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Revision 0

DATA USABILITY ASSESSMENT FOR THE 200-DV-1 DEEP AND SHALLOW SOIL CHARACTERIZATION BOREHOLES

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

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

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Richland, Washington 99352

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Terms

ADD2	Addendum 2
bgs	below ground surface
COPC	contaminant of potential concern
DUA	data usability assessment
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DVZ	deep vadose zone
DS	decision statement
EB	equipment blank
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FXR	field transfer blank
GEA	gamma energy analysis
GEL	GEL Laboratories
HEIS	Hanford Environmental Information System
HHE	human health and the environment
ICP	inductively coupled plasma
ICP/MS	inductively coupled plasma/mass spectrometry
LCD	laboratory control sample duplicate
LCS	laboratory control sample
MS	matrix spike
MDA	minimum detectable activity
MDL	method detection limit
MSD	matrix spike duplicate
OU	operable unit
PCB	polychlorinated biphenyl
PSQ	principal study question

PQL	practical quantitation limit
QA	quality assurance
QC	quality control
RBL	risk-based level
RPD	relative percent difference
SAP	sampling and analysis plan
SVOA	semivolatile organic analysis
SVOC	semivolatile organic compound
TARL	Test America – Richland
TASL	Test America – St. Louis
TPH	total petroleum hydrocarbons
VOA	volatile organic analysis
VOC	volatile organic compound
WMA	waste management area

1 Introduction

This data usability assessment (DUA) report evaluates the laboratory data for soil samples collected as part of soil characterization conducted at select 200-DV-1 Operable Unit (OU) waste sites in the Hanford Site Central Plateau. The 200-DV-1 OU was created to support remedy selection for waste sites with deep vadose zone (DVZ) contamination. In general, DVZ contamination poses a potential threat to groundwater and cannot be remediated using standard surface-based remedies. The 200-DV-1 OU data needs and the results of the data quality objective (DQO) process for the 200-DV-I OU waste sites are documented in the 200-DV-1 OU work plan (DOE/RL-2011-102, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan*). DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit* (hereinafter referred to as the sampling and analysis plan [SAP]); and DOE/RL-2011-104-ADD2, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 2: Supplemental Shallow Soil Risk Characterization Sampling* (hereinafter referred to as the SAP Addendum 2 [ADD2]) describe how characterization data should be collected so the resulting data are the right type and of sufficient quality and quantity to support remedial action decisions. The purpose of this DUA is to determine whether the data collected meet the SAP and SAP ADD2 requirements and to specify how the quality control (QC) limits were met. The DUA evaluates the data set to determine if the data are sufficient to support remedy selection.

Data collected under the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2) will be used to determine the nature and extent of contamination from the ground surface to the groundwater. Soil sample results will be used during the remedy selection process as follows:

- To evaluate potential impacts to human health and the environment (HHE)
- To evaluate potential impacts on groundwater and the Columbia River
- To evaluate a combination of proven and emerging technologies for characterizing, remediating, and monitoring DVZ contamination
- To evaluate, select, and implement remedial solutions for contamination in the vadose zone to protect HHE and groundwater

The data quality assessment (DQA) process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. When judgmental (focused) sampling designs are implemented in the field, data quality indicators (DQIs) such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets are 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 DQI evaluation process. Results of the DQI processes generated by the CH2M HILL Plateau Remediation Company Sample Management and Reporting organization will be used by the contractor 200-DV-1 OU manager to interpret the data and determine if the DQOs for this activity have been met. This DUA includes soil samples collected using an approach that combines judgmental (SAP [DOE/RL-2011-104] and SAP ADD2 [DOE/RL-2011-104-ADD2]) and randomly selected sample locations (SAP ADD2) to evaluate the DQIs for the resulting analytical data set.

