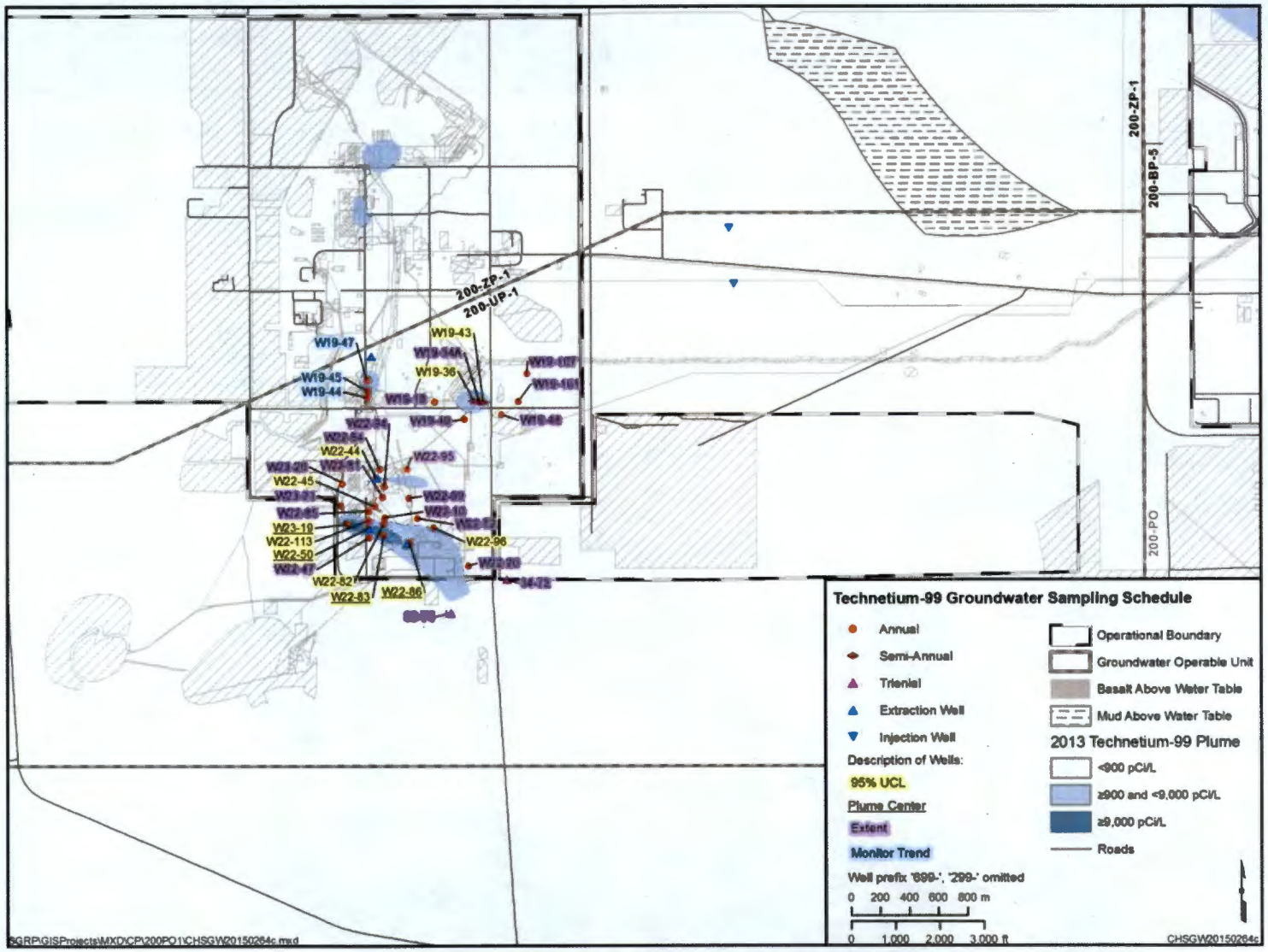

Figure A-11. 200-UP-1 Technetium-99 Groundwater Monitoring Network

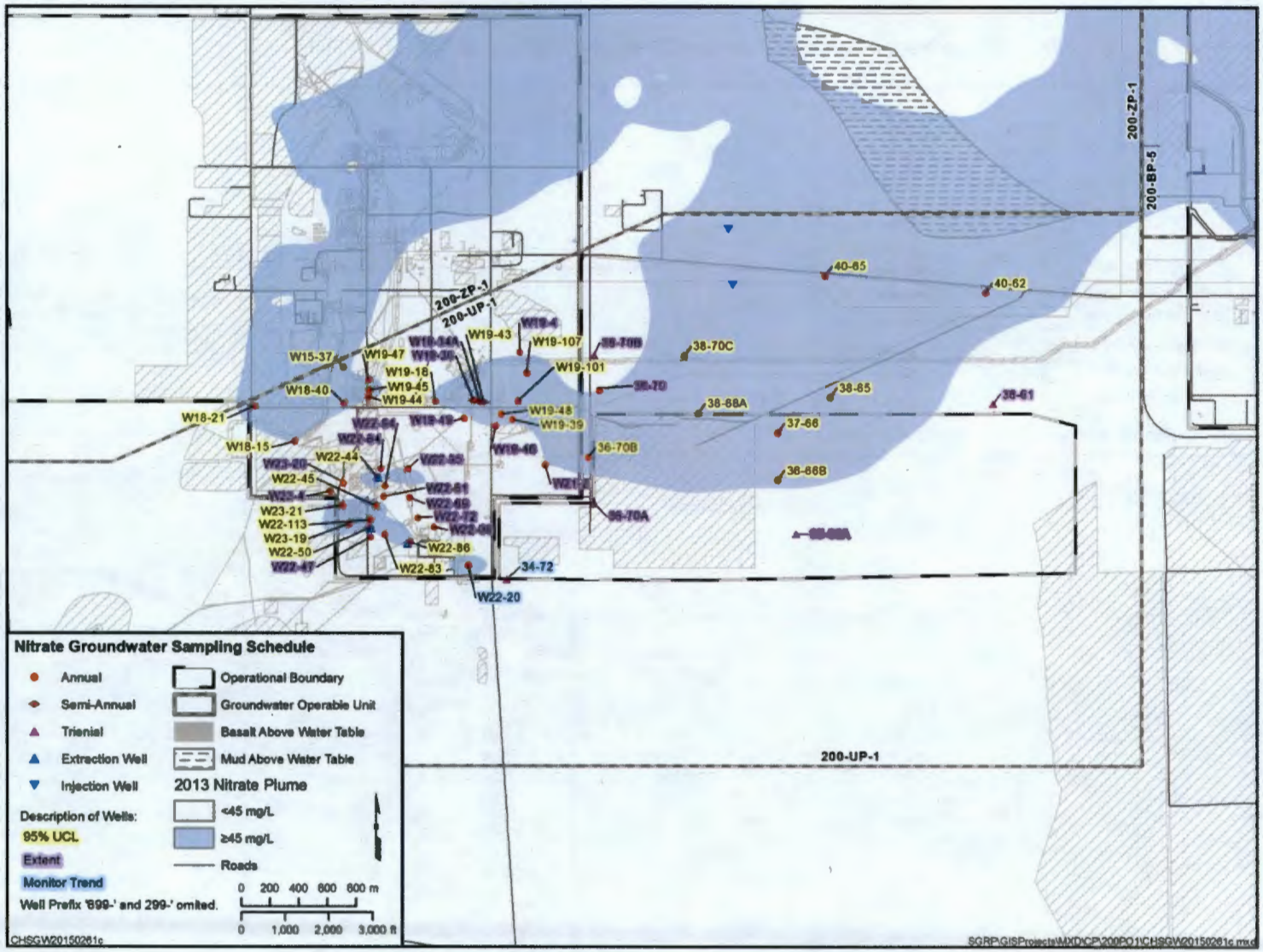

Figure A-12. 200-UP-1 Nitrate Groundwater Monitoring Network

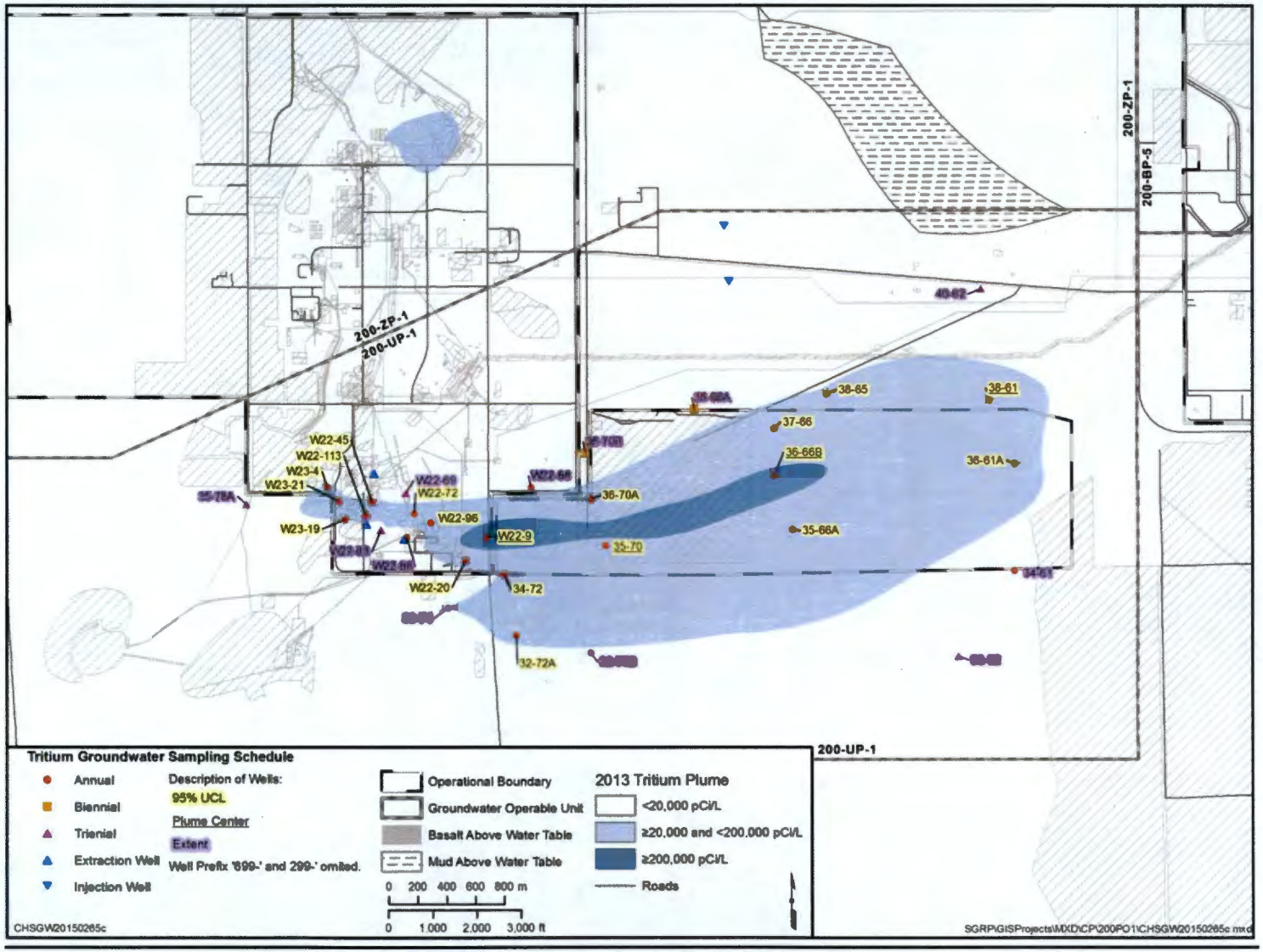

Figure A-13. 200-UP-1 Tritium Groundwater Monitoring Network

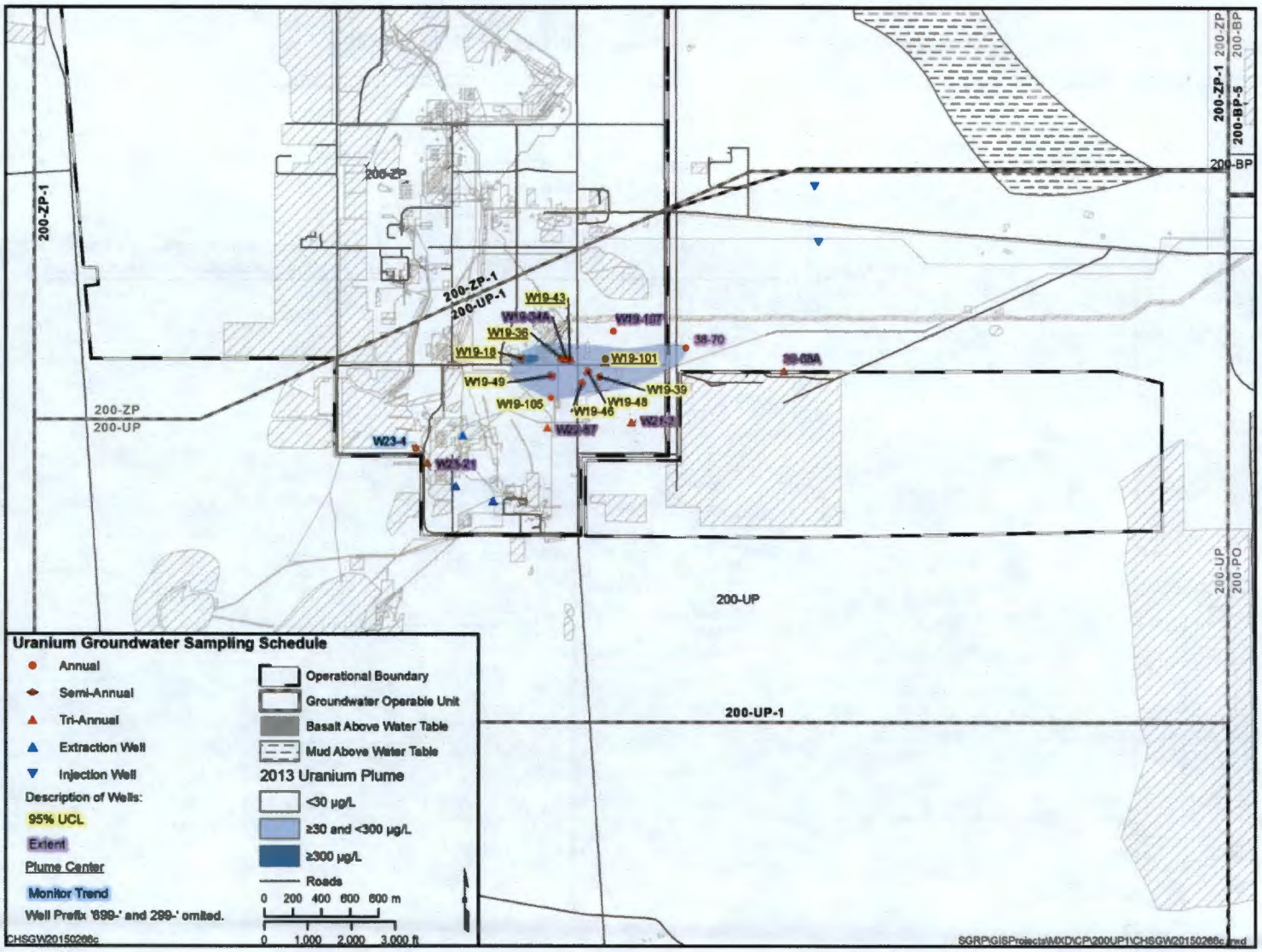

Figure A-14. 200-UP-1 Uranium Groundwater Monitoring Network

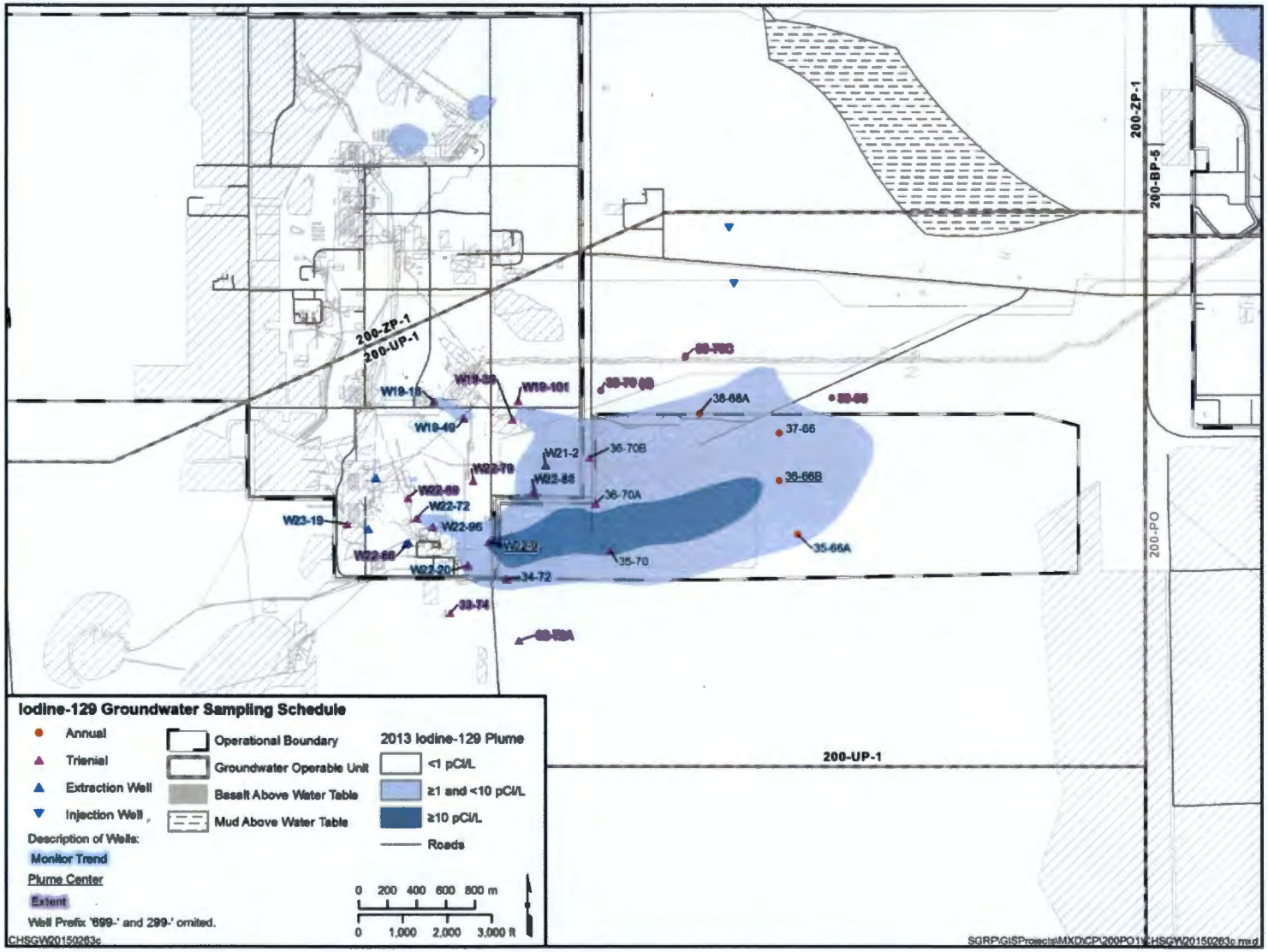

Figure A-15. 200-UP-1 Iodine-129 Groundwater Monitoring Network

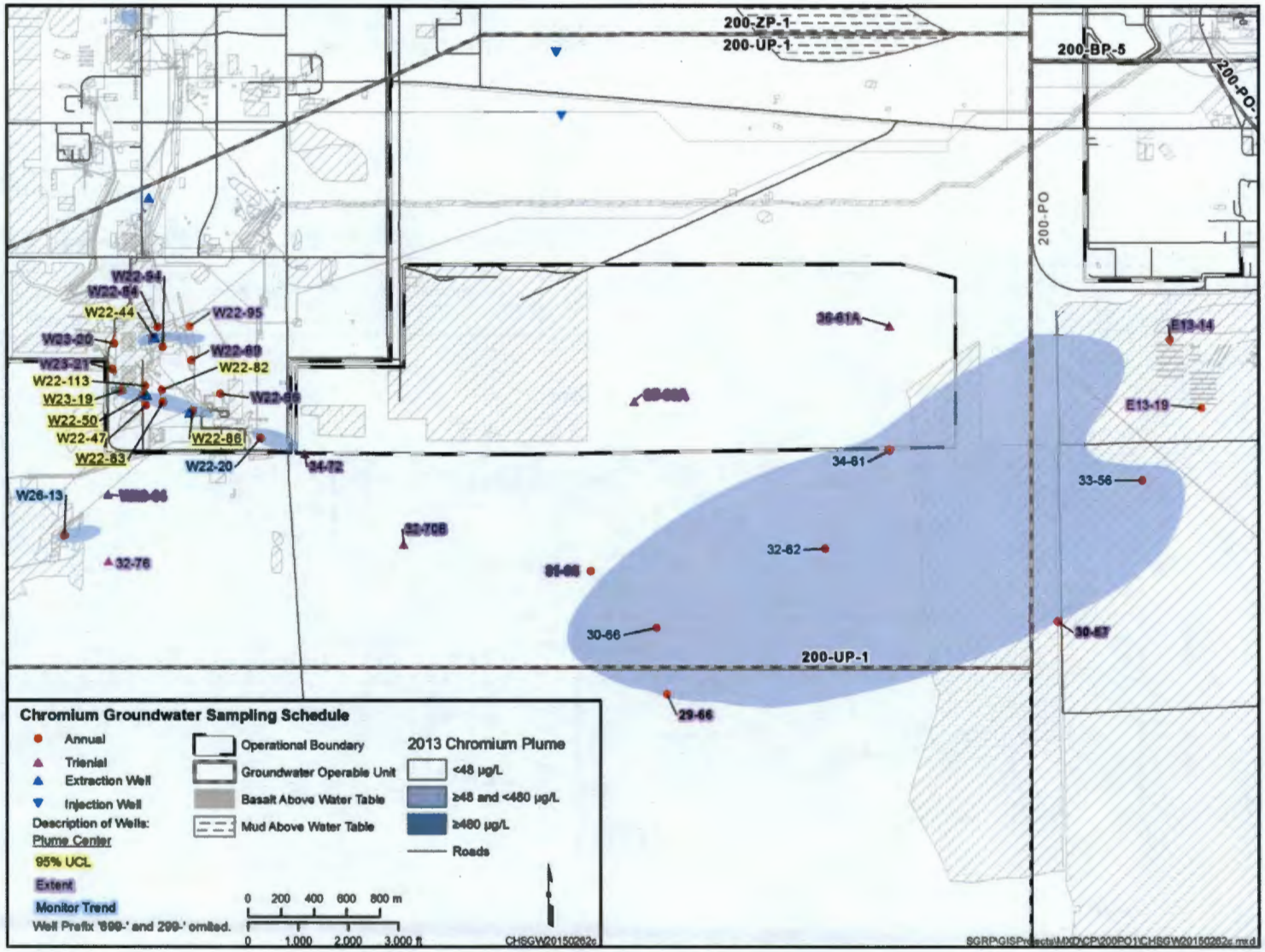

Figure A-16. 200-UP-1 Chromium Groundwater Monitoring Network

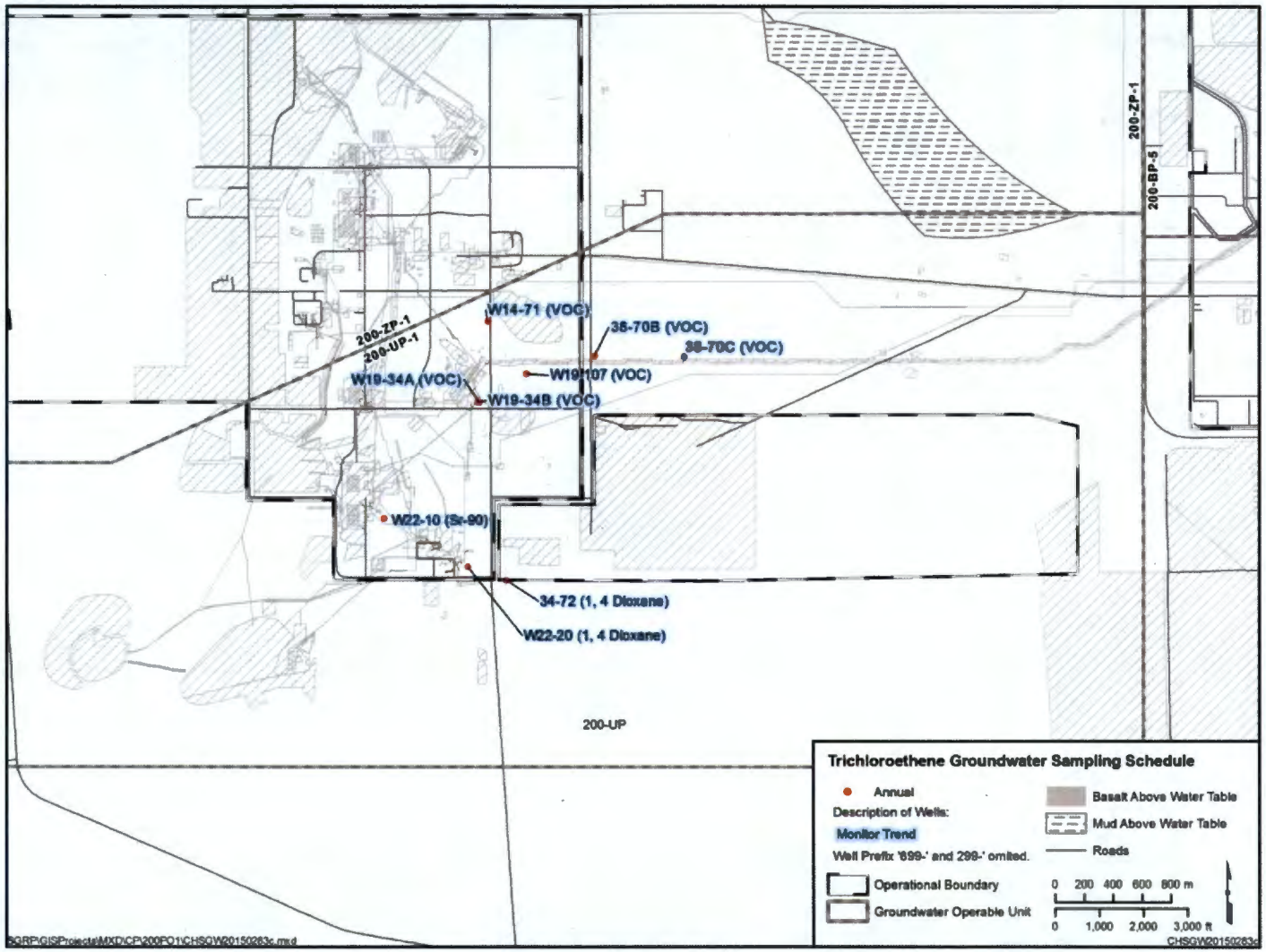

Figure A-17. 200-UP-1 Contaminants of Potential Concern (1,4-Dioxane, Chloroform, Strontium-90, Trichloroethene, Tetrachloroethene) Groundwater Monitoring Network

Table A-7. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential C Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-E13-14	A	--	--	--	--	--	--	--	--	--	--
299-E13-19	A	--	--	--	--	--	--	--	--	--	--
299-W14-71(d)	--	--	--	--	--	--	--	A	A	A	--
299-W15-37	--	--	A	--	--	--	--	--	--	--	--
299-W18-15	--	--	A	--	--	--	--	--	--	--	--
299-W18-21	--	--	A	--	--	--	--	--	--	--	--
299-W18-40	--	--	A	--	--	--	--	--	--	--	--
299-W19-101	--	T	A	A	--	A	--	--	--	--	--
299-W19-105	--	--	--	--	--	A	--	--	--	--	--
288-W19-107(d)	--	--	A	A	--	A	--	A	A	A	--
299-W19-18*	--	T	A	A	--	A	--	--	--	--	--
299-W19-34A(d)	--	--	A	A	--	T	--	A	A	A	--
299-W19-34B(d)	--	--	--	--	--	--	--	A	A	A	--
299-W19-36	--	--	S	S	--	A	--	--	--	--	--
299-W19-39	--	T	A	--	--	A	--	--	--	--	--
299-W19-4	--	--	A	--	--	--	--	--	--	--	--
299-W19-43	--	--	S	S	--	A	--	--	--	--	--
299-W19-44	--	--	A	A	--	--	--	--	--	--	--
299-W19-45	--	--	A	A	--	--	--	--	--	--	--
299-W19-46	--	--	A	--	--	A	--	--	--	--	--
299-W19-47	--	--	A	A	--	--	--	--	--	--	--
299-W19-48	--	--	A	A	--	A	--	--	--	--	--
299-W19-49	--	T	A	A	--	A	--	--	--	--	--
299-W21-2	--	T	A	--	--	T	--	--	--	--	--
299-W22-113	A	--	A	A	A	--	--	--	--	--	--

Table A-7. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential C Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W22-9 (dry, 299-W22-115)	--	T	--	--	A	--	--	--	--	--	--
299-W22-10	--	--	--	A	--	--	--	--	--	--	A
299-W22-20 (dry)**	A	T	A	A	A	--	A	--	--	--	--
299-W22-44 (dry, 299-W22-93)	A	--	A	A	--	--	--	--	--	--	--
299-W22-45	--	--	A	A	A	--	--	--	--	--	--
299-W22-47	A	--	A	A	--	--	--	--	--	--	--
299-W22-50 (dry, 299-W22-116)	A	--	A	A	--	--	--	--	--	--	--
299-W22-69	A	T	A	A	T	--	--	--	--	--	--
299-W22-72	--	T	A	A	A	--	--	--	--	--	--
299-W22-79	--	T	--	--	--	--	--	--	--	--	--
299-W22-81	--	--	A	A	--	--	--	--	--	--	--
299-W22-82	A	--	--	A	--	--	--	--	--	--	--
299-W22-83	A	--	A	A	T	--	--	--	--	--	--
299-W22-84	A	--	A	A	--	--	--	--	--	--	--
299-W22-85	--	--	--	A	--	--	--	--	--	--	--
299-W22-86	A	T	A	A	A	--	--	--	--	--	--
299-W22-87	--	--	--	--	--	T	--	--	--	--	--
299-W22-88	--	T	--	--	A	--	--	--	--	--	--
299-W22-94	A	--	A	A	--	--	--	--	--	--	--
299-W22-95	A	--	A	A	--	--	--	--	--	--	--
299-W22-96	A	T	A	A	A	--	--	--	--	--	--
299-W23-19	A	T	A	A	A	--	--	--	--	--	--
299-W23-20	A	--	A	A	--	--	--	--	--	--	--

Table A-7. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential C Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W23-21	A	--	A	A	A	T	--	--	--	--	--
299-W23-4	--	--	A	--	A	A	--	--	--	--	--
299-W26-13	A	--	--	--	--	--	--	--	--	--	--
299-W26-14	T	--	--	--	--	--	--	--	--	--	--
699-30-66 (d)	A	--	--	--	--	--	--	--	--	--	--
699-32-70B	T	--	--	--	A	--	--	--	--	--	--
699-32-72A	--	T	--	--	A	--	--	--	--	--	--
699-32-62	A	--	--	--	T	--	--	--	--	--	--
699-32-76	T	--	--	--	--	--	--	--	--	--	--
699-33-56	A	--	--	--	--	--	--	--	--	--	--
699-33-74	--	T	--	T	A	--	--	--	--	--	--
699-34-61	A	--	--	--	A	--	--	--	--	--	--
699-34-72	T	T	T	T	A	--	A	--	--	--	--
699-35-66A	T	A	T	--	A	--	--	--	--	--	--
699-35-70 (dry, 299-W21-3)	--	T	--	--	A	--	--	--	--	--	--
699-35-78A	--	--	--	--	T	--	--	--	--	--	--
699-36-61A	T	--	--	--	A	--	--	--	--	--	--
699-36-66B	--	A	A	--	A	--	--	--	--	--	--
699-36-70A	--	T	T	--	A	--	--	--	--	--	--
699-36-70B	--	T	A	--	B	--	--	--	--	--	--
699-37-66	--	A	A	--	A	--	--	--	--	--	--
699-38-61	--	--	T	--	A	--	--	--	--	--	--
699-38-65	--	A	A	--	A	--	--	--	--	--	--
699-38-68A	--	A	A	--	B	T	--	--	--	--	--

Table A-7. 200-UP-1 Operable Unit Contaminant of Concern and Contaminant of Potential C Monitoring Well Networks and Sampling Frequency

