DOE/RL-2019-23
Revision 0

200-ZP-1 OPERABLE UNIT RINGOLD FORMATION UNIT A CHARACTERIZATION SAMPLING AND ANALYSIS PLAN

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Concurrence Page

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Terms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
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
DR	decision rule
DS	decision statement
DUP	laboratory sample duplicate
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
F&T	fate and transport
FS	feasibility study
FSO	Field Sampling Operations
FTB	full trip blank
FWS	field work supervisor
FXR	field transfer blank
FY	fiscal year
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System
HSGF	Hanford South Geologic Framework
IATA	International Air Transportation Association
IC	institutional control
LCS	laboratory control sample
MB	method blank

MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
O&M	operations and maintenance
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCT	radiological control technician
RD/RAWP	remedial design/remedial action work plan
Rlm	Ringold Formation member of Wooded Island – lower mud unit
ROD	Record of Decision
Rwia	Ringold Formation member of Wooded Island – unit A
Rwie	Ringold Formation member of Wooded Island – unit E
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
TCE	trichloroethene
TIC	total inorganic carbon
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOA	volatile organic analysis
VOC	volatile organic compound

1 Introduction

This sampling and analysis plan (SAP) addresses the phased installation of monitoring wells in and around the 200-ZP-1 Groundwater Operable Unit (OU) to support characterization of the Ringold Formation member of Wooded Island – unit A (Rwia). This SAP is separate and distinct from the remediation well installation SAP provided in Appendix G of DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (hereinafter referred to as the 200-ZP-1 OU performance monitoring plan [PMP]).

The 200-ZP-1 OU comprises groundwater contaminated by releases from facilities and waste sites associated with former Hanford Site plutonium concentration and recovery operations at the Plutonium Finishing Plant and plutonium separation operations at T Plant. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, located at the western end of the Central Plateau. The 200 West Area is about 8 km (5 mi) south of the Columbia River and 11 km (7 mi) from the nearest Hanford Site boundary. The 200-ZP-1 OU includes several groundwater contaminant plumes that span about 13 km^2 (5 mi^2) beneath the 200 West Area. Figure 1 shows the location of the 200-ZP-1 OU at the Hanford Site. The primary contaminant of concern (COC) in groundwater for the 200-ZP-1 OU is carbon tetrachloride. Figure 2 shows the approximate mapped concentration distribution in 2017 of the carbon tetrachloride plume within the Rwia, below the Ringold Formation member of Wooded Island – lower mud unit (Rlm) (ECF-200W-16-0092, *Calculation of Three-Dimensional Groundwater Concentration Plumes for 200-West for Calendar Year (CY) 2015*).

This SAP supports implementation of the 200-ZP-1 OU selected remedy, as described in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* (hereinafter referred to as the 200-ZP-1 OU Record of Decision [ROD]). The monitoring wells proposed in this SAP are in addition to those proposed in the 200-ZP-1 OU PMP (DOE/RL-2009-115) and previous SAPs. The additional wells have been identified to continue fulfillment of requirements in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

Under this SAP, 12 monitoring wells are proposed for installation from fiscal year (FY) 2020 through FY 2022 at a planned installation rate of 4 monitoring wells per year. The actual schedule for installation, construction, and operation of the monitoring wells will be determined based on priority of Hanford Site work activities and available funding each FY. Table 1 lists the monitoring wells proposed for installation, as well as the known key hydrogeologic units and anticipated depths for each well.

Figure 2 shows the identified approximate locations of the proposed monitoring wells. Locations for only 8 of the proposed 12 monitoring wells have currently been identified for the first phase. Table 1 provides details for the eight monitoring wells (MW-A through MW-H) with identified locations. Using information collected during and after the installation of the first eight monitoring wells, the other four monitoring well locations (MW-I through MW-L) will be identified for the second phase through probabilistic optimization analyses that includes fate and transport (F&T) modeling combined with a continuation of the data gap analysis process, as initially documented in SGW-61350, *Data Gaps Evaluation in Groundwater Monitoring at the Hanford 200-ZP-1 Groundwater Operable Unit*. The remaining four monitoring well locations will be selected based on results of the initial data collected under this SAP, as well as data collected under other SAPs. Once selected, the remaining four well locations will be incorporated into this SAP by adhering to the document change control process described in Section 2.1.4.

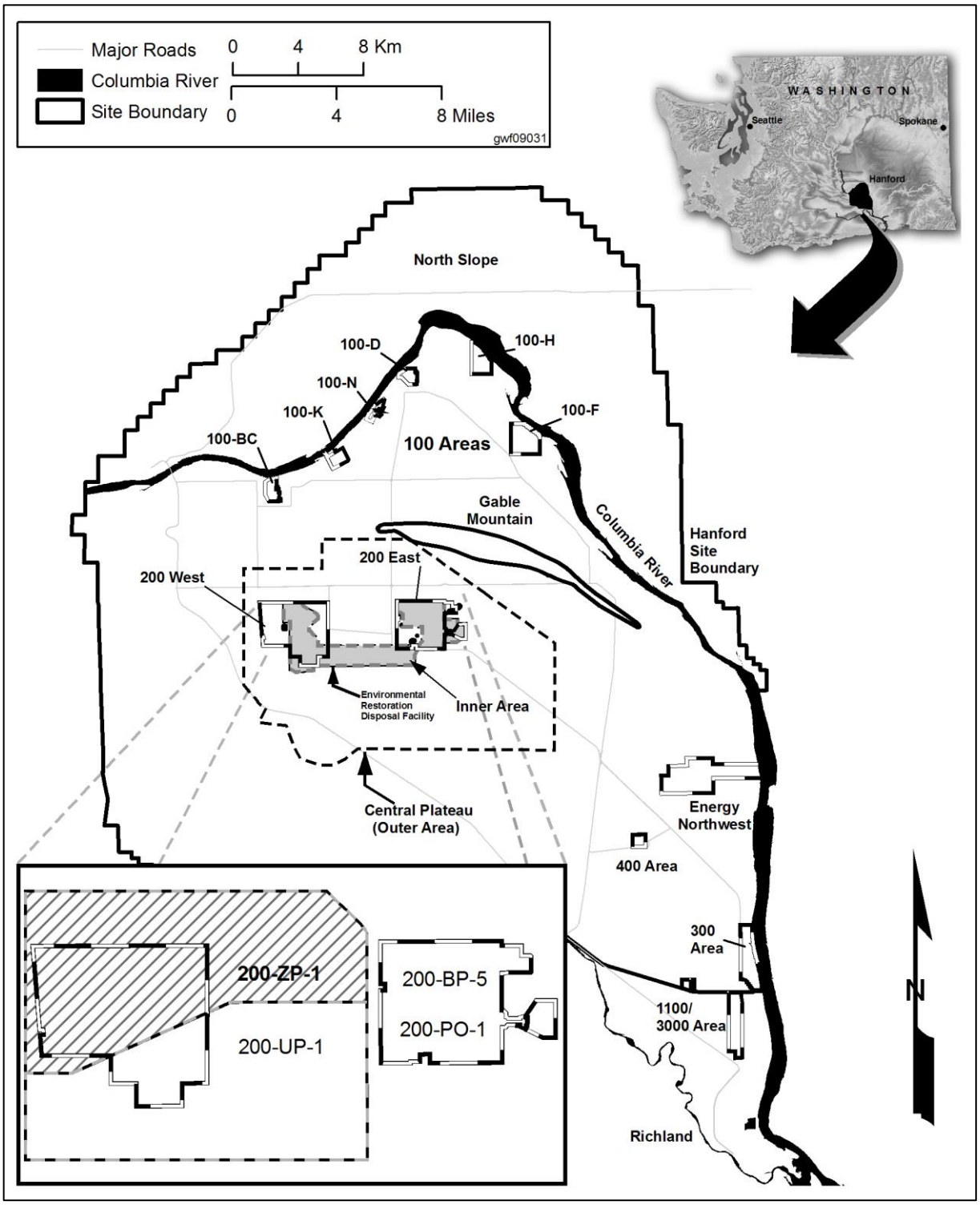

Figure 1. Location of Hanford Site and the 200-ZP-1 OU

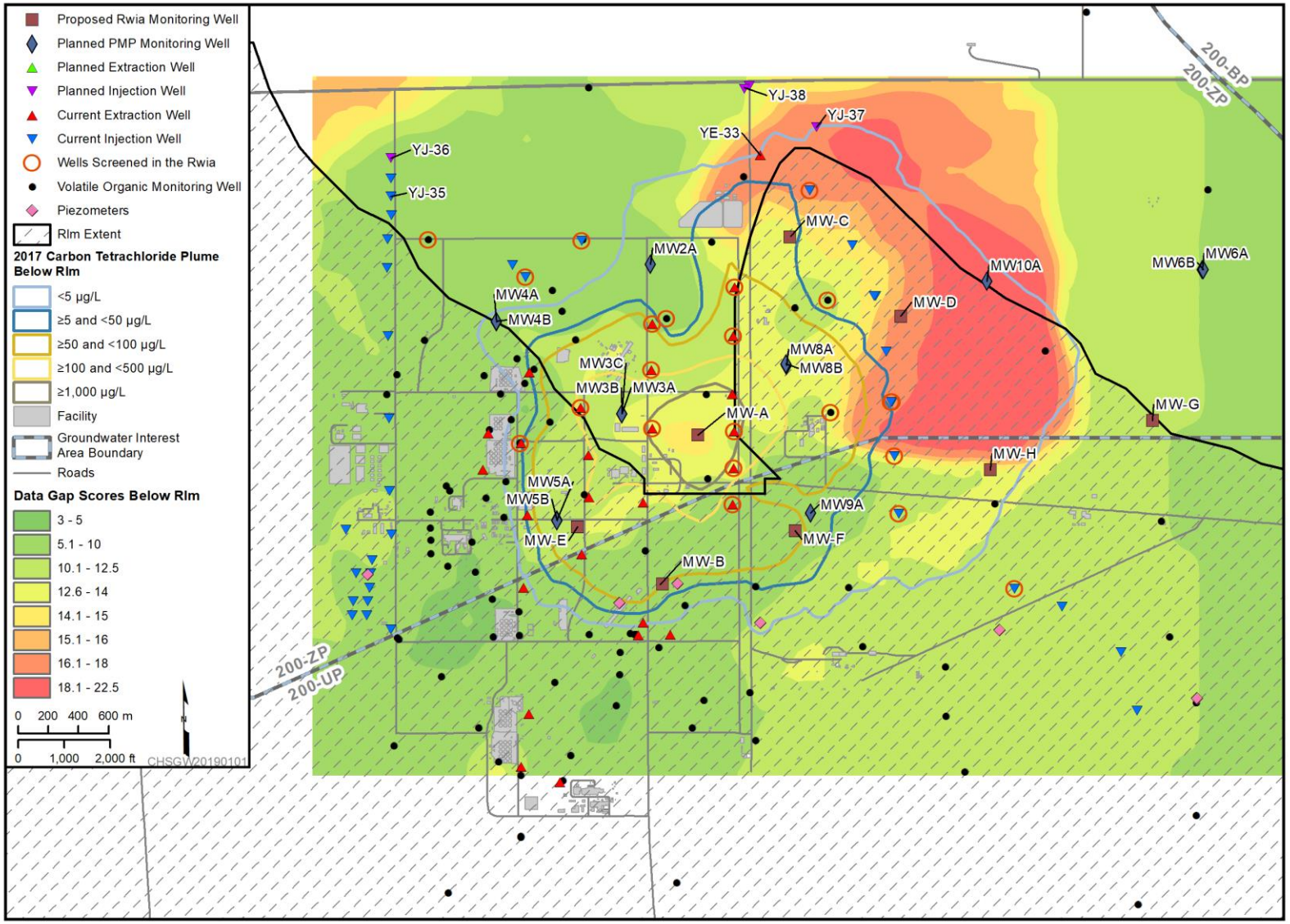

Figure 2. Approximate Location of Proposed Rwia Monitoring Wells

Table 1. Proposed Rwia Monitoring Wells with Estimated Geologic Contacts

Monitoring Well	Well Name	Well ID	Easting (m)	Northing (m)	Elevation (m)	Elevation (ft)	Estimated Total Depth (ft bgs)	Estimated Depth to Water (ft bgs)	Estimated Depth to Geologic Contacts* (ft bgs)								
									Hf1	Hf2	CCU	CCU_c	Rtf	Rwie	Rlm	Rwia	Basalt
MW-A	299-W13-4	D0080	568086	136340	225.6	740	536	322	14	68	140	157	167	189	NP	452	526
MW-B	299-W19-133	D0081	567849	135350	219.5	720	564	293	3	67	176	186	198	240	445	466	554
MW-C	699-46-70	D0082	568697	137656	217.0	712	431	287	1	33	105	146	158	185	340	361	421
MW-D	699-45-67C	D0083	569433	137129	221.6	727	464	311	7	62	196	202	203	214	322	366	454
MW-E	299-W14-26	D0084	567285	135729	216.4	710	551	286	10	61	138	143	151	160	428	468	541
MW-F	699-40-70	D0085	568732	135703	224.9	738	559	315	6	40	157	173	242	261	419	430	549
MW-G	699-42-62	D0086	571106	136438	224.0	735	461	335	5	46	275	308	308	318	NP	360	451
MW-H	699-41-65	D0087	570029	136109	230.4	756	518	344	8	47	236	NP	273	283	369	416	508
MW-I	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MW-J	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MW-K	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
MW-L	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

*The estimated depths to geologic contacts are based on the Hanford South Geologic Framework Model, as documented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*; and CP-60925, *Model Package Report: The Central Plateau Vadose Zone Geoframework Version 1.0*.

bgs = below ground surface
CCU = Cold Creek unit
CCU_c = Cold Creek unit caliche
Hf1 = Hanford formation unit 1
Hf2 = Hanford formation unit 2
ID = identification
NP = not present
Rtf = Ringold Formation member of Taylor Flat
Rlm = Ringold Formation member of Wooded Island – lower mud unit
Rwia = Ringold Formation member of Wooded Island – unit A
Rwie = Ringold Formation member of Wooded Island – unit E
TBD = to be determined

Collection of measurements and observations provides an opportunity for integration with other projects and activities, including data collection performed for other OUs. Conversely, information and developed knowledge may be shared with other projects through integration activities. Measurements and observations collected and used through integration activities must be assessed to ensure that they meet the data quality requirements of the current activity and that their uncertainty and limitations are understood. Information should be clearly identified as based on either direct data (i.e., collected under the auspices of this activity) or indirect data (i.e., collected through an integration activity).

In an effort to facilitate this integration process with other projects and activities, the project teams for collocated and nearby source and groundwater OUs were consulted to determine if additional sampling activities should be included in this SAP to support data needs for these other OUs. At the time of this SAP issuance, no additional sampling activities or needs were identified for the initial eight proposed well locations.

1.1 Project Scope and Objectives

The 200-ZP-1 OU ROD (EPA et al., 2008) presents the remedial actions for restoring the aquifer and the cleanup levels to be achieved. The preferred alternative for the 200-ZP-1 OU consists of pump and treat (P&T), monitored natural attenuation (MNA), flow-path control, and institutional controls (ICs). DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (hereinafter referred to as the 200-ZP-1 P&T remedial design/remedial action work plan [RD/RAWP]) describes how the design and implementation of the remedial action process required by the ROD will be executed.

This SAP addresses the drilling of monitoring wells within the Rwia to further characterize the nature and extent of contaminants, to refine the geologic framework for the Rwia, and to provide hydraulic properties for contaminant F&T modeling. This effort is supplemental to the 200-ZP-1 OU PMP (DOE/RL-2009-115) and supports the performance evaluation of the selected remedy by improving the understanding of the Rwia. The work will also support P&T optimization efforts focused on the Rwia and associated contamination. The overall goal of this project is to obtain additional data (with emphasis on the Rwia) to provide for reliable and predictive F&T modeling to support P&T and MNA remedy optimization.

1.1.1 Remedy Implementation Documentation

As discussed in Section 5.5 of the 200-ZP-1 P&T RD/RAWP (DOE/RL-2008-78), remedy implementation documents include the RD/RAWP; the 200-ZP-1 OU PMP; DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan* (hereinafter referred to as the 200 West P&T operations and maintenance [O&M] plan); DOE/RL-2019-38, *200-ZP-1 Operable Unit Optimization Study Plan* (hereinafter referred to as the 200-ZP- OU optimization study); and this SAP.

Figure 3 depicts the relationship between 200-ZP-1 OU remedy implementation documents and their relation to remedy reporting, optimization, decisions, and management. As shown in the figure, the 200-ZP-1 P&T RD/RAWP (DOE/RL-2008-78) describes the remedy tasks and provides the overall direction for remedy implementation to meet 200-ZP-1 OU ROD (EPA et al., 2008) requirements.

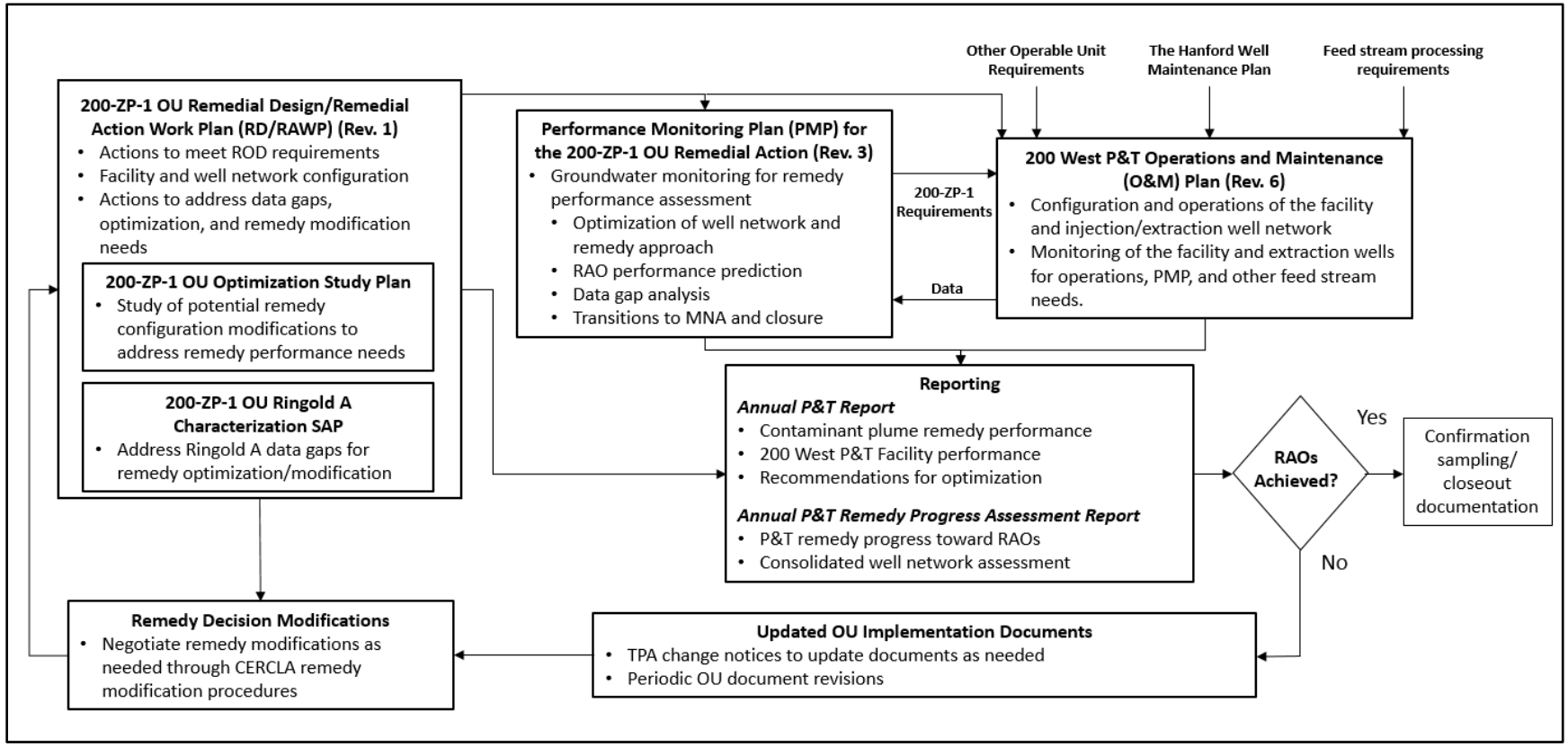

Figure 3. 200-ZP-1 OU Remedy Implementation Documentation

1.2 Background

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

The following sections summarize the hydrogeology, groundwater flow, contaminant plumes, and sources of contamination for the 200-ZP-1 OU. An overview is also provided of the data quality objective (DQO) process directing the sampling objectives, and the contaminants are identified.

1.2.1 Site Geology/Hydrology

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

The uppermost aquifer in the 200-ZP-1 OU is unconfined and occurs in the Ringold Formation. In the 200 West Area, the Ringold Formation is primarily comprised of the Rwia at the base; the Rlm, an aquitard present in part of the 200-ZP-1 interest area; and the Ringold Formation member of Wooded Island – unit E (Rwie) overlying the Rlm and Rwia. Figure 2 shows the current modeled extent of the Rlm in the 200-ZP-1 OU, and Table 1 provides details on the anticipated depths to geologic contacts at each proposed well location based on the current Hanford South Geologic Framework (HSGF) Model, as documented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*; and CP-60925, *Model Package Report: The Central Plateau Vadose Zone Geoframework Version 1.0*. Figure 4 shows the modeled carbon tetrachloride plume with the proposed Rwia monitoring wells and the location of HSGF Model cross sections depicted in Figures 5 and 6. The HSGF Model cross sections shown in Figures 5 and 6 were used to help select sampling intervals for the proposed wells, as discussed in Chapter 3.

Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where the water table is lower (the Columbia River). The depth of the water table in the 200 West Area varies from about 50 m (164 ft) in the southwest corner (near the former 216-U-10 Pond) to >100 m (328 ft) to the north. Table 1 also provides anticipated depths to water for each proposed well location.

1.2.2 Groundwater Flow

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

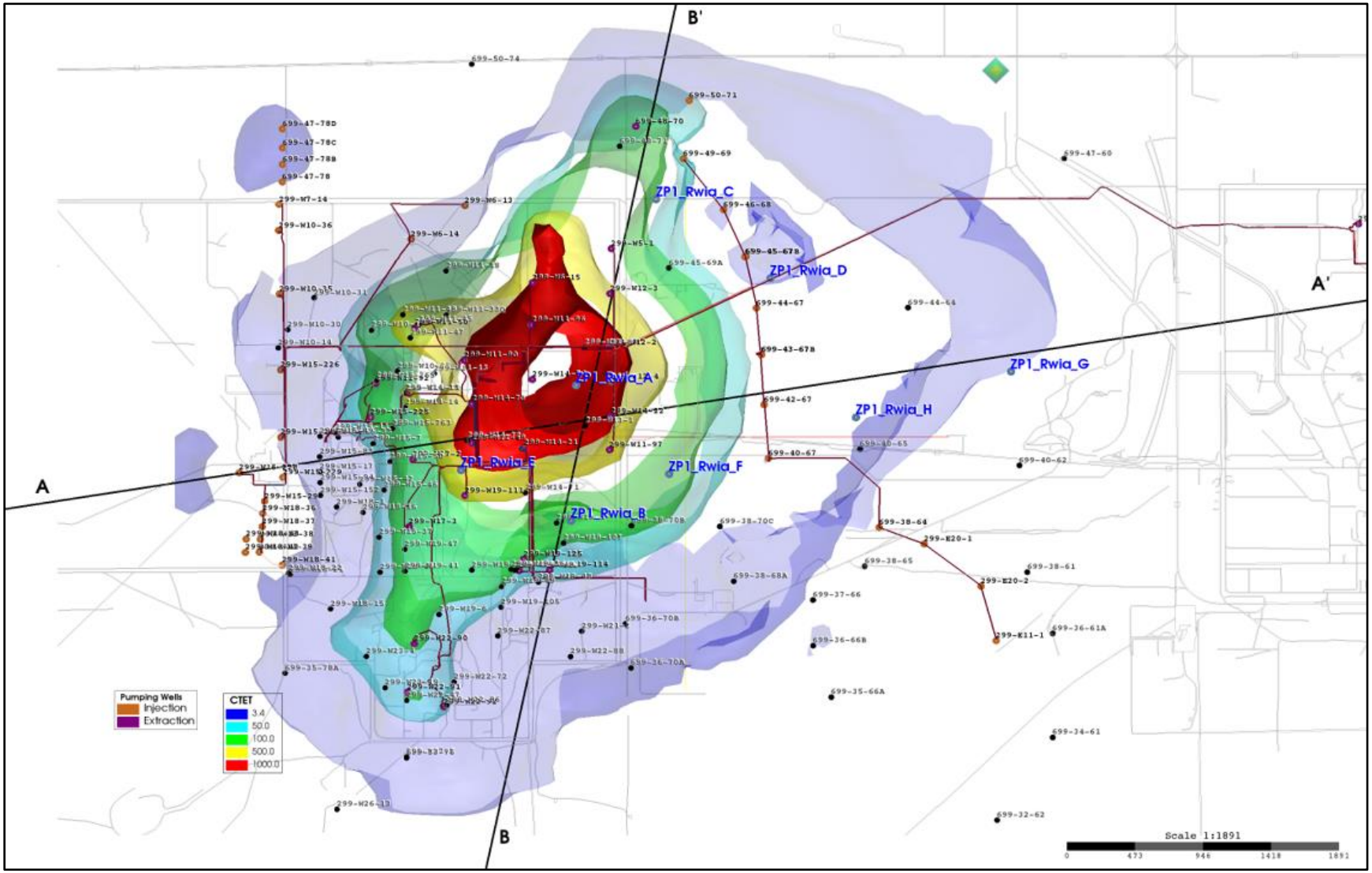

Figure 4. Carbon Tetrachloride Plume with Proposed Wells and Location of HSGF Model Cross Sections

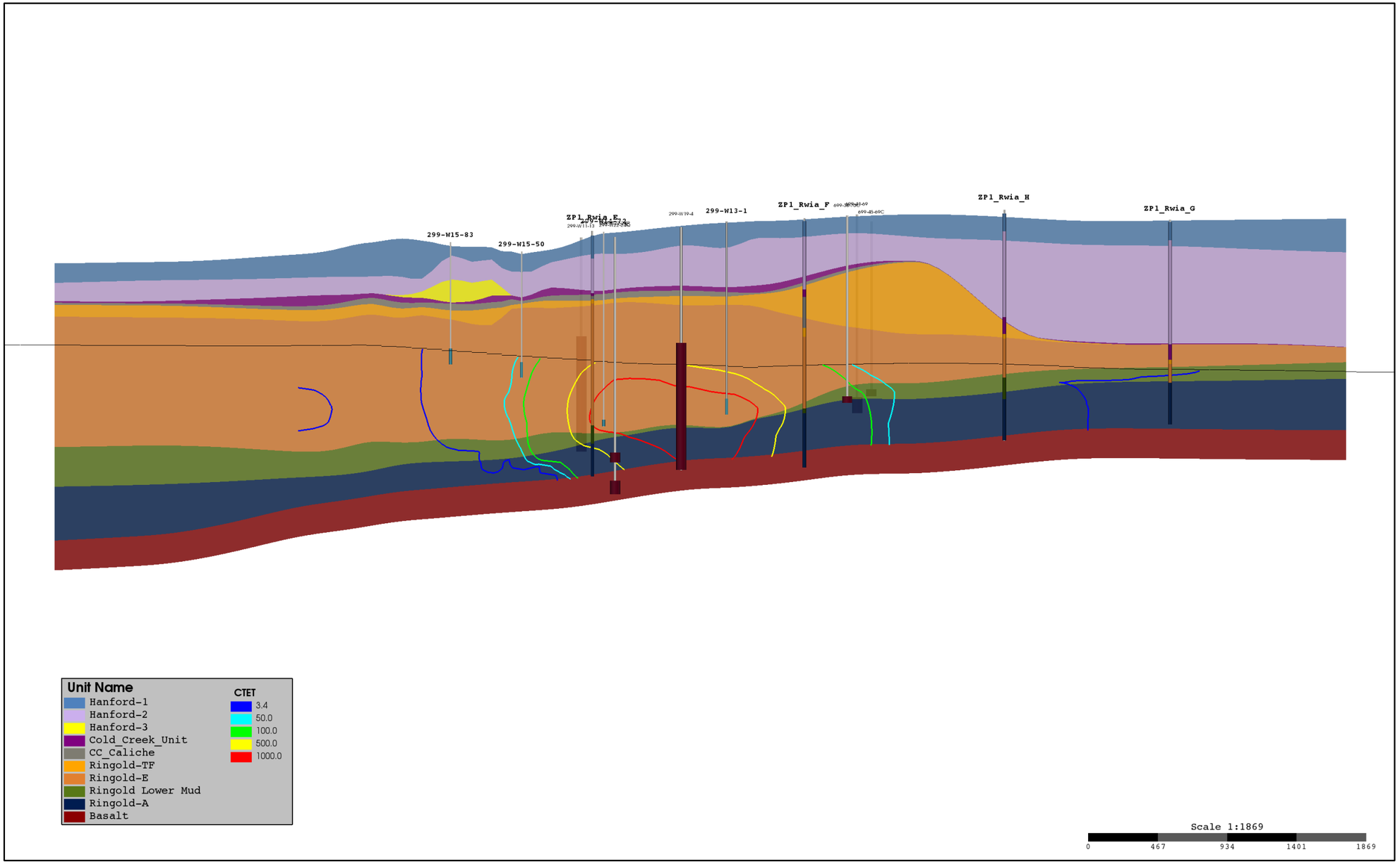

Figure 5. HSGF Model Cross Section with Proposed Wells and Carbon Tetrachloride Concentrations, West to East (A to A')

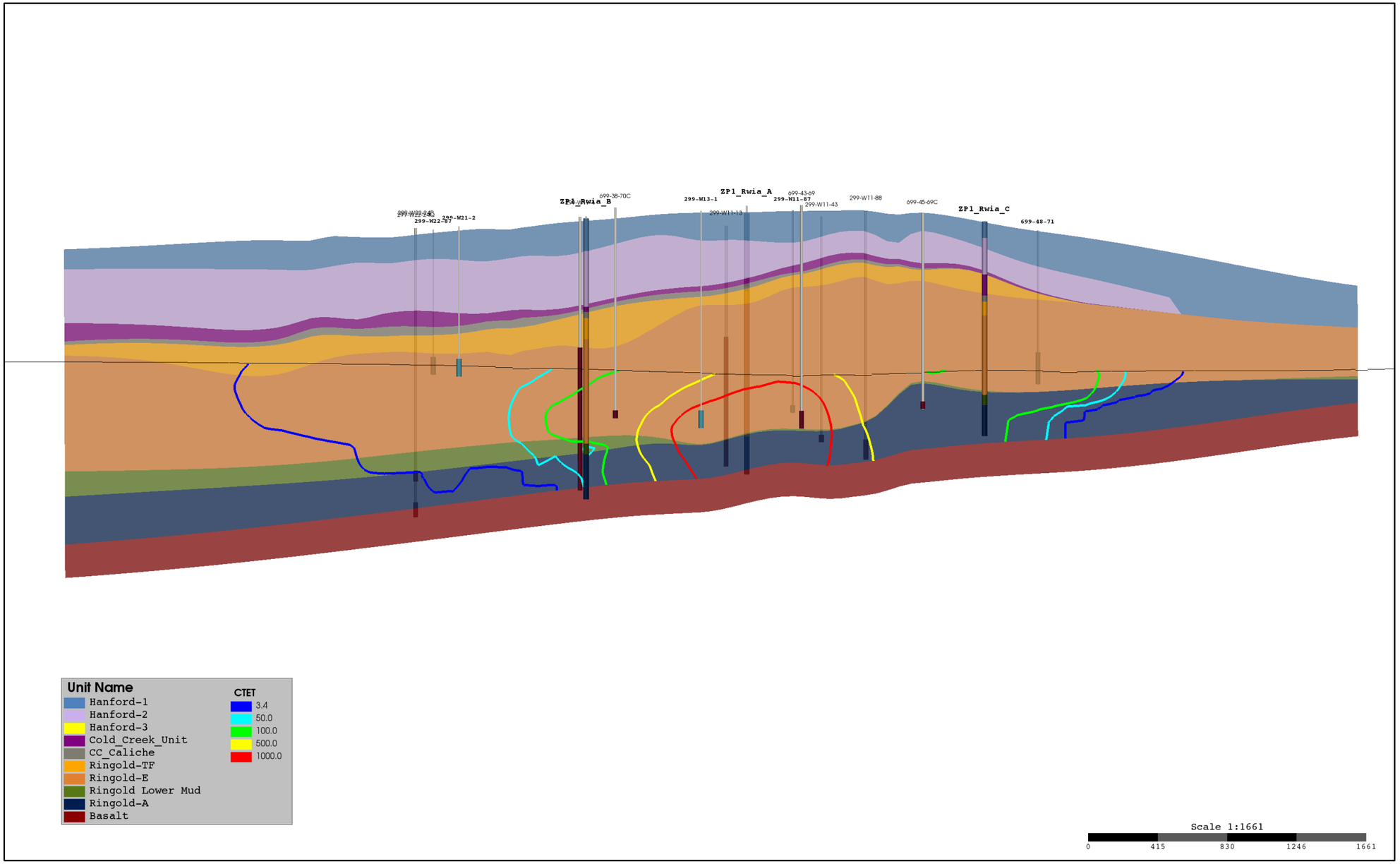

Figure 6. HSGF Model Cross Section with Proposed Wells and Carbon Tetrachloride Concentrations, South to North (B to B')

1.2.3 Sources of Groundwater Contamination

The groundwater COCs identified in the 200-ZP-1 OU ROD (EPA et al., 2008) include carbon tetrachloride, total chromium, hexavalent chromium, iodine-129, nitrate, technetium-99, trichloroethene (TCE), and tritium. Carbon tetrachloride is the primary risk driver in groundwater, forming a plume area of about 20 km^2 (7.9 mi^2) and primarily extending north, south, and east from the source areas. The primary carbon tetrachloride and TCE sources were associated with liquid waste discharges from plutonium separation processes at the Plutonium Finishing Plant to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. These sources have been mitigated and there is no longer a continuing carbon tetrachloride source that would contribute to a plume of concern (DOE/RL-2014-48, *Response Action Report for the 200-PW-1 Operable Unit Soil Vapor Extraction Remediation*).