In the 200 East Area, the 200-DV-1 OU waste sites are near Waste Management Area (WMA) B-BX-BY, referred to in the SAP (DOE/RL-2011-104) as the B Complex area. In the 200 West Area, the 200-DV-I OU waste sites are near WMA T-TX-TY, referred to in the SAP as the T Complex area; and WMA S-SX, referred to in the SAP as the S Complex area. Characterization activities included collecting soil samples from 26 boreholes in the B Complex area (Figure 1), 11 boreholes in the S Complex area (Figure 2), and 28 boreholes in the T Complex area (Figure 3). Soil samples collected under the SAP are referred to as "deep borehole" samples; soil samples collected under the SAP ADD2 (DOE/RL-2011-104-ADD2) are referred to as "shallow borehole" samples.

The SAP (DOE/RL-2011-104) identifies 26 borehole locations at 18 waste sites for characterization. Twenty-two of the boreholes included soil sample collection, and 4 boreholes required geophysical logging only. This DUA focuses on laboratory analytical data obtained from the soil samples. The four boreholes that were geophysically logged but not sampled are not included in the scope of this DUA. The SAP ADD2 (DOE/RL-2011-104-ADD2) identifies 28 additional borehole locations at 16 waste sites for soil sample collection. Due to difficult drilling conditions, at times multiple boreholes were required to be drilled at each of the locations shown in Figures 1, 2, and 3 to reach total depth. The identification number for all of the boreholes required at each location are listed next to each location shown in Figures 1, 2, and 3.

2 Laboratory Information

Soil samples were analyzed at the following laboratories:

- GEL Laboratories (GEL), located in Charleston, South Carolina, performed chemical and radiological analyses on 173 deep borehole samples between July 2015 and July 2016 and 139 shallow borehole samples collected between January 9, 2018, and March 13, 2018.
- Test America – Richland (TARL), located in Richland, Washington, performed chemical and radiological analyses on 201 deep borehole samples between November 2015 and August 2017.
- Test America – St. Louis (TASL), located in St. Louis, Missouri, performed chemical analyses on 278 deep borehole samples between November 2015 and October 2017 and 128 shallow borehole samples collected between January 9, 2018, and March 13, 2018.

Chapters 8, 9, and 10 discuss the analytical data provided by these laboratories.

2.1 Analytical Methods

Samples were analyzed using the methods listed in Table 1. Both multi- and single-component, method-based analyses were used. Multi-component, method-based analyses are typically based on U.S. Environmental Protection Agency (EPA) methods (as applicable) that yield concentration data for multiple analytes in a single analysis. The analytes may include both target and nontarget analytes. Single-component, method-based analyses are typically based upon EPA methods (as applicable) that yield concentration data for a single target analyte in a single analysis. Sample results were stored in the Hanford Environmental Information System (HEIS) database. In addition, tentatively identified volatile organic compounds (VOCs) were reported for Method 8260 (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended).