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
699-38-70 (dry, 299-W19-116)	--	A	A	--	--	A	--	--	--	--	--
699-38-70B (d)	--	--	T	--	--	--	--	A	A	A	--
699-38-70C (d)	--	A	A	--	--	--	--	A	A	A	--
699-40-62	--	--	A	--	T	--	--	--	--	--	--
699-40-65	--	--	A	--	--	--	--	--	--	--	--
699-29-66***	A	--	--	--	--	--	--	--	--	--	--
699-30-57***	A	--	--	--	--	--	--	--	--	--	--
699-31-68***	A	--	--	--	--	--	--	--	--	--	--

A = annual

B = biennial

S = semiannual

T = triennial

(d) = well screened in the deeper portion of unconfined aquifer

(dry, replacement well name) = well currently yields insufficient water for sampling and will be replaced. Replacement well will be sampled quarterly for the first year, then on sample schedule shown in the table thereafter.

* Well to be replaced by 299-W19-115

** Replacement well number not yet assigned

*** Southeast chromium plume characterization well, not yet installed

A4.1.11 Quality Assurance and Quality Control Program

QA/QC is described and documented in the associated SAP (Appendix B).

A4.1.12 Rationale for New or Replacement Wells

New wells or replacement wells will likely be required in the course of monitoring 200-UP-1 OU groundwater. Table A-8 summarizes the replacement wells currently identified for groundwater chromium monitoring.

The need for any future additional wells will be based on the results of sampling monitoring networks identified for COCs. For example, if COC concentrations in new wells intended to delimit plumes are greater than CUL, consider installing additional wells farther downgradient. As other replacement or new wells are identified for 200-UP-1, they will be addressed through the M-24 process.

Table A-8. Chromium Plume Proposed Characterization Monitoring Wells

Potential Well Location Identifier	Purpose	Accessibility
699-31-68 (CR1)	Identify the western boundary of the plume at the 48 µg/L level. Located on a particle track that runs through the center of the currently mapped high concentration portion of the plume (i.e., >100 µg/L).	Need a new road to access, probably from existing Well 699-30-66.
699-29-66 (CR2)	Identify the southern boundary of the plume at the 48 µg/L level. Located on the interpolated 48 µg/L contour due south from Well 699-30-66.	Need a new road to access, probably from existing Well 699-30-66.
CR3	Identify the northern extent of the >100 µg/L portion of the plume. Will also provide information useful for mapping the 48 µg/L contour between this well and 699-35-66A.	Located not far from the road used to access Well 699-30-66.
CR4	Identify the southern extent of the >100 µg/L portion of the plume.	Need a new road to access, probably from existing Well 699-30-66.
CR5	Identify the eastern extent of the >100 µg/L portion of the plume. Located on the same particle track as CR1 through the center of the mapped high-concentration area. May be a good location for an extraction well, so maybe construct as an 8 in. (20 cm) dual-purpose well (monitoring and extraction).	Would need a new road to access.
699-30-57 (CR6)	Identify the southeastern boundary of the plume at the 48 µg/L level.	Located adjacent to an existing road.

A4.2 Groundwater Level Monitoring

Water level monitoring is an integral component of remedy performance evaluations. To assess the adequacy of the monitoring well network for sampling, information on groundwater flow directions is needed to identify likely future directions of contaminant plume migration. Groundwater flow directions are determined by collecting water level measurements from wells and preparing potentiometric surface maps and/or calculating hydraulic gradients. This needs to be done on a periodic basis during the life of the remedies to detect changes in groundwater flow directions that may occur in order to help interpret groundwater sample results and evaluate the necessity for changes to the sampling well network.

Another use of water level measurements is to establish the current and likely future usability of the wells. Water levels are declining over much of the Hanford Site in response to the curtailment of effluent discharges to the soil column. Water level measurements are used to determine the amount of water that currently remains in a well, and water level trends are used to project when a monitoring well may go dry. This supports the planning and drilling of replacement wells.