Sources of chromium, iodine-129, nitrate, TCE, technetium-99, and tritium contamination in the 200-ZP-1 OU include releases from past leaks in single-shell tanks and pipelines in Waste Management Areas T and TX/TY, and liquid waste disposal from plutonium processing operations to cribs and trenches adjacent to the waste management areas. Except for nitrate, the remaining contaminant plumes in the 200-ZP-1 OU are predominately located within the boundaries of the carbon tetrachloride plume.

1.3 Data Quality Objective Summary

The DQO process is a strategic planning approach to define the criteria that a data collection design should satisfy. This process is used to ensure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. The DQOs for this SAP were developed in accordance with EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4). The DQO process involves a series of logical steps used to plan for the resource-effective acquisition of environmental data. The performance and acceptance criteria are determined through the DQO process, which serves as the basis for designing the plan to collect data of sufficient quality and quantity to support project goals. The DQO process used to support the sample design presented in this SAP is provided in Appendix A.

This SAP supports implementation of the 200-ZP-1 OU preferred cleanup alternative, as provided in the 200-ZP-1 OU ROD (EPA et al., 2008). Samples collected as part of this SAP will be used to support decisions related to remedy performance and optimization in the Rwia. Sample analysis includes the COCs in the 200-ZP-1 OU (as provided in the ROD), as well as chloroform, uranium, and other indicator constituents of interest, to assist in monitoring and implementing the preferred cleanup alternative. In addition, to update and improve groundwater modeling parameters, samples will be analyzed for physical properties, and hydraulic tests will be performed during drilling and following installation of the wells. This section presents the key outputs resulting from the DQO process.

1.3.1 Statement of the Problem

For the 200-ZP-1 OU, evaluation and optimization of the selected remedy (as specified in the 200-ZP-1 OU ROD [EPA et al., 2008]) is the ultimate purpose of data collection for the OU. To support this purpose, the nature and extent of carbon tetrachloride and other 200-ZP-1 OU COCs (as defined by the ROD) in the Rwia and Rlm must be better understood.

Since implementation of the 200-ZP-1 OU ROD (EPA et al., 2008), a greater proportion of carbon tetrachloride has been found below the Rlm (in the Rwia) (ECF-200W-16-0092) than was originally estimated in the remedial investigation (DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*) and the 200-ZP-1 OU feasibility study (FS) (DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*). The majority of the carbon tetrachloride mass within the Rwia appears to be located further to the east (i.e., in the downgradient

direction) than was understood during the remedial investigation. As discussed in SGW-62137, *200 West Pump-and-Treat Performance Against Remedial Action Objectives Specified in the 200-ZP-1 Operable Unit Record of Decision*, recent estimates indicate that approximately 25% of the remaining total carbon tetrachloride mass is found deep within the unconfined aquifer below the Rlm. The more recently modeled Rwia plume in 2015 is substantially larger than previously estimated in 2008, is located farther to the northeast, and represents a greater fraction of the overall contaminant mass within the 200-ZP-1 OU. Currently, there are limited characterization data, hydrogeologic data, hydraulic data, and transport parameter information for the Rwia and Rlm. A specific area where additional data are needed is to the north and northeast of the 200 West Area, where a portion of the carbon tetrachloride plume >100 µg/L is not currently being hydraulically contained by the P&T component of the selected remedy. In addition, the region to the northeast where contaminants are transported and discharge into groundwater from the 200 West Area toward the 200 East Area via a zone of higher transmissivity needs to be better understood. Although this SAP addresses the primary data needs associated with the Rwia and Rlm, some Rwie data are also needed in this area of potential contaminant migration.

Based on these needs, sufficient data must be collected within the defined study area to adequately define the nature and extent of the 200-ZP-1 OU COC plumes and the hydrogeologic properties, hydraulic properties, and transport parameters of the Rwia, the Rlm, and, to a limited extent, the Rwie. The data will support F&T modeling, the well design process, facilitate performance evaluation of the 200-ZP-1 OU remedy, and assist in making recommendations for optimizing or modifying the remedy.

A determination regarding the adequacy of the information and knowledge obtained from these studies will be made in the context of improving the ability to reasonably predict the likely future performance of the remedy in attaining the remedial action objectives as specified in the 200-ZP-1 OU ROD (EPA et al., 2008). Section A.6.2 in Appendix A discusses the approach for determining data adequacy.

1.3.2 Decision Statements and Decision Rules

The DQO process identifies the key decisions and goals that must be addressed to achieve the final solution to the problem statement. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the selected remedy combines P&T, MNA, flow-path control, and ICs. This SAP addresses monitoring well installation and associated data collection at depth to solve the problem statement. The key questions that the data collection must address and the alternative actions that may result from the data analysis are presented in decision statements (DSs).

The DSs consolidate potential questions and alternative actions. Decision rules (DRs) are generated from the DSs. A DR is an “IF…THEN…” statement incorporating the parameter of interest, unit of decision making, action level, and actions resulting from resolution of the decision. Tables 2 and 3 present the DSs and DRs, respectively, as identified during the DQO process. Appendix A presents the principal study questions and alternative actions used to develop the DSs and DRs.

Table 2. Decision Statements

DS #	Decision Statement
1	Determine if the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling; otherwise, collect additional data to define the vertical and lateral distribution of COCs.
2	Determine if the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and contacts and transitions between the Rwie, Rlm, Rwia, and basalt are adequately defined to support F&T modeling and the well design process; otherwise, collect additional data to define these properties.
3	Determine if the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling; otherwise, collect additional data to define these properties.
4	Determine if the transport parameters for the 200-ZP-1 Operable Unit COCs are adequately defined within the Rwia and Rlm to support F&T modeling; otherwise, collect additional data to define these properties.

COC = contaminant of concern
DS = decision statement
F&T = fate and transport
Rlm = Ringold Formation member of Wooded Island – lower mud unit
Rwia = Ringold Formation member of Wooded Island – unit A
Rwie = Ringold Formation member of Wooded Island – unit E

Table 3. Decision Rules

DS #	DR #	Decision Rule
1	1	If the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling, then no further data collection is required. Otherwise, collect additional data to define the vertical and lateral distribution of COCs.
2	2	If the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and contacts and transitions between the Rwia, Rwie, Rlm, and basalt are adequately defined to support F&T modeling and the well design process, then no further data collection is required. Otherwise, collect additional data to define these properties.
3	3	If the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling, then no further data collection is required. Otherwise, collect additional data to define these properties.
4	4	If the transport parameters for the 200-ZP-1 Operable Unit COCs are adequately defined within the Rwia and Rlm to support F&T modeling, then no further data collection is required. Otherwise, collect additional data to define these properties.

COC = contaminant of concern
DR = decision rule
DS = decision statement
F&T = fate and transport
Rlm = Ringold Formation member of Wooded Island – lower mud unit
Rwia = Ringold Formation member of Wooded Island – unit A
Rwie = Ringold Formation member of Wooded Island – unit E

1.3.3 Sampling Designs

The supplemental data gathered from installing 12 Rwia monitoring wells in the 200-ZP-1 OU will address the DSs identified in Table 2. Table 4 summarizes the primary data inputs needed to resolve the DSs. Chapter 3 discusses the data collection efforts required to resolve each DS, the estimated number of depth-discrete samples to be collected from each well boring, and the analyses to be performed on individual water samples.

Table 4. Summary of Data Inputs to Resolve DSs

Data Inputs	DS #
Data Collection Specified in this SAP	
Groundwater (aqueous contaminants, transformation products, and other constituents of interest) sample results from new monitoring wells to better define the lateral and vertical extent and distribution of contaminant plumes to support remedy performance evaluation and F&T modeling	1
Sediment (sorbed contaminants, transformation products, and other constituents of interest) sample results from new monitoring wells to better define the sorbed versus aqueous contaminant concentrations to support remedy performance evaluation and F&T modeling	1
Geologic observations (during drilling, using visual observation and geophysical logging) of the contacts and transitions between the Rwia, Rwie, Rlm, and basalt to better define the geologic framework to support F&T modeling	2
Geologic observations (during drilling, using visual observation and geophysical logging) of the erosional features and unconformities in the Rwia and Rlm to better define the geologic framework to support F&T modeling	2
Sediment physical properties (bulk density, particle density, total porosity, particle-size distribution, and saturated hydraulic conductivity) sample results from new monitoring wells used to better define hydrogeologic and hydraulic properties and differences between the Rwia and Rwie to support F&T modeling to support the well design process.	2 and 3
Hydraulic head distribution observations during drilling to better define hydraulic conditions to support F&T modeling	3
Slug testing (during drilling) results to better define the vertical profile of hydraulic conductivity for the Rwia associated with major zones of different transmissivity to support F&T modeling	3
Sediment transport-related (geochemical parameters and organic content) sample results from new monitoring wells to better define the transport parameters to support F&T modeling	4
Results of supplemental laboratory contaminant mobility and transport studies performed at Pacific Northwest National Laboratory will be used to better understand sediment/water partitioning and develop distribution coefficients for carbon tetrachloride to support F&T modeling	4
Data Collection to be Specified in a Subsequent Testing Plan*	
Hydraulic testing (TBD*) to better define large-scale transmissivity and storage properties to support F&T modeling	3
Hydraulic testing (TBD*) to better define the vertical profile of hydraulic conductivity for the Rwia associated with major zones of different transmissivity to support F&T modeling	3
Hydraulic testing (TBD*) to better define the vertical hydraulic conductivity (leakage factor) to support F&T modeling	3
Hydraulic testing (TBD*) to better define the effective porosity of the Rwia within the observed/interpreted plume migration pathways to support F&T modeling	3

Table 4. Summary of Data Inputs to Resolve DSs

Additional Data	
Sample results for contaminants, transformation products, and other constituents of interest that arise from other 200-ZP-1 OU data collection activities, primarily performed under the 200-ZP-1 OU PMP (DOE/RL-2009-115), the 200 West pump and treat operations and maintenance plan (DOE/RL-2009-124), and the 200-ZP-1 optimization study plan (DOE/RL-2019-38)	1
Sample results for contaminants, transformation products, and other constituents of interest that arise from outside the 200-ZP-1 OU under other SAPs, PMPs, etc.	1

References: DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*.

DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*.

DOE/RL-2019-38, *200-ZP-1 Operable Unit Optimization Study Plan*.

*Data collection efforts for hydraulic properties will mostly be specified and conducted under a separate hydraulic testing plan that will be developed following the issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing plan and completion of the associated hydraulic testing work is a required task under this SAP.

DS = decision statement
OU = operable unit
PMP = performance monitoring plan
Rlm = Ringold Formation member of Wooded Island – lower mud unit
Rwia = Ringold Formation member of Wooded Island – unit A
Rwie = Ringold Formation member of Wooded Island – unit E
SAP = sampling and analysis plan
TBD = to be determined

Chapter 3 discusses the data collection efforts required to resolve each DS, the estimated number of depth-discrete samples to be collected from each well, and the analyses to be performed on individual water samples. Table 5 lists the constituents of interest for groundwater during drilling and for groundwater post-development. Table 6 lists the constituents of interest and the physical properties for sediments during drilling. In addition, slug tests will be performed during drilling as described in Section 3.4.6.

Table 5. Constituents of Interest for Groundwater During Drilling and for Groundwater Post-Development

Constituent of Interest	CAS Number
Groundwater Constituents During Drilling	
Carbon tetrachloride[a]	56-23-5
Chloroform	67-66-3
Chloromethane	74-87-3
Chromium, total[a, b]	7440-47-3
Cyanide	57-12-5
cis-1,2-Dichloroethene	156-59-2
Dichloromethane	75-09-2
Iron	7439-89-6
Iodine-129[a]	15046-84-1
Manganese	7439-96-5
Nitrate[a]	14797-55-8

Table 5. Constituents of Interest for Groundwater During Drilling and for Groundwater Post-Development

Constituent of Interest	CAS Number
pH	N/A
Total dissolved solids	TDS
Total carbon	7440-44-0
Total organic carbon	TOC
Total inorganic carbon	TIC
Technetium-99[a]	14133-76-7
Trichloroethene[a]	79-01-6
Tritium[a]	10028-17-8
Uranium[c]	7440-61-1
Vinyl chloride	75-01-4
Post-Development Groundwater Constituents	
Alkalinity	ALKALINITY
Carbon tetrachloride[a]	56-23-5
Chloroform	67-66-3
Chloride	16887-00-6
Chloromethane	74-87-3
cis-1,2-Dichloroethene	156-59-2
Dichloromethane	75-09-2
Chromium, total[a, b]	7440-47-3
Chromium, hexavalent[a, b]	18540-29-9
Cyanide	57-12-5
Iodine-129[a]	15046-84-1
Iron[b]	7439-89-6
Manganese[b]	7439-96-5
Nickel[b]	7440-02-0
Nitrate[a]	14797-55-8
Nitrite	14797-65-0
Sulfate	14808-79-8
Sulfide	18496-25-8
Technetium-99[a]	14133-76-7
Total organic carbon	TOC
Total dissolved solids	TDS
Trichloroethene[a]	79-01-6
Tritium[a]	10028-17-8
Uranium[b, c]	7440-61-1
Vinyl chloride	75-01-4

Table 5. Constituents of Interest for Groundwater During Drilling and for Groundwater Post-Development

Constituent of Interest	CAS Number
Field Screening Parameters [d]	
Dissolved oxygen	N/A
Oxidation-reduction potential	N/A
pH	N/A
Specific conductance	N/A
Temperature	N/A
Turbidity	N/A

a. The COCs are specified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*.

b. Both filtered and unfiltered samples will be collected for all metal constituents except hexavalent chromium. A filtered sample will be collected for hexavalent chromium.

c. Uranium (total) will also be analyzed as a target constituent. While not a COC specified in the 200-ZP-1 OU Record of Decision (EPA et al., 2008), it is a COC for the adjacent 200-UP-1 OU.

d. Field screening parameters to be collected in accordance with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document, Vol. 3, Field Analytical Technical Requirements*.

CAS = Chemical Abstracts Service
COC = contaminant of concern
N/A = not applicable
OU = operable unit
TDS = total dissolved solids
TIC = total inorganic carbon
TOC = total organic carbon

Table 6. Constituents of Interest and Physical Properties for Sediments During Drilling

Constituent of Interest	CAS Number	Purpose
Sediment Constituents		
Carbon tetrachloride[a, b]	56-23-5	Used for comparison to aqueous concentrations
Chloroform[b]	67-66-3	Used for comparison to aqueous concentrations
Chloromethane[b]	74-87-3	Used for comparison to aqueous concentrations
Chromium, total[a]	7440-47-3	Used for comparison to aqueous concentrations
Chromium, hexavalent[a]	18540-29-9	Used for comparison to aqueous concentrations
Cyanide	57-12-5	Used for comparison to aqueous concentrations
cis-1,2-Dichloroethane[b]	156-59-2	Used for comparison to aqueous concentrations
Dichloromethane[b]	75-09.2	Used for comparison to aqueous concentrations
Iron	7439-89-6	Used for comparison to aqueous concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals
Manganese	7439-96-5	Used for comparison to aqueous concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals
pH	N/A	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Total carbon[b]	7440-44-0	Used for comparison to aqueous concentrations and to establish baseline geochemistry

Table 6. Constituents of Interest and Physical Properties for Sediments During Drilling

Constituent of Interest	CAS Number	Purpose
Total organic carbon[b]	TOC	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Total inorganic carbon[b]	TIC	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Technetium-99[a]	14133-76-7	Used for comparison to aqueous concentrations
Trichloroethene[a, b]	79-01-6	Used for comparison to aqueous concentrations
Uranium[c]	7440-61-1	Used for comparison to aqueous concentrations
Vinyl chloride[b]	75-01-4	Used for comparison to aqueous concentrations
Sediment Physical Properties		
Bulk density, particle density, and porosity	N/A	Used in evaluating soil texture needed to support geologic interpretation, interpretation of physical and chemical testing data, and provide parameter inputs to fate and transport modeling
Particle-size distribution	N/A	Used in evaluating soil texture needed to support geologic interpretation and interpretation of physical and chemical testing data, as well as the well design process
Saturated hydraulic properties[d]	N/A	Used in geologic interpretation and provides parameter inputs to fate and transport modeling

a. The COCs are specified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*.

b. Analysis to be performed by Pacific Northwest National Laboratory to accommodate potential for supplemental studies from full, intact liners C or D. If there is a question regarding the intact nature of the liners, the project scientist should be contacted for direction.

c. Uranium (total) will also be analyzed as a target constituent. While not a COC specified in the 200-ZP-1 OU Record of Decision (EPA et al., 2008), it is a COC for the 200-UP-1 OU to the south.

d. A full, intact liner is required for this analysis. If there is a question regarding the intact nature of the liner for this analysis, the project scientist should be contacted for direction.

CAS = Chemical Abstracts Service
COC = contaminant of concern
N/A = not applicable
OU = operable unit
TIC = total inorganic carbon
TOC = total organic carbon

To support the need for collecting transport parameter data (identified in Appendix A and summarized in Table 4), sediment samples will also be provided to Pacific Northwest National Laboratory (PNNL) for laboratory contaminant mobility and transport studies to better understand sediment/water partitioning and to develop distribution coefficients for carbon tetrachloride in the Rwia and Rlm. Split-spoon sample liners C and D collected for each sample interval will be provided to PNNL. The full, intact liner C will be designated for volatile organic compound (VOC), total carbon, total organic carbon (TOC), total inorganic carbon (TIC) analyses. Liner D will be held in reserve at PNNL for use if reanalysis or additional sample material is needed. Only sediment samples that correspond to groundwater samples with higher carbon tetrachloride concentrations (based on quick-turnaround analytical results) will undergo supplemental studies at PNNL.

To support the need for collecting the remaining hydraulic properties data (identified in Appendix A and summarized in Table 4), a hydraulic testing plan will be developed following the issuance of this SAP. The testing plan will focus on hydraulic testing activities to be performed for the completed

Rwia monitoring wells installed under this SAP. The development of the testing plan and completion of the associated work is a requirement under this SAP.

1.4 Contaminants of Concern

Section 1.2.3 lists the COCs for the 200-ZP-1 OU, as identified the 200-ZP-1 OU ROD (EPA et al., 2008). Table 5 lists the groundwater constituents of interest for samples collected during drilling and after well development. Table 6 lists the sediment constituents of interest and physical properties for samples collected during drilling. The constituents of interest that are not COCs were derived from a review of the documents listed in Table 7. The additional constituents include anticipated degradation products of COCs that can be used to assist in evaluating natural attenuation processes and rates. Additional parameters for post-development sampling include the contaminants sampled under the 200-ZP-1 OU performance monitoring SAP (Appendix B of the 200-ZP-1 OU PMP [DOE/RL-2009-115]).

Table 7. Document References for Constituents of Interest

Reference	Summary
DOE/RL-2006-24, *Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit*	Includes a summary of data for the 200-ZP-1 OU, including individual well information and a summary of the logic for screening contaminants based on available data.
DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*	Establishes a basis for remedial action in the 200-ZP-1 OU, formulates preliminary objectives for conducting the remedial action, and develops and evaluates alternatives for remediating groundwater in the 200-ZP-1 OU. A baseline risk assessment is also presented.
DOE/RL-2007-33, *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit*	Issued by DOE and EPA for public and Tribal Nations comment, and Ecology has concurred with the preferred alternative. The plan identifies the preferred approach for remediating 200-ZP-1 OU groundwater and explains the reasons for this preference. The proposed plan facilitates public and Tribal Nations review by summarizing the findings of the remedial investigation report, feasibility study report, and baseline risk assessment contained in the feasibility study report.
DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*	Includes the plan and schedule for implementing all of the tasks to design, install, and operate the remedy set forth in the 200-ZP-1 OU Record of Decision (EPA et al., 2008).
DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*	Provides guidance for collecting and evaluating groundwater monitoring data associated with implementing the 200-ZP-1 OU remedial action.
DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*	Provides guidance for collecting extracted groundwater data from the 200-ZP-1 OU, 200-UP-1 OU, and 200-BP-5 OU P&T extraction wells prior to treatment at the 200 West P&T. It also provides guidance for collecting operational data associated with various treatment processes in the P&T facility and for collecting treated groundwater data for the facility effluent prior to injection into the aquifer.
EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*	Presents the selected remedy for the 200-ZP-1 OU, which is part of the Hanford Site 200 Areas.

DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
OU = operable unit
P&T = pump and treat

The 200-ZP-1 OU FS (DOE/RL-2007-28) outlines the statistical measures used to determine the COCs. In addition to the COCs presented in the 200-ZP-1 OU ROD (EPA et al., 2008), other parameters or constituents may be analyzed (e.g., chloroform and other byproducts of COC degradation) to support future MNA monitoring. The reporting requirements for certain broad-spectrum U.S. Environmental Protection Agency (EPA) methods are provided in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended; and Methods 6020, 8260, and 300.0. If analyses indicate tentatively identified compounds beyond those listed in Tables 5 and 6, these will also be reported in the Hanford Environmental Information System (HEIS) database and will have a "J" qualifier (estimated value).

2 Quality Assurance Project Plan

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementing, and assessing sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements provided 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). DoD and DOE, 2017, *Department of Energy (DOD) / Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, is also discussed. Section 7.8 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (hereinafter referred to as the Tri-Party Agreement Action Plan), requires that QA/quality control (QC) and sampling and analysis activities specify the QA requirements for past-practice processes. This QAPjP also describes applicable requirements and controls based on guidance provided in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*; and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP supplements the contractor's environmental QA program plan.

The QAPjP includes the following sections that describe the quality requirements and controls applicable to Hanford Site OU sampling activities:

- Section 2.1, "Project Management"
- Section 2.2, "Data Generation and Acquisition"
- Section 2.3, "Assessment and Oversight"
- Section 2.4, "Data Review and Usability"

2.1 Project Management

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

2.1.1 Project/Task Organization

The contractor (or its approved subcontractor) is responsible for planning, coordinating, sampling, and shipping samples to the appropriate laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) project manager in obtaining approval of the SAP and future proposed revisions. The project organization for soil and groundwater sampling is described in the following sections and is shown in Figure 7.

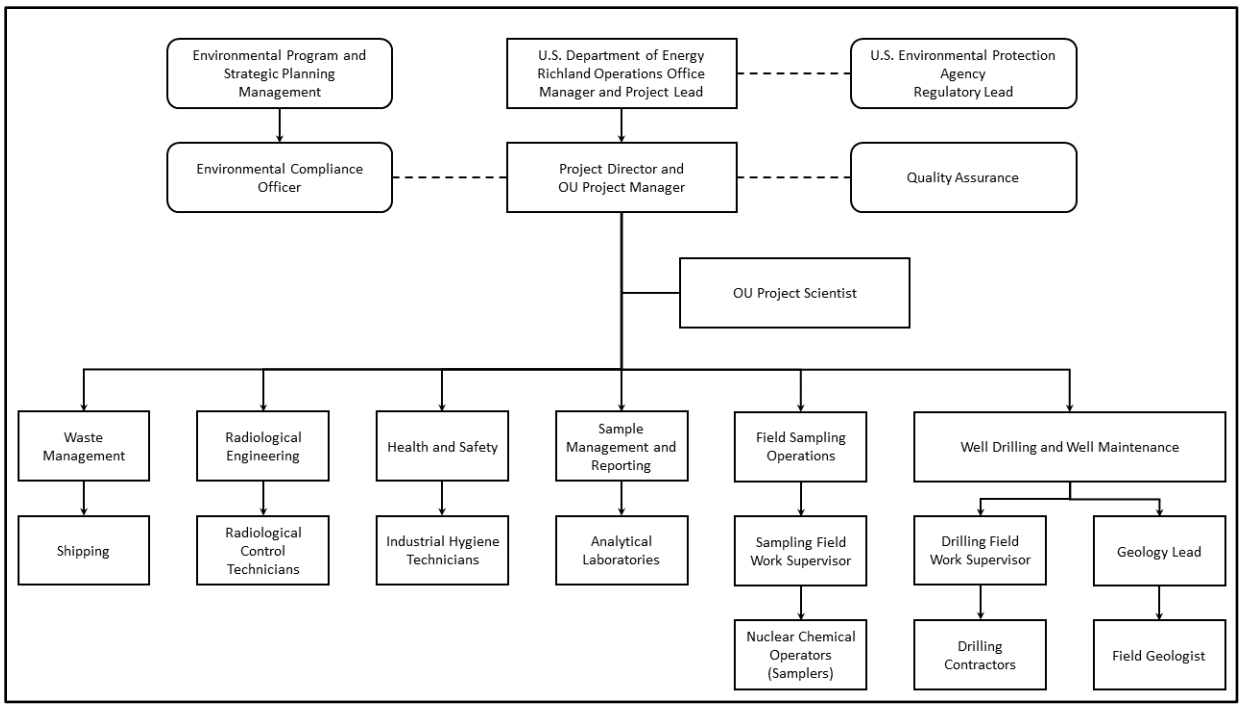

Figure 7. Project Organization

2.1.1.1 Regulatory Lead

The lead regulatory agency for the 200-ZP-1 OU is EPA. EPA is responsible for regulatory oversight of cleanup projects and activities; EPA also retains authority for all SAPs. EPA will work with DOE-RL to resolve concerns regarding the work described in this SAP in accordance with Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

2.1.1.2 DOE-RL Manager

DOE-RL is responsible for cleanup of the Hanford Site. The DOE-RL manager is responsible for authorizing the contractor to perform activities at the Hanford Site under CERCLA, the *Resource Conservation and Recovery Act of 1976*, the *Atomic Energy Act of 1954*, and the Tri-Party Agreement (Ecology et al., 1989a).