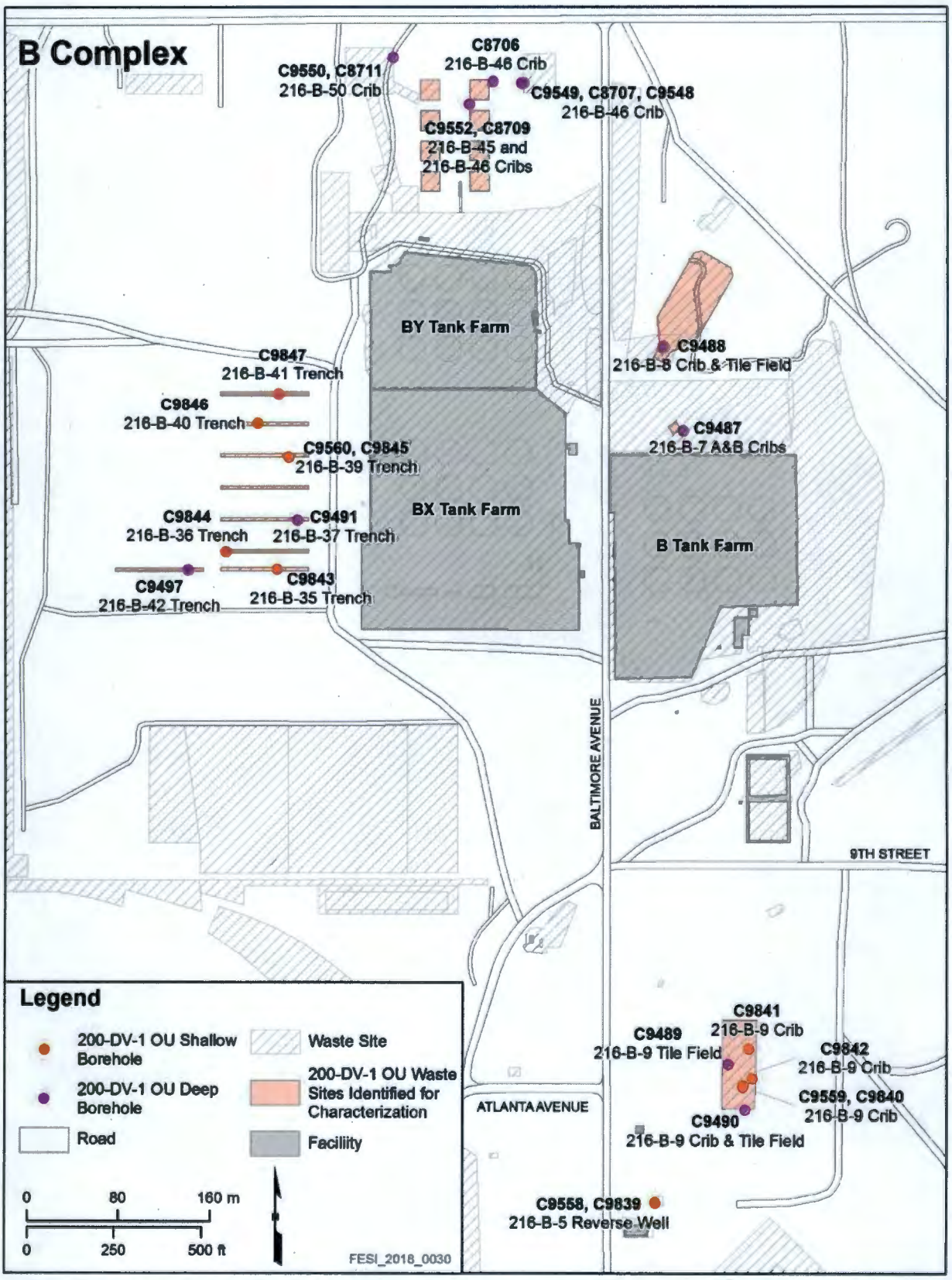

Figure 1. Location of 200-DV-1 OU Deep and Shallow Characterization Boreholes in B Complex Area