The water level monitoring program for the 200-UP-1 OU is described in SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*. The water level network is summarized in Section 3.2 and shown in Figures A-18 and A-19. Selection of monitoring wells for water level monitoring was not part of this DQO effort.

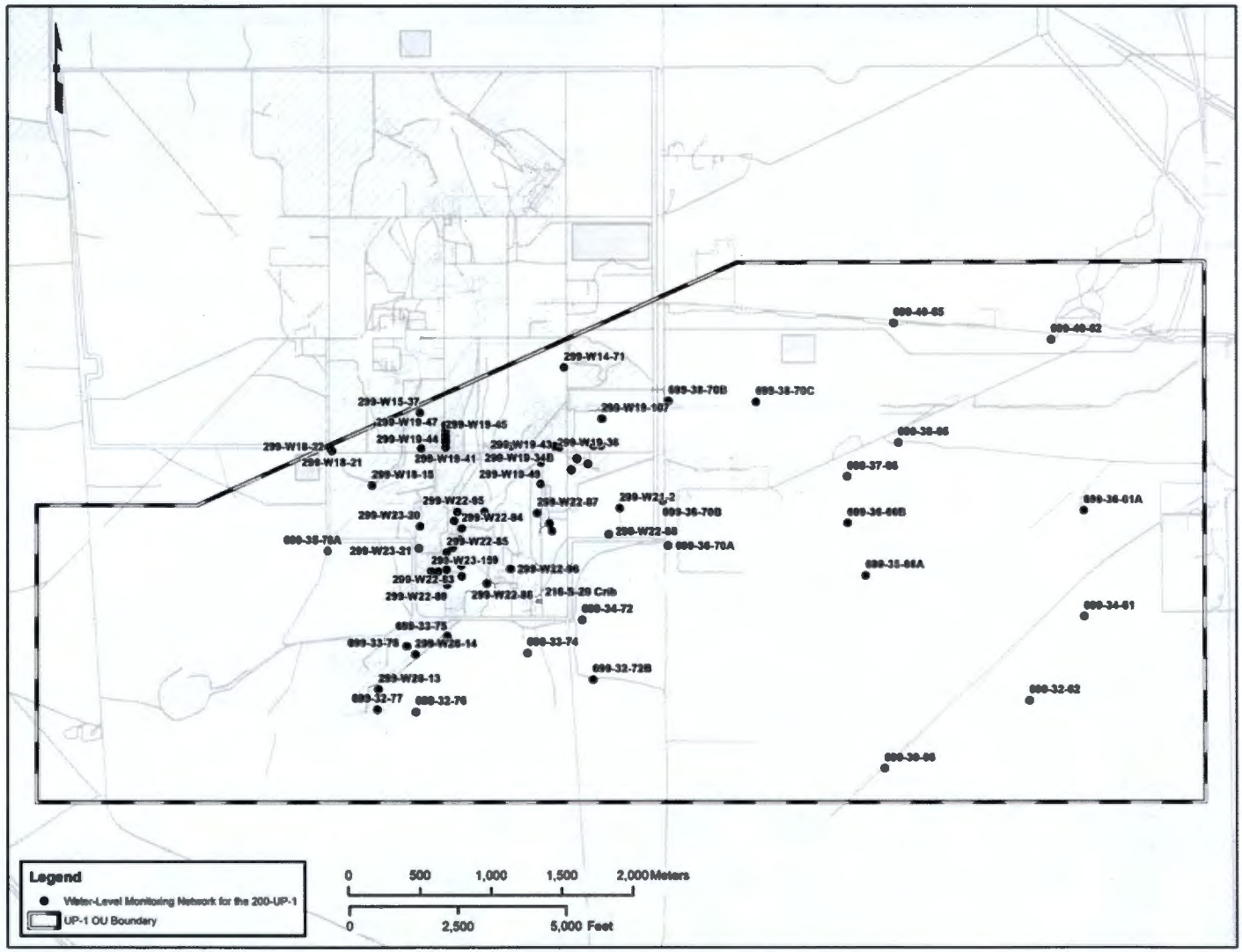

Figure A-18. Regional Water Level Network for the 200-UP-1 Operable Unit

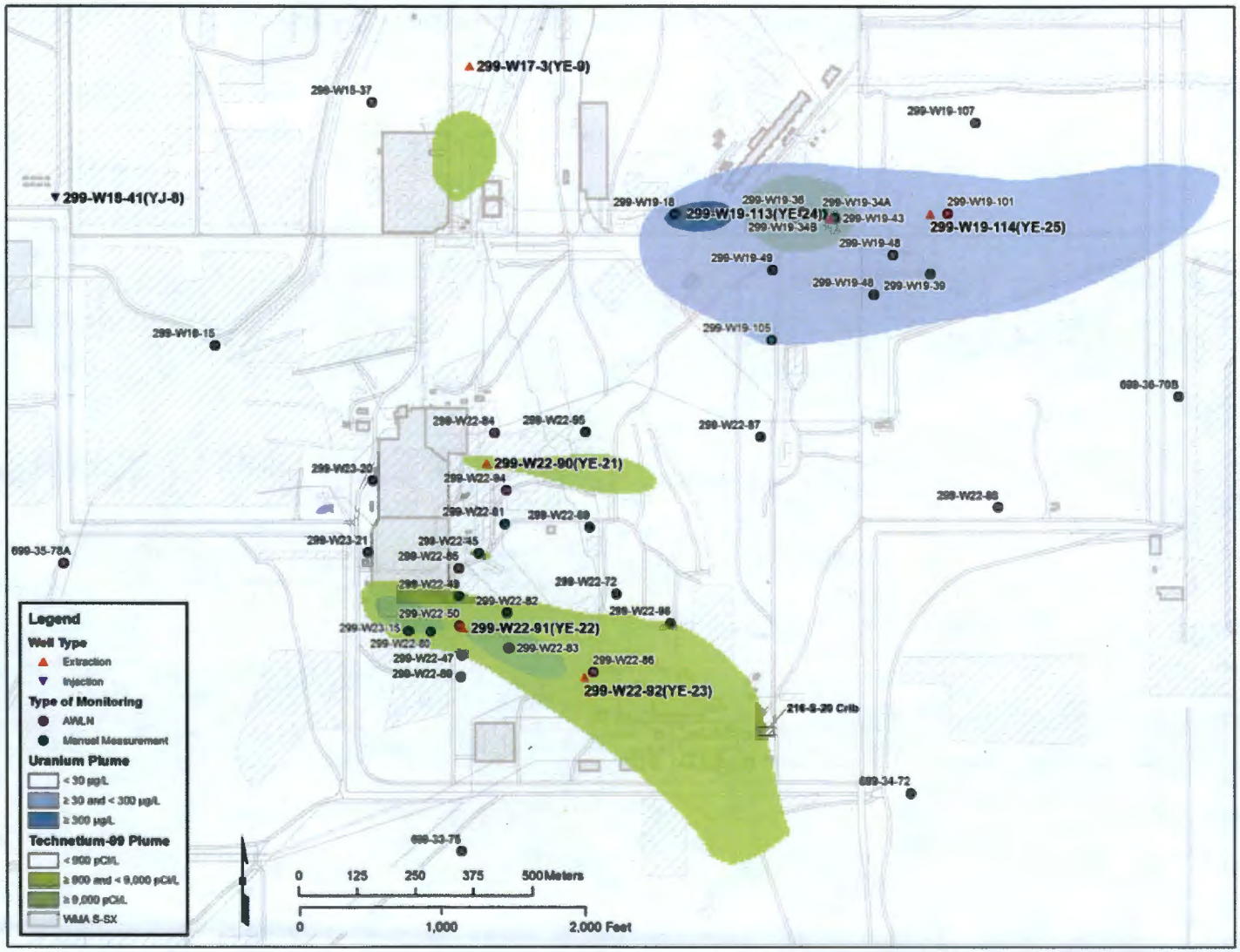

Figure A-19. Water Level Network for the Waste Management Area S-SX and U Plant Area Groundwater Extraction Systems

Table A-9. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
299-W14-71	C5102	LU			X
299-W15-37	B2753	UU	X		X
299-W18-15	A4932	TU		X	X
299-W18-21	A4933	TU			X
299-W18-22	A4934	LU			X
299-W18-40	C3395	TU			X
299-W19-101	C4966	TU	X	X	X
299-W19-105	C4968	TU		X	X
299-W19-107	C5193	UU	X		X
299-W19-12	A4945	TU			X
299-W19-18	A7743	TU		X	X
299-W19-34A	A9517	MU		X	X
299-W19-34B	A9513	MU		X	X
299-W19-36	B2461	TU	X	X	X
299-W19-39	B2460	TU		X	X
299-W19-41	B8551	TU			X
299-W19-42	B8553	TU			X
299-W19-43	C3381	TU		X	X
299-W19-44	C3393	TU			X
299-W19-45	C3394	TU			X
299-W19-46	C3958	TU		X	X
299-W19-47	C4258	TU			X
299-W19-48	C4300	TU	X	X	X
299-W19-49	C4695	TU		X	X
299-W21-2	C4639	TU			X
299-W22-24R	A9570	LU			X
299-W22-24S	A9571	MU			X

Table A-9. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
299-W22-24T	A9572	MU			X
299-W22-93	C8202	TU			X
299-W22-115	C9430	TU		X	X
299-W22-47	C4667	TU		X	X
299-W22-113	C8943	TU		X	X
299-W22-116	C9431	TU	X	X	X
299-W22-69	C4969	TU		X	X
299-W22-72	C4970	TU		X	X
299-W22-79	B8552	TU			X
299-W22-80	C3115	TU		X	X
299-W22-81	C3123	TU		X	X
299-W22-82	C3124	TU		X	X
299-W22-83	C3126	TU	X		X
299-W22-84	C3398	TU	X	X	X
299-W22-85	C3399	TU	X	X	X
299-W22-86	C4971	TU	X	X	X
299-W22-87	C4977	TU		X	X
299-W22-88	C4978	TU	X		X
299-W22-89	C7664	TU		X	X
299-W22-94	C8203	TU	X	X	X
299-W22-95	C8240	UU		X	X
299-W22-96	C8241	TU		X	X
299-W23-236	C9432	TU		X	X
299-W23-20	C3112	TU		X	X
299-W23-21	C3113	TU		X	X
299-W26-13	B8817	TU			X
299-W26-14	B8828	TU			X

Table A-9. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]
299-W27-2	A5410	LU			X
699-30-66	C4298	LU			X
699-32-62	A5128	TU			X
699-32-72B	A9525	TU			X
699-32-76	C4975	TU			X
699-32-77	A5131	TU			X
699-33-74	C4973	TU			X
699-33-75	C4974	TU		X	X
699-33-76	C4976	TU			X
699-34-61	A5463	TU			X
699-34-72	C4972	TU		X	X
699-35-66A	A5139	TU			X
699-35-78A	A5141	TU	X		X
699-36-61A	A5144	TU			X
699-36-66B	C6219	TU			X
699-36-70A	A9901	TU			X
699-36-70B	C4299	TU		X	X
699-37-66	C5704	TU			X
699-38-65	A5148	TU			X
699-38-70B	C4236	MU			X
699-38-70C	C4256	LU			X
699-40-62	A5158	TU			X
699-40-65	C4235	TU			X

Table A-9. Water Level Monitoring Network for the 200-UP-1 Operable Unit

Well Name	Well Identification	Relative Monitoring Zone[a]	Water Level Measurement Type and Purpose		
			AWLN – Active Remedy Performance	Manual – Active Remedy Performance[b]	Manual – Regional Water Levels[c]

a. Identifies the relative position of the screened interval in the aquifer, as follows:

- TU (top of unconfined): Screened across or within 1.5 m (5 ft) of the water table with less than 10.7 m (35 ft) of the open interval extending below the water table.
- UU (upper unconfined): Screened across or within 1.5 m (5 ft) of the water table with more than 10.7 m (35 ft) but no more than 15.2 m (50 ft) of the open interval extending below the water table, or screened deeper than 1.5 m (5 ft) below the water table, and open interval extends no more than 15.2 m (50 ft) below the water table.
- MU (middle unconfined): Open interval begins at greater than 15.2 m (50 ft) below the water table and does not extend below the middle course of the Ringold Formation (unit 7) or to within 15.2 m (50 ft) of the top of basalt.
- LU (lower unconfined): Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle course of the Ringold Formation (unit 7) or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
- CR (confined Ringold): Open interval is within a confined aquifer in the Ringold Formation and does not extend more than 3.0 m (10 ft) below the top of basalt.

b. Monthly for 1 year, then evaluate if a quarterly frequency is acceptable thereafter.

c. Collected annually in March.

AWLN = Automated Water Level Network

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Appendix B

Sampling and Analysis Plan

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Terms

AEA	alpha energy analysis
ALARA	as low as reasonably achievable
ASTM	ASTM International, formerly American Society for Testing and Materials
BTR	Buyer's Technical Representative
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DWS	drinking water standard
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEAD	format for electronic analytical data
FSO	Field Sampling Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)

HEIS	Hanford Environmental Information System
HSU	hydrostratigraphic unit
IATA	International Air Transport Association
IC	ion chromatography
LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MCL	maximum contaminant level
MDL	method detection limit
MS	matrix spike
MSA	Mission Support Alliance
MSD	matrix spike duplicate
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
NCO	Nuclear Chemical Operator
OU	operable unit
P&T	pump and treat
PPE	personal protective equipment
PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	Radiological Control Technician
RD/RAWP	remedial design/remedial action work plan
RDR	request for data review
ROD	record of decision
RPD	relative percent difference
SAF	Sample Authorization Form
SAP	sampling and analysis plan

SMR	Sample Management and Reporting
SPLIT	field split sample
SST	single-shell tank
SUR	surrogate
TPA	Tri-Party Agreement
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UPR	unplanned release
VOA	volatile organic analysis
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WMA	waste management area

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B1 Introduction

This document presents the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater monitoring program for the 200-UP-1 Groundwater Operable Unit (OU) (Figure B-1).

The plan describes sampling for groundwater performance monitoring associated with implementation of the selected remedy for the 200-UP-1 OU, as described in the record of decision (ROD) (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). The 200-UP-1 Groundwater OU includes several groundwater plumes that span an area approximately 10 km^2 (4 mi^2), underlying the southern portion of the Hanford Site 200 West Area (Figure B-1). Major waste streams that contributed to 200-UP-1 OU groundwater contamination were associated with the plutonium-separation and uranium recovery operations at the S Plant and U Plant facilities, where liquid wastes were disposed to the ground via ponds, cribs, ditches, and trenches. As effluent was discharged to these sites in the past, more mobile contaminants migrated through the vadose zone to the groundwater. Some groundwater contamination also resulted from single-shell tank (SST) leaks or unplanned releases (UPRs), particularly associated with Waste Management Area (WMA) S-SX. Groundwater contamination has migrated from the adjacent 200-ZP-1 OU into the 200-UP-1 OU that originated from liquid waste disposed to the ground at Z Plant plutonium concentration and recovery facilities.

The ROD (EPA et al., 2012) identified the following contaminants of concern (COCs) for the 200-UP-1 OU: carbon tetrachloride, total chromium, hexavalent chromium (Cr(VI)), iodine-129, nitrate, technetium-99, tritium, and uranium. The ROD (EPA et al., 2012) requires monitoring of final contaminants of potential concern (COPCs), including 1,4-dioxane, chloroform, strontium-90, tetrachloroethene, and trichloroethene. The selected remedy for the 200-UP-1 OU consists of five components: groundwater pump and treat (P&T), monitored natural attenuation, iodine-129 hydraulic containment and treatment technology evaluation, remedy performance monitoring, and institutional controls. The first four components require periodic groundwater monitoring and data evaluation to assess remedy performance and determine when the remedial action is complete. The remedy components were developed to support future use of groundwater as a potential domestic drinking water source. In accordance with this goal, the following specific remedial action objectives (RAOs) for remediation of the contaminated 200-UP-1 OU groundwater are listed:

- **RAO 1:** Return the 200-UP-1 OU groundwater to beneficial use as a potential drinking water source.
- **RAO 2:** Prevent human exposure to contaminated 200-UP-1 OU groundwater that exceeds acceptable risk levels for drinking water.

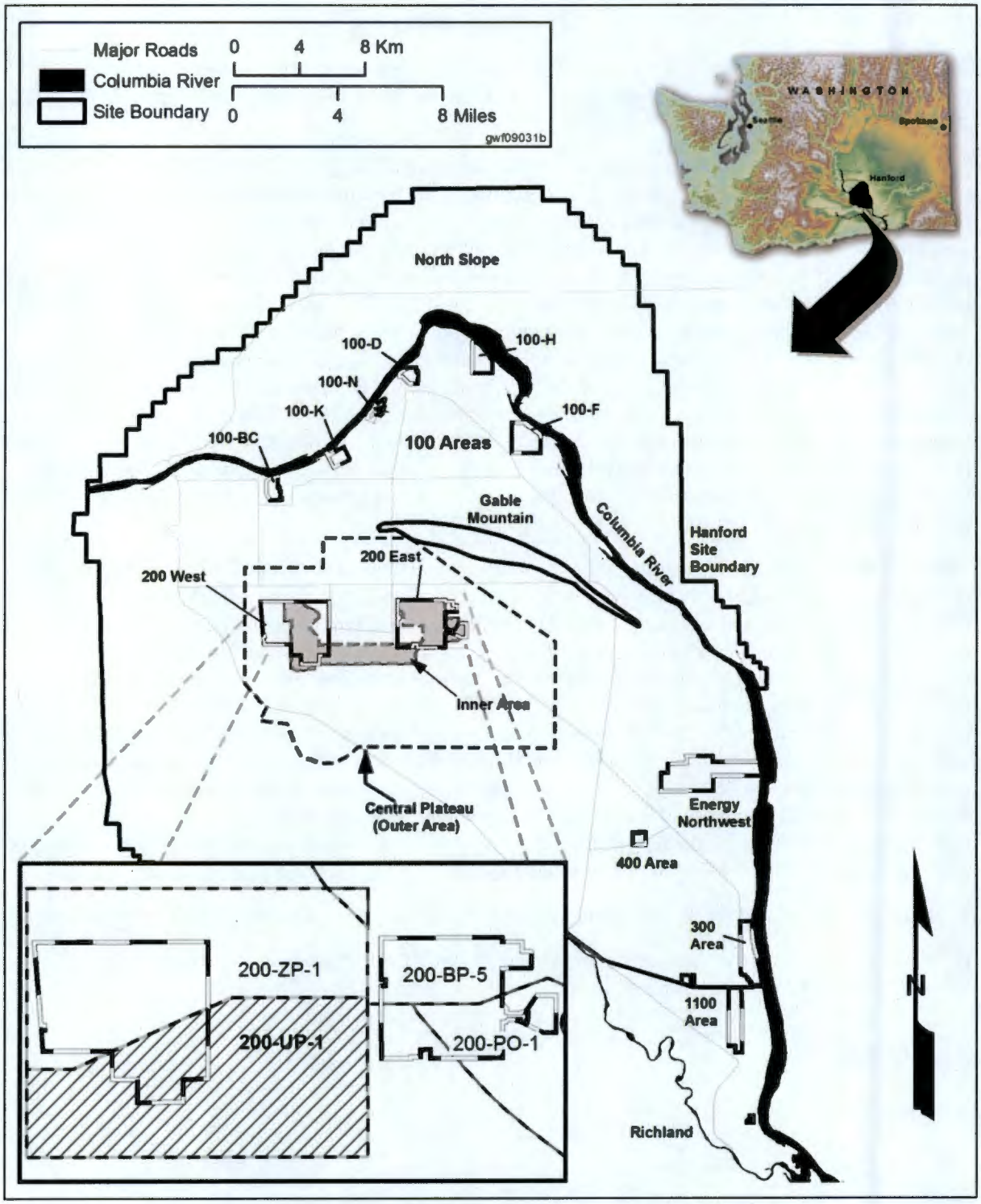

Figure B-1. Location of the 200-UP-1 Groundwater Operable Unit

This plan supersedes the following previous CERCLA groundwater sampling and analysis documents for the OU:

- Appendix B of DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*
- Appendix A of DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit*

This appendix provides the sampling interval information for wells within the 200-UP-1 groundwater monitoring network and consists of five chapters, with the remainder of this chapter addressing the project scope and objectives, background, summary of data quality objectives (DQOs), COCs, and project schedule. Chapter B2 discusses quality assurance (QA) requirements. Chapter B3 provides the field sampling plan. Chapters B4 and B5 address waste management and health and safety requirements. Chapter B6 includes a list of references cited in this appendix. Appendix A contains the DQO report.