2.1.1.3 DOE-RL Project Lead

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

2.1.1.4 Project Director

The project director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The project director also provides support to the OU project manager to ensure that work is performed safely and cost effectively.

2.1.1.5 Operable Unit Project Manager

The OU project manager (or designee) provides oversight for activities and coordinates with DOE-RL, the regulatory agencies, and contractor management in support of sampling activities to ensure that work is performed safely and cost effectively. The OU project manager (or designee) is also responsible for managing sampling documents and requirements, field activities, and subcontracted tasks, and for ensuring that the project file is properly maintained.

2.1.1.6 Operable Unit Project Scientist

The OU project scientist is responsible for developing specific sampling designs, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process. The OU project scientist ensures that sampling and analysis activities (as delegated by OU project manager) are carried out in accordance with the SAP. The OU project scientist works closely with the environmental compliance officer, the QA and Health and Safety organizations, the field work supervisor (FWS), and the Sample Management and Reporting (SMR) organization to integrate these and other technical disciplines in planning and implementing the work scope.

2.1.1.7 Sample Management and Reporting

The SMR organization oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to SAP requirements, and verifies that laboratories are qualified to perform Hanford Site analytical work. SMR generates field sampling documents, labels, and instructions for field sampling personnel and develops the sample authorization form, which provides information and instructions for the analytical laboratories. SMR ensures that field sampling documents are revised to reflect approved changes. SMR receives analytical data from the laboratories, ensures that the data are appropriately reviewed, performs data entry into the HEIS database, and arranges for data validation and recordkeeping. SMR is responsible for resolving sample documentation deficiencies or issues associated with Field Sampling Operations (FSO), laboratories, or other entities. SMR is responsible for informing the OU project manager of any issues reported by the analytical laboratories.

2.1.1.8 Field Sampling Operations

FSO is responsible for planning and coordinating field sampling resources and provides the FWS for sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect samples in accordance with this SAP and corresponding standard methods and procedures. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling documentation. Samplers also complete field logbooks, data forms, and chain-of-custody forms (including any shipping paperwork) and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO in accordance with work management and work release requirements to evaluate activities and associated hazards by considering the following factors:

- 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

2.1.1.9 Quality Assurance

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

2.1.1.10 Environmental Compliance Officer

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

2.1.1.11 Health and Safety

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

2.1.1.12 Radiological Engineering

Radiological Engineering is responsible for radiological engineering and health physics support for the project. Specific responsibilities include conducting as low as reasonably achievable reviews, exposure and release modeling, and radiological controls optimization for work planning. In addition, radiological hazards are identified, and appropriate controls are implemented to maintain worker exposures to hazards at levels as low as reasonably achievable. Radiological Engineering interfaces with the project Health and Safety representative and other appropriate personnel as needed to plan and direct radiological control technician (RCT) support for activities.

2.1.1.13 Waste Management

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

2.1.1.14 Analytical Laboratories

The analytical laboratories analyze samples in accordance with established procedures and their subcontracts and provide necessary data packages containing analytical and QC results. The laboratories provide explanations of results to support data review and in response to resolving analytical issues. Statements of work flow down quality requirements consistent with HASQARD (DOE/RL-98-68). The laboratories are evaluated under DoD and DOE (2017) requirements and must be accredited by EPA and the Washington State Department of Ecology (Ecology) for the analyses performed for the DOE prime contractor.

2.1.1.15 Well Drilling and Well Maintenance

The well drilling and maintenance and the well coordination and planning managers are responsible for the following:

- Planning, coordinating, and executing drilling construction
- Performing well maintenance activities
- Coordinating with the OU project scientist regarding field constraints that could affect sampling design
- Coordinating well decommissioning with DOE-RL and Ecology approval, as appropriate, in accordance with the substantive standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"; and DOE/RL-2005-70, *Hanford Site Well Decommissioning Plan*

The well drilling and well maintenance organization will oversee, and may assist in, hydraulic testing activities to be conducted under this SAP and under the subsequently developed hydraulic testing plan (discussed in Section 1.3.3).

2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in this SAP. Data quality indicators (DQIs) are data descriptors that help determine the acceptability and usefulness of data to the user. For the purposes of this SAP, the principal DQIs (precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity) are defined in Table 8.

2.1.3 Special Training Requirements and Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting samples in compliance 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.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable DOE, *Code of Federal Regulations*, and *Washington Administrative Code* requirements.

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

2.1.4 Documentation and Records

The OU project manager (or designee) is responsible for ensuring that the current version of this SAP is being used and for providing updates to field personnel. Version control is maintained by the administrative document control process. Table 9 defines the types of changes that may impact sampling and the associated approvals, notifications, and documentation requirements.

Table 8. Data Quality Indicators

Data Quality Indicator (QC Element)	Definition	Determination Methodologies	Corrective Actions
Precision[a] (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy[a] (laboratory control samples, matrix spikes, surrogates, carriers, and tracers, as applicable)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or remeasurement.
Representativeness (field duplicates)	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 that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are obtained 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 results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table 8. Data Quality Indicators

Data Quality Indicator (QC Element)	Definition	Determination Methodologies	Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent on 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 (no QC element; addressed in data quality assessment)	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet 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.

Table 8. Data Quality Indicators

Data Quality Indicator (QC Element)	Definition	Determination Methodologies	Corrective Actions
Bias (equipment blanks, field transfer blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	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 practices to limit preferential selection or loss of sample media. • Use sample handling practices, 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 laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	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[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

a. Acceptance criteria for QC elements of precision and accuracy for groundwater and sediment analyses are provided in Tables 10 and 11, respectively.

b. For purposes of this sampling and analysis plan, the lower limit of quantitation is interchangeable with the practical quantitation limit as specified in Table 10 for groundwater samples and Table 11 for sediment samples.

QC = quality control

Table 9. Change Control for Sampling Projects

Type of Change[a]	Action	Documentation
Minor Field Change. Changes that have no adverse effect on the technical adequacy of the sampling activity 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.
Minor Change. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU Project Manager will inform DOE-RL and the Regulatory Lead of the change. DOE-RL and EPA determines there is no need to revise the document.	Documentation of this change approval would be in the Project Manager's Meeting minutes or comparable Tri-Party Agreement Change Notice.[b]
Revision Necessary. Lead regulatory agency determines changes to approved plans require revision to document.	If it is anticipated that a revision is necessary, the OU Project Manager will inform DOE-RL and EPA determines the change requires a revision to the document.	Formal revision of the sampling document.

References: DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents*.
Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*.
Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*.
a. Consistent with DOE/RL-96-68 and Sections 9.3 and 12.4 of Ecology et al., 1989b.
b. The Tri-Party Agreement Action Plan, Section 9.3, defines the minimum elements of a change notice.

DOE-RL	=	U.S. Department of Energy, Richland Operations Office
EPA	=	U.S. Environmental Protection Agency
OU	=	operable unit
Tri-Party Agreement	=	*Hanford Federal Facility Agreement and Consent Order*

Regarding minor field changes, the OU technical lead in coordination with the soil and groundwater subject matter expert will approve deviations from the SAP that do not have an adverse effect on the technical integrity or adequacy of the sampling activity. Below are examples of minor field changes:

1. During groundwater sampling, most groundwater samples will be pumped, although use of another method may be authorized by the OU technical lead.

2. The sample depths provided in this SAP are estimated based on known characterization data and geology from nearby wells. For this reason, adjustments to the sample depths are anticipated. The sample depths may be altered during drilling in consultation with the OU technical lead.

3. During split-spoon sampling, if insufficient material is recovered or the split spoon is overdriven, then (when feasible) a second split spoon will be collected prior to advancing the borehole. If there is not enough sample volume recovered during split-spoon sampling, laboratory-approved minimum sample volumes will be used to run all required sample analyses. If it is not possible to collect sufficient sample volume and perform all the analyses, then DOE-RL will be consulted to concur on the path forward.

4. Groundwater samples may not be collected before a minimum of three well casing volumes have been purged and water chemistry (e.g., temperature, pH, and conductivity) has stabilized within 10% variance over three consecutive measurements unless approved by the OU technical lead. Note that one borehole volume is acceptable if water chemistry (e.g., temperature, pH, and conductivity) has

stabilized within 10% variance over three consecutive measurements for the depth-discrete groundwater samples collected during drilling.

Regarding minor changes, the OU technical lead in coordination with the soil and groundwater subject matter expert will consult with DOE-RL and the Regulatory Lead when deviations from the SAP do not affect the overall intent of the plan. Below are examples of minor changes:

1. Changing the type of sample being collected. For example, collecting continuous grab samples instead of continuous cores.
2. Selecting a different well construction material and/or well design.
3. Changing to a different drilling method.

The project scientist in coordination with the soil and groundwater subject matter expert (SMEs) will inform RL and EPA of deviations from the SAP that do affect the overall intent and schedule that may require revision to the approved plan.

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

The FWS and SMR 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 field sampling documents for the samplers and analytical laboratories. The FWS will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook).

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

- Forms required by the substantive standards of WAC 173-160 and the master drilling contract
- Field drilling and geology data forms
- Borehole summary reports
- Geophysical log data reports
- Civil survey data reports
- Inspection or assessment reports and corrective action reports
- Photographs

The following records are managed and maintained by SMR:

- Completed field sampling logbooks
- Field screening and analytical data
- Completed chain-of-custody forms
- Sample receipt records

- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by the offsite analytical laboratories

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

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Sample chain-of-custody and sample storage temperature logs
- Instrument calibration information
- Training records for employees (in regard to analytical methods)
- Laboratory state accreditation records
- Laboratory audit records

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hardcopy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with requirements listed therein.

2.2 Data Generation and Acquisition

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

2.2.1 Sampling Methods Requirements

The procedures to be implemented in the field will be in accordance with those presented in Section 3.4 of this SAP. In the event that sampling activities cannot be performed in accordance with this SAP, deviations will be communicated by the FWS to SMR and the OU project manager, documented in the field logbook, and may result in field changes to the work instructions and/or the SAP.

2.2.2 Analytical Methods Requirements

Table 10 presents the selected analytical methods to meet the practical quantitation limits (PQLs) and the analytical performance requirements for groundwater samples. Table 11 presents the selected analytical methods to meet PQLs and analytical performance requirements for sediment samples. The PQLs will meet the DQO requirements. Table 12 presents the selected methods for analyzing physical properties of sediments, as specified in Table 6. Some of the analyses identified in Tables 11 and 12 are conducted at PNNL. The analytical performance requirements for methods listed in Table 12 are identified and defined in the method procedures or in the laboratory's internal QA requirements and are not specified in this SAP.

Updated EPA methods and nationally recognized standard methods may be substituted for the analytical methods identified in Tables 10, 11, and 12 in order to follow any changed requirements in method updates. The new method must achieve project DQOs as well as or better than the replaced method.

Table 10. Constituent Methods and Analytical Performance Requirements for Groundwater Samples

Survey/Analytical Method[a]	Required PQL[b]
SW-846, Method 8260, Carbon tetrachloride	3 µg/L
SW-846, Method 8260, Trichloroethene	2.1 µg/L
SW-846, Method 8260, Chloroform	5 µg/L
SW-846, Method 8260, Chloromethane	10 µg/L
SW-846, Method 8260, Dichloromethane	5.25 µg/L
SW-846, Method 8260, cis-1,2-Dichloroethene	5 µg/L
SW-846, Method 8260, Vinyl chloride	2.1 µg/L
SW-846 Method 6020, Chromium (total)	10.5 µg/L
SW-846, Method 7196, Chromium (hexavalent)	10.5 µg/L
SW-846, Method 6010, Iron	105 µg/L
SW-846, Method 6020, Manganese	5.25 µg/L
SW-846, Method 9056 or 300.0, Nitrate-N	250 µg/L
SW-846, Method 9056 or 300.0, Nitrite-N	250 µg/L
SW-846, Method 9045, pH	N/A
SW-846, Method 9056 or 300.0, Chloride	400 µg/L
SW-846, Method 9056 or 300.0A, Sulfate	1,050 µg/L
EPA 4500-S, 376.1, Sulfide	2.1 mg/L
SW-846, Method 9012/9014, 335.4, or SM 4500, Cyanide (total)	10.5 µg/L
SW-846, Method 2320 or 310.1, Alkalinity	5.25 mg/L
SW-846, Method 2540 or 160.1, Total dissolved solids	21 mg/L
SW-846, Method 9060 or 415.1, Total carbon	1.05 mg/L
SW-846, Method 9060 or 415.1, Total inorganic carbon	1.05 mg/L
SW-846, Method 9060 or 415.1, Total organic carbon	1.05 mg/L
SW-846, Method 6020, Uranium (total)	1.05 µg/L
Low-energy photon spectroscopy, Iodine-129	1 pCi/L
Liquid scintillation, Tritium	700 pCi/L

Table 10. Constituent Methods and Analytical Performance Requirements for Groundwater Samples

Survey/Analytical Method[a]	Required PQL[b]
Liquid scintillation, Technetium-99	50 pCi/L

a. Equivalent methods may be substituted in future sampling and analysis instructions or other documents. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

b. PQLs are specified in contracts with analytical laboratories. Actual PQLs vary by laboratory and may be lower. Method detection limits for chemical analyses are three to five times lower than quantitation limits.

EPA = U.S. Environmental Protection Agency

N/A = not applicable

PQL = practical quantitation limit

Table 11. Constituent Methods and Analytical Performance Requirements for Sediment Samples

Analytical Method[a]	Required PQL[b]
SW-846, Method 8260, Carbon tetrachloride[c]	5 µg/kg
SW-846, Method 8260, Trichloroethene[c]	5 µg/kg
SW-846, Method 8260, Chloroform[c]	5 µg/kg
SW-846, Method 8260, Chloromethane[c]	10 µg/kg
SW-846, Method 8260, Dichloromethane[c]	5 µg/kg
SW-846, Method 8260, cis-1,2-Dichloroethene[c]	5 µg/kg
SW-846, Method 8260, Vinyl chloride[c]	10 µg/kg
SW-846 Method 6020, Chromium (total)	1,000 µg/kg
SW-846, Method 7196, Chromium (hexavalent)	500 µg/kg
SW-846, Method 6010, Iron	25,000 µg/kg
SW-846, Method 6020, Manganese	1,000 µg/kg
SW-846, Method 9045, pH	N/A
SW-846, Method 9012/9014, 335.4, or SM 4500, Cyanide (total)	1,000 µg/kg
SW-846, Method 9060 or 415.1, Total carbon[c]	100,000 µg/kg
SW-846, Method 9060 or 415.1, Total inorganic carbon[c]	100,000 µg/kg
SW-846, Method 9060 or 415.1, Total organic carbon[c]	100,000 µg/kg
SW-846, Method 6020, Uranium (total)	150 µg/kg
Liquid scintillation, Technetium-99	5 pCi/g

a. Equivalent methods may be substituted in future sampling and analysis instructions or other documents. For EPA Method 300.0, see EPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

b. PQLs are specified in contracts with analytical laboratories. Actual PQLs vary by laboratory and may be lower. Method detection limits for chemical analyses are three to five times lower than quantitation limits.

c. Analysis to be performed by Pacific Northwest National Laboratory using full, intact liners C or D. If there is a question about the intact nature of the liners, the project scientist should be contacted for direction.

Table 11. Constituent Methods and Analytical Performance Requirements for Sediment Samples

Analytical Method[a]	Required PQL[b]

EPA = U.S. Environmental Protection Agency
N/A = not applicable
PQL = practical quantitation limit

Table 12. Physical Properties Methods for Sediment Samples

Physical Property	Analytical Method
Bulk density	ASTM D2937 or ASTM D7263[a]
Particle density	ASTM D854[a]
Particle-size distribution	ASTM D422 or ASTM D4464/D6913[a]
Porosity (apparent)	Calculated from bulk density and particle density
Saturated hydraulic properties (hydraulic conductivity/permeability)[b]	ASTM D5084 or ASTM D5856[a]

Note: Equivalent methods may be substituted in future sampling and analysis instructions or other documents.

a. For ASTM methods, see the following:

- ASTM D422: ASTM Standard D422-63(2007)e2, *Standard Test Method for Particle-Size Analysis of Soils*
- ASTM D854: ASTM Standard D854-14, *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer*
- ASTM D2937: ASTM Standard D2937-17e2, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*
- ASTM D4464: ASTM Standard D4464-15, *Standard Test Method for Particle Size Distribution of Catalytic Materials by Laser Light Scattering*
- ASTM D5084: ASTM Standard D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*
- ASTM D5856: ASTM Standard D5856-15, *Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter*
- ASTM D6913: ASTM Standard D6913/D6913M-17, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*
- ASTM D7263: ASTM Standard D7263-09(2018)e2, *Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens*

b. A full, intact liner is required for this analysis. If there is a question regarding the intact nature of the liner for this analysis, the project scientist should be contacted for direction.

ASTM = ASTM International (formerly the American Society for Testing and Materials)

Table 13. QC Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Equipment blank	Contamination from nondedicated sampling equipment	1 in 20 samples when nondedicated equipment is used to collect samples[a, b]
Full trip blank	Contamination from containers, preservative reagents, storage, or transportation	1 in 20 samples[c]
Field transfer blank	Contamination from sampling site	One each day VOCs are sampled; additional field transfer blanks are collected

Table 13. QC Samples

Sample Type	Primary Characteristics Evaluated	Frequency
		if VOC samples are acquired on the same day for multiple laboratories (wells or other media samples)
Field duplicate samples	Reproducibility/sampling precision	1 in 20 samples[c]
Field split samples	Interlaboratory comparability	As needed, determined by Sample Management and Reporting
Laboratory Batch QC[d]		
Carrier	Recovery/yield	Added to each sample and QC sample[e]
Method blanks	Laboratory contamination	One per analytical batch[e]
Laboratory sample duplicate	Laboratory reproducibility and precision	One per analytical batch[e]
Matrix spikes	Matrix effect/laboratory accuracy	One per analytical batch[e]
Matrix spike duplicate	Laboratory reproducibility, and method accuracy and precision	One per analytical batch[e]
Surrogates	Recovery/yield for organic compounds	Added to each sample and QC
Tracers	Recovery/yield	Added to each sample and QC
Laboratory control	Method accuracy	One per analytical batch[e]

Grundfos® is a registered trademark of Grundfos Corporation, Bjerringbro, Denmark.

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

b. Vendor-provided borehole equipment is considered dedicated equipment, and equipment blanks are not typically acquired in this instance.

c. For groundwater, a sample is collected any time a well is accessed for sampling; this is also known as a well trip. Field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month (not just those restricted to a single treatment, storage, and disposal unit).

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

e. Unless not required by, or a different frequency is called out, in laboratory analysis method.

DOE = U.S. Department of Energy
QC = quality control
VOC = volatile organic compound

The laboratory contaminant mobility and transport studies performed by PNNL will be conducted using PNNL-developed methods and procedures that are not specified in this SAP.

2.2.3 Field Screening Methods

Field screening parameters used for site characterization will be measured in accordance with HASQARD requirements (DOE/RL-96-68), as applicable. Field screening methods may also be performed in accordance with manufacturers' manuals. Table 5 provides the parameters identified for field screening.

2.2.4 Quality Control

The QC requirements specified in this 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 to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Table 13 summarizes the field and laboratory QC sample requirements, and Table 14 lists the general field and laboratory QC elements and acceptance criteria.

Table 14. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria		Corrective Action
		Water	Soil	
General Physical and Chemical Parameters				
Alkalinity	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Total dissolved solids	MB	< MDL <5% sample concentration	N/A	Flag with "C"
	LCS	80%–120% recovery	N/A	Flag with "o"[a]
	DUP[b]	≤20% RPD	N/A	Review data[d]
	EB, FTB	< MDL <5% sample concentration	N/A	Flag with "Q"
	Field duplicate[b]	≤20% RPD	N/A	Review data[d]
Total organic carbon/total inorganic carbon	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Ammonia and Anions				
Anions by IC	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"

Table 14. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria		Corrective Action
		Water	Soil	
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Cyanide (total)/ cyanide (free)	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Sulfide	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Metals				
ICP/AES metals	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
ICP/MS metals	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]

Table 14. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria		Corrective Action
		Water	Soil	
Hexavalent chromium	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Uranium (total) by ICP/MS	MB	< MDL <5% sample concentration		Flag with "C"
	LCS	80%–120% recovery		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	≤35% RPD	Review data[d]
	MS/MSD[c]	75%–125% recovery		Flag with "N"
	EB, FTB	< MDL <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Volatile Organic Compounds				
Volatile organics by GC/MS	MB	< MDL[f] <5% sample concentration		Flag with "B"
	LCS	70%–130% recovery or % recovery statistically derived[g]		Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤ 20% RPD		Review data[d]
	MS/MSD[c]	70%–130% recovery		Flag with "T"
	SUR	70%–130% recovery	% recovery statistically derived[g]	Review data[d]
	EB, FTB, FXR	< MDL [f] <5% sample concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Radiological Parameters				
AEA (uranium, isotopic)	MB	< MDC <5% sample activity concentration		Flag with "B"
	LCS	80%–120% recovery or statistically derived limits[g]		Flag with "o"[a]
	DUP[b]	≤20% RPD	≤30% RPD	Review data[d]
	Tracer	30%–105% recovery		Review data[d]

Table 14. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria		Corrective Action
		Water	Soil	
	EB, FTB	< MDC <5% sample activity concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Iodine-129	MB	< MDC <5% sample activity concentration		Flag with "B"
	LCS	80%–120% recovery or statistically derived limits[g]		Flag with "o"[a]
	DUP[b]	≤20% RPD	≤30% RPD	Review data[d]
	Carrier	40%–110% recovery		Review data[d]
	EB, FTB	< MDC <5% sample activity concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Technetium-99	MB	< MDC <5% sample activity concentration		Flag with "B"
	LCS	80%-120% recovery or statistically derived limits[g]		Flag with "o"[a]
	DUP[b]	≤20% RPD	≤30% RPD	Review data[d]
	MS	75%–125% recovery		Flag with "N"
	EB, FTB	< MDC <5% sample activity concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]
Tritium	MB	< MDC <5% sample activity concentration		Flag with "B"
	LCS	80%–120% recovery or statistically derived limits[g]		Flag with "o"[a]
	DUP[b]	≤20% RPD	≤30% RPD	Review data[d]
	MS	75%–125% recovery		Flag with "N"
	EB, FTB	< MDC <5% sample activity concentration		Flag with "Q"
	Field duplicate[b]	≤20% RPD	Footnote e	Review data[d]

Note: Specific analytes and methods for determination are available from SMR.

a. The reporting laboratory will apply the "o" flag with SMR concurrence.

b. Applies when at least one result is greater than the laboratory practical quantitation limit (chemical analyses) or greater than five times the MDC (radiochemical analyses).

c. Either a sample duplicate or an MSD is to be analyzed to determine measurement precision (if insufficient sample volume, an LCS duplicate is analyzed with the acceptance criteria defaulting to the DUP/MSD criteria).

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.

e. A field duplicate RPD for soils is not recommended because of possible soil matrix heterogeneity effects.

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

Table 14. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria		Corrective Action
		Water	Soil	

g. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

AEA = alpha energy analysis
DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
GC/MS = gas chromatography/mass spectrometry
IC = ion chromatography
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDC = minimum detectable concentration
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QC = quality control
RPD = relative percent difference
SMR = Sample Management and Reporting
SUR = surrogate

Data flags:

B, C = Possible laboratory contamination; analyte was detected in the associated MB (laboratory applied). The "B" flag is used for organic analytes and radioanalytes. The "C" flag is used for general chemical parameters and inorganic analytes.
o = Result may be biased; associated LCS result was outside the acceptance limits (laboratory applied).
N = Result may be biased; associated MS result was outside the acceptance limits (all methods except GC/MS) (laboratory applied).
Q = Problem with associated field QC samples; results were out of limits (SMR review).
T = Result may be biased; associated MS result was outside the acceptance limits (GC/MS only) (laboratory applied).

For groundwater analytical methods, Table 10 summarizes the specific field and laboratory precision and accuracy requirements for each groundwater analysis to be performed. Table 11 summarizes the specific precision and accuracy requirements for each sediment analysis to be performed. Data will be qualified and flagged in the HEIS database, as appropriate.

The QC requirements for the laboratory contaminant mobility and transport studies performed by PNNL will be based on PNNL procedures and laboratory requirements that are not specified in this SAP.

2.2.4.1 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. The QC sample definitions and their required collection frequencies are described below:

- **Field duplicates:** Independent samples collected as close as possible to the same time and location as the scheduled sample that are intended to be identical. Field duplicates are placed in separate sample containers and are analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.
- **Field splits (SPLITs):** Two samples are collected as close as possible to the same time and location that are intended to be identical. The SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. The SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

- **Equipment blanks (EBs):** High-purity water is passed through or poured over the decontaminated sampling equipment and collected in sample containers, as identified on the sample authorization form. The EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. The EB samples are analyzed for the same constituents as the samples from the associated sampling event and are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

- **Field transfer blanks (FXRs):** Preserved volatile organic analysis (VOA) sample vials are filled with high-purity reagent water at the sample collection site where VOC samples are collected. FXRs 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.

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

2.2.4.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by the laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), surrogates (SURs), tracers, and carriers. These QC analyses are required by EPA methods (e.g., methods identified in SW-846) 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 assessments of data quality. Table 13 lists the laboratory QC checks and their typical frequencies, and Table 14 lists the acceptance criteria. Descriptions of the various types of laboratory QC samples are as follows:

- **Carrier:** A known quantity of nonradioactive isotope that is expected to behave similarly and is added to a sample aliquot. Sample results are generally corrected based on carrier recovery.

- **Laboratory control sample (LCS):** A control matrix (e.g., reagent water) spiked with analytes representing the target analytes or certified reference material used to evaluate laboratory accuracy.

- **Laboratory sample duplicate (DUP):** An intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

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

- **Matrix spike duplicate (MSD):** A replicate spiked sample aliquot 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.

- **Method blank (MB):** An analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through sample preparation and the analytical process and is used to quantify contamination resulting from the analytical process.
- **Surrogate (SUR):** A compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined but they are not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to every standard, sample, and QC sample, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.
- **Tracer:** A known quantity of a radioactive isotope that differs from the isotope of interest but is expected to behave similarly and is added to a sample aliquot. Sample results are generally corrected based on tracer recovery.

Laboratories are required to analyze samples within the holding times specified in Tables 15 and 16. In some instances, constituents in the samples not analyzed within the specified holding times may be compromised by volatilization, decomposition, or by other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an "H."

Table 15. Groundwater Preservations and Holding Times

Constituents	Preservations[a]	Holding Times[b]
General Chemical Parameters		
Alkalinity	Store ≤6°C	14 days
pH	None	Analyze immediately
Specific conductance	Store ≤6°C	28 days
Total inorganic carbon	Store ≤6°C, adjust pH to <2 with H_2SO_4 or HCl	28 days
Total organic carbon	Store ≤6°C, adjust pH to <2 with H_2SO_4	28 days
Total dissolved solids	Store ≤6°C	7 days
Total suspended solids	Store ≤6°C	7 days
Ammonia, Anions, and Cyanide		
Ammonia	Store ≤6°C, adjust pH to <2 with H_2SO_4	28 days
Cyanide (total and free)	Store ≤6°C, adjust pH to >12 with NaOH	14 days
Chloride, sulfate	Store ≤6°C	28 days
Nitrate, nitrite	Store ≤6°C	48 hours
Sulfide	Store ≤6°C, ZnAc + NaOH to pH >9	7 days
Metals		
Hexavalent chromium	Store ≤6°C	24 hours
Metals (except mercury and hexavalent chromium), including uranium	Adjust pH to <2 with HNO_3	6 months

Table 15. Groundwater Preservations and Holding Times

Constituents	Preservations[a]	Holding Times[b]
Dissolved metals (except mercury and hexavalent chromium), including uranium	Filter prior to adjust pH to <2 with HNO_3	6 months
Volatile Organic Compounds		
Volatile organics (by GC/MS)	Store ≤6°C, adjust pH to <2 with HCl or H_2SO_4	7 days unpreserved 14 days preserved
Radiological Parameters		
Uranium, isotopic, by alpha energy analysis	Adjust pH to <2 with HNO_3	6 months
Iodine-129	None	6 months
Technetium-99, by liquid scintillation	Adjust pH to <2 with HNO_3	6 months
Tritium	None	6 months

a. For preservation identified as store at <6°C, the sample should be protected against freezing unless it is known that freezing will not affect the sample integrity.

b. References for holding times are provided in CHPRC-00189, *Environmental Quality Assurance Program Plan*.

GC/MS = gas chromatography/mass spectrometry

Table 16. Soil and Sediment Preservations and Holding Times

Constituents	Preservations[a]	Holding Times[b]
General Chemical Parameters		
pH	None	Analyze immediately
Total organic carbon	Store ≤6°C	28 days
Total inorganic carbon	Store ≤6°C	28 days
Anions		
Cyanide (total and free)	Store ≤6°C	14 days before extraction 14 days after extraction
Metals		
Hexavalent chromium	Store ≤6°C	30 days before extraction 24 hours after extraction
Metals (except mercury and hexavalent chromium), including uranium	None	6 months
Volatile Organic Compounds		
Volatile organics (by GC/MS)	Store ≤6°C	14 days
Radiological Parameters		
Uranium, isotopic, by alpha energy analysis	None	6 months
Technetium-99, by liquid scintillation	None	6 months

Table 16. Soil and Sediment Preservations and Holding Times

Constituents	Preservations[a]	Holding Times[b]
Physical Properties		
Bulk density	None	None
Particle density	None	None
Particle-size distribution	None	None
Porosity	None	None
Saturated hydraulic properties	None	None

a. For preservation identified as store at <6°C, the sample should be protected against freezing unless it is known that freezing will not affect the sample integrity.

b. References for holding times are provided in CHPRC-00189, *Environmental Quality Assurance Program Plan*.

GC/MS = gas chromatography/mass spectrometry

2.2.5 Measurement Equipment

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

2.2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International [formerly the American Society for Testing and Materials]) or 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 the laboratory will be subject to preventive maintenance measures to minimize 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.