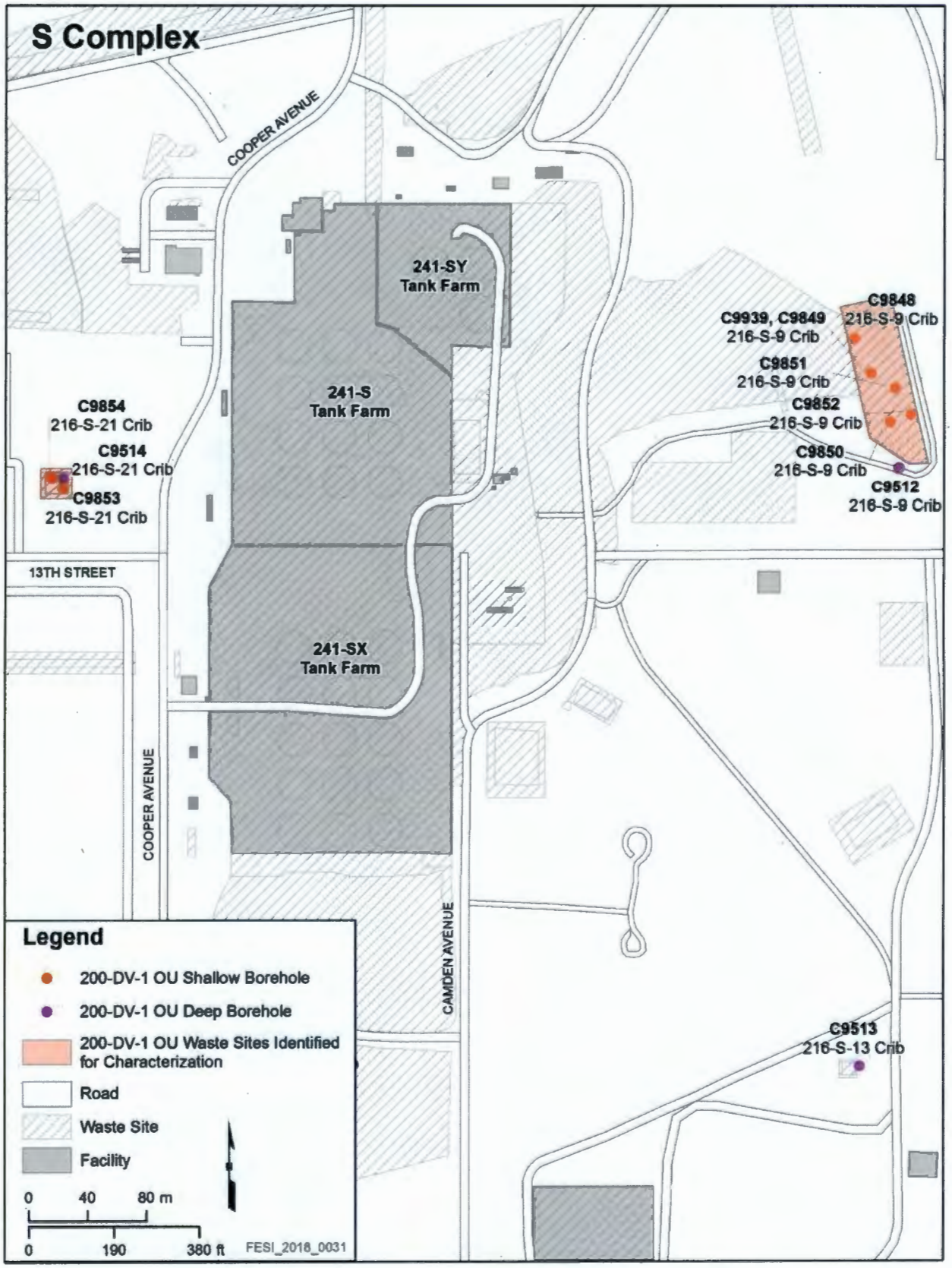

Figure 2. Location of 200-DV-1 OU Deep and Shallow Characterization Boreholes in S Complex Area