B1.1 Project Scope and Objective

The following objectives apply to this groundwater monitoring plan:

- Demonstrate whether the remedial action being taken, including natural attenuation, will achieve cleanup levels for all COCs (except for iodine-129) in the estimated time frame.
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may impact the P&T system, natural attenuation processes, and the hydraulic containment actions.
- Verify that the contamination is not expanding downgradient, laterally, or vertically subsequent to the period of time over which the P&T and hydraulic containment components have been functional..

This sampling and analysis plan (SAP) includes both COCs and COPCs listed in the 200-UP-1 ROD (EPA et al., 2012). COCs include carbon tetrachloride, total chromium, Cr(VI), iodine-129, nitrate, technetium-99, tritium, and uranium. The ROD (EPA et al., 2012) requires monitoring of final COPCs including 1,4-dioxane, chloroform, strontium-90, tetrachloroethene, and trichloroethene.

As part of the DQO process described in Appendix A, historical sampling locations and analytical results generated from the 200-UP-1 monitoring network were reviewed in conjunction with this SAP. Locations of monitoring wells with respect to the 2013 plume configurations were analyzed with the objective of optimizing the current well network and sampling requirements. The analysis was directed at defining the wells needed for contaminant monitoring and determination of an appropriate sampling frequency.

The monitoring network wells identified in this new SAP are designed to collect groundwater data sufficient to evaluate and monitor remedy performance for the 200-UP-1 OU. This routine groundwater monitoring data will be reported in an annual performance monitoring plan. Monitoring under this plan for remedy performance will continue until the remedy is complete. The data gathered under this plan help satisfy the requirements of CERCLA (40 CFR 300.430(b), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy").

Table B-1 identifies existing documents that currently have sampling requirements associated with the 200-UP-1 OU and identifies which existing document is completely or partially superseded by this SAP.

Table B-1. Sampling and Analysis Plans for the 200-UP-1 Operable Unit

Regulatory Program	Unit Monitored	Document Number	Document Title	Publication Year	Superseded
CERCLA and *Atomic Energy Act of 1954*	--	DOE/RL-2012-59	*Surveillance Groundwater Monitoring on the Hanford Site*	2013	No
CERCLA	200-UP-1	Appendix A of DOE/RL-2013-07	*200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*	2013	Yes
CERCLA	Environmental Restoration Disposal Facility	WCH-198	*Groundwater Protection Plan for the Environmental Restoration Disposal Facility*	2008	No
RCRA	216-S-10	DOE/RL-2008-61	*Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*	2010	No
RCRA	WMA S-SX	DOE/RL-2009-73	*Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*	2011	No
RCRA	WMA U	DOE/RL-2009-74	*Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*	2012	No

Note: Complete reference citations are provided in Chapter 6.

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

RCRA = Resource *Conservation and Recovery Act of 1976*

CERCLA groundwater monitoring requirements in the 200-UP-1 OU are addressed by this new plan. Programmatic requirements (*Atomic Energy Act of 1954*, *Resource Conservation and Recovery Act of 1976* [RCRA], and Environmental Restoration Disposal Facility) for other sampling within the 200-UP-1 area will continue to be performed pursuant to other sampling plans, and those requirements are not included in this SAP. RCRA groundwater monitoring is conducted for 216-S-10, WMA S-SX, and WMA U under separate plans (Table B-1). Data collected under the separate plans are considered supplementary groundwater quality information to the CERCLA OU process.

Surveillance Groundwater Monitoring on the Hanford Site (DOE/RL-2012-59), issued in October 2013, includes monitoring specifications of the upper basalt-confined aquifer and the Ringold-confined aquifer.

Groundwater within the upper basalt-confined aquifer is monitored because it is a potential pathway for contaminants to move offsite. The confined to semiconfined aquifer within Ringold Unit A is present beneath most of the Hanford Site. The confined aquifer sampling will be continued under DOE/RL-2012-59 and not brought under this SAP.

B1.2 Background

Hydrogeology, groundwater flow, contaminant plumes, and source of contamination are summarized in this subsection. An overview of the DQO process directing the sampling objectives and identification of contaminants is also provided.

B1.2.1 Site Geology/Hydrology

The Hanford Site lies within the semiarid, shrub-steppe Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure B-1). The 200 Areas are located on a broad, relatively flat area that constitutes a local topographic high near the center of the Hanford Site. The 200-UP-1 OU underlies the southern portion of the 200 West Area, which is on the western end of the Central Plateau. Surface elevations above the OU range from approximately 183 m (600 ft) to more than 213 m (700 ft) above mean sea level.

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 primarily of sand and gravel, with some silt layers. Figure B-2 shows a generalized cross section of the Central Plateau and illustrates the hydrogeologic conditions present at the OU, including the water table. The following geologic units are above the basalt bedrock (in descending sequence):

- Unconsolidated sand and gravel of the Hanford formation (HSU 1)
- Fine- to coarse-grained sediment of the Cold Creek Unit (CCU) (HSU 3)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 5 (HSU 5)
- Silt and clay of the Ringold Formation lower mud unit 8 (HSU 8)
- Semiconsolidated silt, sand, and gravel of the Ringold Formation unit 9 (HSU 9)

These sedimentary layers are laterally continuous across the majority of the OU and are referred to as hydrostratigraphic units (HSUs). Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the upper Ringold unit), the CCU, and the Hanford formation.

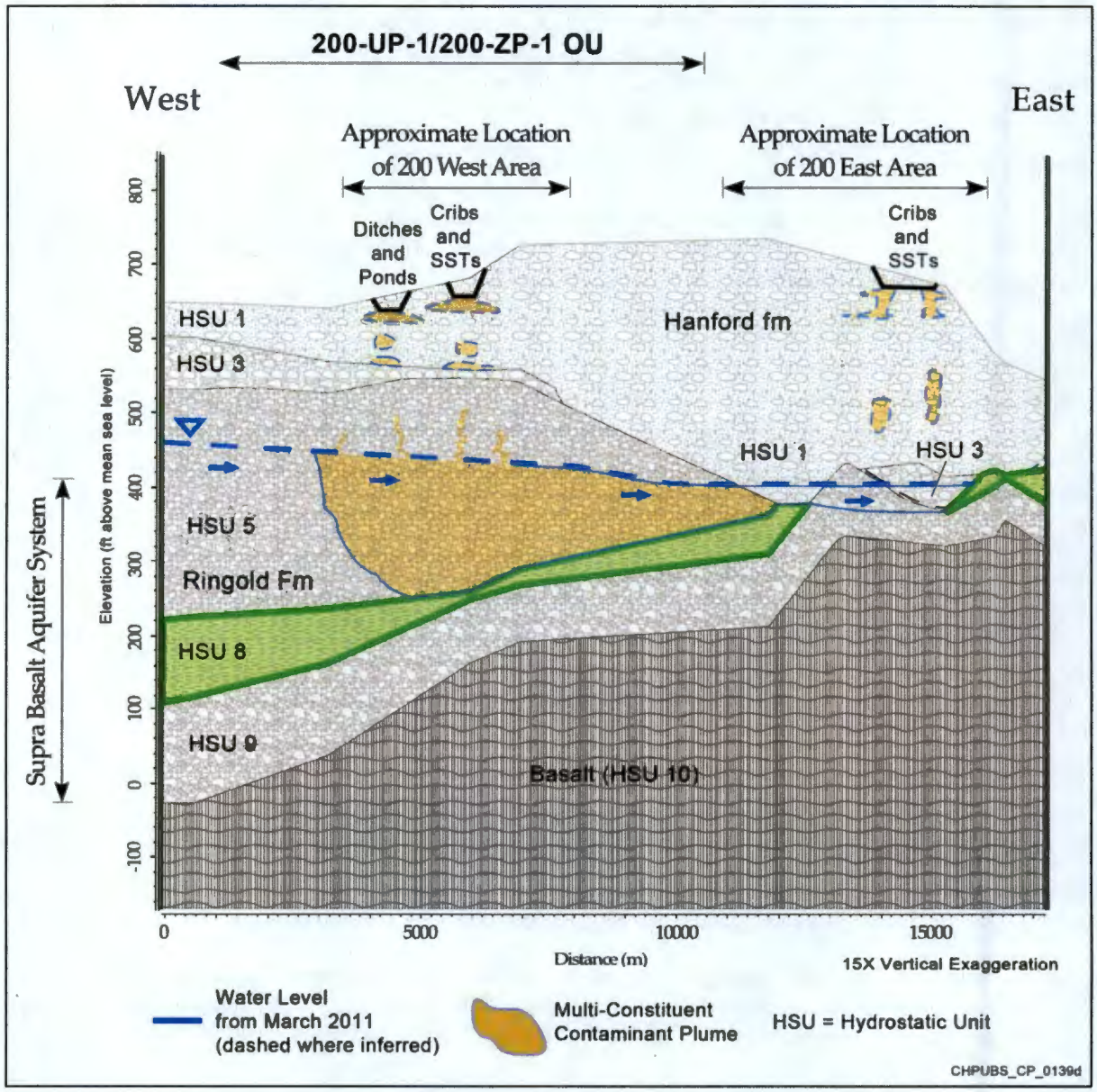

Figure B-2. Conceptual Physical Site Model for the 200 West Area

B1.2.2 Groundwater Flow

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the lower Ringold Formation and the basalt. 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 (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 B-2). The water table is relatively deep within the 200-UP-1 OU, averaging approximately 75 m (250 ft) below ground surface. Groundwater contamination is largely contained within the uppermost unconfined aquifer, which ranges in thickness from approximately 10 to 100 m (33 to 330 ft). The unconfined aquifer controls lateral movement of groundwater contaminants across the OU and is bounded below by the Ringold Formation lower mud unit (HSU 8). This mud layer acts as a hydraulic impediment over the majority of the OU and

limits groundwater flow from moving into the confined aquifer below. Groundwater flow is locally influenced by the 200-ZP-1 OU final remedy P&T system and the WMA S-SX interim remedial measure extraction system.

B1.2.3 Sources of Groundwater Contamination

The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities that have been grouped into four process areas: U Plant, Z Plant, S Plant (Reduction-Oxidation Plant), and T Plant. The major waste streams that contributed to 200-UP-1 OU groundwater contamination were associated with the plutonium separation and uranium recovery operations at the S Plant and U Plant facilities, where liquid wastes were disposed to the ground via ponds, cribs, ditches, and trenches. As effluent was discharged to these sites in the past, the more mobile contaminants migrated through the vadose zone to the groundwater. Some groundwater contamination also resulted from SST leaks or UPRs, particularly associated with WMA S-SX. Groundwater contamination has migrated from the adjacent 200-ZP-1 OU into the 200-UP-1 OU that originated from liquid waste disposed to the ground at Z Plant plutonium concentration and recovery facilities.

B1.2.4 Contaminant Plumes

More than 90 groundwater monitoring wells were used to assess the nature and extent of these contaminants within and surrounding the 200-UP-1 OU. The 200-ZP-1 OU plumes to the north are also shown on Figure 1-2. The following plumes originated within the 200-UP-1 OU:

- Uranium plume originating from the U Plant cribs
- Widespread nitrate plume originating from U Plant and S Plant cribs and WMA S-SX
- Total chromium and Cr(VI) plume associated with WMA S-SX, and a dispersed chromium (total and hexavalent) plume in the southeast corner of the OU that originated from an S Plant crib
- A widespread iodine-129 plume originating from U Plant and S Plant cribs
- Four separate technetium-99 plumes associated with WMA U, U Plant cribs, and WMA S-SX
- A widespread tritium plume originating from S Plant cribs

In addition to the plumes that formed within the 200-UP-1 OU, a widespread carbon tetrachloride plume exists over a large portion of the 200 West Area. This plume originated from operation of the Plutonium Finishing Plant (Z Plant) facilities and has spread south and east from the 200-ZP-1 OU and into the 200-UP-1 OU. Additional details regarding contaminant plumes are provided in the DQO (Appendix A).

In association with development of this SAP, the DQO process was undertaken to support identification of sampling requirements appropriate for the current SAP objectives. The DQO process followed for this SAP and its resulting application to refine the well network and focus the sampling requirements, is provided in Appendix A. The purpose of this DQO process was to support the optimization of the routine monitoring network for the 200-UP-1 groundwater OU to support groundwater monitoring with implementation of the active portion of the 200-UP-1 remedy operation.

The following characteristics and conditions impact the sampling design:

- Additional wells that do not yield sufficient water for sampling in the future
- Changes in groundwater flow direction from operation of groundwater extraction and injection wells

The DQO process was conducted to support development of a performance monitoring plan and this SAP for the 200-UP-1 OU. The DQO summary report has been developed in accordance with EPA/240/B-

06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process*. In evaluating readily available 200-UP-1 data and information through the U.S. Environmental Protection Agency (EPA) seven-step process, the environmental data needed to evaluate groundwater remedy performance, guide remedy optimization, measure the progress toward final cleanup level and RAO achievement, and monitor the southeast chromium plume in the 200-UP-1 OU have been identified.

Two principal study questions (PSQs) were identified for resolution in the DQO to support data collection and evaluation to support the project RAOs (Section B1):

- Are the 200-UP-1 cleanup criteria and RAOs for groundwater being achieved within the time frames projected in the remedial design/remedial action work plan (RD/RAWP)?
- Are concentrations of COPCs below action levels over the next 5-year time frame?

This SAP describes the data collection activities necessary to support implementation of the remedy performance monitoring component in providing environmental data of sufficient quality to support the 200-UP-1 RAOs and PSQs.

B1.3 Data Quality Objectives Summary

In association with development of this SAP, the DQO process was undertaken to support identification of sampling requirements appropriate for the current SAP objectives. The DQO process followed for this SAP and its resulting application to refine the well network and focus the sampling requirements, is provided in Appendix A. The purpose of this DQO process was to support the development of the monitoring network for remedy performance monitoring for the 200-UP-1 groundwater OU.

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In addition, monitoring of the iodine-129 plume during hydraulic containment, and addition of new wells drilled to characterize the southeast chromium plume were considered in the DQO.

B1.4 Contaminants

Specific analytes for CERCLA groundwater monitoring are provided in Table B-2. The CERCLA contaminants listed are those identified in 200-UP-1 ROD (EPA et al., 2012). Although listed as a COC in the 200-UP-1 ROD, sampling for carbon tetrachloride within the 200-UP-1 OU is described in DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*.

Table B-2. Analytes for 200-UP-1 OU Groundwater Monitoring

Contaminant	Chemical Abstracts Service Number
Inorganics – Metals	
Chromium (Total)	7440-47-3
Chromium (Hexavalent)	18540-29-9
Uranium	7440-61-1
Inorganics – Anions	
Nitrate	14797-55-8
Organics	
1,4-Dioxane	123-91-1
Chloroform	67-66-3
Tetrachloroethene	127-18-4
Trichloroethene	79-01-6
Radionuclides	
Iodine-129	15046-84-1
Strontium-90	10098-97-2
Technetium-99	14133-76-7
Tritium	10028-17-8
Field Measurements	
Depth to Groundwater	Not applicable

B1.5 Project Schedule

This SAP will direct CERCLA monitoring activities needed for the 200-UP-1 OU during implementation of the remedy to monitor remedy performance. The sampling schedule will be established by the Sample Management and Reporting (SMR) organization through processes and applications, such as the *Sample Management Integrated Lifecycle Environment*, which optimizes the overall number of sampling trips and limits schedule redundancy. SMR tracks overlapping requirements, so single sampling events can co-sample wells and optimize schedules.

B2 Quality Assurance Project Plan

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review.

This chapter describes the applicable environmental data collection requirements and controls based on the QA elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement (Tri-Party Agreement [TPA]) Action Plan (Ecology et al., 1989b require QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal units, as well as for past practice processes. This QAPjP also describes the applicable requirements and controls based on guidance found in Washington State Department of

Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Review and Usability.

B2.1 Project Management

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

B2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the RL project manager in obtaining approval of the SAP and future proposed revisions. The project organization (regarding routine groundwater monitoring) is described in the following subsections and illustrated in Figure B-3.

B2.1.1.1 Regulatory Lead

The lead regulatory agency (LRA) is responsible for regulatory oversight of cleanup projects and activities. LRA has SAP approval authority for the OUs they manage and works with the U.S. Department of Energy (DOE)-Richland Operations Office (RL) to resolve concerns over the work described in this SAP in accordance with the TPA (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*).