2.2.6.1 Instrument/Equipment Calibration and Frequency

Section 3.5 discusses field equipment calibration. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

2.2.6.2 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use. Supplies and consumables used to support 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.

2.2.7 Data Management

SMR, in coordination with the 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 the HEIS database. Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

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

2.3 Assessment/Oversight

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

Routine evaluation of data quality described for this project will be documented and filed with the data in the project file. The OU project manager and/or the drilling and sampling FWS will monitor field activities for this SAP. The OU project manager retains overall responsibility for sampling but may delegate specific responsibilities to the drilling and sampling FWS or other appropriate DOE prime contractor staff. SMR will select a laboratory to perform the soil and groundwater analyses for this SAP. SMR will also assess and verify that analytical data are reported by the laboratory and will then enter the verified data into the HEIS database.

2.3.1 Assessments and Response Action

Management assessments and/or independent assessments may be performed at the direction of the OU project manager or QA organization to verify compliance with the requirements outlined in this SAP, project field instructions, the QAPjP methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project management chain coordinates the corrective actions/deficiency 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). A data usability assessment will be performed for the identified SAP activities, and the data usability assessment results will be provided to the OU project manager. No other planned assessments have been identified. If circumstances arise in the field dictating the need for additional assessments, then additional assessments will be performed.

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

2.3.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by management assessments, corrective actions from the environmental compliance officer, and findings from independent assessments and surveillances. Issues reported by the laboratories are communicated to SMR, which then initiates a sample issue resolution form. The process is used to document analytical or sample issues and to establish resolution with the OU project manager. If an assessment finding results in sampling issues that affect a regulatory requirement, DOE will be informed, and the matter will be discussed with the regulatory agencies.

2.4 Data Review and Usability

This section addresses 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.

2.4.1 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 and reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times (if any) have been met. Furthermore, review of QC data is used 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 (i.e., samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results will be reviewed to ensure that they are usable.

The OU project scientist performs data reviews to help determine if observed changes reflect potential data errors, which may result in submitting a request for data review for questionable data. The laboratory may be asked to check calculations or reanalyze the sample. In extreme cases, another sample may be collected. Results of the request for the data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

2.4.2 Data Validation

Data validation is an independent assessment to ensure reliability of the data. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation may also include the following:

- Verification of instrument calibrations
- Evaluation of analytical results based on MBs
- Recovery of various internal standards
- Correctness of uncertainty calculations
- Correctness of identification and quantification of analytes
- Effect of quality deficiencies on data reliability

The contractor follows the data validation process described in EPA-540-R-2017-001, *National Functional Guidelines for Inorganic Superfund Methods Data Review*; and EPA-540-R-2017-002, *National Functional Guidelines for Organic Superfund Methods Data Review*, adjusted for use with SW-846, HASQARD requirements (DOE/RL-96-68), and radiochemistry methods. The criteria for data validation are based on a graded approach using five levels of validation (Levels A through E). Level A

is the lowest level and is the same as verification. Level E is a 100% review of all data (e.g., calibration data and calculations of representative samples from the data set). Data validation may be performed to Level C, which is a review of the QC data. Level C validation consists of a review of the QC data and specifically requires verification of deliverables; requested versus MB blank results, MS/MSD results, surrogate recoveries, and duplicate sample results. Level C data validation is generally equivalent to Level 2A (EPA 540-R-08-005, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*). Level C data validation will be performed on at least 5% of the data by matrix and analyte group under the direction of SMR. "Analyte group" refers to categories such as radionuclides, volatile chemicals, semivolatiles, metals, and anions. The goal is to include each of the various analyte groups and matrices during the data validation process. The DOE-RL project lead or OU project manager may specify a higher percentage of data to be validated or that data validation be performed at higher levels.

2.4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet project data needs. The DQA process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data are of the right type, quality, and quantity to support their intended use. The DQA process uses the entirety of the collected data to determine usability for decision-making purposes. If a statistical sampling design was used during field sampling activities, then the DQA will be performed in accordance with EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners* (EPA QA/G-9S). When judgmental (focused) sampling designs are implemented in the field, DQIs such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets (individual data packages) will be evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G-8). Data verification and data validation are integral to the statistical DQA evaluation process and the DQI evaluation process. Results of the DQA or DQI processes generated by SMR will be used by the OU project manager to interpret the data and determine if the DQOs for this activity have been met.

3 Field Sampling Plan

This SAP includes the 12 Rwia monitoring wells planned to be installed during FY 2020, FY 2021, and FY 2022. The field sampling plan defines the sampling and analysis requirements for samples and the field measurements to be collected from each well. Groundwater samples will be analyzed for the eight COCs identified in the 200-ZP-1 OU ROD (EPA et al., 2008), as well as uranium and various other constituents (including additional VOCs), as specified in Table 5. Sediment samples will be analyzed for some of the 200-ZP-1 OU COCs, as well as uranium, various other constituents (including additional VOCs), and physical properties, as specified in Table 6.

Additionally, selected sediment samples will undergo laboratory contaminant mobility and transport studies at PNNL to better understand sediment/water partitioning and to develop distribution coefficients for carbon tetrachloride in the Rwia and Rlm. Split-spoon sample liners C and D collected for each sample interval will be provided to PNNL. The full, intact liner C will be designated for VOC, total carbon, TOC, TIC analyses, and potential special studies. Liner D will be held in reserve at PNNL for use if reanalysis or additional sample material is needed. These supplemental studies will only be conducted on sediment samples that correspond to groundwater samples with higher carbon tetrachloride concentrations (based on quick-turnaround analytical results).

The sampling data results from all sources except PNNL will be entered into the HEIS database. PNNL will report results in laboratory reports, and the associated data will not be entered into the HEIS database. All sampling data results will be used to support performance evaluation of the selected remedy by improving the understanding of the Rwia. The data will also support P&T optimization efforts focused on the Rwia.

Additional details regarding field-specific sample collection requirements are provided in the following sections.

3.1 Sampling Objectives

The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the DQO process and identifies sampling locations, the total number of samples to be collected, the sampling procedures to be implemented and analyses to be performed, and sample bottle requirements.

The proposed monitoring wells to be installed will support the 200-ZP-1 OU selected remedy. The drilling schedule will be defined by the drilling manager.

3.2 Sampling Locations and Frequencies

This section identifies the locations of the proposed monitoring wells to be installed and defines the sampling and analysis requirements for the samples and measurements to be collected from each well.

Figure 2 shows the approximate locations of the monitoring wells proposed in this SAP (listed in Table 1). The actual locations will be determined based on field reconnaissance of current site conditions to comply with the *National Historic Preservation Act of 1966* and avoid restrictions, roads, waste sites, and other obstructions. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data. Geophysical logging will be conducted based on direction from the drilling manager. Table 17 lists the locations and depths to be sampled at each well during drilling, and Table 13 lists the field QC requirements. After well acceptance, the wells may be hydraulically tested as part of an aquifer testing plan, which is subsequent to and outside the direct scope of this SAP.

The well locations proposed in this SAP were selected based on the following information regarding contaminant distribution and migration, as well as the currently modeled geologic framework for the 200-ZP-1 OU:

- Maps depicting the contamination extent of the primary COC (carbon tetrachloride), as presented in DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for Pump-and-Treat Operations in the Hanford Central Plateau Operable Units*
- Locations, thicknesses, and extents of the primary water-bearing geologic units in the 200-ZP-1 OU (Rwia, Rwie, and Rlm), as modeled in HSGF Model and described in ECF-HANFORD-13-0029
- The data gap analysis process documented in SGW-61350 and summarized further in Appendix A of this SAP

Table 17. Summary of Rwia Characterization Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling: Split-Spoon Soil Samples,[a,b, c] Groundwater Samples,[a, d] and Slug Tests[a, e] (ft bgs)	Saturated Zone Sampling During Drilling: Targeted Geologic Formation	Geologic Archive Grab Sampling[a]	Sieve Analysis Grab Sampling[a]	Post-Development Groundwater Sampling[a, f]
MW-A	299-W13-4	D0080	332, 358, 390, 420	Rwie	Every 5 ft or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint jar and a chip tray from drill cuttings.	Every 5 ft, from water table to top of basalt. Collect sieve analysis grab samples from drill cuttings for field screening sieve analysis.	Following well construction and final well development. Collect groundwater sample from the screened interval.
			454, 470, 485, 498, 510, 524	Rwia			
MW-B	299-W19-133	D0081	303, 360, 420	Rwie			
			447, 460	Rlm			
			470, 485, 500, 515, 530, 541, 552	Rwia			
MW-C	699-46-70	D0082	297, 310, 330	Rwie			
			345, 355	Rlm			
			365, 382, 400, 420	Rwia			
MW-D	699-45-67C	D0083	321	Rwie			
			330, 350	Rlm			
			366, 377, 387, 399, 410, 430, 442, 453	Rwia			
MW-E	299-W14-26	D0084	296, 345, 395	Rwie			
			435, 455	Rlm			
			470, 483, 495, 515, 527, 539	Rwia			

Table 17. Summary of Rwia Characterization Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling: Split-Spoon Soil Samples,[a,b, c] Groundwater Samples,[a, d] and Slug Tests[a, e] (ft bgs)	Saturated Zone Sampling During Drilling: Targeted Geologic Formation	Geologic Archive Grab Sampling[a]	Sieve Analysis Grab Sampling[a]	Post-Development Groundwater Sampling[a, f]
MW-F	699-40-70	D0085	325, 360, 400	Rwie			
			422	Rlm			
			432, 446, 460, 475, 490, 505, 520, 534, 548	Rwia			
MW-G	699-42-62	D0086	345, 355	Rwie			
			360, 365, 380, 400, 420, 435, 450	Rwia			
MW-H	699-41-65	D0087	354, 362	Rwie			
			372, 392, 410	Rlm			
			420, 436, 450, 465, 480, 493, 506	Rwia			
MW-I[g]	TBD	TBD	TBD	TBD			
MW-J[g]	TBD	TBD	TBD	TBD			
MW-K[g]	TBD	TBD	TBD	TBD			
MW-L[g]	TBD	TBD	TBD	TBD			

a. Samples will be collected in accordance with Section 3.4.5. The sample intervals listed are anticipated depths based on the estimated depths to groundwater and geologic contacts listed in Table 1 for each well. The actual depths to groundwater and to geologic contacts may be different during drilling. During drilling, the field geologist, in consultation with the geology subject matter expert, will identify the depth at which groundwater and the transition between target formations occurs and, in consultation with the project scientist, may adjust the sample depth in response to these conditions, provided the target formation is sampled and the intent of the sample interval is achieved. The following must be considered when adjusting sample intervals:

- The first (shallowest) sample within the Rwie is intended to be collected approximately 3 m (10 ft) into the saturated zone. Only one sample is planned in the Rwie at MW-D, so this sample is intended to be collected approximately 3 m (10 ft) into the saturated zone and above the anticipated contact with the Rlm.
- The last (deepest) sample within the Rwie is intended to be collected within the Rwie at a depth approaching, but above, the transition to the next target geologic formation (i.e., the Rlm when present, otherwise the Rwia). Only one sample is planned in the Rwie at MW-D, so this sample is intended to be collected approximately 3 m (10 ft) into the saturated zone and above the anticipated contact with the Rlm.
- The first (shallowest) Rlm sample is intended to be collected within the first few feet of the Rlm.
- The last (deepest) Rlm sample is intended to be collected within the Rlm and a few feet above the Rwia.
- The first (shallowest) Rwia sample is intended to be collected within the first few feet of the Rwia.
- The last (deepest) Rwia sample is intended to be collected within the Rwia and a few feet above the anticipated contact with the basalt.

Table 17. Summary of Rwia Characterization Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling		Geologic Archive Grab Sampling[a]	Sieve Analysis Grab Sampling[a]	Post-Development Groundwater Sampling[a, f]
			Split-Spoon Soil Samples,[a,b, c] Groundwater Samples,[a, d] and Slug Tests[a, e] (ft bgs)	Targeted Geologic Formation			

Sample intervals within formations, and not above or below transition between target formations (i.e., other than first or last planned within the formation), may be adjusted by the field geologist, in consultation with the project scientist, to accommodate field conditions that resulted in the adjustment of a prior sampling interval and/or the drilling method (e.g., moved ±3 m [10 ft] to accommodate a 6.1 m [20 ft] length of drilling pipe), provided the targeted geologic formation is sampled and approximate even spacing between sample intervals is maintained.

The field geologist will notify the drilling buyer's technical representative and contact the project scientist (or designee) if unexpected conditions are encountered in the field that may warrant collection of additional samples. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data.

b. Split-spoon soil samples collected and analyzed for all of the Table 6 sediment constituents and physical properties (at standard turnaround times). If field screening instruments indicate radiological contamination above background at a given interval, two additional samples will be obtained. One sample will be sent for 24-hour turnaround gamma energy analysis and one additional sample for testing based on the gamma energy analysis results (as determined by the project manager).

c. Material from split-spoon liner A will be sent to an offsite commercial laboratory for contaminant concentration analyses, with the exception of volatile organic compounds, total carbon, total organic carbon, and total inorganic carbon. Liner B will be sent to an offsite commercial laboratory for saturated hydraulic properties testing. Liners C and D will be sent to PNNL. Liner C will be used for volatile organic carbon, total carbon, total organic carbon, and total inorganic carbon analyses, as well as potential special studies. Liner D will be held in reserve at PNNL for use in reanalysis or if additional sample material is needed.

d. Groundwater samples collected during drilling will be analyzed for all "groundwater constituents during drilling" listed in Table 5 (at standard turnaround times) and field screening parameters. Groundwater samples collected during drilling will also be analyzed for carbon tetrachloride and nitrate at quick-turnaround times. If samples have elevated organic concentrations, an "E" flag may be applied to the data due to a lack of time for dilutions and re-runs based on a quick-turnaround time. The standard turnaround time sample will account for dilutions and re-runs, as applicable. Collect filtered and unfiltered samples for all metals. Samples will not be collected during drilling for hexavalent chromium.

e. Slug tests will be performed during drilling at each identified interval in the Rwie and Rwia and at one of the identified intervals within the Rlm following the collection of split-spoon sediment samples and groundwater samples. Slug tests will be conducted in accordance with the steps outlined in Section 3.4.6.

f. Following construction and final development of each well, one groundwater sample will be collected and analyzed for all "post-development groundwater constituents" identified in Table 5 (at standard turnaround times) and field screening parameters to provide baseline concentrations for each constituent. Collect filtered and unfiltered samples for all metals except hexavalent chromium. A filtered sample will be collected for hexavalent chromium.

g. Specific locations have not been identified for monitoring wells MW-I through MW-L. Once these four additional locations have been selected, additional information will be provided in this table in accordance with the change control process discussed in Section 2.1.4.

bgs = below ground surface
ID = identification
PNNL = Pacific Northwest National Laboratory
Rlm = Ringold Formation member of Wooded Island – lower mud unit
Rwia = Ringold Formation member of Wooded Island – unit A
Rwie = Ringold Formation member of Wooded Island – unit E
TBD = to be determined

The eight proposed monitoring well locations initially identified were selected to collect data in the study area to adequately define the nature and extent of the COC plumes and the hydrogeologic properties, hydraulic properties, and transport parameters of the Rwia, the Rlm, and, to a limited extent, the Rwie. This data will support F&T modeling, allow for performance evaluation of the 200-ZP-1 OU remedy, and assist in making recommendations for optimizing or modifying the remedy.

Locations for the remaining four proposed monitoring wells will be identified through F&T modeling combined with a continuation of the data gap analysis process, as documented in SGW-61350 and summarized in Appendix A of this SAP. Newly identified monitoring well locations will be incorporated into this SAP by adhering to the document change control process described in Section 2.1.4.

3.3 Well Drilling and Completion Procedures

Well drilling will be performed in accordance with the substantive standards of WAC 173-160 for resource protection wells. The wells will be drilled approximately 3.0 m (10 ft) into basalt or to refusal. The drilling method will likely use an air circulation technique; however, the final drilling method will be determined during negotiation of the drilling contract.

The monitoring wells will be constructed as 4 in. diameter wells. The wells will be constructed with a Type 304 or 316 stainless-steel, continuous wire-wrap screen (V-slot or other, depending on application and sieve analysis results), on top of approximately a 0.9 to 3 m (3 to 10 ft) long, Schedule 10 Type 304 or 316 stainless-steel sump with end cap. A Schedule 10 Type 304 or 316 stainless-steel riser will be used to extend the permanent well into the vadose zone, with Schedule 10 Type 304 or 316 stainless-steel casing through the vadose zone to the ground surface. Screen slot size and sand pack grain size will be determined after evaluating the sample data collected every 1.5 m (5 ft) from saturated zone drill cuttings for field screening grain-size (sieve) analysis (Table 17). Colorado silica sand (or an equivalent quality material) will be used for the sand pack. Sodium bentonite pellets and/or natural sodium bentonite chunks or crumbles, or powdered bentonite, will be used for bentonite sealing material. Type I/II Portland cement will be used for cement grout. A bentonite seal will be placed between the well screen sections (for wells with multiple screen sections), as required by the design. Any portion of the borehole below the sand pack will be sealed with bentonite or cement to prevent cross-communication between aquifers. Bentonite slurry or cement will not be poured down the long annulus but will instead be placed by tremie tube.

Surface construction consisting of protective casing, protective guard posts, and cement pad must be in place prior to well acceptance. The protective casing will be a minimum 2 in. larger in diameter than the permanent casing. The protective casing will rise approximately 0.9 m (3 ft) above ground surface. The permanent casing will rise to approximately 0.3 m (1 ft) below the top of the protective casing. The protective casing will have a lockable well cap that extends approximately 38.1 cm (15 in.) above the top of the protective casing. An access port will be provided on the protective casing and configured as shown in Figure 8. If the completion differs from the WAC 173-160 minimum standards, then a comparable alternative specification will be used that will provide equal or greater human health and resource protection.

3.3.1 Monitoring Well Construction

Monitoring wells will typically have a minimum 6.1 m (20 ft) screen length as a single casing well. Figures 9 and 10 provide conceptual illustrations of well designs for monitoring wells installed in unconfined and confined aquifers, respectively. Monitoring wells will generally be constructed with 4 in. diameter casing. Actual well designs, including screen lengths and locations, will be determined by observations made and characterization data collected during drilling. Sieve analysis will be used to size the filter pack and select well screen slot size.

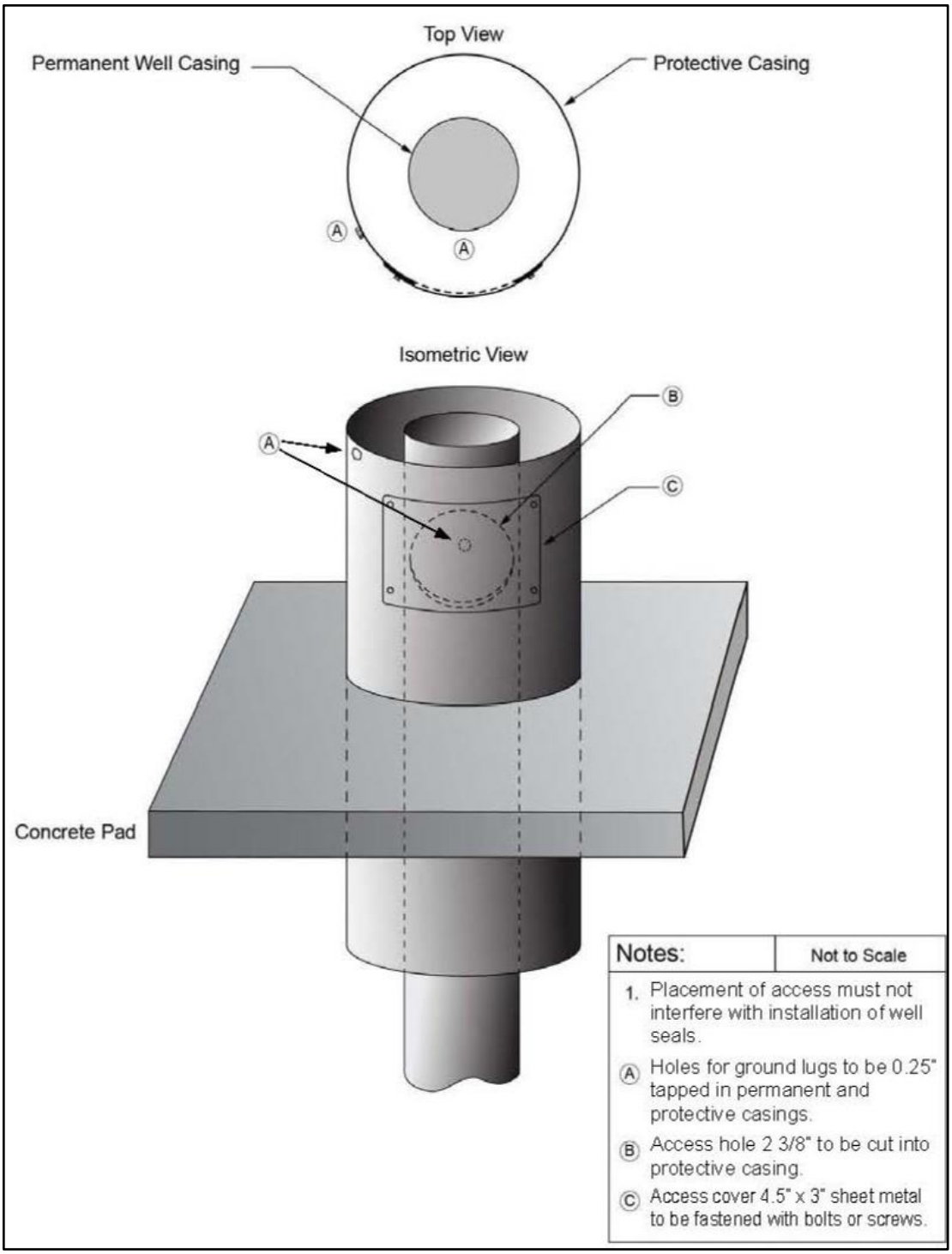

Figure 8. Diagram Showing Configuration of Access Port in Protective Casing

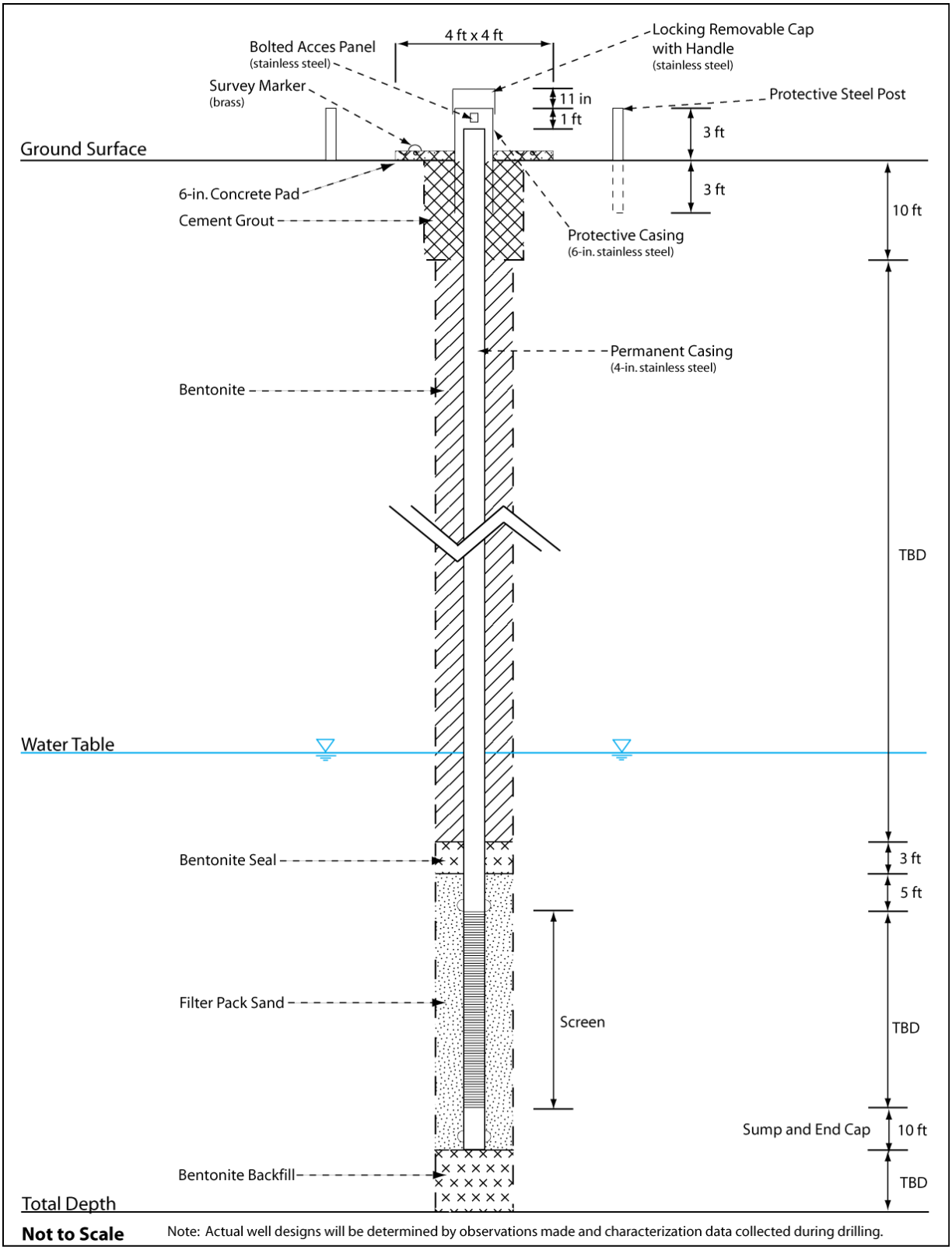

Figure 9. Conceptual Illustration of Monitoring Well Design When the Rlm is Not Present

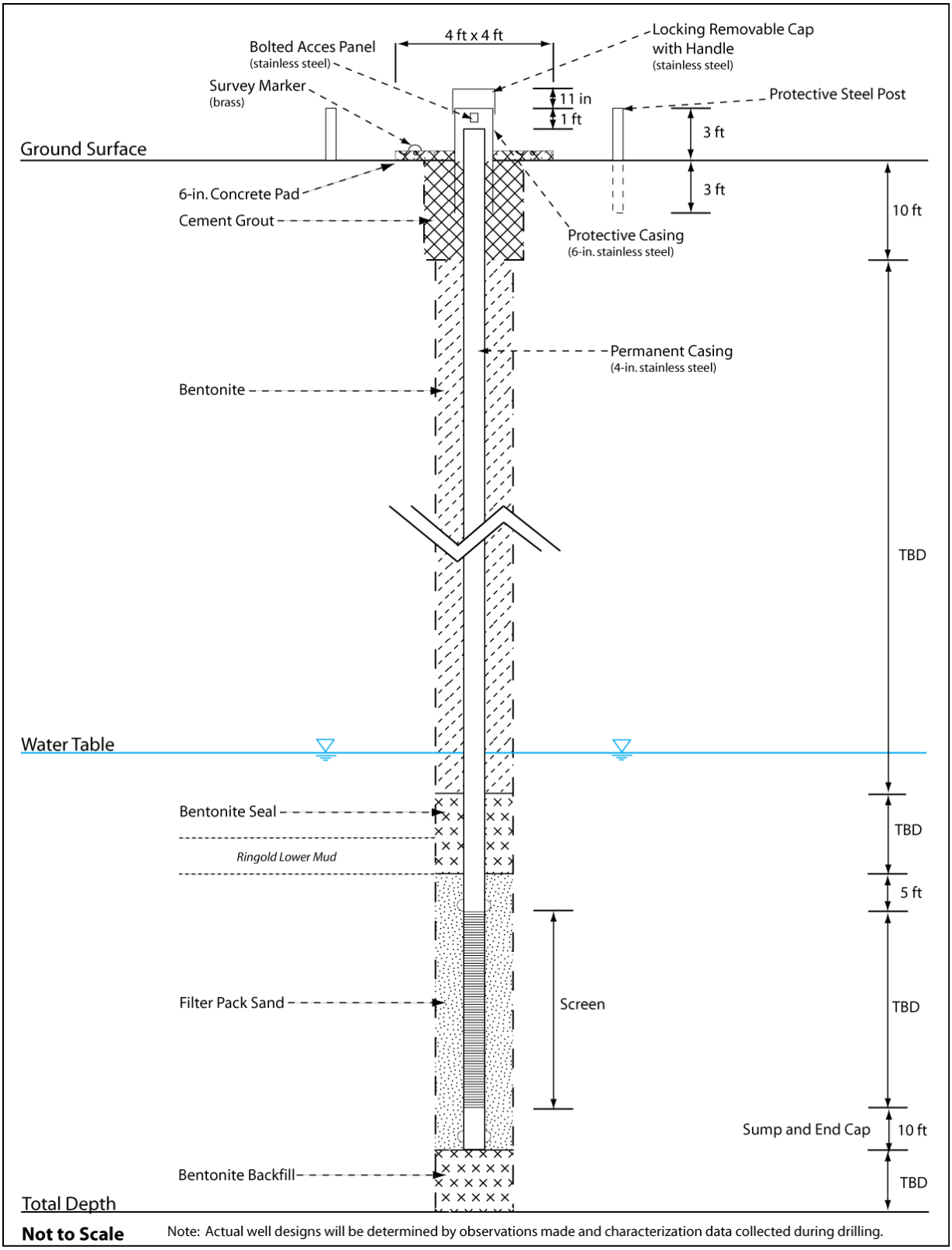

Figure 10. Conceptual Illustration of Monitoring Well Design When the Rlm is Present

3.4 Field-Specific Collection Requirements

The field-specific collection requirements for sampling are outlined in this section.

3.4.1 Sample Location and Depth

The sample number, well identification number, and depth will be documented. Each bottle/container and chain-of-custody form must be identified by sample number and sample authorization form number.