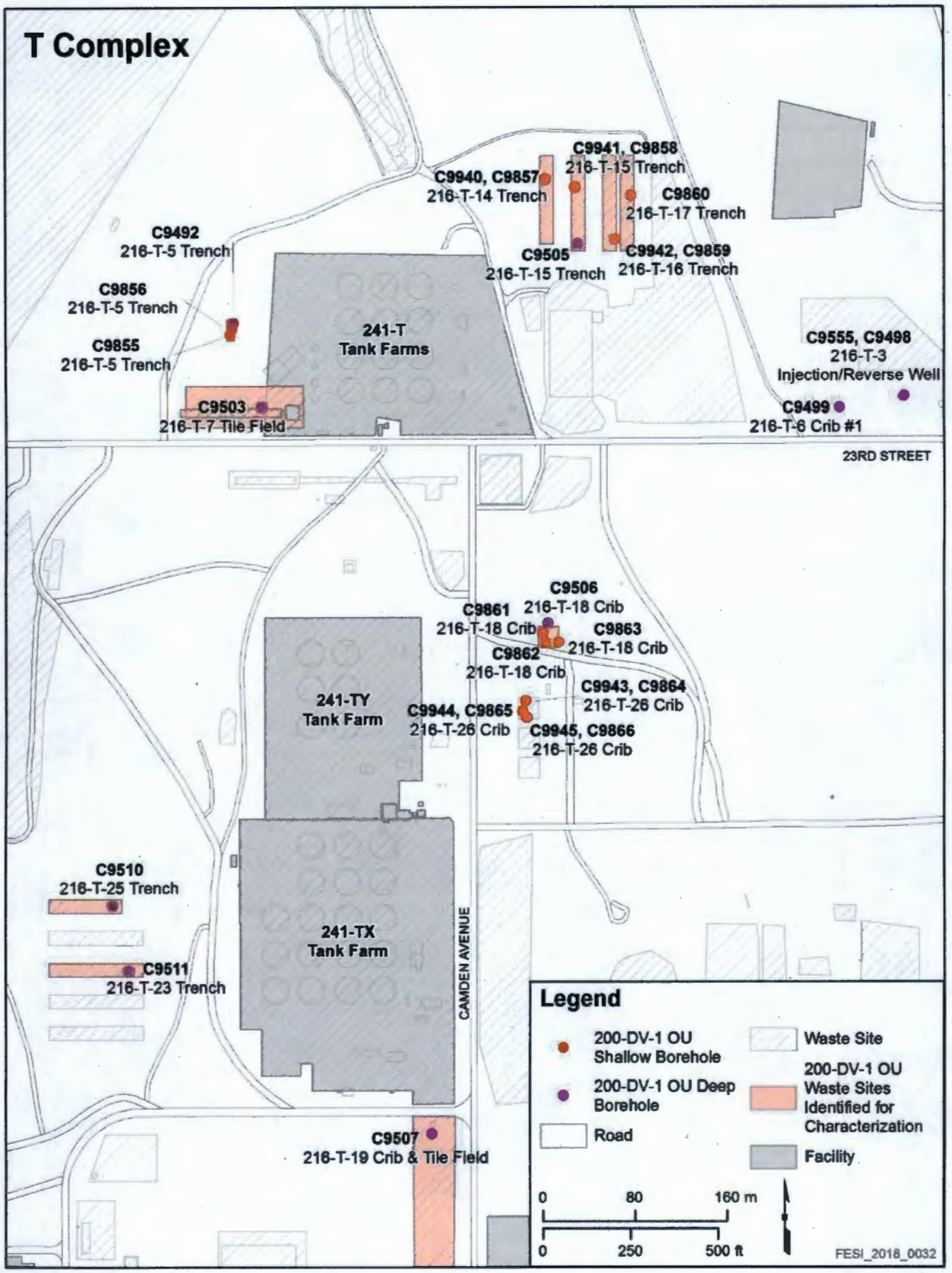

Figure 3. Location of 200-DV-1 OU Deep and Shallow Characterization Boreholes in T Complex Area

Table 1. Analytical Methods for 200-DV-1 OU Soil Characterization

Analyte	Analytical Method
Americium-241, neptunium-237, plutonium-238, plutonium-239/240, uranium-233/234, uranium-235, uranium-238	Alpha energy analysis[a]
Ammonia	EPA Method 350.1[b]
Anions	EPA Method 300.0[c] or 9056
Carbon-14, nickel-63, technetium-99, tritium	Liquid scintillation counter
Cesium-137, cobalt-60, europium-152, europium-154, europium-155	Gamma energy analysis
Cyanide	EPA Method 9012[d]
Hexavalent chromium	EPA Method 7196
ICP metals	EPA Method 6010 (soil) or 6010M (water)
ICP/MS metals	EPA Method 6020
Iodine-129	Low-energy photon spectroscopy
Mercury	EPA Method 7471 (soil) or 7470 (water)
Polychlorinated biphenyls	EPA Method 8082
Semivolatile organic compounds	EPA Method 8270
Strontium-90 (total)	Gas-flow proportional counting
Total petroleum hydrocarbons	NWTPH[e]
Volatile organic compounds	EPA Method 8260

Note: For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended.