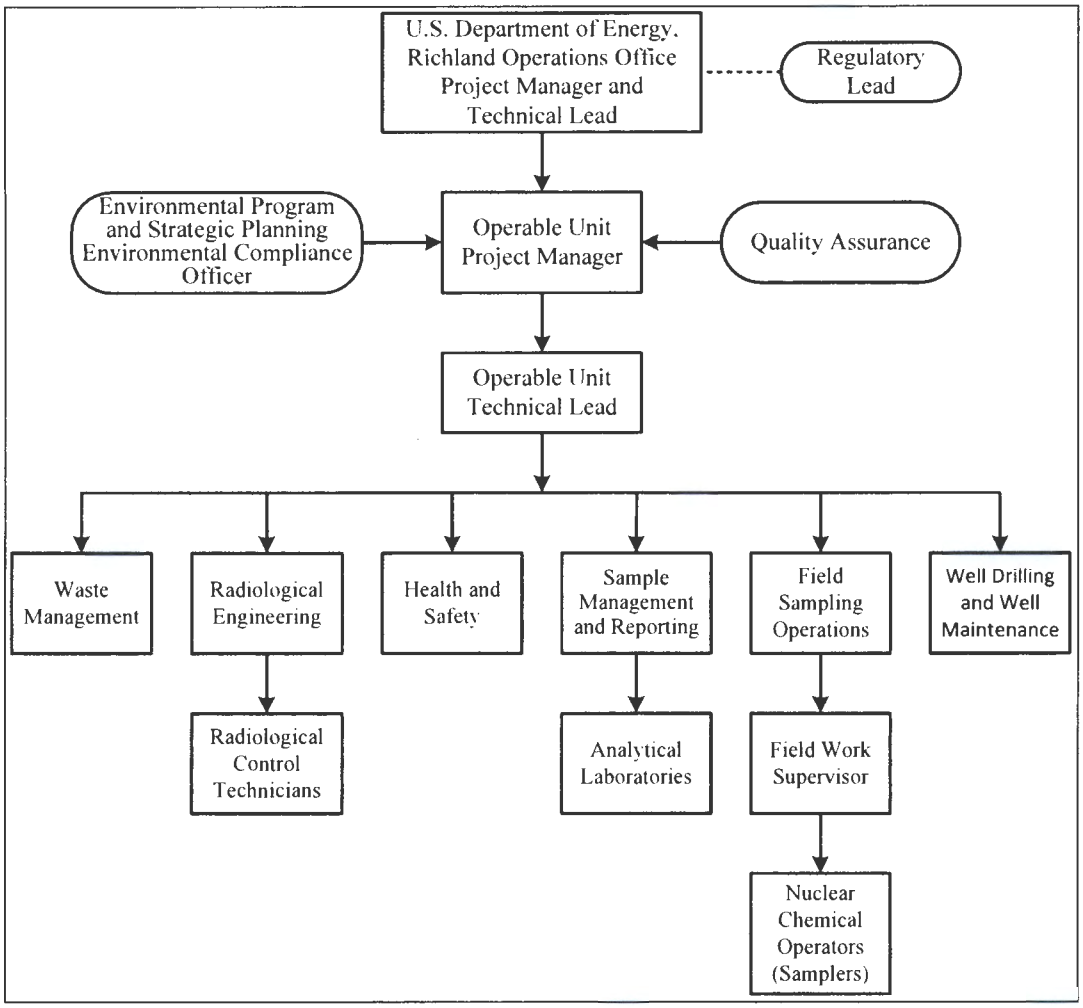

Figure B-3. Project Organization

B2.1.1.2 DOE-RL Project Manager

The DOE-RL Project Manager is responsible for the following tasks:

- Monitoring the contractor's performance of activities under CERCLA, RCRA, Atomic Energy Act of 1954, and the TPA (Ecology et al., 1989a) for the Hanford Site
- Obtaining LRA approval of the SAP
- Authorizing field sampling activities
- Approving the SAP
- Functioning as the primary interface with regulators

B2.1.1.3 DOE-RL Technical Lead

The DOE-RL Technical Lead is responsible for the following tasks:

- Providing day-to-day oversight of the contractor's work scope performance
- Working with the contractor and the regulatory agencies to identify and resolve technical issues
- Providing technical input to the DOE-RL Project Manager

B2.1.1.4 Operable Unit Project Manager

The OU Project Manager (or designee) is responsible and accountable for the following tasks:

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

B2.1.1.5 Operable Unit Technical Lead

The OU Technical Lead is responsible for the following tasks:

- Developing specific sampling design, analytical requirements, and QC requirements either independently or as defined through a systematic planning process
- Ensuring that sampling and analysis activities, as delegated by the OU Project Manager, are carried out in accordance with the SAP
- Working closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, the Field Work Supervisor (FWS), and the SMR organization to integrate these and other technical disciplines in planning and implementing the work scope

B2.1.1.6 Environmental Compliance Officer

The ECO is responsible for the following tasks:

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

B2.1.1.7 Quality Assurance

The QA point-of-contact is responsible for the following tasks:

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

B2.1.1.8 Health and Safety

The Health and Safety organization is responsible for the following tasks:

- Coordinating industrial safety and health support within the project, in accordance with the health and safety program, job hazard analyses, and other pertinent federal regulation

- Assisting project personnel in complying with the applicable health and safety program
- Coordinating with Radiological Engineering to determine personal protective equipment (PPE) requirements

B2.1.1.9 Radiological Engineering

Radiological Engineering is responsible for the following tasks:

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

B2.1.1.10Sample Management and Reporting Organization

The SMR organization is responsible for the following activities:

- Interfacing between the OU Technical Lead, Field Sampling Operations (FSO), Well Maintenance Organization, and analytical laboratories
- Generating field sampling documents, labels, and instructions for field sampling personnel
- Developing the Sample Authorization Form (SAF), which provides information and instruction to the analytical laboratories)
- Providing instructions to FSO Nuclear Chemical Operators (NCOs) on collection of samples as specified in a SAP
- Monitoring the entire sample and data process
- Coordinating laboratory analytical work, and ensuring that laboratories conform to Hanford Site QA requirements (or their equivalent), as approved by DOE, EPA, and Ecology
- Resolving sample documentation deficiencies or issues associated with FSO, laboratories, or other entities to ensure that project needs are met
- Receiving analytical data from the laboratories
- Ensuring that data are uploaded into the Hanford Environmental Information System (HEIS)
- Arranging for and overseeing data validation, as requested
- Informing the OU Project Manager and/or OU Technical Lead of any issues reported by the analytical laboratory

B2.1.1.11Analytical Laboratories

Analytical laboratories are responsible for the following tasks:

- Analyzing samples in accordance with established methods
- Providing data packages containing analytical and QC results
- Providing explanations in response to resolution of analytical issues
- Meeting the requirements of this plan
- Being on the Mission Support Alliance (MSA) Evaluated Suppliers List

- Being accredited by Ecology for the analyses performed for the Soil and Groundwater Remediation Project

B2.1.1.12Waste Management

Waste Management is responsible for the following tasks:

- Communicating policies and protocols
- Ensuring compliance for waste storage, transportation, disposal, and tracking in a safe and cost effective manner
- Identifying waste management sampling and characterization requirements to ensure regulatory compliance
- Interpreting data to determine waste designations and profiles
- Preparing and maintaining other documents confirming compliance with waste acceptance criteria

B2.1.1.13Field Sampling Operations

FSO is responsible for the following tasks:

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

B2.1.1.14Well Maintenance

The Well Maintenance Manager is responsible for the following tasks:

- Well maintenance activities
- Coordinating with the OU Technical Lead to identify field constraints that could affect groundwater sampling

B2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure that generation of analytical data of known and appropriate quality is acceptable and useful for decision making. In support of this objective, statistics and data descriptors, known as data quality indicators (DQIs), help determine the acceptability and utility of data to the user. The principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity, as defined for the purposes of this document in Table B-3.

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

Table B-3. Data Quality Indicators

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

Table B-3. Data Quality Indicators

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

Table B-3. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet the objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

B2.1.3 Special Training/Certification

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

In addition, pre-job briefings, in accordance with work management and work release requirements, documents the following evaluation activities and associated hazards:

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

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

B2.1.4 Documents and Records

The OU Project Manager (or designee) is responsible for ensuring that the current version of the SAP is being used and providing updates to field personnel. Version control is maintained by the administrative document control process. Changes to the sampling document are handled consistent with HASQARD (DOE/RL-96-68) and the TPA Action Plan (Ecology et al., 1989b). The OU Project Manager is responsible for tracking all SAP changes, obtaining appropriate review, and alerting DOE-RL of these changes. Appropriate documentation will follow, in accordance with the requirements for the type of change. Table B-4 summarizes the changes that may be made and their documentation requirements.

The FWS, SMR, and appropriate BTR are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the SAP. SMR will ensure that any deviations

from the SAP are reflected in revised paperwork for the samplers and the analytical laboratory. The FWS, or appropriate BTR, will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook) in accordance with corrective action protocols.

Table B-4. Change Control for Sampling Projects

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

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

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

c. Section 9.3 of the action plan (Ecology et al., 1989b) defines the minimum elements of a change notice.

DOE-RL = U.S. Department of Energy-Richland Operations Office
DQO = data quality objective
LRA = lead regulatory agency
OU = operable unit
SAP = sampling and analysis plan

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

- Operational records and logbooks
- Data forms

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

The following records are managed and maintained by SMR personnel:

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

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

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

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

B2.2 Data Generation and Acquisition

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

B2.2.1 Analytical Methods Requirements

Analytical method performance requirements for samples collected are presented in Table B-15. In consultation with the laboratory and the OU Project Manager, SMR can approve changes to analytical methods as long as the new method is based upon a nationally recognized standard method (e.g., EPA, ASTM International, formerly American Society for Testing and Materials [ASTM]) and the new method delivers analytical data that are comparable to those provided by the old method. The new method must

achieve project DQOs, as well or better than the replaced method, and is required due to the nature of the sample (e.g., high radioactivity). The laboratory using the new method must be accredited by Ecology to perform that method. Issues that may affect analytical results are resolved by SMR in coordination with the OU Project Manager.

B2.2.2 Field Analytical Methods

Chemical field screening and radiological field survey data used for site characteristics will be measured in accordance with HASQARD requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Chapter B3 provides the parameters identified for field survey analyses.

B2.2.3 Quality Control

The QC requirements specified in the SAP must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample requirements are summarized in Table B-6. Acceptance criteria for field and laboratory QC are shown in Table B-7.

Data will be qualified and flagged in HEIS, as appropriate.

Constituent	Chemical Abstracts Service Number	MCL or WAC[a]	Analytical Method[b]	Required Quantitation Limit
Radionuclides (pCi/L)				
Iodine-129	15046-84-1	1	Iodine-129 liquid scintillation (low level)	1
Strontium-90	10098-97-2	8	Gas proportional counting	2
Technetium-99	14133-76-7	900	Technetium-99 liquid scintillation or gas proportional counting	15
Tritium	10028-17-8	20,000	Tritium liquid scintillation (mid-level)	400
Inorganics – Metals (µg/L)				
Chromium (Total)	7440-47-3	100	EPA 6020/200.8	15
Chromium (Hexavalent)	18540-29-9	48	EPA 7196	10
Uranium (Total)	7440-61-1	30	EPA 6020/200.8	15
Inorganics – Anions (µg/L)				
Nitrate	14797-55-8	10,000 (as N)	Anions by IC – 300.0	250
Organics (µg/L)				
1,4-Dioxane	123-91-1	1,000	Volatile Organics EPA 8260	4
Chloroform	67-66-3	1,000	Volatile Organics EPA 8260	5
Tetrachloroethene	127-18-4	0.081[a]	Volatile Organics EPA 8260	5
Trichloroethene	79-01-6	0.49[a]	Volatile Organics EPA 8260	1

a. WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," Method B.

b. For EPA Method 200.8, see EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Equivalent methods may be substituted.

Constituent	Chemical Abstracts Service Number	MCL or WAC[a]	Analytical Method[b]	Required Quantitation Limit

EPA = U.S. Environmental Protection Agency
IC = ion chromatography

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Table B-6. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field Duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed. When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in Table B-8.	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	One in 20 well trips	Cross-contamination from containers or transportation
Field Transfer Blanks	One each day volatile organic compounds are sampled	Contamination from sampling site
Equipment Blanks	As needed. If only disposable equipment is used or equipment is dedicated to a particular well, then an EB is not required. Otherwise, 1 for every 20 samples.[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[b]		
Laboratory Duplicates	1 per analytical batch[c]	Laboratory Reproducibility and Precision
Matrix Spikes	1 per analytical batch[c]	Matrix Effect/Laboratory Accuracy
Post-Preparation Spikes	1 per analytical batch[c]	Matrix Effect/Laboratory Accuracy
Matrix Spike Duplicates	1 per analytical batch[c]	Laboratory Accuracy and Precision
Laboratory Control Samples	1 per analytical batch[c]	Evaluate Laboratory Accuracy
Method Blanks	1 per analytical batch[c]	Laboratory Contamination
Surrogates	1 per analytical batch[c]	Recovery/Yield
Tracers	1 per analytical batch[c]	Recovery/Yield

a. For portable pumps, EBs are collected 1 for every 10 well trips. Whenever a new type of nondedicated equipment is used, an EB will be collected every time sampling occurs until it can be shown that less frequent collection of EBs is adequate to monitor the decontamination methods for the nondedicated equipment.

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

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

EB = equipment blank

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Table B-7. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Hexavalent Chromium	MB[b]	<MDL <5% Sample Concentration	Flagged with "C"
	LCS	80 to 120%	Data reviewed[d]

Table B-7. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
		Recovery[c]	
	Laboratory Duplicate or MS/MSD	≤20% RPD	Data reviewed[d]
	Post-preparation spike	75 to 125% Recovery[c]	Flagged with "N"
	EB	<2 Times MDL	Flagged with "Q"
	Field Duplicate	≤20% RPD[e]	Flagged with "Q"
Anions			
Anions by IC	MB	<MDL <5% Sample Concentration	Flagged with "C"
	LCS	80 to 120% recovery[c]	Data reviewed[d]
	Laboratory Duplicate or MS/MSD	≤20% RPD	Data reviewed[d]
	MS	75 to 125% Recovery[c]	Flagged with "N"
Metals			
Inductively Coupled Plasma Metals **Inductive Coupled Plasma/Mass Spectrometry Metals**	MB	<RDL <5% Sample Concentration	Flagged with "C"
	LCS	80 to 120% recovery[c]	Data reviewed[d]
	MS	75 to 125% recovery[c]	Flagged with "N"
	MSD	75 to 125% recovery[c]	Flagged with "N"
	MS/MSD	≤20% RPD	Data reviewed[d]
	EB, FTB	<2 Times MDL	Flagged with "Q"
	Field Duplicate	≤20% RPD[e]	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS	MB	<MDL[f] <5% Sample Concentration	Flagged with "B"
	LCS	Statistically Derived[c]	Data reviewed[d]
	MS	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MSD	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MS/MSD	%RPD Statistically Derived[c]	Data reviewed[d]
	SUR	Statistically Derived[c]	Data reviewed[d]
	EB, FTB, FXR	<2 Times MDL[f]	Flagged with "Q"
	Field Duplicate	≤20% RPD[e]	Flagged with "Q"

Table B-7. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
Semivolatile Organic Compounds			
Semivolatiles by GC/MS	MB	<MDL[f] <5% Sample Concentration	Flagged with "B"
	LCS	Statistically Derived[c]	Data reviewed[d]
	MS	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MSD	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MS/MSD	% RPD Statistically Derived[c]	Data reviewed[d]
	SUR	Statistically Derived[c]	Data reviewed[d]
	EB, FTB	<2 Times MDL[f]	Flagged with "Q"
	Field Duplicate	≤20% RPD[e]	Flagged with "Q"
Radiochemical Analyses			
Iodine-129 **Strontium-89/90** **Technetium-99** **Tritium** **Tritium (Low Level)** **Uranium (Total)**	MB	<MDA <5% Sample Concentration	Flagged with "B"
	LCS	70 to 130% Recovery	Data reviewed[d]
	Laboratory Duplicate[e]	≤20% RPD	Data reviewed[d]
	MS[g]	60 to 140% Recovery	Flagged with "N"
	Tracer (where applicable)	20 to 105% Recovery	Data reviewed[d]
	Carrier (where applicable)	30 to 105% Recovery	Data reviewed[d]
	EB, FTB	<2 Times MDA	Flagged with "Q"
	Field Duplicate	≤20% RPD[e]	Flagged with "Q"

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

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

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

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

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

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

g. Applies only to isotopic technetium-99, total uranium by inductive coupled plasma/mass spectrometry, and tritium.

EB = equipment blank
FEAD = format for electronic analytical data
FTB = full trip blank
FXR = field transfer blank
GC = gas chromatography
GC/MS = gas chromatography/mass spectrometry
IC = ion chromatography
LCS = laboratory control sample
MB = method blank
MDA = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference
SUR = surrogate

Table B-7. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action

Data Flags:

B = (organics)/C (inorganics/wetchem) = analyte was detected in both the associated QC blank and the sample)

N = All except GC/MS – matrix spike outlier

T = volatile organic analyte and semivolatile organic analyte GC/MS – matrix spike outlier

Q = associated QC sample is out of limits

B2.2.3.1 Field Quality Control Samples

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

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

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

Full Trip Blanks (FTBs): Bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis (VOA) only or identical to the set that will be collected in the field. It is filled with high-purity reagent water (or dead water from Well 699-S11-E12AP for low-level tritium FTBs[1]), and the bottles are sealed and transported, unopened, to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Field Transfer Blanks (FXRs): Preserved VOA sample vials filled with high-purity reagent water at the sample collection site where volatile organic compound (VOC) samples are collected. The samples will be prepared during sampling to evaluate potential contamination attributable to field conditions. After collection, FXR sample vials will be sealed and placed in the same storage containers with the samples collected the same day for the associated sampling event. FXR samples will be analyzed for VOCs only.

Equipment Blanks (EBs): Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. EB samples will be analyzed for the same constituents as samples from the associated

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

sampling event. EBs are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

B2.2.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by the laboratories utilized by the project. Laboratory QA includes a comprehensive QC program that includes the use of matrix spikes, matrix duplicates, matrix spike duplicates, laboratory control samples, surrogates, tracers, and method blanks. These samples are recommended in guidance documents, required by EPA protocol (e.g., EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC and their typical frequencies are listed in Table B-6. Acceptance criteria are shown in Table B-7. The following text describes the various laboratory QC samples.