3.4.2 Sample Identification

A sample data-tracking database will be used to track the samples from collection and through the laboratory analysis process. The HEIS database is the Hanford Site repository for laboratory analytical results. The HEIS sample numbers will be issued to the project sampling organization. The radiological and physical properties of each sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS number will be documented in the sampler's field logbook/data forms. Each sample container will be labeled with the following information, using a waterproof marker on firmly affixed, water-resistant labels:

- Sample authorization form number
- HEIS number
- Sample collection date and time
- Analysis required
- Preservation method (if applicable)
- Collector's name or initials

3.4.3 Field Sample Logbook

Logbooks or data forms are required for field activities and will be used in accordance with HASQARD requirements (DOE/RL-96-68). A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make logbook entries. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented by 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, 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 or on the data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were

conducted; and reference to any forms that were used, other data records, and methods followed when conducting the activity.

- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation (if any) of SPLITs, DUPs, MSs, or MBs. Reference the methods used for sample collection or preparation; list the locations of the samples collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom sample custody was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page numbers of any logbook where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

3.4.4 Corrective Actions and Deviations for Sampling Activities

The OU project manager, FWS, appropriate field crew supervisors, and SMR personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. An example of a deviation is samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The OU project manager, FWS, field crew supervisors, or SMR will be responsible for communicating field corrective action requirements and for 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 9.

3.4.5 Sampling Procedure

Procedures from the DOE prime contractor (or its approved subcontractor) will be used for sampling. Depth-discrete soil samples will be collected from the aquifer at the intervals identified in Table 17 using split-spoon sampling equipment and methods. These split-spoon sediment samples will be used for the analyses listed in Table 6. Additional depth-discrete grab soil samples will be collected from saturated zone drill cuttings at 1.5 m (5 ft) intervals from the water table to basalt to enable sieve analyses to be completed to design both the filter pack and the slot size for the well screens. Geologic archive grab soil samples will be collected from the drill cuttings at 1.5 m (5 ft) intervals from ground surface to basalt.

The sample intervals listed in Table 17 are anticipated depths based on the estimated depths to groundwater and geologic contacts listed in Table 1 for each well. The actual depths to groundwater and to geologic contacts may be different during drilling. During drilling, the field geologist, in consultation with the geology subject matter expert, will identify the depth at which groundwater and the transition between target formations occurs and, in consultation with the project scientist, may adjust the sample depth in response to these conditions, provided the target formation is sampled and the intent of the sample interval is achieved. The following must be considered when adjusting sample intervals:

- The first (shallowest) sample within the Rwie is intended to be collected approximately 3 m (10 ft) into the saturated zone. Only one sample is planned in the Rwie at MW-D, so this sample is intended to be collected approximately 3 m (10 ft) into the saturated zone and above the anticipated contact with the Rlm.
- The last (deepest) sample within the Rwie is intended to be collected within the Rwie at a depth approaching, but above, the transition to the next target geologic formation (i.e., the Rlm when present, otherwise the Rwia). Only one sample is planned in the Rwie at MW-D, so this sample is intended to be collected approximately 3 m (10 ft) into the saturated zone and above the anticipated contact with the Rlm.
- The first (shallowest) Rlm sample is intended to be collected within the first few feet of the Rlm.
- The last (deepest) Rlm sample is intended to be collected within the Rlm and a few feet above the Rwia.
- The first (shallowest) Rwia sample is intended to be collected within the first few feet of the Rwia.
- The last (deepest) Rwia sample is intended to be collected within the Rwia and a few feet above the anticipated contact with the basalt.

Sample intervals within formations, and not above or below transition between target formations (i.e., other than first or last planned within the formation), may be adjusted by the field geologist, in consultation with the project scientist, to accommodate field conditions that resulted in the adjustment of a prior sampling interval and/or the drilling method (e.g., moved ±3 m [10 ft] to accommodate a 6.1 m [20 ft] length of drilling pipe), provided the targeted geologic formation is sampled and approximate even spacing between sample intervals is maintained.

The field geologist will notify the drilling buyer's technical representative and contact the project scientist (or designee) if unexpected conditions are encountered in the field that may warrant collection of additional samples. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data.

The split-spoon liners collected from each sampling interval will be designated for laboratory analyses as follows (designated from deepest to shallowest):

- **Liner A** – contaminant concentration analyses, excluding VOC, total carbon, TOC, and TIC at offsite analytical laboratory
- **Liner B** – saturated hydraulic conductivity (full, intact liner) and other physical parameters at offsite laboratory

- **Liner C** – analyses for VOCs (full, intact liner), total carbon, TOC, and TIC to be performed on all samples, and special studies on select samples at PNNL
- **Liner D** – held in reserve at PNNL for use in reanalysis or if additional sample material is needed

If inadequate sample material is generated from the first attempt at collecting a sediment sample (due to incomplete recovery), another sample will be collected immediately below the initially sampled interval.

Most groundwater samples will be collected from selected intervals using a submersible pump, although collecting samples with a bailer is also acceptable (e.g., near the water table where insufficient head may be available for pumping, or where groundwater turbidity is high enough to interfere with pumping). Prior to sample capture, the pump will be operated for a sufficient period of time to provide stabilized field readings. Groundwater samples will be used for the analyses listed in Table 5.

Split-spoon soil samples and groundwater samples collected during drilling as the boring is advanced will support performance evaluation of the selected remedy by improving the understanding of the Rwia and will also support P&T optimization efforts focused on the Rwia.

3.4.6 Slug Testing

Slug tests will be conducted at the frequencies and locations described in Table 17. For slug testing performed during drilling, the water level in a borehole is quickly changed by inserting, removing, or otherwise displacing a known volume of water inside the borehole. The subsequent water-level response is then monitored, and hydraulic parameters are calculated using these data. The slug testing procedure steps are as follows:

- General slug testing steps for Rwia and Rwie sample depths for each borehole (with temporary screen):
    1. Advance the borehole to the targeted sample depth.
    2. Remove drill stem and bit from borehole.
    3. Lower tubing string (minimum 4 in. diameter) with short (2 to 3 ft) temporary screen and packer to bottom of borehole.
    4. Pull back drill casing a few feet to expose the entire screen to the formation.
    5. Inflate packer to provide seal between tubing string and drill casing to isolate the sample depth.
    6. Measure the depth to water inside the tubing string (needed to determine slug testing depth).
    7. Lower sample pump to the depth of the screen.
    8. Purge borehole until field parameters pH, temperature, conductivity, and turbidity stabilize (effectively developing the borehole prior to slug testing).
    9. Collect groundwater sample.
    10. Remove sample pump from borehole.
    11. Install pressure transducer inside tubing string to a depth of approximately 1 to 2 ft below the expected depth of the slug rod at full immersion. Slug test will be conducted near the top of the water column, as determined by the water-level measurement (from step 6 above).
    12. Monitor baseline water level with the transducer and allow water levels to stabilize.

13. Perform slug injection and withdrawal test per slug test procedure using a slug rod (allow up to 1 to 2 hours to complete slug tests).
14. Following slug testing, remove slug rod and pressure transducer from borehole.
15. Deflate packer and remove tubing string and screen from borehole.
16. Continue drilling to the next sample depth.

- General slug testing steps for Rlm sample depth for each borehole (with no temporary screen):

  NOTE: These steps assume the drill cuttings/soil sample indicate silty or clayey materials (i.e., low permeability), as determined by the field geologist. Because the Ringold lower mud unit is expected to produce low water yield, stabilizing the field parameters for the groundwater sample and developing the sample depth for the slug test may be limited. A slug test will be performed in only one of the sample depths within the Rlm unit for each borehole.

  1. Advance the borehole to the targeted sample depth.
  2. Remove drill stem and bit from borehole.
  3. Measure depth to water in the borehole.
  4. Evacuate water column in the borehole with pump or bailer to collect groundwater sample and to initiate the slug test.
  5. Immediately following groundwater sample collection, measure the depth to water.
  6. Install pressure transducer in borehole and begin logging the water level to monitor the slug test recovery. The duration of the slug test will be determined by the field geologist, in consultation with the project scientist. If the water level does not respond to the borehole evacuation (e.g., water level does not change over a reasonable period following initiation of the test [2 hours]), as determined by the field geologist in consultation with the project scientist, then abandon the slug test.

Supplemental hydraulic testing will be performed after well acceptance and will be specified and conducted under a separate hydraulic testing plan that will be developed following issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing plan and completion of the associated hydraulic testing work is a required task under this SAP.

3.4.7 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Generally, cuttings from drilled boreholes (excluding slough) will be field screened for evidence of radiological contamination. Screening will be conducted visually and with field instruments in accordance with 10 CFR 835, “Occupational Radiation Protection.” Radiological screening will be performed by the RCT or other qualified personnel in accordance with Hanford procedures. The RCT will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the field geologist for inclusion into the field logbook or operational records daily, as applicable.

3.5 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with manufacturers’ operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment

calibration or verification of accuracy by analytical methods. Calibration records will include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with HASQARD requirements (DOE/RL-96-68).

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

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Calibration of radiological field instruments at the Hanford Site is performed by the Mission Support Alliance prime contractor, as specified by their calibration program.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently similar to the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturers' recommendations for storage and handling of standards (if any) will be followed. Expired standards will not be used for calibration.

3.6 Sampling 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. If it is discovered during the chain-of-custody process that the custody tape has been tampered with or broken on the sample bottle, SMR personnel will be notified. The sample will be analyzed, but the results will include a flag to indicate that custody was broken. If the custody tape on the cooler has been tampered with or broken, this condition will be documented in the data package. If the sample data did not trend with the other data or were not as expected, the data from the sample would be flagged accordingly.

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

3.6.1 Containers

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

Containers will be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions will be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

The Radiological Engineering organization will measure the contamination levels and the dose rates associated with the filled sample containers. This information and other data will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the FWS (in consultation with SMR) can send smaller sample volumes to the laboratory.

3.6.2 Container Labeling

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

3.6.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained 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 sample or set of samples shipped to any laboratory.

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

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

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Number of sample containers per unique sample identification number
- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any sample anomalies. If anomalies are found, samplers should inform SMR so special instructions for analysis can be provided to the laboratory if deemed necessary.

3.6.4 Sample Transportation

Packaging and transportation instructions will comply with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 177, "Carriage by Public Highway."[1] Carrier-specific requirements defined in the current edition of the International Air Transportation Association (IATA) *Dangerous Goods Regulations* will also be used when preparing sample shipments conveyed by air freight providers.

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

Materials are classified by DOT/IATA as radioactive when the isotope-specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," are exceeded. Samples will be screened, or relevant historical data will be used, to determine if these values are exceeded. When screening or historical data indicate that samples are radioactive, the samples will 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 will notify the laboratory of the approximate number 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. Prior to sample receipt, the laboratory will provide SMR with written acceptance for samples with elevated radioactive contamination or dose.

4 Management of Waste

Waste generated by drilling and sampling activities (e.g., personal protective clothing and equipment) will be managed in accordance with the 200-ZP-1 OU waste management plan (Appendix B of the 200 West P&T O&M plan [DOE/RL-2009-124]). The waste management plan establishes the requirements for managing and disposing waste associated with groundwater wells used to monitor and remediate the 200-ZP-1 OU, as required by the 200-ZP-1 OU ROD (EPA et al., 2008). Remediation-derived waste from well sampling and installation activities is handled in accordance with CERCLA. The characterization of waste generated by drilling and the sampling of wells identified in this SAP will vary by location, depth, and the time of each well's installation.

Saturated zone soils and related miscellaneous solid waste will be designated for disposal on the basis of an existing waste profile developed using data previously obtained from numerous other 200-ZP-1 OU wells in accordance with the 200-ZP-1 OU waste management plan (Appendix B of DOE/RL-2009-124).

Offsite analytical laboratories are responsible for disposing unused sample quantities and wastes generated during analytical processes. Pursuant to 40 CFR 300.440, "National Oil and Hazardous

[1] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the DOE remedial project manager is required before returning any unused samples or waste from offsite laboratories.

5 Health and Safety

DOE has established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, "Worker Safety and Health Program," which incorporates the standards of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response"; 10 CFR 830, "Nuclear Safety Management"; and 10 CFR 835. The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control and general emergency response to spills, fire, accidents, injury, site visitors; and incident reporting are governed by the health and safety program. Site-specific health and safety plans will be used to supplement the general health and safety program.

6 References

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title10-vol4/xml/CFR-2010-title10-vol4-part830.xml.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title10-vol4/xml/CFR-2010-title10-vol4-part835.xml.

10 CFR 851, "Worker Safety and Health Program," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=47e3de0454360a17406cb89ade0c966d&mc=true&node=pt10.4.851&rgn=div5.

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Appendix A

200-ZP-1 Operable Unit Ringold Formation Unit A Data Quality Objectives

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Terms

AA	alternative action
COC	contaminant of concern
DQO	data quality objective
DR	decision rule
DS	decision statement
F&T	fate and transport
IC	institutional control
MNA	monitored natural attenuation
O&M	operations and maintenance
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
PNNL	Pacific Northwest National Laboratory
PSQ	principal study question
PQL	practical quantitation limit
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
Rlm	Ringold Formation member of Wooded Island – lower mud unit
ROD	Record of Decision
Rwia	Ringold Formation member of Wooded Island – unit A
Rwie	Ringold Formation member of Wooded Island – unit E
SAP	sampling and analysis plan
TBD	to be determined

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A 200-ZP-1 Operable Unit Ringold Formation Unit A Data Quality Objectives

The data quality objective (DQO) process used to support the sample design presented the main text of this sampling and analysis plan (SAP) is provided in this appendix.

A1 Data Quality Objectives

The DQO process is a strategic planning approach to define the criteria that a data collection design should satisfy. This process is used to ensure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. The DQOs for the 200-ZP-1 Groundwater Operable Unit (OU) Ringold Formation unit A SAP were developed in accordance with EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4). The DQO process involves a series of logical steps used to plan for the resource-effective acquisition of environmental data. The performance and acceptance criteria are determined through the DQO process, which serves as the basis for designing the plan to collect data of sufficient quality and quantity to support project goals. The DQO process consists of the following seven iterative steps.

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

Each of the DQO steps is further discussed in Sections A2 through A8.

As discussed in Section 5.5 of DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (hereinafter referred to as the 200-ZP-1 pump and treat (P&T) remedial design/remedial action work plan [RD/RAWP]), and in Section 1.1.1 in the main text of this SAP, an optimization study will be conducted in accordance with DOE/RL-2019-38, *200-ZP-1 Operable Unit Optimization Study Plan* (hereinafter referred to as the 200-ZP-1 optimization study plan), which is focused on evaluating the potential for accelerating carbon tetrachloride cleanup by increasing the treatment capacity of the 200 West P&T. While many of the DQOs identified herein for this SAP may be used to support the optimization study, additional DQOs may be developed. The potential additional DQOs for the optimization study are not identified in this SAP and will be identified separately as part of the optimization study plan and/or associated SAPs.

A2 State the Problem

The first step in the DQO process is to define the problem. For the 200-ZP-1 OU, evaluation and optimization of the selected remedy, as specified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* (hereinafter referred to as the 200-ZP-1 OU Record of Decision [ROD]), is the ultimate purpose of data collection for the OU. To support this purpose, the nature and extent of carbon tetrachloride and other 200-ZP-1 OU contaminants of concern (COCs) (as defined in the 200-ZP-1 OU ROD) in the Ringold Formation

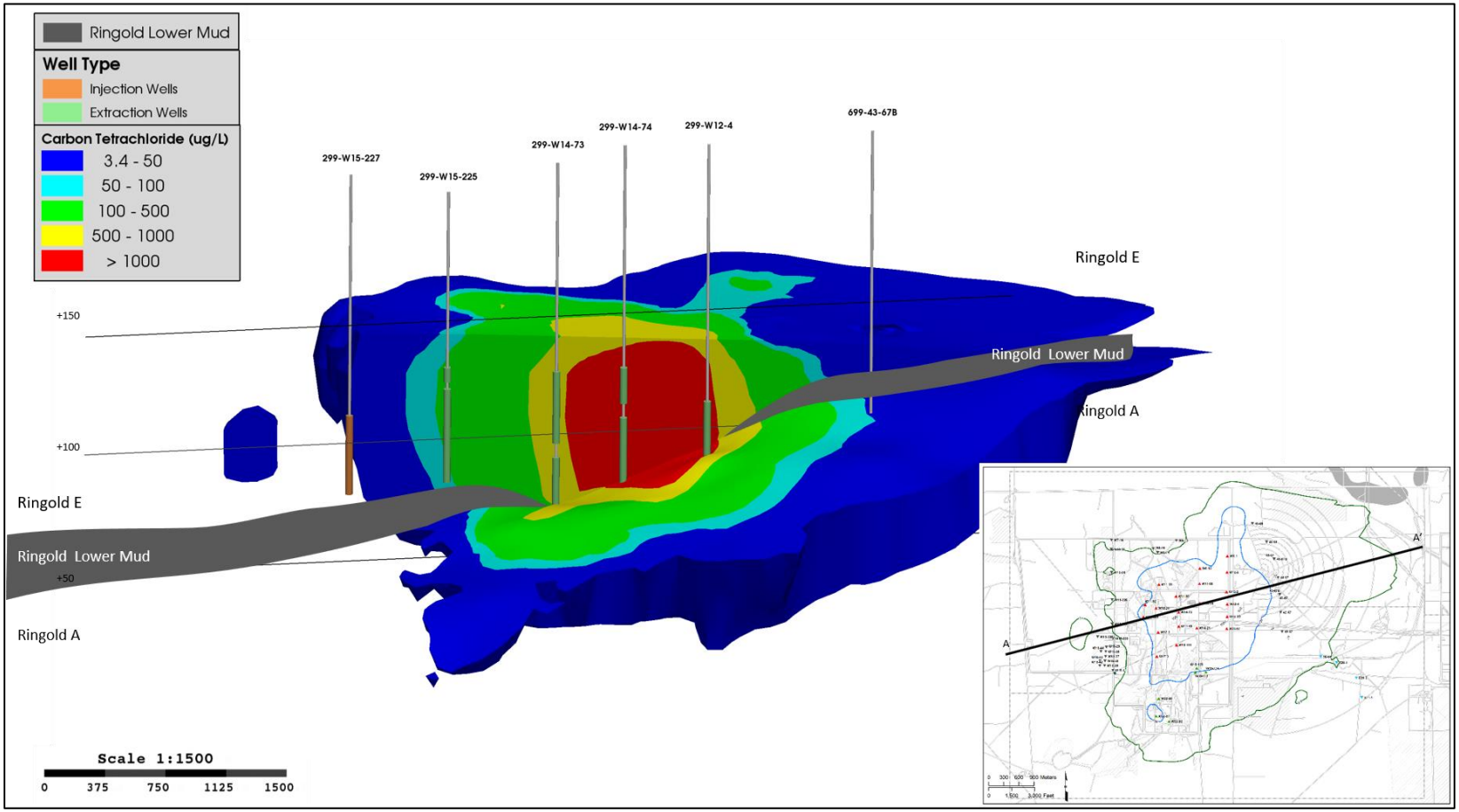
member of Wooded Island – unit A (Rwia) and the Ringold Formation member of Wooded Island – lower mud unit (Rlm) must be better understood. Figure A-1 provides a cross-section map of the carbon tetrachloride concentrations in the 200 West Area as approximated in 2017 through interpolation of groundwater sample data.

Since implementation of the 200-ZP-1 OU ROD (EPA et al., 2008), a larger proportion of carbon tetrachloride has been identified below the Rlm that is substantially larger than previously estimated (located farther to the northeast) and represents a greater fraction of the overall contaminant mass within the 200-ZP-1 OU (Figure A-2). For comparison, the 2015 carbon tetrachloride plume estimate above the Rlm is only moderately larger in extent in the east-west direction than was estimated during the 2008 feasibility study (DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*) but is more extensive in the north and south directions (Figure A-3). In both Figures A-2 and A-3 (below and above the Rlm, respectively), more recent data have identified a greater extent of contamination in the northeast area.

Currently, there are limited characterization data, hydrogeologic data, hydraulic data, and information to define transport parameters for the Rwia and Rlm. A specific area where additional data are needed is to the north and northeast of the Hanford Site 200 West Area, where a portion of the carbon tetrachloride plume >100 µg/L is not currently being hydraulically contained by the P&T component of the selected remedy (Figure A-4). In addition, the region to the northeast (where contaminants are transported and discharge in groundwater from the 200 West Area toward the 200 East Area via a zone of higher transmissivity) needs to be better understood. Although the main text of this SAP addresses the primary data needs associated with the Rwia and Rlm, some Ringold Formation member of Wooded Island – unit E (Rwie) data will facilitate improving the understanding of groundwater and contaminant movement in this area.

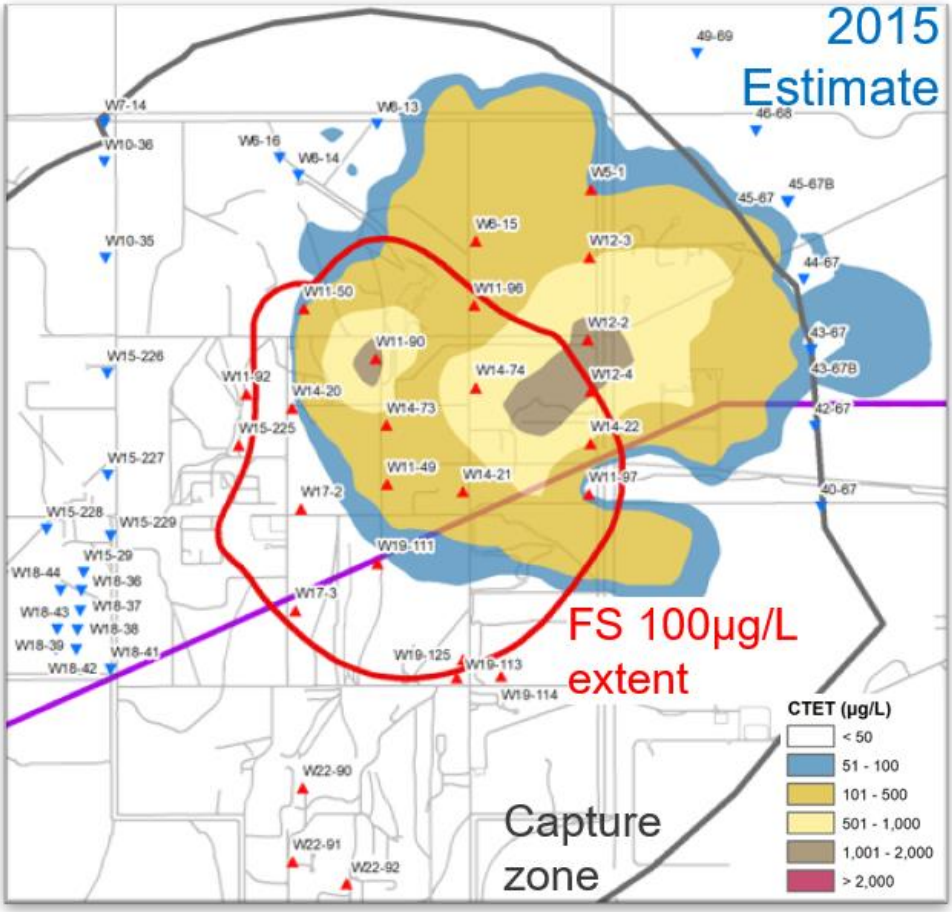
Based on these needs, data must be collected within the defined study area to adequately define the nature and extent of the 200-ZP-1 OU COC plumes and the hydrogeologic properties, hydraulic properties, and transport parameters of the Rwia, the Rlm, and, to a limited extent, the Rwie. The data will support fate and transport (F&T) modeling, facilitate performance evaluation of the 200-ZP-1 OU remedy, and assist in making recommendations for optimizing or modifying the remedy. The data will supplement data to be collected as part of well installation, as defined in DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (hereinafter referred to as the 200-ZP-1 OU performance monitoring plan [PMP]), which occur concurrently with the effort described in the main text of this SAP. The 200-ZP-1 OU PMP effort is focused on monitoring for current remedy implementation needs. This SAP focuses specifically on characterization in the Rwia, Rlm, and Rwie that is associated with future remedy optimization efforts.

A determination regarding the adequacy of the information and knowledge obtained from these studies will be made in the context of improving the ability to reasonably predict the likely future performance of the remedy in attaining the remedial action objectives (RAOs) specified in the 200-ZP-1 OU ROD (EPA et al., 2008). The process for determining what is meant by “adequately defined” is discussed in Section A6 as part of the analytical approach development. The overall goal of this project is to obtain additional data (with emphasis on the Rwia) to provide for reliable and predictive F&T modeling to support P&T and monitored natural attenuation (MNA) remedy optimization.



Source: DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for Pump-and-Treat Operations in the Hanford Central Plateau Operable Units*.

Figure A-1. Hydrogeologic Three-Dimensional Model Cross Section of 2017 Carbon Tetrachloride Plume, West to East (A to A')

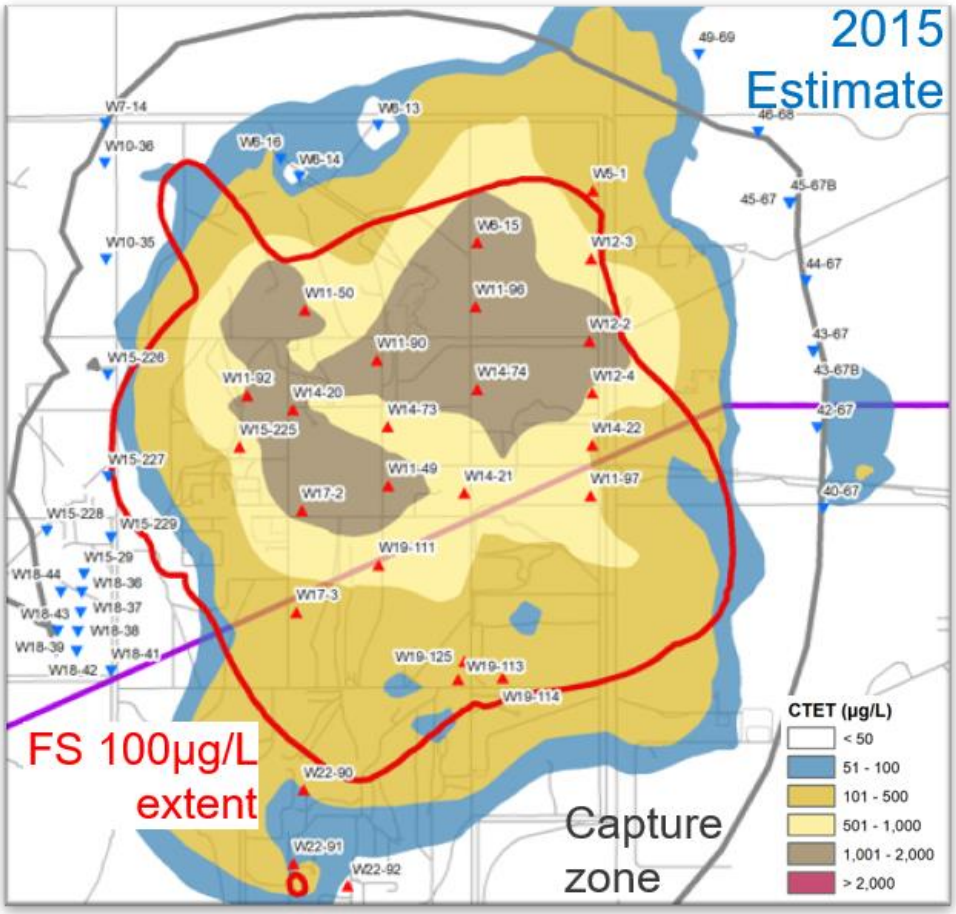


Note: Comparison based on DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*; and 2015 modeling presented in ECF-200W-16-0092, Rev. 1, *Calculation of Three-Dimensional Groundwater Concentration Plumes for 200-West for Calendar Year (CY) 2015*.

Figure A-2. Carbon Tetrachloride Plume Estimates Below the Rlm in the 2008 Feasibility Study Versus 2015

A3 Identify the Goals of the Study

The second step of the DQO process identifies the key decisions and/or goals that must be addressed to achieve the final solution. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the selected remedy combines the components of groundwater P&T, MNA, flow-path control, and institutional controls (ICs). As specified in the 200-ZP-1 P&T RD/RAWP (DOE/RL-2008-78), monitoring will be conducted to evaluate performance of the P&T system, flow-path control, and MNA. Performance monitoring for the first three components is primarily addressed by the 200-ZP-1 OU PMP (DOE/RL-2009-115). The ICs are specifically excluded from the 200-ZP-1 OU PMP and are monitored in accordance with DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*. The data collected under this study will be supplemental to the data collected under the 200-ZP-1 OU PMP, with a focus on obtaining characterization information for the Rwia and Rlm to support future remedy optimization needs.