a. Thorium-232, radium-226, radium-228 were identified as a contaminant of potential concern in DOE-RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*. In accordance with Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) change notice TPA-CN-668 (*Tri-Party Agreement Change Notice Form: DOE/RL-2011-104, Rev. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*), these naturally occurring background radionuclides were identified by consensus of EPA, Ecology, and DOE managers as not directly related to Hanford Site operations or processes in the Central Plateau and were not included for analysis.

b. EPA Method from EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Waste*.

c. EPA Method from EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*.

d. DOE-RL-2011-104 identified EPA Method 9010 or 9014 as the preferred analytical method.

e. See Ecology Publication ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*. The Ecology methods use a modification to EPA Method 8015.

DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
MS = mass spectrometry
NWTPH = Northwest total petroleum hydrocarbons

2.2 Data Verification

Data verification is the process of evaluating the completeness, correctness, conformance, and compliance of a specific data set against the method or against procedural or contractual requirements. It includes confirmation that the specified sampling and analytical requirements have been completed (i.e., verification that the number, type, and location of all samples identified in the SAP [DOE/RL-2011-104] and SAP ADD2 [DOE/RL-2011-104-ADD2] have been collected and that all required measurements and analyses were performed). This evaluation is documented in the completeness section (Chapter 6), which evaluates the sampling design versus field implementation. In addition, verification is performed for field QC and laboratory QC samples and is documented in field QC and laboratory QC sections (Chapters 9 and 10, respectively).

3 Purpose

The purpose of the 200-DV-1 OU remedial investigation/*Resource Conservation and Recovery Act of 1976* facility investigation includes the following: (1) determine the nature and extent of contamination, (2) fill data gaps to support development of a conceptual site model, (3) support development of risk assessment models, and (4) provide information to support selection of remedies and remedial treatment technologies. The soil samples were collected and analyzed in accordance with the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2). The DUA process assessed the quality of the data collected for meeting the SAP and SAP ADD2 requirements, which provides assurance that the data collected are of sufficient quality and quantity to achieve the DQOs.

4 Scope

This DUA focuses specifically on select laboratory results from soil samples collected in the 200-DV-1 OU as required by the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2). The data are evaluated to determine whether they meet the analytical criteria outlined in the SAP and are adequate to support decision making. The DUA methodology includes data verification, data validation, and data usability evaluations. The data usability assessment of physical properties data and samples collected under DOE/RL-2011-104-ADD1, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 1: Attenuation Process Characterization*, is not part of the scope of this report because the data needs identified in SAP are significantly different than those identified in DOE/RL-2011-104-ADD1. Data collected under the SAP Addendum 1 also includes testing and evaluations that do not have QC acceptance criteria.

Soil samples collected and analyzed under the SAP (DOE/RL-2011-104) (referred to as "deep borehole" samples) were collected from July 2015 to October 2017. Soil samples collected under the SAP ADD2 (DOE/RL-2011-104-ADD2) (referred to as "shallow borehole" samples) were collected from January 9 to March 13, 2018. Deep borehole samples were collected as deep as 79.9 m (262 ft) below ground surface (bgs), and shallow borehole samples were collected as deep as 4.6 m (15.2 ft) bgs. Table 2 lists the deep and shallow borehole identification numbers with the drilling dates and associated 200-DV-1 OU waste sites.

Table 2. Identification of 200-DV-1 OU Characterization Boreholes with Associated Waste Site