Laboratory Duplicate: An intra-laboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

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

Post Preparation Spike: The same as MS; however, spiking occurs after sample preparation.

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

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

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

Surrogate (SUR): A compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. The SUR is typically similar in chemical composition to the analyte being determined, yet is not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Tracer: A tracer is a known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of a sample. Sample results are generally corrected based on tracer recovery.

Laboratories are required to analyze samples within the holding time specified in Table B-8. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilizing, decomposing, or other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an "H."

Table B-8. Preservation, Container, and Holding Time Guidelines

Constituent/ Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time
Organic Analyses				
Volatile Organics	4 × 40 mL	Amber glass VOA vial with Teflon®-lined septum lid	Store <6°C (if free Cl_2 add 4 drops of 10% sodium thiosulfate), adjust pH to <2 with HCl	14 days
Semivolatile Organics	4 × 1 L	Narrow mouth amber glass with Teflon-lined lid	Store <6°C (if residual Cl_2, add 3 mL 10% sodium thiosulfate/gal of sample)	7 days before extraction 40 days after extraction
Metals[c]				
Inductive Coupled Plasma/Mass Spectrometry (with/without Mercury)	250 mL	Narrow-mouth poly or glass	Adjust pH to <2 with nitric acid	28 days/6 months[c]
Inductively Coupled Plasma/Atomic Emission Spectroscopy (with/without Mercury)	250 mL	Narrow-mouth poly or glass	Adjust pH to <2 with nitric acid	28 days/6 months[c]
Dissolved Metals (with/without Mercury)	500 mL	Narrow-mouth poly or glass	Filter prior to pH adjustment to <2 with nitric acid	28 days/6 months[c]
Miscellaneous Inorganic				
Hexavalent Chromium	500 mL	Poly or glass	Store ≤6°C	24 hours
Inorganic Ions				
Nitrate	60 mL	Poly or glass	Store ≤6°C	48 hours
Radiochemical Analyses				
Uranium Isotopic by AEA	1 L for all AEA	Narrow-mouth poly or glass	Adjust pH to <2 with HNO_3	6 months
Iodine-129	2 × 4L	Narrow-mouth poly or glass	None	6 months
Strontium-90 (Total Beta Radiostrontium)	2 × 1 L	Wide-mouth poly or glass	Adjust pH to <2 with HNO_3	6 months
Technetium-99 by Liquid Scintillation	1 L	Narrow-mouth glass	Adjust pH to <2 with HCl	6 months
Tritium	250 mL	Narrow-mouth glass	None	6 months
Total Uranium by Kinetic Phosphorescence Analysis	250 mL	Poly or glass	Adjust pH to <2 with HNO_3	6 months

Table B-8. Preservation, Container, and Holding Time Guidelines

Constituent/ Parameter	Minimum Volume	Container Type[a]	Preservation[b]	Holding Time

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

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

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

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

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

AEA = alpha energy analysis
DQO = data quality objective
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
TPH = total petroleum hydrocarbon (Ecology)
VOA = volatile organic analysis

B2.2.4 Measurement Equipment

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

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

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

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

B2.2.6 Instrument/Equipment Calibration and Frequency

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

B2.2.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with applicable requirements (e.g., SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*) and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system

ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

B2.2.8 Nondirect Measurements

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

B2.2.9 Data Management

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

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

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

B2.3 Assessment and Oversight

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

B2.3.1 Assessments and Response Actions

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

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

B2.3.2 Reports to Management

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

B2.4 Data Review and Usability

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

B2.4.1 Data Review and Verification

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

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

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

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

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

B2.4.2 Data Validation

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

B2.4.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet project DQOs. For routine groundwater monitoring undertaken through this integrated SAP, the DQA is captured in QC associated with the annual groundwater report (e.g., DOE/RL-2014-32), which evaluates field and lab QC and the usability of data. Further DQAs will be performed at the discretion of the OU Project Manager and documented in a report overseen by SMR.

B3 Field Sampling Plan

This chapter lists the groundwater wells to be monitored, sampling frequency, and constituents to be analyzed.

B3.1 Sampling Objectives

As described in Appendix A, the objectives of groundwater monitoring in this OU are to (a) determine whether cleanup criteria and RAO for groundwater being achieved within the time frames projected in the RD/RAWP, and (b) determine whether concentrations of COPCs are below action levels over the next 5 year time frame. Groundwater monitoring wells will be sampled for the COCs and COPCs to provide data to address these objectives. To support these objectives, groundwater will be monitored to provide information on extent, movement, and concentrations of groundwater contaminants.

B3.2 Sample Location, Frequency, and Constituents To Be Monitored

Table B-9 lists the specific constituents to be analyzed and the sampling frequency for those wells that have been selected for monitoring. Appendix C provides information on the hydrogeologic unit monitored by the wells. Appendix A contains the criteria used to identify the wells needed to answer each PSQ of the DQO and to determine the sampling frequency to be employed. Some wells are co-sampled with other monitoring programs (e.g., monitored to meet RCRA requirements). Monitoring requirements for those other monitoring programs are described in separate plans. The reported data from these networks are supplementary to information gathered under this SAP. The breakdown of well networks to answer individual PSQs is discussed in Section B3.2.1.

B3.2.1 Monitoring Network

The SAP organizes the wells within the 200-UP-1 Groundwater OU according to the associated PSQ. Not all of the wells identified for potential use in the monitoring network within the 200-UP-1 OU are needed to answer PSQs. An analysis of the network to identify those wells needed for use in monitoring specific COC plumes is presented in Appendix A.

B3.2.1.1 PSQ 1: 200-UP-1 Groundwater Cleanup Criteria and RAOs

PSQ 1 helps define whether cleanup criteria and RAOs for groundwater are being achieved within the time frames projected in the RD/RAWP (DOE/RL-2013-07). Monitoring locations for PSQ 1 are shown in Figures B-4 to B-9 and were selected based on proximity to source areas, plume boundaries, expected future flow directions based on operation of the 200-UP-1 remedy components and continued operation of the 200 West P&T system, contamination trends, and the inferred plume travel centerline. The wells were selected to provide sufficient data to calculate a 95 percent upper confidence limit for each COC except the southeast chromium plume. Additional wells are included for determining the extent of contamination, plume areas, and contaminant concentration trends. An annual sampling frequency was selected for most of the wells. Higher frequency (i.e., semiannual) was specified for wells in areas where relatively rapid changes in groundwater concentrations are expected (e.g., areas associated with groundwater P&T). Lower frequency (biennial or triennial) was selected for wells near the plume margins where concentrations have remained stable for several years.

B3.2.1.2 PSQ 2: Monitoring of Contaminants of Potential Concern

Monitoring locations for PSQ 2 (Figure B-10) were selected based on detections of COPCs in previous sampling events, and expected future flow directions based on operation of the 200-UP-1 remedy components and continued operation of the 200 West P&T system, and historical contaminant trends in the well. An annual sampling frequency was selected for wells with previous detections of each COPC above the identified action level. Triennial frequency was selected for wells to monitor the extent and possible downgradient migration of the COPCs. Monitoring is specified for the five COPCs (1,4-dioxane, chloroform, strontium-90, tetrachloroethene, and trichloroethene). Locations selected for monitoring the COPCs are provided in Figure B-10.