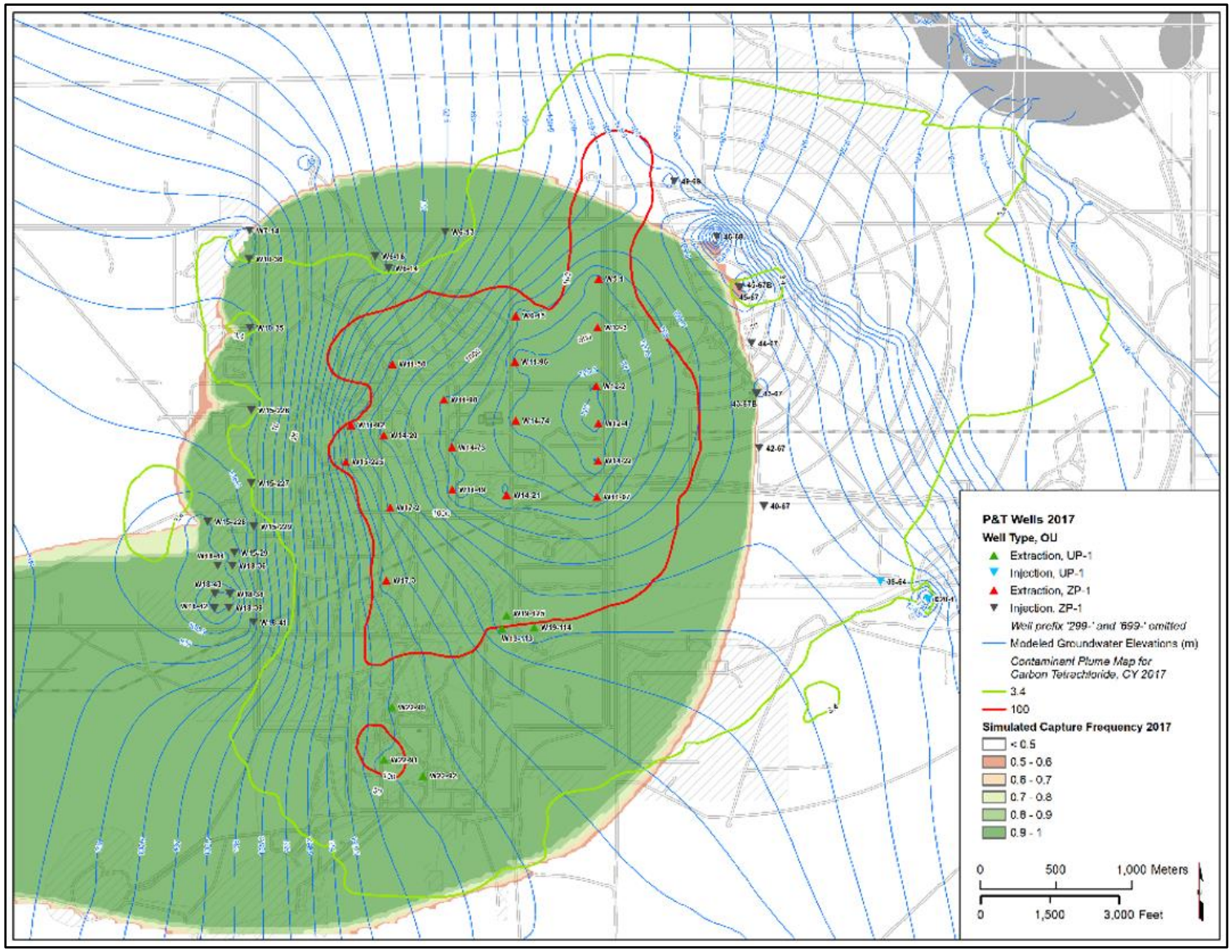


Note: Comparison based on DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*; and 2015 modeling presented in ECF-200W-16-0092, *Calculation of Three-Dimensional Groundwater Concentration Plumes for 200-West for Calendar Year (CY) 2015*.

Figure A-3. Carbon Tetrachloride Plume Estimates Above the Rlm in the 2008 Feasibility Study Versus 2015

The principal study questions (PSQs) that the data collected under this study must address, along with alternative actions (AAs) that may result based on the analysis of the collected data, are as follows:

- **PSQ #1:** Are the nature and extent of the COCs in the major facies of the Rwia and Rlm adequately defined?
  - **AA #1A:** Yes. No action required; <u>or</u>
  - **AA #1B:** No. Collect additional data to define the nature and extent of COCs within the Rwia and Rlm.
- **PSQ #2:** Are the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and the contacts and transitions between the Rwia, Rwie, Rlm, and basalt adequately defined?
  - **AA #2A:** Yes. No action required; <u>or</u>
  - **AA #2B:** No. Collect additional data to define the hydrogeologic properties of the Rwia, Rwie, Rlm, and basalt.



Source: DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for Pump-and-Treat Operations in the Hanford Central Plateau Operable Units*.

Figure A-4. Carbon Tetrachloride Plume >100 µg/L and Simulated Capture Zone, 2017

- **PSQ #3:** Are the typical values and the variabilities of the hydraulic properties of the major facies of the Rwia and Rlm adequately defined?
  - **AA #3A:** Yes. No action required; or
  - **AA #3B:** No. Collect additional data to define the hydraulic properties of the Rwia and Rlm.
- **PSQ #4:** Are the transport parameters for the 200-ZP-1 OU COCs within the Rwia and Rlm adequately defined?
  - **AA #4A:** Yes. No action required; or
  - **AA #4B:** No. Collect additional data to define the transport properties.

The resulting decision statements (DSs) are the basis for discussion in the subsequent DQO process steps:

- **DS #1:** Determine if the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling; otherwise, collect additional data to define the vertical and lateral distribution of COCs.
- **DS #2:** Determine if the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and the contacts and transitions between the Rwia, Rwie, Rlm, and basalt are adequately defined to support of F&T modeling; otherwise, collect additional data to define these properties.
- **DS #3:** Determine if the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling; otherwise, collect additional data to define these properties.
- **DS #4:** Determine if the transport parameters for the 200-ZP-1 OU COCs are adequately defined within the Rwia and Rlm to support F&T modeling; otherwise, collect additional data to define these properties.

A4 Identify the Information Inputs

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

- **Contaminant sampling data collected during drilling and post-development:** Groundwater contaminant sampling during drilling and following development of the proposed Rwia monitoring wells is needed to better define the horizontal and vertical extent and the distribution of aqueous contamination above cleanup levels. Sediment contaminant sampling during drilling of the proposed wells is needed to better define the sorbed versus aqueous partitioning of contamination in the aquifer. The groundwater samples will be analyzed for the constituents listed in Table A-1, and the sediment samples will be analyzed for the constituents listed in Table A-2. In addition to analysis for 200-ZP-1 OU COCs, Tables A-1 and A-2 also summarize other constituents to be sampled for various data uses. These other constituents include COC transformation and degradation products, COCs from other OUs, and key geochemical and field parameters. The constituents of interest that are not identified as COCs were derived from a review of the documents listed in Table 7 in the main text of this SAP.

Table A-1. Constituents of Interest for Groundwater During Drilling and for Groundwater Post-Development

Constituent of Interest	CAS Number
Groundwater Constituents During Drilling	
Carbon tetrachloride[a]	56-23-5
Chloroform	67-66-3
Chloromethane	74-87-3
Chromium, total[a, b]	7440-47-3
Cyanide	57-12-5
cis-1,2-Dichloroethene	156-59-2
Dichloromethane	75-09-2
Iron	7439-89-6
Iodine-129[a]	15046-84-1
Manganese	7439-96-5
Nitrate[a]	14797-55-8
pH	N/A
Total dissolved solids	TDS
Total carbon	7440-44-0
Total organic carbon	TOC
Total inorganic carbon	TIC
Technetium-99[a]	14133-76-7
Trichloroethene[a]	79-01-6
Tritium[a]	10028-17-8
Uranium[c]	7440-61-1
Vinyl chloride	75-01-4
Post-Development Groundwater Constituents	
Alkalinity	ALKALINITY
Carbon tetrachloride[a]	56-23-5
Chloroform	67-66-3
Chloride	16887-00-6
Chloromethane	74-87-3
cis-1,2-Dichloroethene	156-59-2
Dichloromethane	75-09-2
Chromium, total[a, b]	7440-47-3
Chromium, hexavalent[a, b]	18540-29-9
Cyanide	57-12-5
Iodine-129[a]	15046-84-1
Iron[b]	7439-89-6
Manganese[b]	7439-96-5
Nickel[b]	7440-02-0
Nitrate[a]	14797-55-8

Table A-1. Constituents of Interest for Groundwater During Drilling and for Groundwater Post-Development

Constituent of Interest	CAS Number
Nitrite	14797-65-0
Sulfate	14808-79-8
Sulfide	18496-25-8
Technetium-99[a]	14133-76-7
Total organic carbon	TOC
Total dissolved solids	TDS
Trichloroethene[a]	79-01-6
Tritium[a]	10028-17-8
Uranium[b, c]	7440-61-1
Vinyl chloride	75-01-4
Field Screening Parameters [d]	
Dissolved oxygen	N/A
Oxidation-reduction potential	N/A
pH	N/A
Specific conductance	N/A
Temperature	N/A
Turbidity	N/A

a. The COCs are specified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*.

b. Both filtered and unfiltered samples will be collected for all metal constituents except hexavalent chromium. A filtered sample will be collected for hexavalent chromium.

c. Uranium (total) will also be analyzed as a target constituent. While not a COC specified in the 200-ZP-1 OU Record of Decision (EPA et al., 2008), it is a COC for the adjacent 200-UP-1 OU.

d. Field screening parameters to be collected in accordance with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document, Vol. 3, Field Analytical Technical Requirements*.

CAS = Chemical Abstracts Service
COC = contaminant of concern
N/A = not applicable
OU = operable unit
TDS = total dissolved solids
TIC = total inorganic carbon
TOC = total organic carbon

Table A-2. Constituents of Interest and Physical Properties for Sediments During Drilling

Constituent of Interest	CAS Number	Purpose
Sediment Constituents		
Carbon tetrachloride[a]	56-23-5	Used for comparison to aqueous concentrations
Chloroform	67-66-3	Used for comparison to aqueous concentrations
Chloromethane	74-87-3	Used for comparison to aqueous concentrations
Chromium, total[a]	7440-47-3	Used for comparison to aqueous concentrations
Chromium, hexavalent[a]	18540-29-9	Used for comparison to aqueous concentrations
Cyanide	57-12-5	Used for comparison to aqueous concentrations
cis-1,2-Dichloroethane	156-59-2	Used for comparison to aqueous concentrations
Dichloromethane	75-09.2	Used for comparison to aqueous concentrations
Iron	7439-89-6	Used for comparison to aqueous concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals
Manganese	7439-96-5	Used for comparison to aqueous concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals
pH	N/A	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Total carbon	7440-44-0	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Total organic carbon	TOC	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Total inorganic carbon	TIC	Used for comparison to aqueous concentrations and to establish baseline geochemistry
Technetium-99[a]	14133-76-7	Used for comparison to aqueous concentrations
Trichloroethene[a]	79-01-6	Used for comparison to aqueous concentrations
Uranium[b]	7440-61-1	Used for comparison to aqueous concentrations
Vinyl chloride	75-01-4	Used for comparison to aqueous concentrations
Sediment Physical Properties		
Bulk density, particle density, and porosity	N/A	Used in evaluating soil texture needed to support geologic interpretation, interpretation of physical and chemical testing data, and provide parameter inputs to fate and transport modeling
Particle-size distribution	N/A	Used in evaluating soil texture needed to support geologic interpretation and interpretation of physical and chemical testing data and to support well design process
Saturated hydraulic properties	N/A	Used in geologic interpretation and provides parameter inputs to fate and transport modeling

a. The COCs are specified in EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*.

b. Uranium (total) will also be analyzed as a target constituent. While not a COC specified in the 200-ZP-1 OU Record of Decision (EPA et al., 2008), it is a COC for the 200-UP-1 OU to the south.

CAS = Chemical Abstracts Service
COC = contaminant of concern
N/A = not applicable
OU = operable unit
TIC = total inorganic carbon
TOC = total organic carbon

- **Hydrogeologic properties data collected during drilling:** Geologic observations and geophysical data collection during drilling are needed to better define the geologic framework of the 200-ZP-1 OU, with specific focus on the contacts and transitions between the Rwia, Rwie, Rlm, and basalt and the erosional features and unconformities of the Rwia and Rlm. This need will primarily be satisfied by producing geologic logs of the sediment and basalt encountered during drilling of each new well and using geophysical logging (including spectral gamma and neutron moisture logging) of each drilled borehole prior to well construction. Sediment physical property sampling during drilling is also needed to better define hydrogeologic properties of and differences between the Rwia and Rwie. Specifically, the sediment samples will be analyzed for bulk density, particle density, total porosity, and particle-size distribution, as listed under the sediment physical properties in Table A-2.

- **Hydraulic properties data collected during drilling and following well construction:** Hydraulic head distribution observations collected during drilling are needed to better define hydraulic conditions in the 200-ZP-1 OU. This need will primarily be satisfied by recording hydraulic head measurement in geologic logs during drilling of each new well. Hydraulic slug testing data collection is also needed to better define the hydraulic conductivity vertical profile for the Rwia and Rlm associated with the major zones of different transmissivity encountered during drilling of each well. This need will be satisfied by conducting slug tests during drilling at each planned groundwater and sediment sampling interval, except in the Rlm where only one interval will be tested. Sediment physical property sampling during drilling is needed to better define Rwia hydraulic properties. The sediment samples will be analyzed for saturated hydraulic conductivity, as listed under the sediment physical properties in Table A-2. Following well acceptance of the new Rwia monitoring wells, supplemental hydraulic testing is needed to further define the 200-ZP-1 OU hydraulic properties. These additional tests will be conducted in accordance with a separately developed hydraulic testing plan, with emphasis on data collection to support evaluating vertical conductivity, large-scale transmissivity and storage properties, hydraulic conductivity vertical profiles associated with principal zones of transmissivity, and effective porosity within and downgradient of observed and interpreted plume migration pathways.

- **Transport parameter sampling data collected during drilling:** Sediment sampling for transport parameters during drilling of the proposed Rwia monitoring wells is needed to better define transport parameters of the 200-ZP-1 OU for use in F&T model. The sediment samples will be analyzed geochemical parameters and organic content as listed in Table A-2. Sediment samples will also be provided to Pacific Northwest National Laboratory (PNNL) for laboratory contaminant mobility and transport studies to better understand sediment/water partitioning and develop distribution coefficients for carbon tetrachloride in the Rwia and Rlm. Only sediment samples that correspond to groundwater samples with higher carbon tetrachloride concentrations (based on quick-turnaround analytical results) will undergo the supplemental studies at PNNL. The supplemental studies will be conducted using PNNL-developed methods and procedures that are not specified in this DQO process.

- **Additional contaminant sampling data collected under other sampling plans:** Where appropriate, groundwater and sediment contaminant sampling data collected under other sampling plans will be used to support this study if the data are of acceptable quality and meet the performance requirements specified in the main text of this SAP. The data may include results for contaminants, transformation products, and other constituents that arise from other 200-ZP-1 OU data collection activities, including the 200-ZP-1 OU PMP (DOE/RL-2009-115); the 200-ZP-1 optimization study plan (DOE/RL-2019-38); and DOE/RL-2009-124, *200 West Pump and Treat Operations and*

Maintenance Plan (hereinafter referred to as the 200 West P&T operations and maintenance [O&M] plan); or from other data collection activities outside of the 200-ZP-1 OU.

Collection of measurements and observations provides an opportunity for integration with other projects and activities, including data collection performed for other OUs. Conversely, information and developed knowledge may be shared with other projects through integration activities. Measurements and observations collected and used through integration activities must be assessed to ensure that they meet the data quality requirements of the current activity and that their uncertainty and limitations are understood. Information should be clearly identified as based on either direct data (i.e., collected under the auspices of this activity) or indirect data (i.e., collected through an integration activity).

The following sections identify the data inputs needed to resolve each DS presented in Section A3.

A4.1 Data Inputs to Resolve Decision Statement #1

The following data inputs are required to resolve DS #1, "Determine if the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling…":

- Groundwater (aqueous contaminants, transformation products, and other constituents of interest) sample results from the new monitoring wells to better define the lateral and vertical extent and distribution of contaminant plumes
- Sediment (sorbed contaminants, transformation products, and other constituents of interest) sample results from the new monitoring wells to better define the sorbed versus aqueous contaminant concentrations
- Sample results for contaminants, transformation products, and other constituents of interest that arise from other 200-ZP-1 OU data collection activities, primarily performed under the 200-ZP-1 OU PMP (DOE/RL-2009-115), the 200-ZP-1 optimization study plan (DOE/RL-2019-38), and the 200 West P&T O&M plan (DOE/RL-2009-124)
- Sample results for contaminants, transformation products, and other constituents of interest that arise from outside the 200-ZP-1 OU under other SAPs, PMPs, etc.

These data are described in Section A6 and are discussed in further detail in Section A6.3.1.

A4.2 Data Inputs to Resolve Decision Statement #2

The following data inputs are required to resolve DS #2, "Determine if the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm, and contacts and transitions between the Rwia, Rwie, Rlm, and basalt adequately defined to support F&T modeling…":

- Geologic observations (during drilling, using visual observation and geophysical logging) of the contacts, transitions, erosional features, and unconformities between the Rwia, Rwie, Rlm, and basalt to better define the geologic framework
- Sediment physical properties (bulk density, particle density, total porosity, particle-size distribution, and saturated hydraulic conductivity) sample results from the new monitoring wells to better define hydrogeologic and hydraulic properties and differences between the Rwia, Rwie, and Rlm

These data are described in Section A6 and are discussed in further detail in Section A6.3.2.

A4.3 Data Inputs to Resolve Decision Statement #3

The following data inputs are required to resolve DS #3, "Determine if the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling…":

- Sediment physical properties (bulk density, particle density, total porosity, particle-size distribution, and saturated hydraulic conductivity) sample results from the new monitoring wells to better define hydrogeologic and hydraulic properties and differences between the Rwia, Rwie, and Rlm
- Hydraulic head distribution observations during drilling to better define hydraulic conditions to support F&T modeling
- Slug testing (during drilling) results to better define the vertical profile of hydraulic conductivity for the Rwia associated with major zone of different transmissivity to support F&T modeling
- Hydraulic testing (to be determined [TBD]) to better define large-scale transmissivity and storage properties
- Hydraulic testing (TBD) to better define the vertical profile of hydraulic conductivity for the Rwia associated with major zones of different transmissivity
- Hydraulic testing (TBD) to better define the vertical hydraulic conductivity (leakage factor)
- Hydraulic testing (TBD) to better define the effective porosity of the Rwia within the observed/interpreted plume migration pathways

These data are described in Section A6 and are discussed in further detail in Section A6.3.3.

A4.4 Data Inputs to Resolve Decision Statement #4

The following data inputs are required to resolve DS #4, "Determine if the transport parameters for the 200-ZP-1 OU COCs are adequately defined within the Rwia and Rlm to support F&T modeling…":

- Sediment transport-related (geochemical parameters and organic content) sample results from the new monitoring wells to better define the transport parameters
- Results of supplemental laboratory contaminant mobility and transport studies performed by PNNL will be used to better understand sediment/water partitioning and develop distribution coefficients for carbon tetrachloride

These data are described in Section A6 and are discussed in further detail in Section A6.3.4.

A5 Define the Boundaries of the Study

The fourth step of the DQO process is used to identify the spatial and temporal features pertinent to the decision-making process. The overall spatial study boundaries include the area of the current carbon tetrachloride plume and the discharge zone of Rwia and Rlm groundwater into a zone of higher transmissivity at the eastern margin of the Rwia. Specific study zones within the overall study boundaries are as follows:

- Carbon tetrachloride plume core, where carbon tetrachloride concentrations exceed or are near 100 µg/L
- Eastern margin of the Rlm, where the Rlm appears to be thinning or absent

- Northeastern uncontained extent of the carbon tetrachloride plume >100 µg/L
- The likely discharge zone into a zone of higher transmissivity, as identified in part through groundwater F&T modeling

The temporal study boundaries are limited to fiscal years 2020 through 2023 in order to meet other 200-ZP-1 OU remedy evaluation schedule requirements.

A6 Develop the Analytic Approach

The fifth step of the DQO process involves developing an analytic approach and the associated decision rules (DRs) that outline how data collected under this study will be used for decision-making purposes. The DRs for each DS provide clear requirements that guide the decision-making process.

The 200-ZP-1 OU PMP (DOE/RL-2009-115) presents and supports a multi-stage decision-making process that is tied to the remedy components (excluding ICs) stated in the 200-ZP-1 OU ROD (EPA et al., 2008). The data collection activities developed in the main text of this SAP to resolve the four DSs for this study ultimately support the multi-stage decision-making process identified in the 200-ZP-1 OU PMP by providing characterization information to support future remedy optimization.

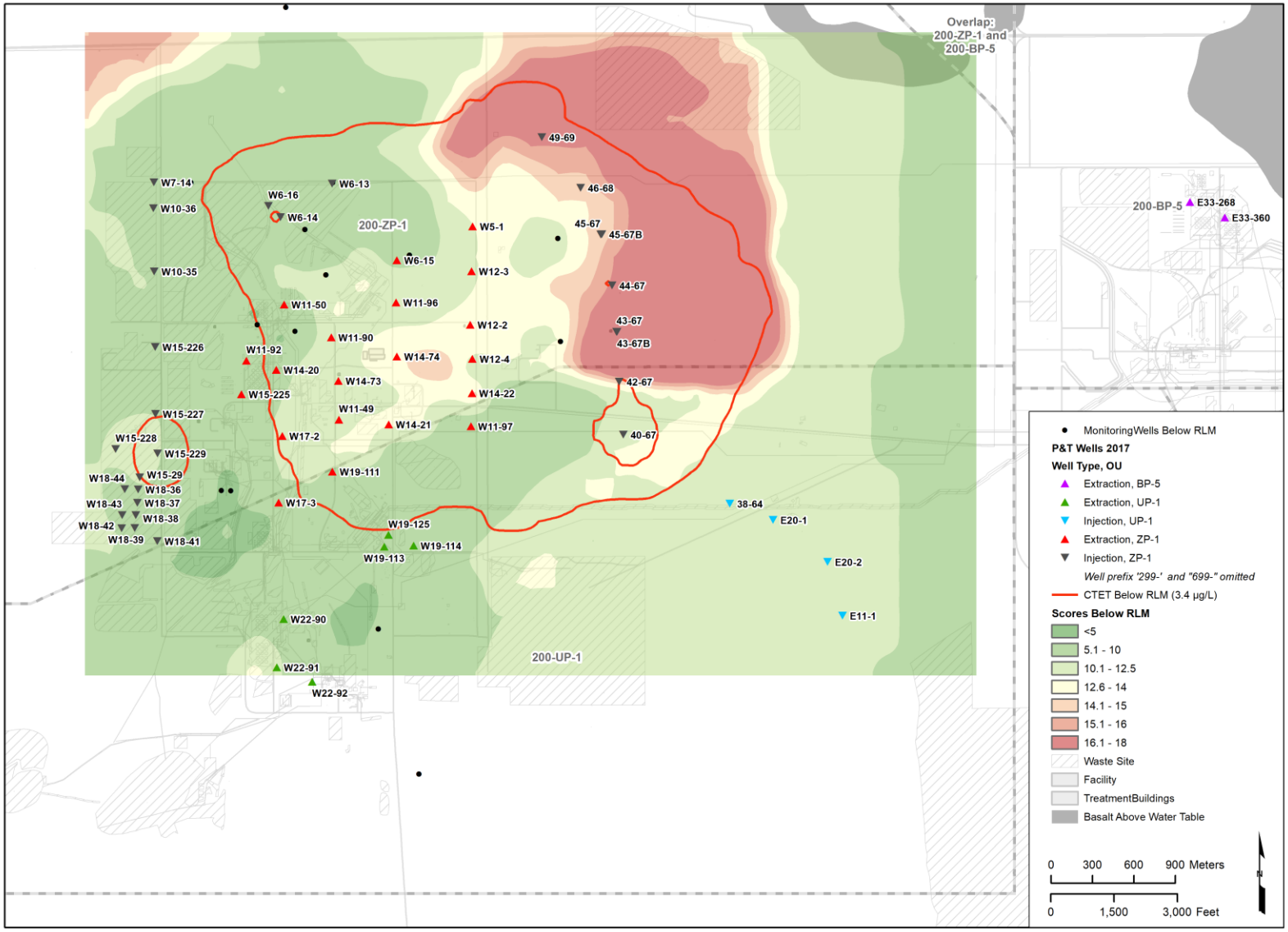
A6.1 Approach for Selecting Proposed Rwia Monitoring Well Locations

Since this study ultimately supports the multi-stage decision-making process identified in the 200-ZP-1 OU PMP (DOE/RL-2009-115), consistency and integration with the PMP, where appropriate, is a goal. The systematic data gap analysis process developed in 2017 (SGW-61350, *Data Gaps Evaluation in Groundwater Monitoring at the Hanford 200-ZP-1 Groundwater Operable Unit* [hereinafter referred to as the 200-ZP-1 OU data gap analysis]) for use in the PMP is one of the primary methods in this study to evaluate the need for and locations of new monitoring wells below the Rlm (in the Rwia).

The 200-ZP-1 OU data gap analysis (SGW-61350) followed the established and industry-standard methods to combine spatial statistics with evaluations of hydraulics and modeling using the Central Plateau Groundwater Model, as documented in CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.4.5*. The existing monitoring network was evaluated based on four primary factors:

- Proximity to active monitoring wells
- Kriging error variances (a factor that reflects the uncertainty associated with concentration interpolations)
- Hydraulic capture (containment) frequency predictions
- Predicted concentrations over time

These primary factors are assessed independently, and the associated results are then combined to identify and score potential monitoring well locations. The 200-ZP-1 OU data gap analysis (SGW-61350) provides additional information on the systematic process used to score potential locations for new monitoring wells below the Rlm (within the Rwia), and Figure A-5 shows a spatial representation of the resulting scores. The higher score locations shown in the figure generally indicate areas having a potential need for new Rwia monitoring wells based on the data gap study process.



Source: SGW-61350, *Data Gaps Evaluation in Groundwater Monitoring at the Hanford 200-ZP-1 Groundwater Operable Unit*.

Figure A-5. Data Gap Analysis Scores for Potential Monitoring Well Locations Below the Rlm

In addition to using the systematic process of the 200-ZP-1 OU data gap analysis (SGW-61350), professional judgment and conventional methods are used to evaluate the need for and locations of new Rwia monitoring wells. Figure A-6 provides a comparison of available monitoring wells that are screened in the Rwia, as well as the estimated extent of the Rlm based on the current Hanford South Geologic Framework Model, as documented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*. This comparison shows several areas that lack Rwia monitoring well coverage in the study area. The locations of the proposed monitoring wells to be installed in accordance with the 200-ZP-1 OU PMP (DOE/RL-2009-115) are also considered in relation to the areas that lack Rwia monitoring well coverage. The monitoring wells proposed in the PMP are also considered (as well as existing wells and piezometers) for potential use in post-installation hydraulic testing. The resulting map of the first eight proposed Rwia monitoring wells is shown in Figure 2 in the main text of this SAP, and a list of the proposed wells is provided in Table 1 in the main text.

The systematic data gap analysis process (SGW-61350) was developed so it could be updated as new data are collected from existing monitoring wells and from new monitoring wells installed under the main text of this SAP and the 200-ZP-1 OU PMP (DOE/RL-2009-115). The results of the updated data gap analysis will be combined with professional judgment, conventional methods, and evaluations of uncertainties to develop a new list of locations for the remaining four proposed Rwia monitoring wells to supplement the initial eight proposed Rwia monitoring wells.

A6.2 Approach for Determining Adequacy

The overall goal of the analytical approach is to obtain additional data (with emphasis on the Rwia) to provide for reliable and predictive F&T modeling to support P&T and MNA remedy optimization. The general approach to resolve the four DSs in this study is to adopt and expand upon previous work using methods similar to those used in past studies to complete integrated data analyses, set within an uncertainty management framework that considers the value added by new data and information.

This uncertainty management framework will be developed to establish the process for determining what is “adequately defined” for use in resolving the DSs. As discussed in Section A2, “adequately defined” will be determined in the context of the ability to reasonably predict the likely future performance of the remedy in attaining the RAOs specified in the 200-ZP-1 OU ROD (EPA et al., 2008), recognizing that although data may be sufficient to make a prediction, the data may not necessarily be adequate to make a reliable prediction.

Some uncertainties may not be meaningfully reduced by further data collection efforts and are, therefore, irreducible uncertainties. These uncertainties have to be managed in the decision-making process. To support the need for establishing what is considered to be adequately defined, the uncertainty management framework will be developed to propose a strategy incorporating the following three elements and associated specifications:

- **Data collection procedures and methods:** Data collection will be guided by integrated analyses of existing available data. The planning process will be founded on formalized and documented DQOs. Peer review will be conducted of the planning stages. State-of-the-art field techniques will be implemented. Data obtained will be subject to thorough quality assurance and quality control procedures.