Borehole ID	Drill Dates	Complex	Associated 200-DV-1 OU Waste Site
Deep Boreholes[a]			
C8706	October 21, 2015	B Complex	216-B-46 Crib
C8707	July 13, 2015, to February 29, 2016	B Complex	216-B-46 Crib
C8709	October 9, 2015, to October 13, 2015	B Complex	216-B-45 and 216-B-46 Cribs
C8711	July 8, 2016, to July 22, 2015	B Complex	216-B-50 Crib
C9487	October 29, 2015, to March 30, 2016,	B Complex	216-B-7A&B Cribs
C9488	March 8, 2016, to April 26, 2016,	B Complex	216-B-8 Crib and Tile Field
C9489	November 4, 2015, to April 24, 2016	B Complex	216-B-9 Tile Field
C9490	November 2, 2015, to August 15, 2016	B Complex	216-B-9 Crib and Tile Field
C9491	October 26, 2015, to March 15, 2016	B Complex	216-B-37 Trench
C9497	May 17, 2017, to June 22, 2017,	B Complex	216-B-42 Trench
C9548	July 14, 2015, and July 15, 2015	B Complex	216-B-46 Crib
C9549	October 5, 2015, to January 28, 2016	B Complex	216-B-46 Crib
C9550	October 1, 2015, to January 19, 2016	B Complex	216-B-50 Crib
C9552	October 20, 2015, to February 17, 2016	B Complex	216-B-45 and 216-B-46 Cribs
C9512	November 23, 2015, to July 27, 2016	S Complex	216-S-9 Crib
C9513	May 18, 2017, to August 31, 2017	S Complex	216-S-13 Crib
C9514	April 7, 2016, to July 21, 2016	S Complex	216-S-21 Crib
C9492	November 10, 2015, to June 2, 2016	T Complex	216-T-5 Trench
C9498	May 22, 2017, to June 13, 2017	T Complex	216-T-3 Injection/Reverse well
C9499	March 14, 2016, to June 27, 2016	T Complex	216-T-6 Crib #1
C9503	May 22, 2017, to August 10, 2017	T Complex	216-T-7 Tile Field
C9505	November 20, 2015, to June 13, 2016	T Complex	216-T-15 Trench
C9506	March 17, 2016, to June 29, 2016	T Complex	216-T-18 Crib
C9507	April 5, 2016, to June 16, 2016	T Complex	216-T-19 Crib and Tile Field
C9510	November 18, 2015, to July 13, 2016	T Complex	216-T-25 Trench
C9511	November 19, 2015, to July 7, 2016	T Complex	216-T-23 Trench
C9555	June 13, 2017, to October 11, 2017	T Complex	216-T-3 Injection/Reverse well
Shallow Boreholes[b]			
C9558	January 15, 2018	B Complex	216-B-5 Crib
C9559	January 15, 2018	B Complex	216-B-9 Crib
C9560	January 11, 2018	B Complex	216-B-39 Trench

Table 2. Identification of 200-DV-1 OU Characterization Boreholes with Associated Waste Site

Borehole ID	Drill Dates	Complex	Associated 200-DV-1 OU Waste Site
C9839	January 09, 2018	B Complex	216-B-5 Reverse Well
C9840	January 09, 2018	B Complex	216-B-9 Crib
C9841	January 10, 2018	B Complex	216-B-9 Crib
C9842	January 10, 2018	B Complex	216-B-9 Crib
C9843	January 10, 2018, to January 11 2018	B Complex	216-B-35 Trench
C9844	January 11, 2018	B Complex	216-B-36 Trench
C9845	January 11, 2018	B Complex	216-B-39 Trench
C9846	January 15, 2018	B Complex	216-B-40 Trench
C9847	January 15, 2018	B Complex	216-B-41 Trench
C9848	January 16, 2018, to January 18, 2018	S Complex	216-S-9 Crib
C9849	January 18, 2018	S Complex	216-S-9 Crib
C9850	January 22, 2018	S Complex	216-S-9 Crib
C9851	January 22, 2018	S Complex	216-S-9 Crib
C9852	January 22, 2018	S Complex	216-S-9 Crib
C9853	January 23, 2018	S Complex	216-S-21 Crib
C9854	January 23, 2018	S Complex	216-S-21 Crib
C9939	January 18, 2018	S Complex	216-S-9 Crib
C9855	January 24, 2018	T Complex	216-T-5 Trench
C9856	January 24, 2018	T Complex	216-T-5 Trench
C9857	January 24, 2018	T Complex	216-T-14 Trench
C9858	January 24, 2018	T Complex	216-T-15 Trench
C9859	January 25, 2018	T Complex	216-T-16 Trench
C9860	January 25, 2018	T Complex	216-T-17 Trench
C9861	March 12, 2018	T Complex	216-T-18 Crib
C9862	March 12, 2018	T Complex	216-T-18 Crib
C9863	March 12, 2018	T Complex	216-T-18 Crib
C9864	March 12, 2018	T Complex	216-T-26 Crib
C9865	March 13, 2018	T Complex	216-T-26 Crib
C9866	March 13, 2018	T Complex	216-T-26 Crib
C9940	January 24, 2018	T Complex	216-T-14 Trench
C9941	January 24, 2018	T Complex	216-T-15 Trench