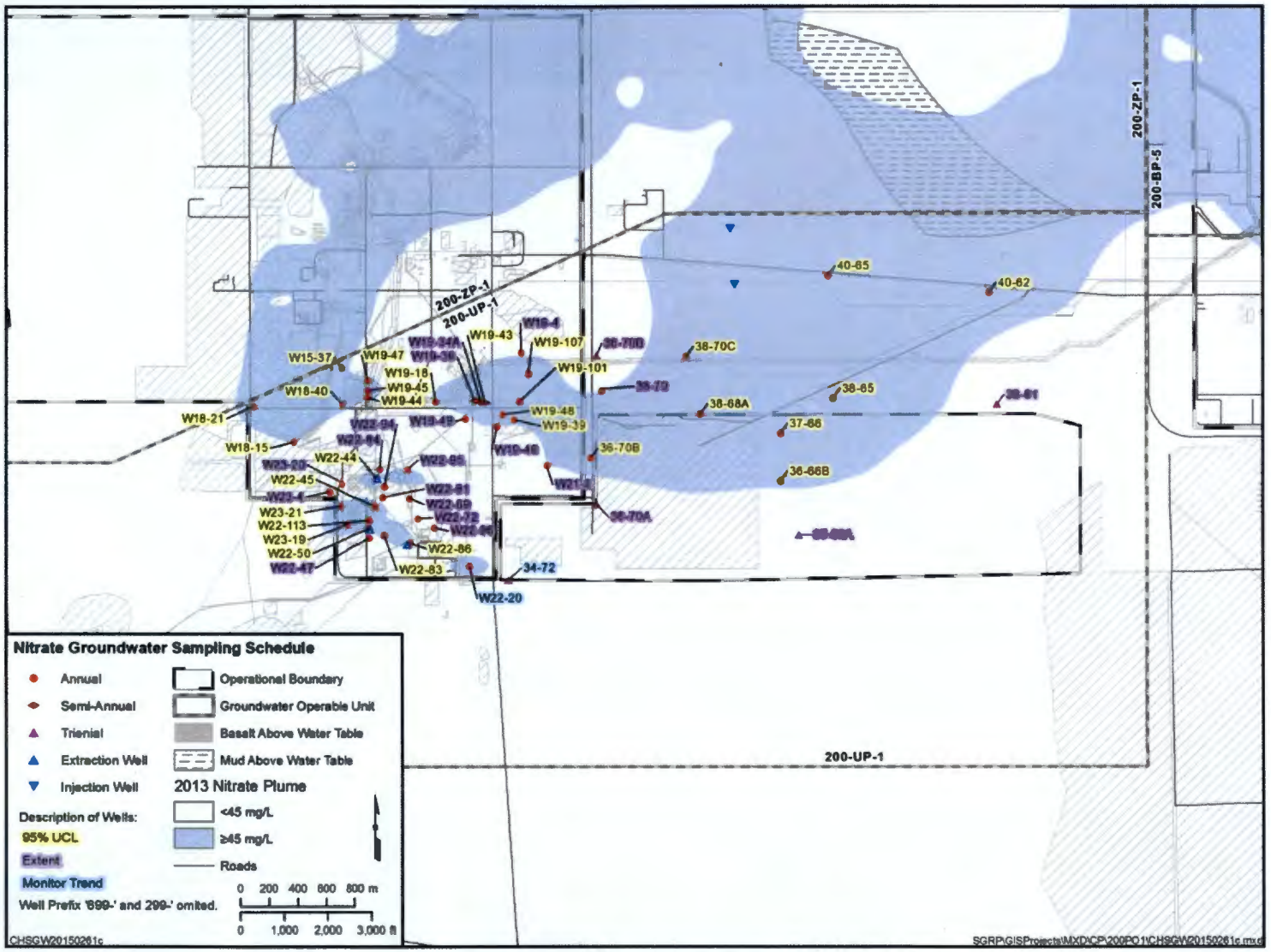

Figure B-4. Monitoring Locations for Nitrate

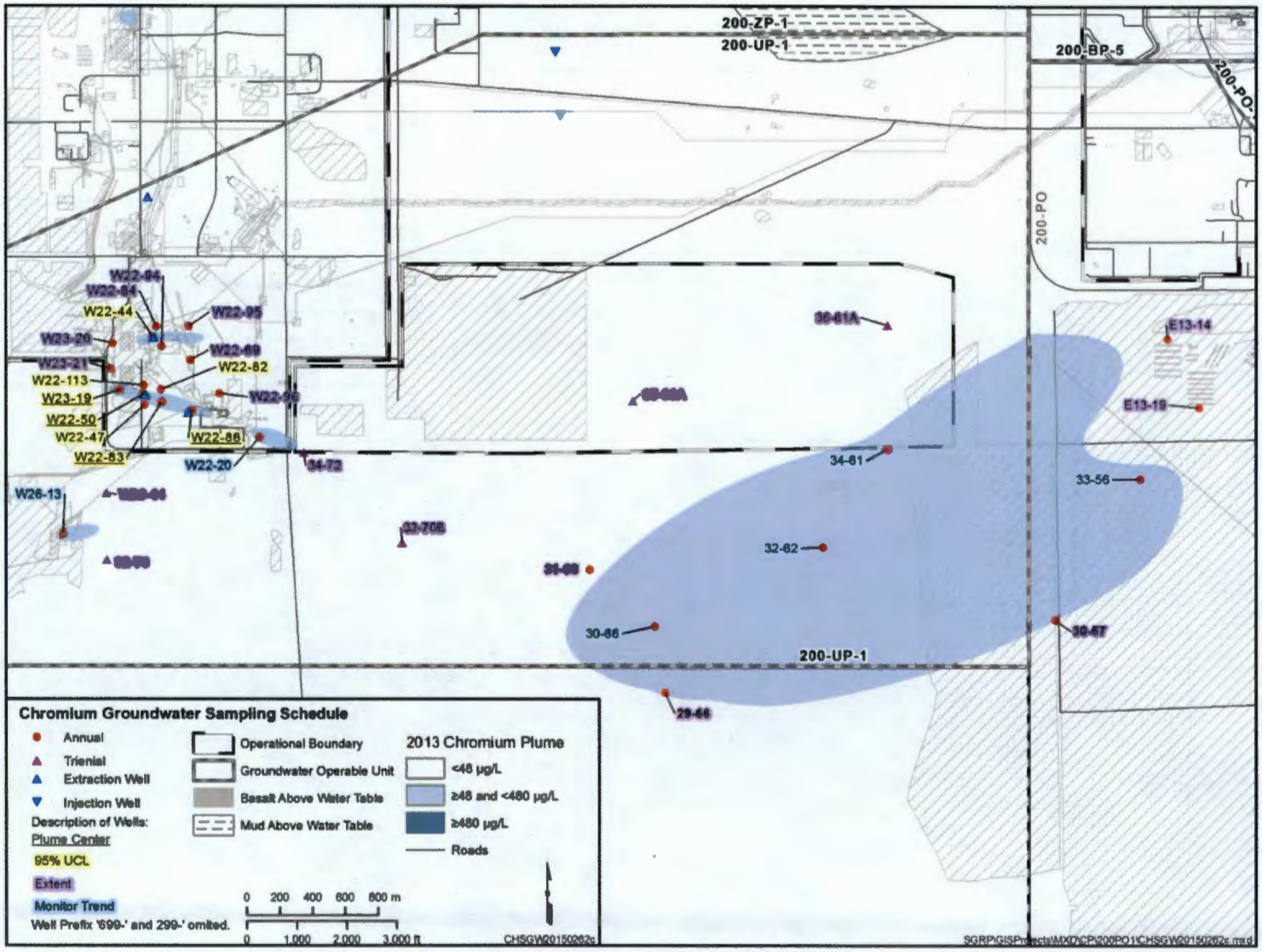

Figure B-5. Monitoring Locations for Chromium

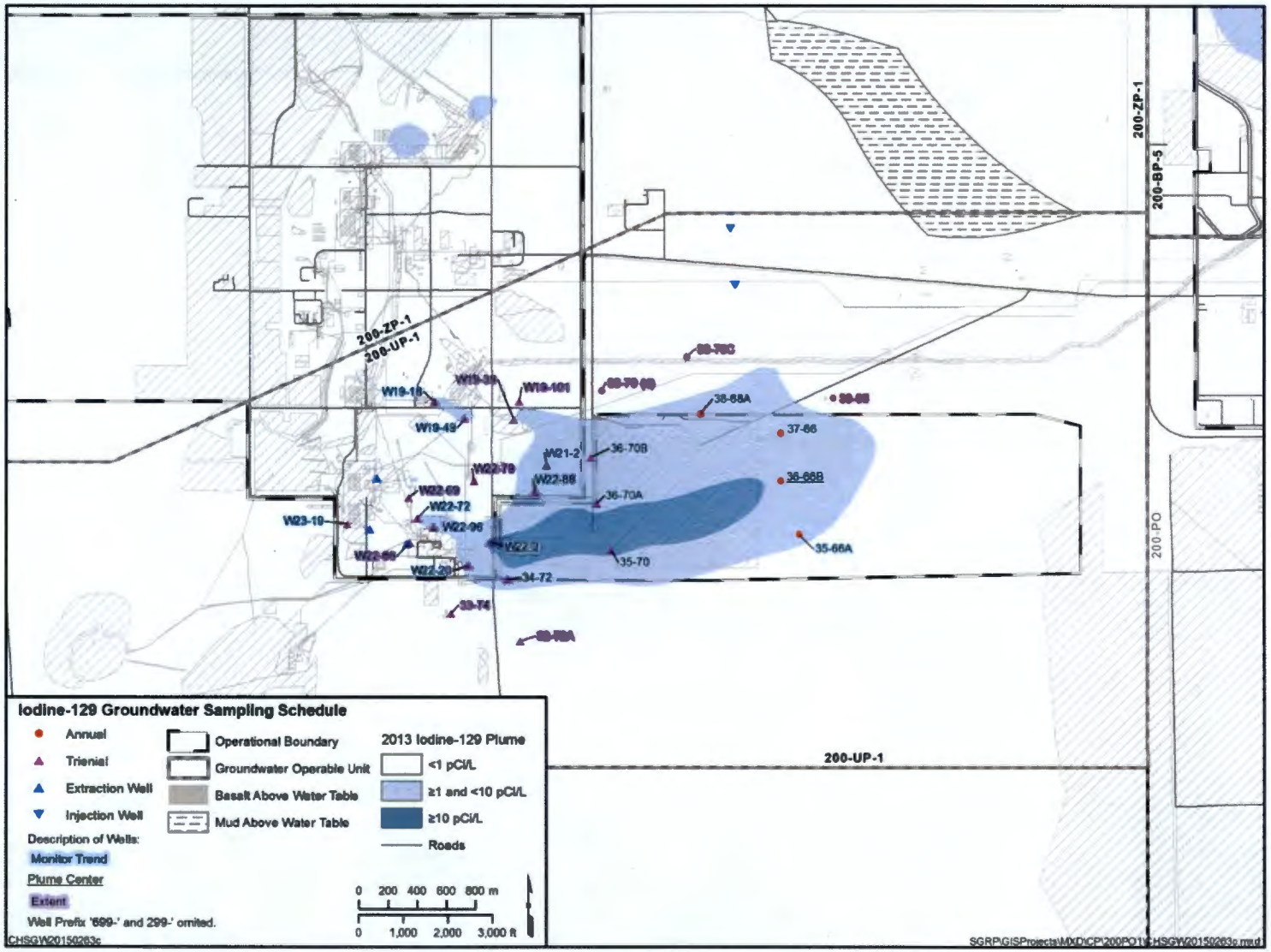

Figure B-6. Monitoring Locations for Iodine-129

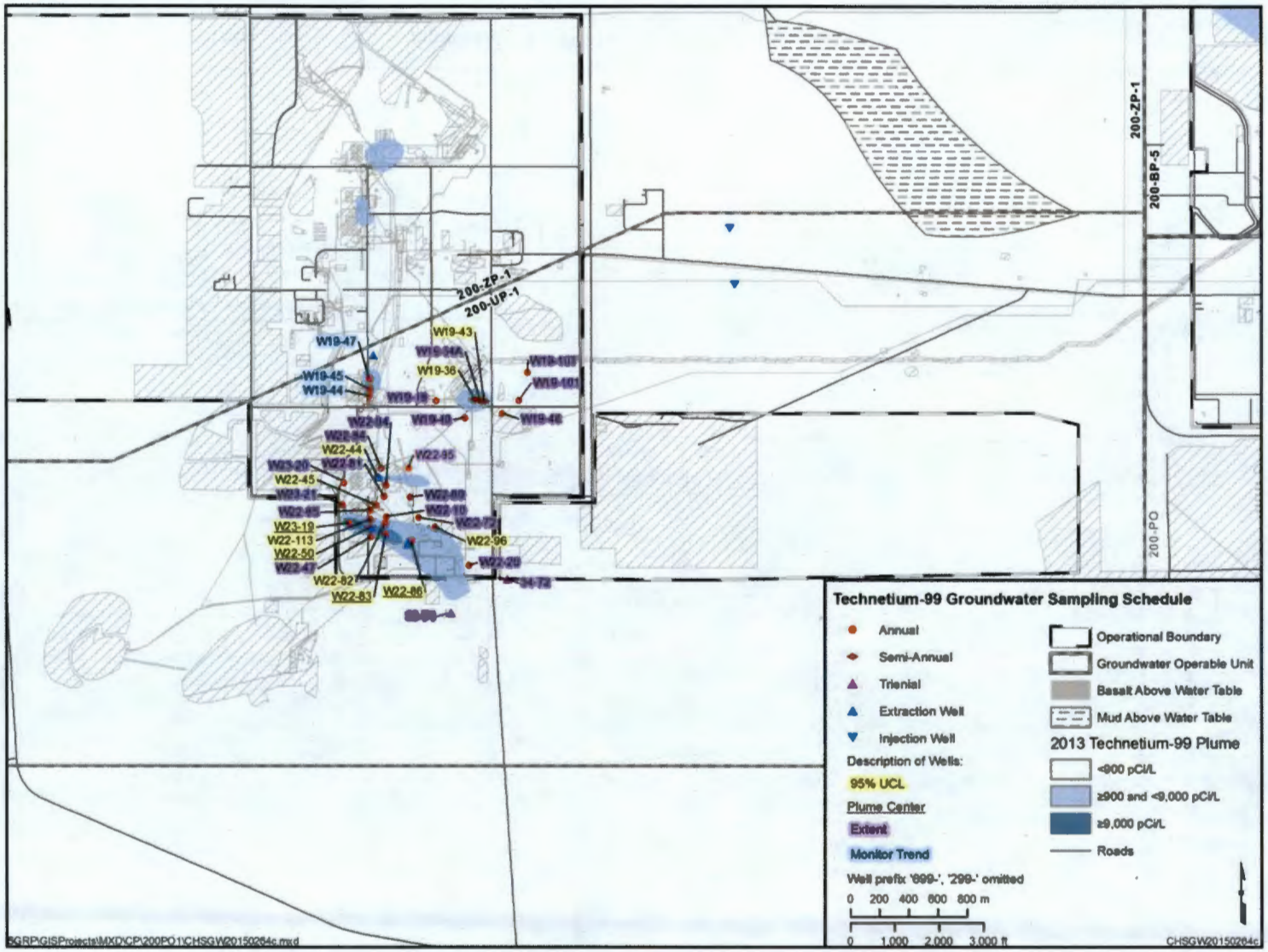

Figure B-7. Monitoring Locations for Technetium-99

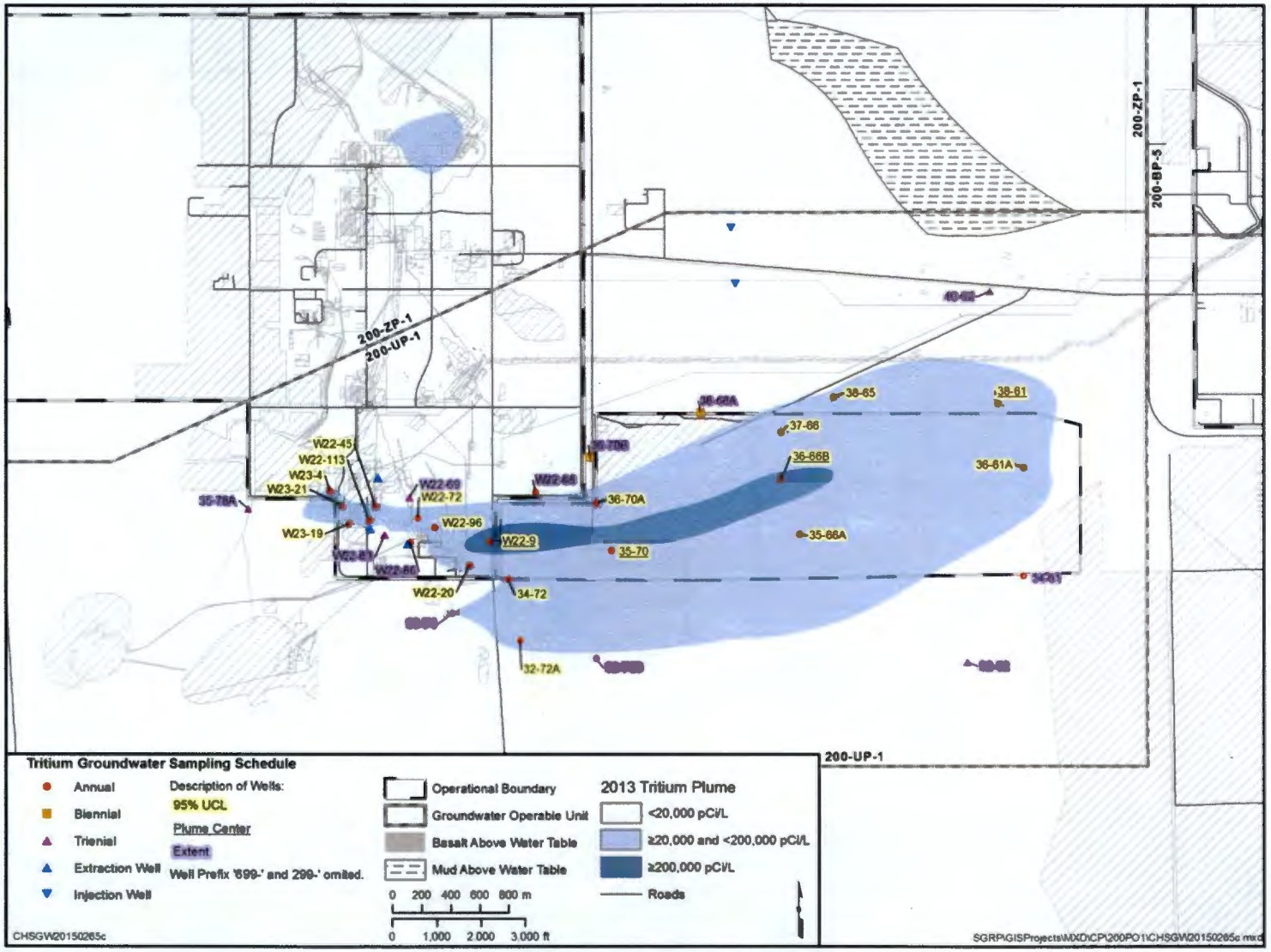

Figure B-8. Monitoring Locations for Tritium

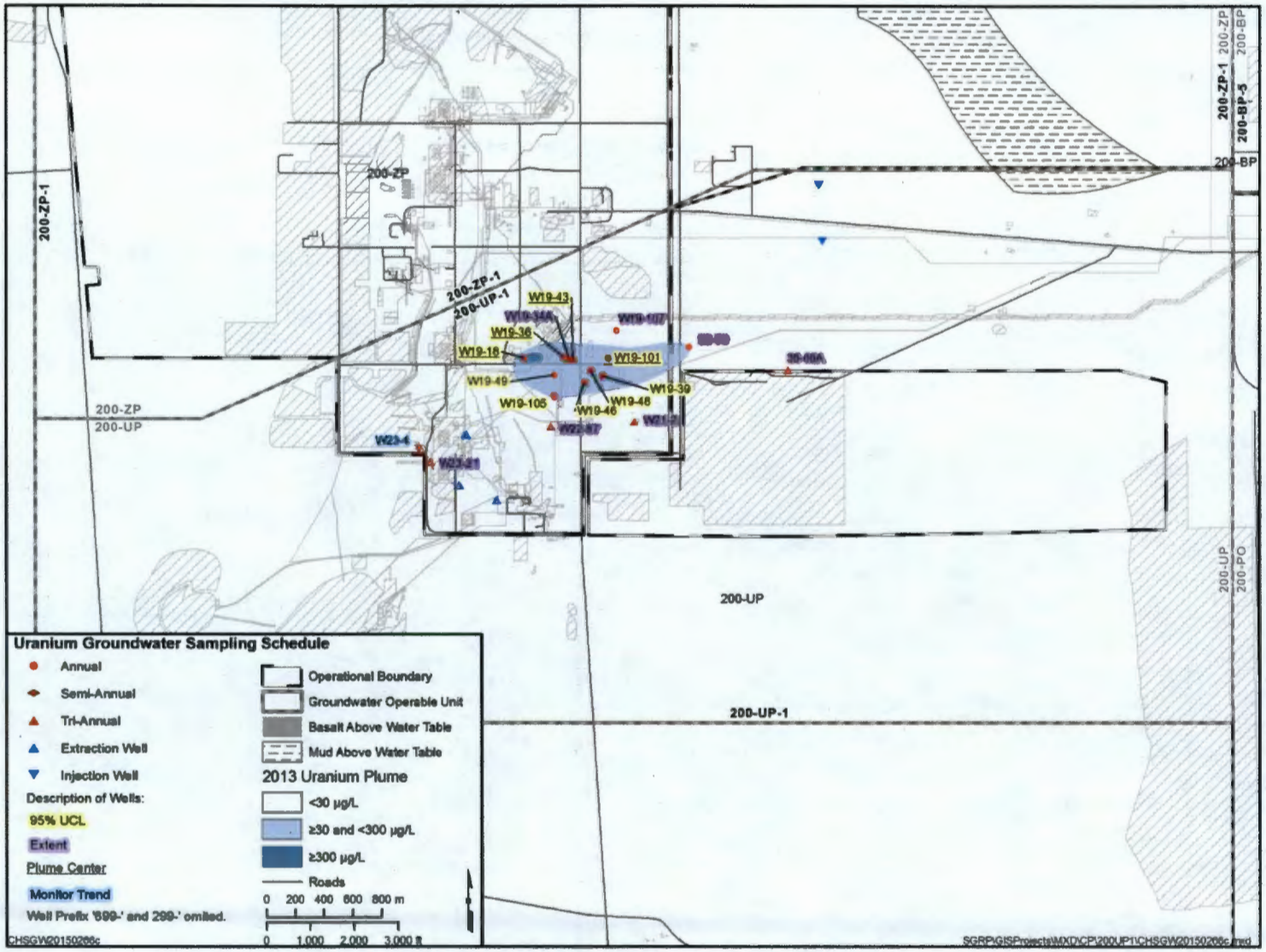

Figure B-9. Monitoring Locations for Uranium

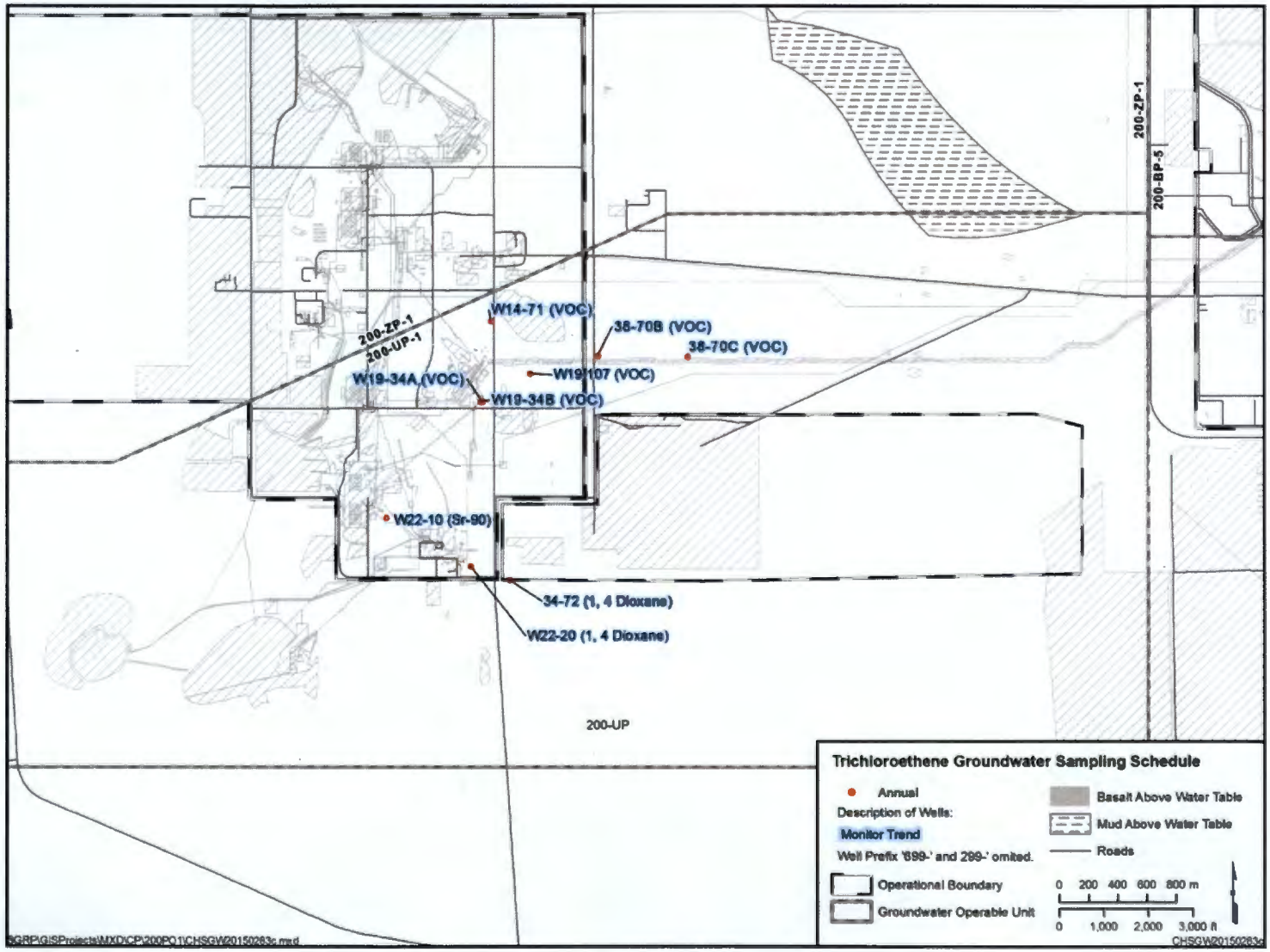
200-ZP-1
200-BP-5
W14-71 (VOC)
38-70B (VOC)
38-70C (VOC)
200-ZP-1
200-UP-1
W19-34A (VOC)
W19-107 (VOC)
W19-34B (VOC)
W22-10 (Sr-90)
34-72 (1, 4 Dioxane)
W22-20 (1, 4 Dioxane)
200-UP
Trichloroethene Groundwater Sampling Schedule
Annual
Description of Wells:
Monitor Trend
Well Prefix '699-' and 299-' omited.
Operational Boundary
Groundwater Operable Unit
Basalt Above Water Table
Mud Above Water Table
Roads
0 200 400 600 800 m
0 1,000 2,000 3,000 ft
CHSGW20150283c

Figure B-10. Monitoring Locations for Contaminants of Potential Concern

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-E13-14	A	--	--	--	--	--	--	--	--	--	--
299-E13-19	A	--	--	--	--	--	--	--	--	--	--
299-W14-71(d)	--	--	--	--	--	--	--	A	A	A	--
299-W15-37	--	--	A	--	--	--	--	--	--	--	--
299-W18-15	--	--	A	--	--	--	--	--	--	--	--
299-W18-21	--	--	A	--	--	--	--	--	--	--	--
299-W18-40	--	--	A	--	--	--	--	--	--	--	--
299-W19-101	--	T	A	A	--	A	--	--	--	--	--
299-W19-105	--	--	--	--	--	A	--	--	--	--	--
288-W19-107(d)	--	--	A	A	--	A	--	A	A	A	--
299-W19-18*	--	T	A	A	--	A	--	--	--	--	--
299-W19-34A(d)	--	--	A	A	--	T	--	A	A	A	--
299-W19-34B(d)	--	--	--	--	--	--	--	A	A	A	--
299-W19-36	--	--	S	S	--	A	--	--	--	--	--
299-W19-39	--	T	A	--	--	A	--	--	--	--	--