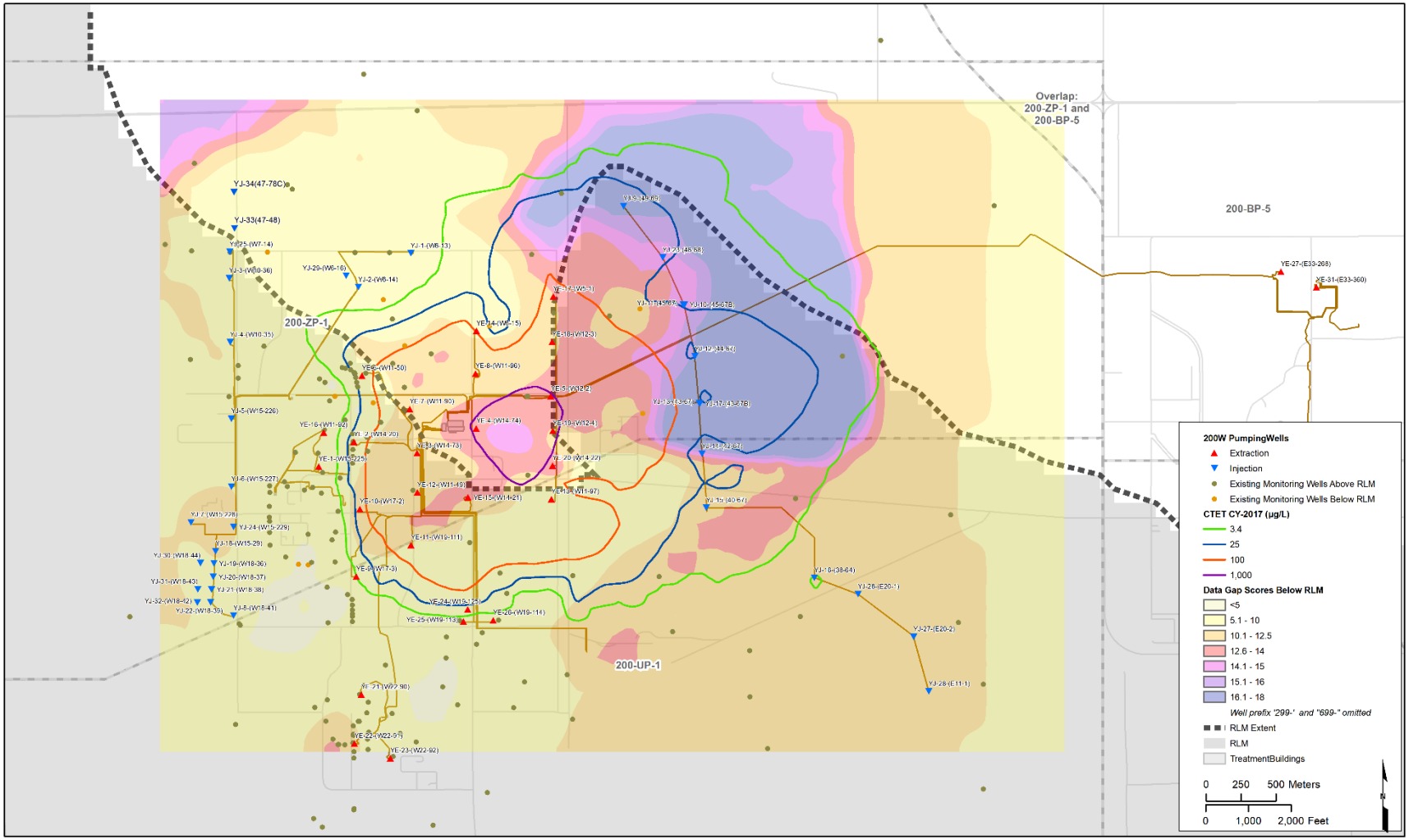


Figure A-6. Combined Map of Rlm Extent and the Carbon Tetrachloride Plume, Data Gap Analysis Scores, and Existing Monitoring Wells Below the Rlm

- **Spatial distribution and variability:** Sample data and geological characteristics will be evaluated using geostatistical methods that facilitate evaluation of spatial (and temporal) variability and uncertainty.
- **Statistical and modeling analysis methods:** The sequential analysis process will be focused on empirical data evaluations, historical modeling to calibrate flow fields and aspects of contaminant transport, and predictive modeling. The data gap analysis combines geostatistical descriptions of spatial variability with predictive modeling to estimate future migration to prioritize new data acquisition and improve knowledge.

Data collection methods are implemented to provide representative data values over space and time. Using these data, methods are available to characterize and quantify spatial and temporal variability. In addition, some aspects of associated uncertainties can also be quantified, although this also relies upon the judgment of subject matter experts.

Groundwater flow and contaminant F&T modeling have been used at the Hanford Site to guide remedy decisions and make predictions of likely future performance. Although imperfect, F&T modeling is the most suitable mechanism to combine available data and information to make predictions of future behavior and performance. When available data are combined with F&T modeling, predictions can be made, and some aspects of the uncertainty associated with those predictions can be quantified. For the purpose of this study, the reduction in the uncertainty associated with model predictions of future groundwater flow conditions, contaminant migration patterns and rates, and remedy performance will be used to evaluate the adequacy of the available data and information.

The uncertainty management framework developed will be documented in an internal document. The approach used and the outcome will be summarized and presented in the characterization report.

A6.3 Decision Rules and Approaches to Resolve Decision Statements

The inputs, analyses, and types of questions are described collectively as the analytical approach for resolving each DS. Details of the analytical approach, as well as the associated DRs, are discussed in the following sections. The considerations and planned procedure for determining what is adequately defined is discussed (in principle) in Section A6.2. This process will be further developed following issuance of this SAP and applies to all of the sections that follow.

A6.3.1 Decision Rule and Approach to Resolve Decision Statement #1

To determine if the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling, the following DR has been developed:

- **DR #1:** If the vertical and lateral spatial distribution of the aqueous and sorbed COC concentrations in the major facies of the Rwia and Rlm are adequately defined to support remedy performance evaluation and F&T modeling, then no further data collection is required. Otherwise, collect additional data to define the vertical and lateral distribution of COCs.

For each of the new Rwia monitoring wells installed, groundwater and sediment samples will be collected during drilling at the planned sampling intervals specified in Table 17 in the main text of this SAP. Additional groundwater samples will be collected from the constructed well following final well development. The groundwater samples will be analyzed for COCs and other constituents of interest, as specified in Tables A-1 and A-3. Sediment samples will be analyzed for COCs and other constituents of interest in accordance with Table A-2 and Table A-4.

Table A-3. Constituent Methods and Analytical Performance Requirements for Groundwater Samples

Survey/Analytical Method[a]	Required PQL[b]	Precision Requirement[c, d]	Accuracy Requirement[c, d]
SW-846, Method 8260, Carbon tetrachloride	3 µg/L	≤20%	70-130%
SW-846, Method 8260, Trichloroethene	2.1 µg/L	≤20%	70-130%
SW-846, Method 8260, Chloroform	5 µg/L	≤20%	70-130%
SW-846, Method 8260, Chloromethane	10 µg/L	≤20%	70-130%
SW-846, Method 8260, Dichloromethane	5.25 µg/L	≤20%	70-130%
SW-846, Method 8260, cis-1,2-Dichloroethene	5 µg/L	≤20%	70-130%
SW-846, Method 8260, Vinyl chloride	2.1 µg/L	≤20%	70-130%
SW-846 Method 6020, Chromium (total)	10.5 µg/L	≤20%	80-120%
SW-846, Method 7196, Chromium (hexavalent)	10.5 µg/L	≤20%	80-120%
SW-846, Method 6010, Iron	105 µg/L	≤20%	80-120%
SW-846, Method 6020, Manganese	5.25 µg/L	≤20%	80-120%
SW-846, Method 9056 or 300.0, Nitrate-N	250 µg/L	≤20%	80-120%
SW-846, Method 9056 or 300.0, Nitrite-N	250 µg/L	≤20%	80-120%
SW-846, Method 9045, pH	N/A	N/A	N/A
SW-846, Method 9056 or 300.0, Chloride	400 µg/L	≤20%	80-120%
SW-846, Method 9056 or 300.0A, Sulfate	1,050 µg/L	≤20%	80-120%
EPA 4500-S, 376.1, Sulfide	2.1 mg/L	≤20%	80-120%
SW-846, Method 9012/9014, 335.4, or SM 4500, Cyanide (total)	10.5 µg/L	≤20%	80-120%
SW-846, Method 2320 or 310.1, Alkalinity	5.25 mg/L	≤20%	80-120%
SW-846, Method 2540 or 160.1, Total dissolved solids	21 mg/L	≤20%	80-120%
SW-846, Method 9060 or 415.1, Total carbon	1.05 mg/L	≤20%	80-120%
SW-846, Method 9060 or 415.1, Total inorganic carbon	1.05 mg/L	≤20%	80-120%
SW-846, Method 9060 or 415.1, Total organic carbon	1.05 mg/L	≤20%	80-120%
SW-846, Method 6020, Uranium (total)	1.05 µg/L	≤20%	80-120%
Low-energy photon spectroscopy, Iodine-129	1 pCi/L	≤20%	70-130%
Liquid scintillation, Tritium	700 pCi/L	≤20%	70-130%
Liquid scintillation, Technetium-99	50 pCi/L	≤20%	70-130%

a. Equivalent methods may be substituted in future sampling and analysis instructions or other documents. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

b. PQLs are specified in contracts with analytical laboratories. Actual PQLs vary by laboratory and may be lower. Method detection limits for chemical analyses are three to five times lower than quantitation limits.

c. Precision and accuracy requirements are identified and defined in CHPRC-00189, *Environmental Quality Assurance Program Plan*.

Table A-3. Constituent Methods and Analytical Performance Requirements for Groundwater Samples

Survey/Analytical Method[a]	Required PQL[b]	Precision Requirement[c, d]	Accuracy Requirement[c, d]

d. Accuracy criteria are the minimum for associated batch laboratory control sample percent recoveries. Laboratories may use statistically derived control limits. Additional analyte-specific evaluations are also performed for matrix spikes and surrogates as appropriate to the method. Precision criteria are for batch laboratory replicate matrix spike analyses.

EPA = U.S. Environmental Protection Agency

N/A = not applicable

PQL = practical quantitation limit

Table A-4. Constituent Methods and Analytical Performance Requirements for Sediment Samples

Analytical Method[a]	Required PQL[b]	Precision Requirement[c, d]	Accuracy Requirement[c, d]
SW-846, Method 8260, Carbon tetrachloride[e]	5 µg/kg	≤20%	70-130%
SW-846, Method 8260, Trichloroethene[e]	5 µg/kg	≤20%	70-130%
SW-846, Method 8260, Chloroform[e]	5 µg/kg	≤20%	70-130%
SW-846, Method 8260, Chloromethane[e]	10 µg/kg	≤20%	70-130%
SW-846, Method 8260, Dichloromethane[e]	5 µg/kg	≤20%	70-130%
SW-846, Method 8260, cis-1,2-Dichloroethene[e]	5 µg/kg	≤20%	70-130%
SW-846, Method 8260, Vinyl chloride[e]	10 µg/kg	≤20%	70-130%
SW-846 Method 6020, Chromium (total)	1,000 µg/kg	≤35%	80-120%
SW-846, Method 7196, Chromium (hexavalent)	500 µg/kg	≤35%	80-120%
SW-846, Method 6010, Iron	25,000 µg/kg	≤35%	80-120%
SW-846, Method 6020, Manganese	1,000 µg/kg	≤35%	80-120%
SW-846, Method 9045, pH	N/A	N/A	N/A
SW-846, Method 9012/9014, 335.4, or SM 4500, Cyanide (total)	1,000 µg/kg	≤35%	80-120%
SW-846, Method 9060 or 415.1, Total carbon[e]	100,000 µg/kg	≤35%	80-120%
SW-846, Method 9060 or 415.1, Total inorganic carbon[e]	100,000 µg/kg	≤35%	80-120%
SW-846, Method 9060 or 415.1, Total organic carbon[e]	100,000 µg/kg	≤35%	80-120%
SW-846, Method 6020, Uranium (total)	150 µg/kg	≤35%	80-120%
Liquid scintillation, Technetium-99	5 pCi/g	≤30%	80-120%

a. Equivalent methods may be substituted in future sampling and analysis instructions or other documents. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

b. PQLs are specified in contracts with analytical laboratories. Actual PQLs vary by laboratory and may be lower. Method detection limits for chemical analyses are three to five times lower than quantitation limits.

c. Precision and accuracy requirements are identified and defined in CHPRC-00189, *Environmental Quality Assurance Program Plan*.

d. Accuracy criteria are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional analyte-specific evaluations also performed for matrix spikes and surrogates as appropriate to the method. Precision criteria are for batch laboratory replicate matrix spike analyses.

Table A-4. Constituent Methods and Analytical Performance Requirements for Sediment Samples

Analytical Method[a]	Required PQL[b]	Precision Requirement[c, d]	Accuracy Requirement[c, d]

e. Analysis to be performed by Pacific Northwest National Laboratory using full, intact liners C or D. If there is a question regarding the intact nature of the liners, the project scientist should be contacted for direction.

EPA = U.S. Environmental Protection Agency
N/A = not applicable
PQL = practical quantitation limit

The following inputs and analyses support this evaluation:

- Identify whether observed groundwater COC and other constituent concentration data collected during drilling are deviating from predicted values, which may suggest that contaminant nature and extent estimates used in the F&T model are not representative.
- Identify whether observed groundwater COC and other constituent concentration data collected post-development are deviating from predicted values, which may suggest that contaminant concentration estimates used in the F&T model are not representative.
- Identify whether observed sediment COC and other constituent concentration data collected during drilling are deviating from predicted values, which may suggest that contaminant estimates used in the conceptual site model are not representative.

Additional questions that should be answered include the following:

- Are there other factors that could impact the representativeness of the COC and other constituent concentration data collected?
- What changes to the estimated contaminant concentrations used in the F&T model and/or the conceptual site model would improve remedy evaluation and optimization efforts?

A6.3.2 Decision Rule and Approach to Resolve Decision Statement #2

To determine if the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and the contacts and transitions between the Rwia, Rwie, Rlm, and basalt are adequately defined to support F&T modeling, the following DR has been developed:

- **DR #2:** If the hydrogeologic properties and erosional features/unconformities of the Rwia and Rlm and the contacts and transitions between the Rwia, Rwie, Rlm, and basalt are adequately defined to support F&T modeling, then no further data collection is required. Otherwise, collect additional data to define these properties.

For each of the new Rwia monitoring wells installed, geologic observations are recorded continuously during drilling, and geophysical (spectral gamma and neutron moisture) logging data are collected in the boreholes prior to well construction. Sediment physical property samples will also be collected during drilling at the planned sampling intervals specified in Table 17 in the main text of this SAP. The sediment samples will be analyzed for hydrogeologic properties in accordance with Tables A-2 and A-5.

Table A-5. Physical Properties Methods for Sediment Samples

Physical Property	Analytical Method
Bulk density	ASTM D2937 or ASTM D7263[a]
Particle density	ASTM D854[a]
Particle-size distribution	ASTM D422 or ASTM D4464/D6913[a]
Porosity (apparent)	Calculated from bulk density and particle density
Saturated hydraulic properties (hydraulic conductivity/permeability)[b]	ASTM D5084 or ASTM D5856[a]

Note: Equivalent methods may be substituted in future sampling and analysis instructions or other documents.

a. For ASTM methods, see the following:

- ASTM D422: ASTM Standard D422-63(2007)e2, *Standard Test Method for Particle-Size Analysis of Soils*
- ASTM D854: ASTM Standard D854-14, *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer*
- ASTM D2937: ASTM Standard D2937-17e2, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*
- ASTM D4464: ASTM Standard D4464-15, *Standard Test Method for Particle Size Distribution of Catalytic Materials by Laser Light Scattering*
- ASTM D5084: ASTM Standard D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*
- ASTM D5856: ASTM Standard D5856-15, *Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter*
- ASTM D6913: ASTM Standard D6913/D6913M-17, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*
- ASTM D7263: ASTM Standard D7263-09(2018)e2, *Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens*

b. A full, intact liner is required for this analysis. If there is a question about the intact nature of the liner for this analysis, the project scientist should be contacted for direction.

ASTM = ASTM International (formerly the American Society for Testing and Materials)

The following inputs and analyses support this evaluation:

- Identify whether the geologic observations and geophysical data are deviating from the Hanford South Geologic Framework Model, which may suggest that the geologic framework model is not representative. Specific focus should be on the contacts and transitions between the Rwia, Rwie, Rlm, and basalt and the erosional features and unconformities of the Rwia and Rlm.
- Identify whether observed hydrogeologic properties are deviating from predicted values, which may suggest that estimated hydrogeologic properties used in the F&T model are not representative.

Additional questions that should be answered include the following:

- Are there other factors that could impact the representativeness of the geologic observations, geophysical logging data collected, or hydrogeologic properties data?
- What changes to the estimated geologic framework and hydrogeologic properties used in the F&T model would improve remedy evaluation and optimization efforts?

A6.3.3 Decision Rule and Approach to Resolve Decision Statement #3

To determine if the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling, the following DR has been developed:

- **DR #3:** If the hydraulic properties of the Rwia and Rlm are adequately defined to support F&T modeling, then no further data collection is required. Otherwise, collect additional data to define these properties.

For each of the new Rwia monitoring wells installed, sediment physical property samples will be collected during drilling at the planned sampling intervals specified in Table 17 in the main text of this SAP. These sediment samples will be analyzed for hydraulic properties in accordance with Tables A-2 and A-5. Hydraulic head distribution observations will be recorded regularly during drilling, and slug tests will be performed during drilling at the planned sampling intervals specified in Table 17 in the main text of this SAP. The slug tests will be conducted in accordance with procedures from the U.S. Department of Energy prime contractor (or its approved subcontractor).

Following construction and development of the Rwia monitoring wells, supplemental hydraulic testing will be specified and conducted under a separate hydraulic testing plan that will be developed following issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing plan and completion of the associated hydraulic testing work is a required task under this SAP. Possible post-completion supplemental hydraulic testing may include the following:

- Slug testing
- Multi-well constant-rate drawdown and recovery testing
- Single well constant-rate drawdown and recovery testing
- Single well step testing
- Barometric response function analysis (deconvolution)
- Borehole flowmeter testing
- Tracer testing

The following inputs and analyses support this evaluation:

- Identify whether observed hydraulic properties are deviating from predicted values, which may suggest that estimated hydraulic properties used in the F&T model are not representative.

Additional questions that should be answered include the following:

- Are there other factors that could impact the representativeness of the hydraulic properties data collected?

- What changes to the estimated hydraulic properties used in the F&T model would improve remedy evaluation and optimization efforts?

A6.3.4 Decision Rule and Approach to Resolve Decision Statement #4

To determine if the transport parameters for the 200-ZP-1 OU COCs are adequately defined within the Rwia and Rlm to support F&T modeling, the following DR has been developed:

- **DR #4:** If the transport parameters for the 200-ZP-1 OU COCs are adequately defined within the Rwia and Rlm to support F&T modeling, then no further data collection is required. Otherwise, collect additional data to define these properties.

For each of the new Rwia monitoring wells installed, sediment samples will be collected during drilling at the planned sampling intervals specified in Table 17 in the main text of this SAP. These sediment samples will be analyzed for transport parameters in accordance with Tables A-2 and A-4. Additionally, selected sediment samples will undergo laboratory contaminant mobility and transport studies at PNNL to better understand sediment/water partitioning and develop distribution coefficients for carbon tetrachloride in the Rwia and Rlm. These supplemental studies will only be conducted on sediment samples that correspond to groundwater samples with higher carbon tetrachloride concentrations (based on quick-turnaround analytical results). The supplemental studies will be conducted using PNNL-developed methods and procedures that are not specified in this DQO process.

The following inputs and analyses support this evaluation:

- Identify whether observed transport parameters are not within reasonable bounds given the current understanding of the system, which may suggest that estimated hydraulic properties used in the F&T model are not representative.

Additional questions that should be answered include the following:

- Are there other factors that could impact the representativeness of the transport parameter data collected?
- What changes to the estimated transport parameters used in the F&T model would improve remedy evaluation and optimization efforts?

A7 Specify Performance or Acceptance Criteria

The sixth step of the DQO process involves deriving the performance or acceptance criteria that the collected data need to achieve to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates within acceptable levels. Typically, the DR as a statistical hypothesis test is specified in this section, and the consequences of making incorrect decisions from the statistical hypothesis test are examined. However, the monitoring data statistical tests to support the end of the 200-ZP-1 OU remedial action have not been developed as part of the 200-ZP-1 OU PMP (DOE/RL-2009-115) and may not be applicable. Since this Rwia study supports the decision-making process identified in the 200-ZP-1 OU PMP, the language and requirements of this section will be generally consistent with the PMP, where appropriate.

More quantitative specifications of data quality are defined and presented as part of the quality assurance project plan provided in Chapter 2 in the main text of this SAP. The following sections present the potential uncertainties associated with the data to be collected and the potential impacts of those uncertainties.

A7.1 Groundwater Levels

Groundwater-level data consist of several components:

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

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

Groundwater elevation errors can be detected by preparing a two-dimensional water table map and looking for irregularities in the elevation contours or conducting more formal cross-validation analyses of the groundwater elevation data incorporating suitable trending and regression-based methods. These methods comprise spatial evaluations of data consistency. Newly obtained groundwater elevation data can also be compared to previously collected data through visual hydrograph analysis and more formal temporal cross-validation analyses. These methods comprise temporal evaluations of data consistency. While sometimes difficult to detect, such errors can be managed by designing hydraulic capture zones conservatively with an appropriate margin of safety so small irreducible errors in measured groundwater elevations do not lead to less-than-expected plume capture or unnecessary overpumping.

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

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

Groundwater-level data collected during hydraulic testing (following well construction) will be discussed further in the subsequently developed hydraulic testing plan. Requirements for data collection during hydraulic testing will be specified in that plan.

A7.2 Pumping Rates

Measured pumping-rate data collected during hydraulic testing (following well construction) will be discussed further in the subsequently developed hydraulic testing plan. Requirements for data collection during hydraulic testing will be specified in the testing plan.

A7.3 Contaminant Concentrations

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

needed to construct three-dimensional contaminant plume depictions. To meet this goal, the required practical quantitation limits (PQLs) should be equal to, or ideally less than, required groundwater cleanup levels. Tables A-3 and A-4 list the analytical methods, accuracy and performance requirements, and required PQLs for COCs and other constituents.

Failure to set required PQLs equal to or less than the cleanup levels could result in groundwater contaminant monitoring data of insufficient quality. Since three-dimensional contaminant plume depictions are usually constructed with the lowest concentration isosurface depicting the estimated extent at the cleanup level, using the required PQLs above the cleanup levels will result in a lack of data to establish plume outer boundaries. This will result in errors in the reported mass and volume statistics, errors in extraction well capture analyses, and errors in simulated contaminant transport.

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

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

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

Another aspect of the vertical spatial positioning of data obtained from the 200-ZP-1 OU monitoring wells is that many of the wells have relatively long screened intervals. The screen length for more recently installed groundwater monitoring wells typically ranges from 1.5 to 4.6 m (5 to 20 ft); however, many of the older 200-ZP-1 OU monitoring wells have screen lengths in excess of 9.1 m (30 ft). The screen length variations can lead to uncertainty in the vertical position from which groundwater samples were obtained and can result in high contaminant concentration intervals being diluted by less contaminated groundwater from surrounding aquifer intervals. Again, such errors could potentially lead to errors in the three-dimensional contaminant plume depictions and less-than-expected plume capture.

Vertical spatial position errors in contaminant concentration sampling data are relatively difficult to detect and manage. Well construction information for a particular monitoring well should be reviewed if samples collected from the well are questionable in relation to other upgradient and downgradient samples. However, the relatively low density of samples usually makes it difficult to detect these types of errors. In general, the uncertainty in three-dimensional contaminant plume delineation caused by the

sparse sampling network is much greater than all of the other sources of contaminant concentration uncertainty. This uncertainty is furthered by the relative coarseness of the contaminant transport model grid and the uncertainty in the model transport parameters. These errors are most often managed by using professional judgment when evaluating the three-dimensional plume depictions and resulting model simulations for consistency with the conceptual site model and hydrologic principles, as well as by questioning any discrepancies.

A7.4 Other Measured Parameters

Tables A-1 and A-2 list other constituent parameters that are included with laboratory analyses. Evaluating these parameters may provide a better understanding of natural attenuation conditions and/or reaction pathways within plume reactive zones. Measurement errors for these parameters would usually have little impact on any significant decisions regarding natural attenuation processes.

Table A-1 also lists the groundwater parameters typically measured in the field at each sampled monitoring well during each monitoring event. These parameters may be monitored continuously in a flow-through cell apparatus during monitoring well sampling. Stable readings are an indication that sufficient purgewater has been withdrawn from a well and that a representative sample of the groundwater can be collected. These parameters are also important for monitoring natural attenuation processes. Field measurement errors for these parameters would usually have little impact on any significant decisions regarding natural attenuation processes.

A7.5 Model Predictions

The groundwater flow and transport model is an important tool for simulating hydraulic capture and predicting whether the remedy target of 95% mass reduction within 25 years and the ultimate remedy RAO of aquifer cleanup within 125 years will be achieved. However, there are uncertainties associated with the use of groundwater flow and F&T modeling that can lead to misunderstanding of model prediction reliability. The potential impact of such uncertainties on the decision process can be minimized by using multiple lines of evidence to increase the confidence in model predictions by ensuring that all available data are used. Examples of available methods are described below; however, the procedure outlined in Section A6.2 for determining adequacy will ultimately be used to identify and incorporate suitable methods in the workflow process.

One example method is hydraulic capture (containment). The ability of the groundwater flow model to accurately simulate hydraulic capture can be evaluated by using a residual analysis method. The residual analysis method compares the simulated head distribution from the model to the measured groundwater elevations, displaying the difference in terms of the estimated extent of hydraulic capture. This technique is useful for determining if the model calibration is adequate and ensures that available data are used to support decisions regarding plume capture and remedy optimization. The residual analysis method for analyzing hydraulic data in the context of hydraulic capture (containment) usually includes the following steps.

1. Calculate the differences between groundwater elevations measured at the monitoring wells during the synoptic monitoring event and the elevations simulated by the groundwater flow model using remedy extraction and injection rates recorded during the synoptic monitoring event. These differences constitute the residuals.

2. Combine the simulated elevations with the calculated residuals, producing an estimated groundwater elevation distribution that closely approximates measured values while retaining the underlying trend and structure provided by the groundwater flow model.

3. Implement particle tracking to calculate an estimated extent of hydraulic capture (containment) that combines the measured and modeled information.

4. Compare the estimated extent of hydraulic capture that is obtained in steps 1 through 3 with that estimated on the basis of the groundwater flow model outputs, absent the addition of the residuals.

Groundwater elevation data collected during the most recent water-level monitoring event would provide the calibration targets for model recalibration if the procedure described above suggests that recalibration is warranted.

Another example method is three-dimensional plume depictions. The ability of the groundwater transport model to accurately simulate plume migration depends, in part, on the accuracy of the starting concentration distribution (three-dimensional plume depiction) and the contaminant transport parameters used in the model. Additionally, the processes and parameters represented in the model are approximations of the "real" transport processes and parameters. The three-dimensional plume for each contaminant will adequately represent the available sampling data at the sampling locations based on the construction method (kriging). The uncertainty involves the areas in between the sampling locations and the outer boundaries of the plume depictions. The accuracy of each three-dimensional plume depiction can be increased by providing additional sampling locations. However, increasing the number of monitoring wells is costly and over time suffers from reduced benefit (in terms of reduction in uncertainty).

A third example method that can be used to reduce this uncertainty involves using measured extraction well contaminant concentrations and mass recovery as targets or constraints for transport modeling, and then adjusting the plume contaminant distribution until simulated extraction well concentrations and mass recovery are in reasonable agreement with measured values. The use of such methods ensures that multiple lines of evidence are being used to construct and refine the three-dimensional contaminant distributions.

A fourth example method is predicted contaminant transport. Contaminant transport parameters used in the model can be evaluated by simulating the forward (in time) migration of plume depictions prepared using historical data and comparing the simulated contaminant concentrations to more recently measured contaminant concentrations and concentration trends at monitoring wells. This evaluation can reduce the uncertainty in the transport parameters controlling the physical, chemical, and biological processes that influence contaminant F&T, and it may result in changes to the model parameters that control dispersion, retardation, and biodegradation. The use of such methods ensures that multiple lines of evidence are used to reduce the uncertainty associated with model predictions.

A8 Develop the Plan for Obtaining Data

The seventh step of the DQO process is to develop the sampling and analysis design to generate data needed to address the DSs provided in Section A3. The design for collecting data for contaminant concentration, physical properties, and initial limited hydraulic properties is discussed in Chapter 3 in the main text of this SAP. More extensive hydraulic testing will be documented and performed under a separate hydraulic testing plan that is a required task under this SAP.

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Appendix B

200-ZP-1 Operable Unit Ringold Formation Unit A Proposed Monitoring Well Profiles

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Figures

Figure B-1. Proposed Monitoring Well MW-A Profile B-2
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B 200-ZP-1 Operable Unit Ringold Formation Unit A Proposed Monitoring Well Profiles

Figures B-1 through B-8 in this appendix present well profiles for proposed monitoring wells to be installed in and around the 200-ZP-1 Groundwater Operable Unit (OU) to support characterization of the Ringold Formation member of Wooded Island – unit A. The well profiles are provided to summarize the estimated depths to geologic contacts, anticipated sampling intervals, and potential well construction for each proposed monitoring well.