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W19-4	--	--	A	--	--	--	--	--	--	--	--
299-W19-43	--	--	S	S	--	A	--	--	--	--	--
299-W19-44	--	--	A	A	--	--	--	--	--	--	--
299-W19-45	--	--	A	A	--	--	--	--	--	--	--
299-W19-46	--	--	A	--	--	A	--	--	--	--	--
299-W19-47	--	--	A	A	--	--	--	--	--	--	--
299-W19-48	--	--	A	A	--	A	--	--	--	--	--
299-W19-49	--	T	A	A	--	A	--	--	--	--	--
299-W21-2	--	T	A	--	--	T	--	--	--	--	--
299-W22-113	A	--	A	A	A	--	--	--	--	--	--
299-W22-9 (dry, 299-W22-115)	--	T	--	--	A	--	--	--	--	--	--
299-W22-10	--	--	--	A	--	--	--	--	--	--	A
299-W22-20 (dry)**	A	T	A	A	A	--	A	--	--	--	--
299-W22-44 (dry, 299-W22-93)	A	--	A	A	--	--	--	--	--	--	--
299-W22-45	--	--	A	A	A	--	--	--	--	--	--
299-W22-47	A	--	A	A	--	--	--	--	--	--	--

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W22-50 (dry, 299-W22-116)	A	--	A	A	--	--	--	--	--	--	--
299-W22-69	A	T	A	A	T	--	--	--	--	--	--
299-W22-72	--	T	A	A	A	--	--	--	--	--	--
299-W22-79	--	T	--	--	--	--	--	--	--	--	--
299-W22-81	--	--	A	A	--	--	--	--	--	--	--
299-W22-82	A	--	--	A	--	--	--	--	--	--	--
299-W22-83	A	--	A	A	T	--	--	--	--	--	--
299-W22-84	A	--	A	A	--	--	--	--	--	--	--
299-W22-85	--	--	--	A	--	--	--	--	--	--	--
299-W22-86	A	T	A	A	A	--	--	--	--	--	--
299-W22-87	--	--	--	--	--	T	--	--	--	--	--
299-W22-88	--	T	--	--	A	--	--	--	--	--	--
299-W22-94	A	--	A	A	--	--	--	--	--	--	--
299-W22-95	A	--	A	A	--	--	--	--	--	--	--
299-W22-96	A	T	A	A	A	--	--	--	--	--	--
299-W23-19	A	T	A	A	A	--	--	--	--	--	--

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
299-W23-20	A	--	A	A	--	--	--	--	--	--	--
299-W23-21	A	--	A	A	A	T	--	--	--	--	--
299-W23-4	--	--	A	--	A	A	--	--	--	--	--
299-W26-13	A	--	--	--	--	--	--	--	--	--	--
299-W26-14	T	--	--	--	--	--	--	--	--	--	--
699-30-66 (d)	A	--	--	--	--	--	--	--	--	--	--
699-32-70B	T	--	--	--	A	--	--	--	--	--	--
699-32-72A	--	T	--	--	A	--	--	--	--	--	--
699-32-62	A	--	--	--	T	--	--	--	--	--	--
699-32-76	T	--	--	--	--	--	--	--	--	--	--
699-33-56	A	--	--	--	--	--	--	--	--	--	--
699-33-74	--	T	--	T	A	--	--	--	--	--	--
699-34-61	A	--	--	--	A	--	--	--	--	--	--
699-34-72	T	T	T	T	A	--	A	--	--	--	--
699-35-66A	T	A	T	--	A	--	--	--	--	--	--
699-35-70 (dry, 299-W21-3))	--	T	--	--	A	--	--	--	--	--	--

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
699-35-78A	--	--	--	--	T	--	--	--	--	--	--
699-36-61A	T	--	--	--	A	--	--	--	--	--	--
699-36-66B	--	A	A	--	A	--	--	--	--	--	--
699-36-70A	--	T	T	--	A	--	--	--	--	--	--
699-36-70B	--	T	A	--	B	--	--	--	--	--	--
699-37-66	--	A	A	--	A	--	--	--	--	--	--
699-38-61	--	--	T	--	A	--	--	--	--	--	--
699-38-65	--	A	A	--	A	--	--	--	--	--	--
699-38-68A	--	A	A	--	B	T	--	--	--	--	--
699-38-70 (dry, 299-W19-116)	--	A	A	--	--	A	--	--	--	--	--
699-38-70B (d)	--	--	T	--	--	--	--	A	A	A	--
699-38-70C (d)	--	A	A	--	--	--	--	A	A	A	--
699-40-62	--	--	A	--	T	--	--	--	--	--	--
699-40-65	--	--	A	--	--	--	--	--	--	--	--
699-29-66***	A	--	--	--	--	--	--	--	--	--	--
699-30-57***	A	--	--	--	--	--	--	--	--	--	--

Table B-9. Sampling and Analysis Schedule for the 200-UP-1 Groundwater Operable Unit

Well	Contaminants of Concern				Contaminants of Potential Concern						
	Chromium (total and hexavalent)	Iodine-129	Nitrate	Technetium-99	Tritium	Uranium	1,4-Dioxane	Chloroform	Tetrachloroethene	Trichloroethene	Strontium-90
699-31-68***	A	--	--	--	--	--	--	--	--	--	--

A = annual

B = biennial

S = semiannual

T = triennial

(d) = well screened in the deeper portion of unconfined aquifer

(dry, replacement well name) = well currently yields insufficient water for sampling and will be replaced. Replacement well will be sampled quarterly for the first year, then on sample schedule shown in the table thereafter.

* Well to be replaced by 299-W19-115

** Replacement well number not yet assigned

*** Southeast chromium plume characterization well, not yet installed

B3.3 Sampling Methods

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

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

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

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

The following field parameters may be specified by the project: dissolved oxygen and redox potential.

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

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

Suggested sample container, preservation, and holding time requirements are specified in Table B-8 for groundwater samples. These requirements are in accordance with analytical method specified in Table B-5. The final container type and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a sample as a filled sample bottle for starting the clock for holding time restrictions.

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

B3.3.1 Decontamination of Sampling Equipment

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

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

- Improperly storing or transporting sampling equipment and sample containers

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

B3.3.2 Radiological Field Data

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

The following information will be distributed to personnel performing work in support of this SAP:

- Instructions to RCTs on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.
- Information regarding the portable radiological field instrumentation including: a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments are commonly used on the Hanford Site to obtain measurements of removable surface contamination measurements and direct measurements of the total surface contamination.
- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection."
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of radiological information.
- Minimum standards and practices necessary for preparing, performing, and retaining radiological-related information.

B3.3.3 Water Levels

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

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

To provide the data needed to calculate groundwater gradients and for regional mapping of the 200-UP-1 OU water table, a three-tiered approach to water level monitoring will be used. First, automated water levels will be collected using pressure transducers and data loggers installed in selected monitoring wells near groundwater extraction systems. Second, manual water level measurements will be collected several

times each year from a network of wells in the vicinity of groundwater extraction systems. Third, a set of manual water level measurements are collected in March of each year across the entire 200-UP-1 OU as part of Hanford Site water level monitoring (SGW-38815).

Manual measurements in support of the groundwater extraction systems will be collected monthly for one year after the start of operations in the U Plant area (the WMA S-SX system has been operating since 2012). After one year, the frequency of the manual measurements may be reduced to quarterly if analysis indicate that groundwater conditions are stable enough to allow for reliable determinations of groundwater flow and hydraulic capture using lower frequency measurements. The automated water level measurements will be collected on an hourly frequency.

B3.4 Documentation of Field Activities

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

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

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

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

- Telephone calls relating to field activities

B3.4.1 Corrective Actions and Deviations for Sampling Activities

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

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

Changes in sample activities that require notification, approval, and documentation will be performed, as specified in Table B-4.

B3.5 Calibration of Field Equipment

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

The following field instrumentation, calibration, and QA checks will be performed:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Calibration of radiological field instruments on the Hanford Site is performed by the MSA prime contractor, as specified by their calibration program.
- Daily calibration checks will be performed and documented for each instrument used to characterize areas under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Standards used for calibration will be traceable to nationally or internationally recognized standard agency source or measurement system, if available.

B3.6 Sample Handling

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

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

B3.6.1 Containers

Pre-cleaned sample containers with certificates of analysis denoting compliance with EPA specifications (EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*) for the intended analyses will be used for samples collected for chemical analysis. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. The Radiological Engineering organization will measure both the contamination levels and dose rates associated with the filled sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, FWS (in consultation with the SMR organization) can send smaller volumes to the laboratory. Container types and sample amounts/volumes are identified in Table B-8.

B3.6.2 Container Labeling

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

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

Sample records must include the following information:

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

B3.6.3 Sample Custody

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

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

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

- Project name
- Signature of sampler
- Unique sample number
- Date and time of collection
- Matrix
- Preservatives
- Signatures of individual involved in sample transfer
- Requested analyses (or reference thereto)

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

B3.6.4 Sample Transportation

All packaging and transportation instructions shall be in compliance with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "General Information, Regulations, and Definitions," through 177, "Carriage by Public Highway." Carrier specific requirements defined by the International Air Transport Association (IATA, 2013) will also be used when preparing sample shipments conveyed by air freight providers.

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

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

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

B4 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2000-51, *Interim Waste Management Plan for the 200-UP-1 Operable Unit*. For waste designation purposes, the maximum concentration in 5 years of historical data from HEIS for the analytes and wells listed in Table B-9, as applicable, will comprise a complete analytical data set.

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

B5 Health and Safety

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

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Appendix C

Sampling Interval Information for 200-UP-1 Groundwater Operable Unit Wells

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Table. C1-1. Hydrogeologic Monitoring Unit Classification Scheme C-1

Table C1-2. Sampling Interval Information for Wells within the 200-UP-1 Groundwater Operable Unit Area C-2

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C1 Introduction

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

- Well or aquifer tube name
- Hydrogeologic unit to be monitored – the portion of the aquifer that is located at the well screen or perforated casing (Table C-1)

Sampling interval information for wells within the 200-UP-1 Groundwater OU area is shown in Table C-2 and includes the following:

- Elevation at top of the screen or perforated interval
- Elevation at the bottom of the screen or perforated interval
- Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)
- Water level elevation (i.e., most recent water level elevation in the well)
- Water level date (i.e., date of most recent water level elevation measured in the well)

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
C	Undifferentiated Basalt-Confined.
CR	Confined Ringold. Wells for which the open interval does not extend more than a approximately 3 m (10 ft) below the top of basalt. Typically open to the lower mud (unit 8) and basal gravel (unit 9) of the Ringold Formation. This classification is not used for wells completed in the Ringold Formation upper mud.
LC	Lower Basalt-Confined. Open to the basalt and interflow zones below the Pomona Member of the Saddle Mountains Basalt.
LU	Lower Unconfined. Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse hydrogeologic unit or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
MU	Middle Unconfined. Open interval begins at greater than 15.2 m (50 ft) below the water table and does not extend below the middle coarse hydrogeologic unit or to within 15.2 m (50 ft) of the top of basalt.
NA	Not Applicable. In most cases, not a valid groundwater monitoring well (i.e., no open interval).
P	Perched. Monitors only perched water above the regional water table.
TB	Top Basalt. Open to less than 9.1 m (30 ft) above and below the top of basalt.
TU	Top of Unconfined. Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
U	Undifferentiated Unconfined. Open to more than 15.2 m (50 ft) of the unconfined aquifer system, or the open/monitoring interval depth is not documented but is known to be within the unconfined aquifer system.
UC	Upper Basalt-Confined. Open to the basalt and/or interflow zones but does not extend below the Pomona Member of the Saddle Mountains Basalt.
UU	Upper Unconfined. The top of the open interval is more than 1.5 m (5 ft) below the water table, and the bottom of the open interval is no more than 15.2 m (50 ft) below the water table.
V	Vadose. Completed above the water table. May be temporarily open below the water table during high water conditions.

Table C-2. Sampling Interval Information for Wells within the 200-UP-1 Groundwater Operable Unit Area

Well Name	Hydrogeologic Unit Monitored	Depth to Top of Open Interval (m NAVD88)	Depth to Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Depth to Water (m NAVD88)	Water Level Date
299-W18-21	TU	59.6	68.7	9.1	67.9	1/29/2015
299-W22-48	TU	69.0	73.5	4.6	72.9	3/31/2011
299-W22-26	TU	61.0	76.8	15.8	73.5	3/31/2011
299-W18-30	TU	60.2	71.4	11.2	70.9	11/19/2012
299-W19-35	TU	73.1	82.3	9.2	81.5	7/18/2014
299-W22-49	TU	66.4	71.0	4.6	70.8	6/27/2014
299-W19-18	TU	70.1	82.0	11.9	81.3	7/18/2014
299-W22-45	TU	60.4	71.2	10.8	70.0	7/18/2014
299-W23-15	TU	56.6	67.8	11.2	66.2	12/10/2014
699-38-65	TU	67.1	128.0	61.0	101.9	6/23/2014
699-35-66A	TU	79.2	98.1	18.9	92.0	9/8/2014
699-32-62	TU	83.8	103.6	19.8	88.0	3/18/2014
699-36-61A	TU	100.6	110.6	10.1	104.9	6/23/2014
699-38-68A	TU	81.6	90.7	9.1	87.5	2/4/2014
699-35-78A	TU	54.9	70.1	15.2	66.7	11/18/2014
699-36-70A	TU	78.5	87.7	9.2	84.0	9/9/2014
699-40-62	TU	102.1	112.5	10.4	106.4	1/22/2015
299-W19-36	TU	74.6	88.3	13.7	83.0	8/4/2014

Table C-2. Sampling Interval Information for Wells within the 200-UP-1 Groundwater Operable Unit Area

Well Name	Hydrogeologic Unit Monitored	Depth to Top of Open Interval (m NAVD88)	Depth to Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Depth to Water (m NAVD88)	Water Level Date
299-W18-15	TU	51.8	74.1	22.3	67.2	1/30/2015
299-W22-83	TU	69.0	79.6	10.7	73.7	12/17/2014
299-W19-43	TU	78.6	89.2	10.6	83.4	1/30/2015
299-W19-46	TU	77.7	88.4	10.7	82.0	1/30/2015
299-W23-21	TU	64.8	76.1	11.3	69.2	12/10/2014
299-W23-4	U	54.9	89.9	35.1	68.7	1/30/2015
699-40-65	TU	100.9	111.5	10.7	104.0	5/13/2014
299-W21-2	TU	79.3	90.0	10.7	82.5	6/19/2014
299-W26-13	TU	61.6	72.3	10.7	64.9	11/4/2014
299-W19-105	TU	77.8	88.5	10.7	81.3	1/30/2015
299-W26-14	TU	68.1	78.8	10.7	71.0	5/20/2014
299-W22-87	TU	76.3	87.0	10.7	79.0	3/14/2014
299-W19-101	TU	79.3	89.9	10.7	82.1	8/12/2014
299-W22-86	TU	70.5	81.2	10.7	73.5	12/19/2014
299-W15-37	UU	62.7	78.0	15.2	68.7	12/10/2014
299-W22-72	TU	72.2	82.9	10.7	75.0	12/19/2014
699-36-70B	TU	80.5	91.2	10.7	82.9	3/21/2014
299-W19-49	TU	79.1	89.8	10.7	81.9	1/30/2015
299-W22-69	TU	72.6	83.2	10.7	74.7	12/19/2014
699-33-74	TU	71.0	81.7	10.7	73.1	3/21/2014
699-34-72	TU	71.5	82.2	10.7	73.7	2/12/2015
699-33-76	TU	67.7	78.3	10.7	69.6	11/3/2014
299-W22-88	TU	79.6	90.2	10.7	81.2	11/4/2013
699-33-75	TU	71.6	82.3	10.7	73.5	11/3/2014
699-32-76	TU	69.2	79.9	10.7	70.8	11/3/2014
299-W19-48	TU	79.9	90.6	10.7	80.9	1/30/2015
299-W19-107	UU	94.7	99.2	4.6	86.4	2/4/2015
299-W19-4	U	77.7	128.3	50.6	87.4	1/2/2014

Table C-2. Sampling Interval Information for Wells within the 200-UP-1 Groundwater Operable Unit Area

Well Name	Hydrogeologic Unit Monitored	Depth to Top of Open Interval (m NAVD88)	Depth to Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Depth to Water (m NAVD88)	Water Level Date
299-W19-34A	MU	98.8	103.5	4.7	82.9	7/18/2014
699-38-70C	LU	120.6	125.2	4.6	95.7	5/12/2014
699-38-70B	MU	124.0	128.5	4.6	91.6	5/12/2014
699-30-66	LU	117.3	120.4	3.0	79.6	11/3/2014
699-32-72A	U	64.0	126.5	62.5	72.1	4/11/2014
299-W19-34B	MU	125.5	128.4	2.9	83.3	1/30/2015
299-W18-22	LU	126.9	136.4	9.4	68.4	1/19/2015
299-E13-14	TU	97.5	112.5	14.9	105.5	4/11/2014
299-W22-45	TU	60.4	71.2	10.8	70.3	12/31/2014
699-34-61	TU	92.4	98.6	6.2	95.0	3/24/2014
699-32-70B	TU	63.1	76.2	13.1	70.5	3/13/2007
699-38-61	TU	101.8	108.0	6.2	104.1	2/10/2015
299-W23-19	TU	64.2	73.5	9.3	69.1	9/26/2014
299-W22-10	TU	61.9	94.8	32.9	70.3	5/13/2011
299-W22-79	TU	74.0	84.7	10.7	79.0	7/18/2014
299-W19-45	TU	68.3	79.0	10.6	73.1	12/31/2014
299-W22-85	TU	66.2	76.8	10.6	70.8	12/31/2014
299-W22-84	TU	70.7	81.4	10.7	75.2	12/31/2014
299-W22-82	TU	68.9	79.6	10.7	73.3	9/26/2014
299-W19-39	TU	71.3	86.6	15.3	79.2	1/30/2015
299-W22-81	TU	69.1	79.8	10.7	73.2	12/19/2014
299-W23-20	TU	65.7	76.4	10.7	69.6	9/26/2014
299-W19-44	TU	70.1	80.7	10.7	73.7	12/10/2014
299-W19-47	TU	69.2	79.9	10.7	72.6	7/11/2014
299-W22-47	TU	69.7	80.4	10.7	72.7	12/10/2014
299-E13-19	TU	94.5	109.7	15.2	100.9	7/21/2014
299-W18-40	TU	66.5	77.2	10.7	68.8	12/10/2014
699-37-66	TU	90.7	101.4	10.7	91.8	3/21/2014

Table C-2. Sampling Interval Information for Wells within the 200-UP-1 Groundwater Operable Unit Area

Well Name	Hydrogeologic Unit Monitored	Depth to Top of Open Interval (m NAVD88)	Depth to Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Depth to Water (m NAVD88)	Water Level Date
699-36-66B	TU	89.6	100.3	10.7	90.5	3/21/2014
699-33-56	U	96.0	124.7	28.7	97.2	4/3/2014

C2 Reference

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

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