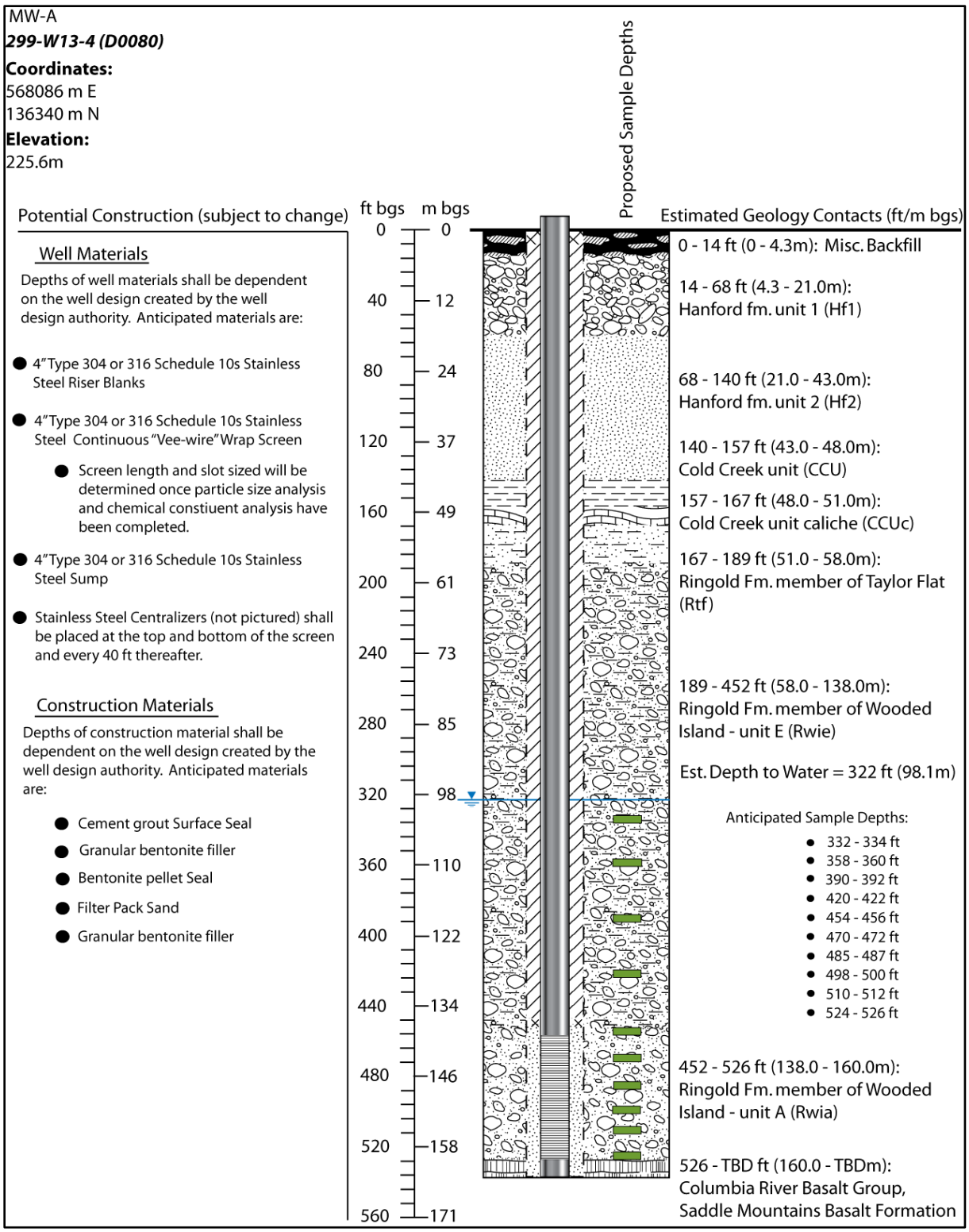


Figure B-1. Proposed Monitoring Well MW-A Profile

MW-B

299-W19-133 (D0081)

Coordinates:
567849 m E
135350 m N

Elevation:
219.5m

Potential Construction (subject to change)

Well Materials

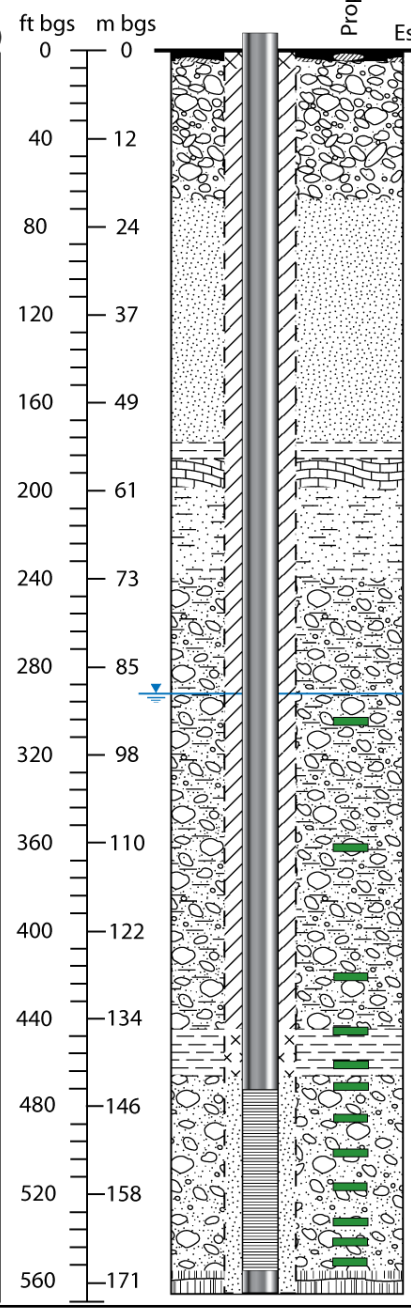
Depths of well materials shall be dependent on the well design created by the well design authority. Anticipated materials are:

- 4"Type 304 or 316 Schedule 10s Stainless Steel Riser Blanks
- 4"Type 304 or 316 Schedule 10s Stainless Steel Continuous "Vee-wire" Wrap Screen
  - Screen length and slot sized will be determined once particle size analysis and chemical constiuent analysis have been completed.
- 4"Type 304 or 316 Schedule 10s Stainless Steel Sump
- Stainless Steel Centralizers (not pictured) shall be placed at the top and bottom of the screen and every 40 ft thereafter.

Construction Materials

Depths of construction material shall be dependent on the well design created by the well design authority. Anticipated materials are:

- Cement grout Surface Seal
- Granular bentonite filler
- Bentonite pellet Seal
- Filter Pack Sand
- Granular bentonite filler



Estimated Geology Contacts (ft/m bgs)

0 - 3 ft (0 - 0.9m): Misc. Backfill

3 - 67 ft (0.9 - 20.4m): Hanford fm. unit 1 (Hf1)

67 - 176 ft (20.4 - 54.0m): Hanford fm. unit 2 (Hf2)

176 - 186 ft (54.0 - 57.0m): Cold Creek unit (CCU)

186 - 198 ft (57.0 - 60.4m): Cold Creek unit caliche (CCUc)

198 - 240 ft (60.4 - 73.2m): Ringold Fm. member of Taylor Flat (Rtf)

240 - 445 ft (73.2 - 136.0m): Ringold Fm. member of Wooded Island - unit E (Rwie)

Est. Depth to Water = 293 ft (89.3m)

Anticipated Sample Depths:

- 303 - 305 ft
- 360 - 362 ft
- 420 - 422 ft
- 447 - 449 ft
- 460 - 462 ft
- 470 - 472 ft
- 485 - 487 ft
- 500 - 502 ft
- 515 - 517 ft
- 530 - 532 ft
- 541 - 543 ft
- 552 - 554 ft

445 - 466 ft (136.0 - 142.0m): Ringold Fm. member of Wooded Island - lower mud unit (Rlm)

466 - 554 ft (142.0 - 169.0m): Ringold Fm. member of Wooded Island - unit A (Rwia)

554 - TBD ft (169.0 - TBDm): Columbia River Basalt Group, Saddle Mountains Basalt Formation

Figure B-2. Proposed Monitoring Well MW-B Profile

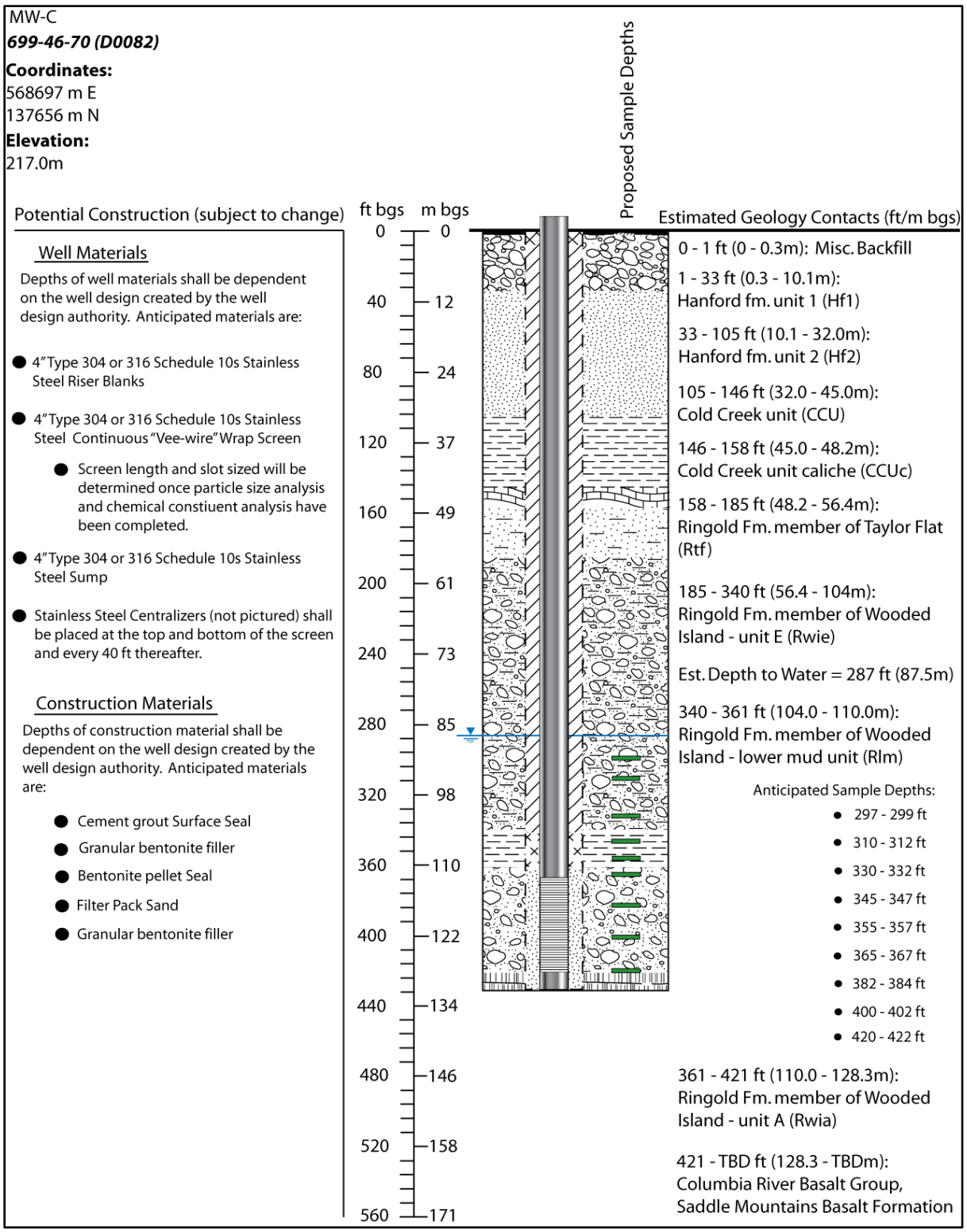


Figure B-3. Proposed Monitoring Well MW-C Profile

MW-D

699-45-67C (D0083)

Coordinates:
569433 m E
137129 m N

Elevation:
221.6m

Potential Construction (subject to change)

Well Materials

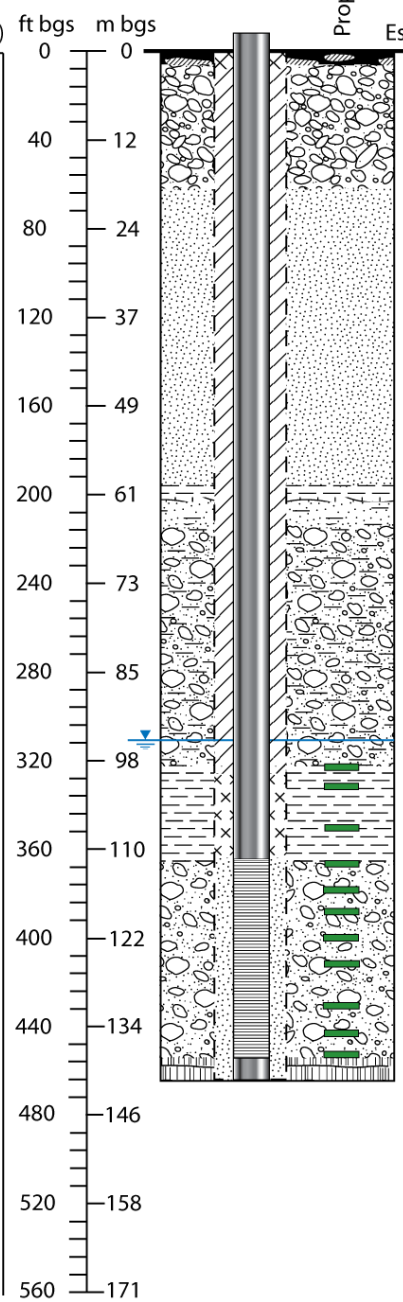
Depths of well materials shall be dependent on the well design created by the well design authority. Anticipated materials are:

- 4"Type 304 or 316 Schedule 10s Stainless Steel Riser Blanks
- 4"Type 304 or 316 Schedule 10s Stainless Steel Continuous "Vee-wire" Wrap Screen
  - Screen length and slot sized will be determined once particle size analysis and chemical constiuent analysis have been completed.
- 4"Type 304 or 316 Schedule 10s Stainless Steel Sump
- Stainless Steel Centralizers (not pictured) shall be placed at the top and bottom of the screen and every 40 ft thereafter.

Construction Materials

Depths of construction material shall be dependent on the well design created by the well design authority. Anticipated materials are:

- Cement grout Surface Seal
- Granular bentonite filler
- Bentonite pellet Seal
- Filter Pack Sand
- Granular bentonite filler



Estimated Geology Contacts (ft/m bgs)

0 - 7 ft (0 - 2.1m): Misc. Backfill

7 - 62 ft (2.1 - 19.0m): Hanford fm. unit 1 (Hf1)

62 - 196 ft (19.0 - 60.0m): Hanford fm. unit 2 (Hf2)

196 - 202 ft (60.0 - 61.6m): Cold Creek unit (CCU)

202 - 203 ft (61.6 - 61.9m): Cold Creek unit caliche (CCUc)

203 - 214 ft (61.9 - 65.2m): Ringold Fm. member of Taylor Flat (Rtf)

214 - 322 ft (65.2 - 98.1m): Ringold Fm. member of Wooded Island - unit E (Rwie)

Est. Depth to Water = 311 ft (95.0m)

322 - 366 ft (98.1 - 111.6m): Ringold Fm. member of Wooded Island - lower mud unit (Rlm)

366 - 454 ft (111.6 - 138.4m): Ringold Fm. member of Wooded Island - unit A (Rwia)

Anticipated Sample Depths:

- 321 - 323 ft
- 330 - 332 ft
- 350 - 352 ft
- 366 - 368 ft
- 377 - 379 ft
- 387 - 389 ft
- 399 - 401 ft
- 410 - 412 ft
- 430 - 432 ft
- 442 - 444 ft
- 453 - 455 ft

454 - TBD ft (138.4 - TBDm): Columbia River Basalt Group, Saddle Mountains Basalt Formation

Figure B-4. Proposed Monitoring Well MW-D Profile

MW-E

299-W14-26 (D0084)

Coordinates:

567285 m E

135729 m N

Elevation:

216.4m

Potential Construction (subject to change)

Well Materials

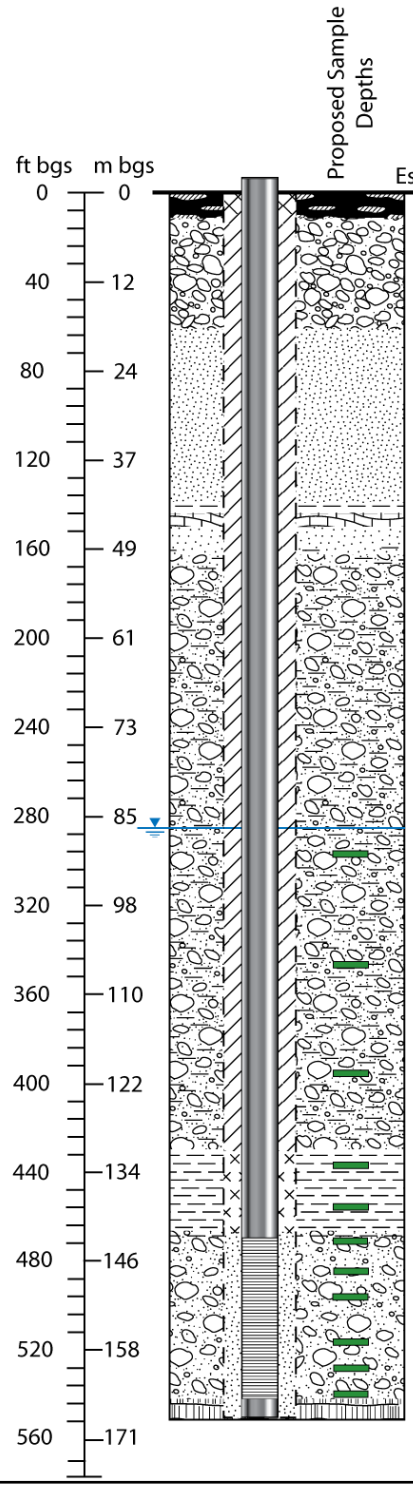
Depths of well materials shall be dependent on the well design created by the well design authority. Anticipated materials are:

- 4"Type 304 or 316 Schedule 10s Stainless Steel Riser Blanks
- 4"Type 304 or 316 Schedule 10s Stainless Steel Continuous "Vee-wire" Wrap Screen
  - Screen length and slot sized will be determined once particle size analysis and chemical constiuent analysis have been completed.
- 4"Type 304 or 316 Schedule 10s Stainless Steel Sump
- Stainless Steel Centralizers (not pictured) shall be placed at the top and bottom of the screen and every 40 ft thereafter.

Construction Materials

Depths of construction material shall be dependent on the well design created by the well design authority. Anticipated materials are:

- Cement grout Surface Seal
- Granular bentonite filler
- Bentonite pellet Seal
- Filter Pack Sand
- Granular bentonite filler



Estimated Geology Contacts (ft/m bgs)

0 - 10 ft (0 - 3.0m): Misc. Backfill

10 - 61 ft (3.0 - 19.0m): Hanford fm. unit 1 (Hf1)

61 - 138 ft (19.0 - 42.1m): Hanford fm. unit 2 (Hf2)

138 - 143 ft (42.1 - 44.0m): Cold Creek unit (CCU)

143 - 151 ft (44.0 - 46.0m): Cold Creek unit caliche (CCUc)

151 - 160 ft (46.0 - 49.0m): Ringold Fm. member of Taylor Flat (Rtf)

160 - 428 ft (49.0 - 130.5m): Ringold Fm. member of Wooded Island - unit E (Rwie)

Est. Depth to Water = 286 ft (87.2m)

Anticipated Sample Depths:

- 296 - 298 ft
- 345 - 347 ft
- 395 - 397 ft
- 435 - 437 ft
- 455 - 457 ft
- 470 - 472 ft
- 483 - 485 ft
- 495 - 497 ft
- 515 - 517 ft
- 527 - 529 ft
- 539 - 541 ft

428 - 468 ft (130.5 - 143.0m): Ringold Fm. member of Wooded Island - lower mud unit (Rlm)

468 - 541 ft (143.0 - 165.0m): Ringold Fm. member of Wooded Island - unit A (Rwia)

541 - TBD ft (165.0 - TBDm): Columbia River Basalt Group, Saddle Mountains Basalt Formation

Figure B-5. Proposed Monitoring Well MW-E Profile

MW-F
699-40-70 (D0085)
Coordinates:
568732 m E
135703 m N
Elevation:
224.9m

Potential Construction (subject to change)

Well Materials

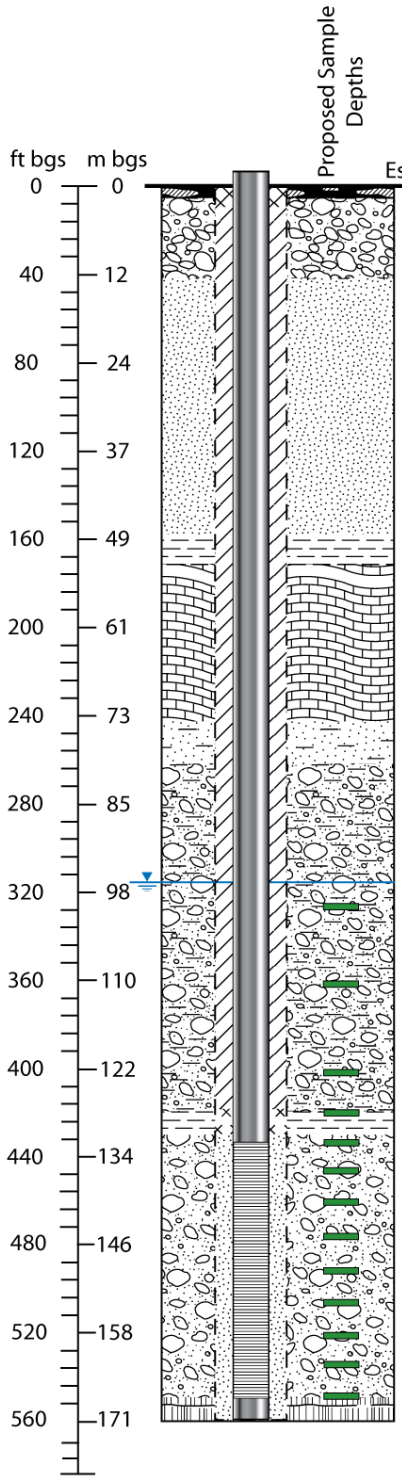
Depths of well materials shall be dependent on the well design created by the well design authority. Anticipated materials are:

- 4" Type 304 or 316 Schedule 10s Stainless Steel Riser Blanks
- 4" Type 304 or 316 Schedule 10s Stainless Steel Continuous "Vee-wire" Wrap Screen
  - Screen length and slot sized will be determined once particle size analysis and chemical constiuent analysis have been completed.
- 4" Type 304 or 316 Schedule 10s Stainless Steel Sump
- Stainless Steel Centralizers (not pictured) shall be placed at the top and bottom of the screen and every 40 ft thereafter.

Construction Materials

Depths of construction material shall be dependent on the well design created by the well design authority. Anticipated materials are:

- Cement grout Surface Seal
- Granular bentonite filler
- Bentonite pellet Seal
- Filter Pack Sand
- Granular bentonite filler



Estimated Geology Contacts (ft/m bgs)

0 - 6 ft (0 - 1.8m): Misc. Backfill

6 - 40 ft (1.8 - 12.2m): Hanford fm. unit 1 (Hf1)

40 - 157 ft (12.2 - 48.0m): Hanford fm. unit 2 (Hf2)

157 - 173 ft (48.0 - 53.0m): Cold Creek unit (CCU)

173 - 242 ft (53.0 - 74.0m): Cold Creek unit caliche (CCUc)

242 - 261 ft (74.0 - 80.0m): Ringold Fm. member of Taylor Flat (Rtf)

261 - 419 ft (80.0 - 128.0m): Ringold Fm. member of Wooded Island - unit E (Rwie)

Est. Depth to Water = 315 ft (96.0m)

Anticipated Sample Depths:

- 325 - 327 ft
- 360 - 362 ft
- 400 - 402 ft
- 422 - 424 ft
- 432 - 434 ft
- 446 - 448 ft
- 460 - 462 ft
- 475 - 477 ft
- 490 - 492 ft
- 505 - 507 ft
- 520 - 522 ft
- 534 - 536 ft
- 548 - 550 ft

419 - 430 ft (128.0 - 131.1m): Ringold Fm. member of Wooded Island - lower mud unit (Rlm)

430 - 549 ft (131.1 - 167.3m): Ringold Fm. member of Wooded Island - unit A (Rwia)

549 - TBD ft (167.3 - TBDm): Columbia River Basalt Group, Saddle Mountains Basalt Formation

Figure B-6. Proposed Monitoring Well MW-F Profile

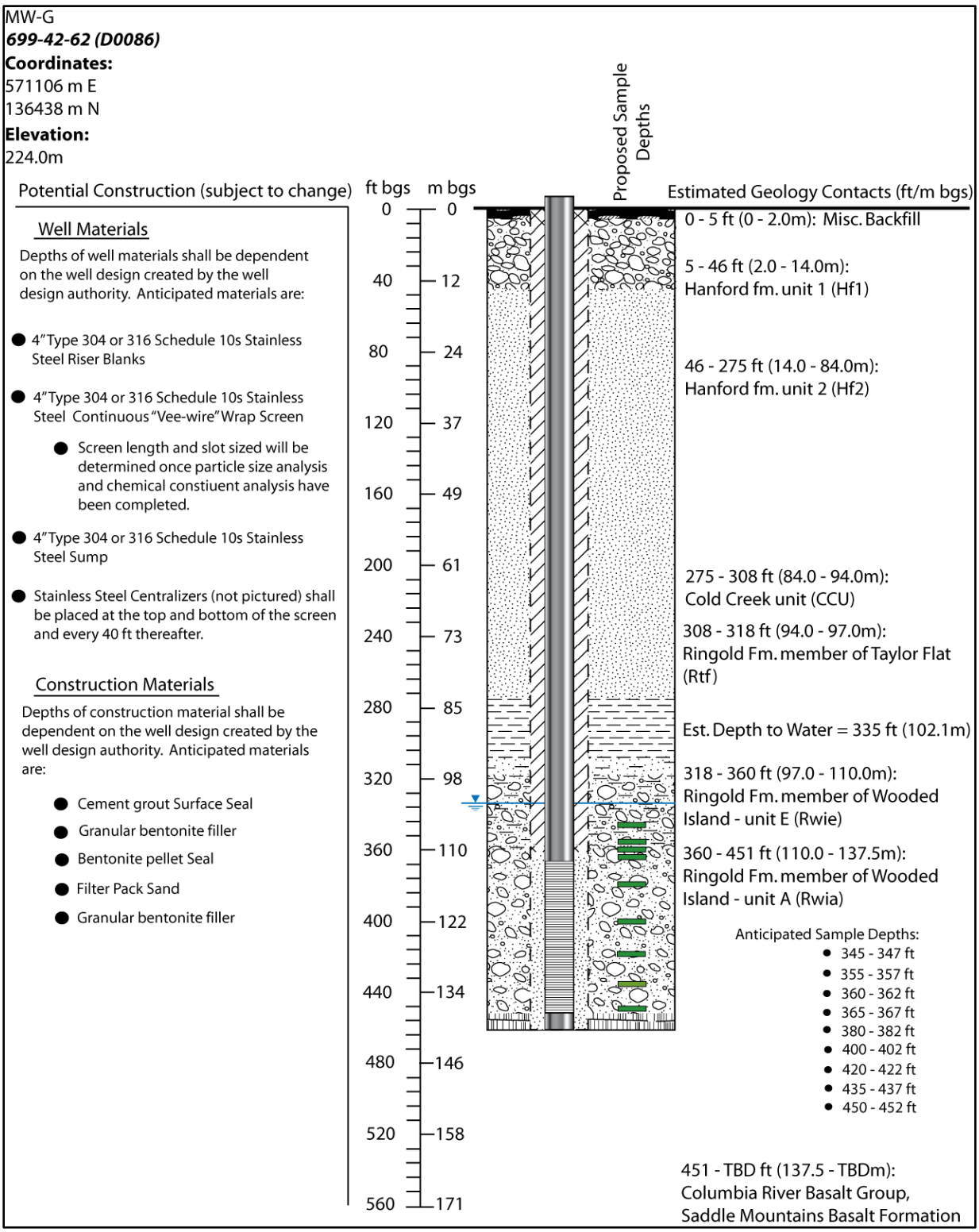


Figure B-7. Proposed Monitoring Well MW-G Profile

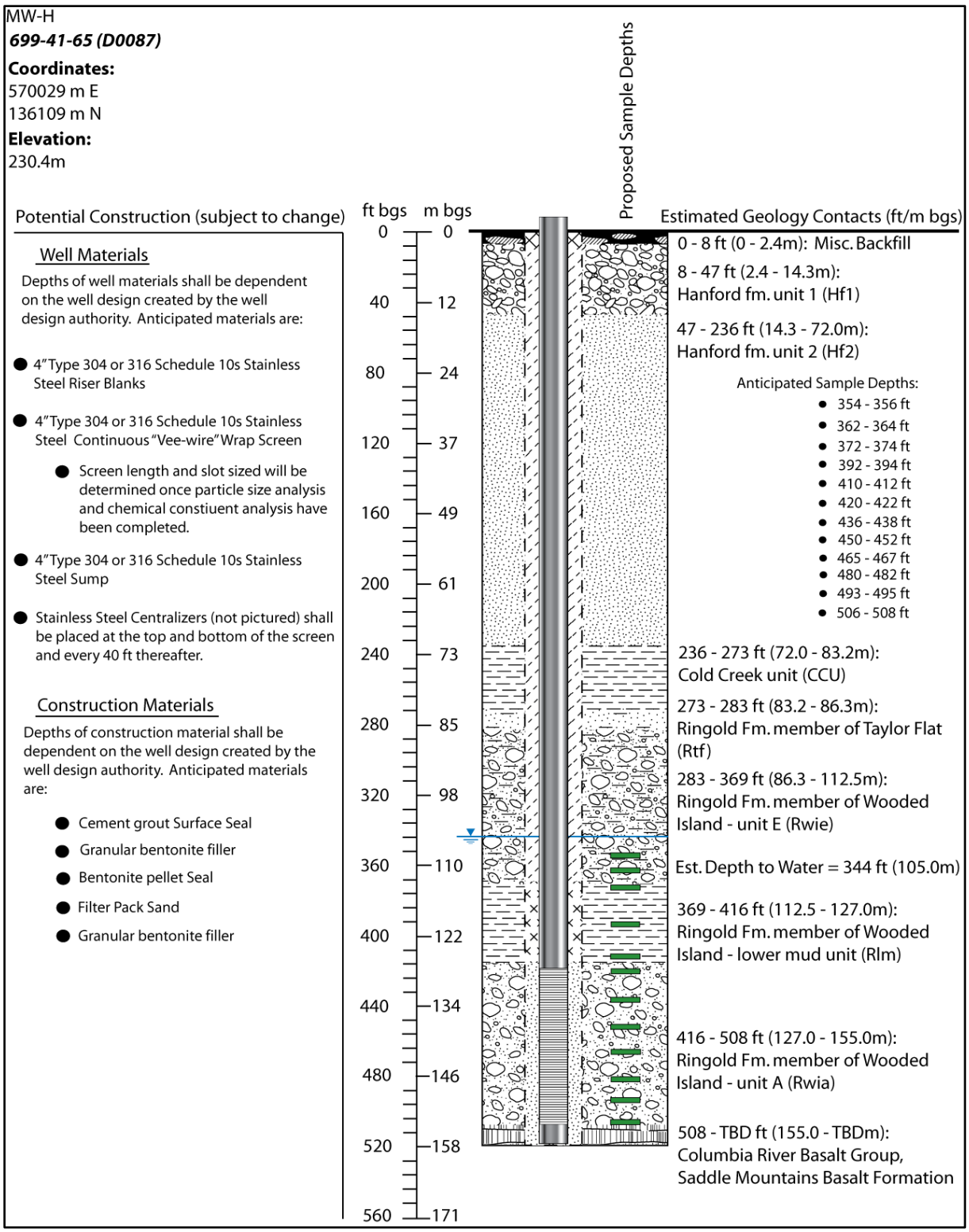


Figure B-8. Proposed Monitoring Well MW-H Profile

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