Table 2. Identification of 200-DV-1 OU Characterization Boreholes with Associated Waste Site

Borehole ID	Drill Dates	Complex	Associated 200-DV-1 OU Waste Site
C9942	January 25, 2018	T Complex	216-T-16 Trench
C9943	March 12, 2018, to March 13, 2018	T Complex	216-T-26 Crib
C9944	March 13, 2018	T Complex	216-T-26 Crib
C9945	March 13, 2018	T Complex	216-T-26 Crib

a. Boreholes drilled under DOE-RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

b. Boreholes drilled under DOE/RL-2011-104-ADD2, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 2: Supplemental Shallow Soil Risk Characterization Sampling.*

ID = identification

OU = operable unit

The DQA process is based on EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide* (EPA QA/G-9R), which outlines five steps for conducting a statistical DQA; however, the portions of the EPA five-step process describing statistical methods do not apply to this DUA. Statistical methods were not used as part of this DUA for three reasons: (1) the collection of samples specified by the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2) was judgmental, the sampling intervals in the SAP were selected by professional judgment, and the sampling intervals in the SAP ADD2 were selected by a random and judgmental process; (2) statistical test was not defined in the SAP or SAP ADD2 for analysis of the results; and (3) the data will not be used for a statistical analysis to confirm the success of a remedial or response action.

Because the sampling design in the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2) was judgmental, the data usability will be assessed using DQIs such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets (individual data packages) in accordance with EPA/240/B-06/002.

4.1 Data Validation

Data validation is an analyte- and sample-specific process that extends the data evaluation beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set (typically data in single analytical batches). Data validation is an independent assessment to ensure that the reliability of data is known by the user. Analytical data validation provides a level of assurance, based on technical evaluation, that an analyte is either present or absent. Validation may include verifying required deliverables (e.g., the minimum detection limits); verifying instrument calibrations; evaluating analytical results based on method blanks; recovering various internal standards; determining correctness of uncertainty calculations; and identifying and quantifying analytes and the effect of quality deficiencies on the analytical sample data. Section 8.3 describes the third-party validation that was performed on a percentage of all project data.

4.2 Data Usability

The DUA is a determination of the adequacy of the entire data set to support a particular environmental decision and is based on verification and validation results. The assessment relates to the adequacy of data to support a specific and defined data need. The usability step (described in this document) involves assessing whether the collected samples and resulting analytical data meet project quality objectives. Chapter 11 summarizes this evaluation.

5 Project Objectives

The 200-DV-1 OU work plan (DOE/RL-2011-102) supports the final remedy selection for the 200-DV-1 OU. A summary of data needs with sampling rationale on a waste site-by-waste site basis for 200-DV-1 OU is presented in Table 4-1 of the 200-DV-1 OU work plan (DOE/RL-2011-102). As developed during the work planning process, Chapter 3 of the SAP (DOE/RL-2011-104) provides brief summaries of the work scope for each 200-DV-1 OU waste site where additional characterization is required.

The SAP (DOE/RL-2011-104) defines the principal study questions (PSQs) and decision statements (DSs) for the OU field characterization:

- **PSQ #1:** Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to HHE under current and/or potential future land use?
  - **DS #1:** Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for HHE.
  - **DS #2:** For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.
- **PSQ #2:** Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to HHE under current and/or potential future land use?
  - **DS #1:** Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
  - **DS #2:** For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

The purpose of sampling under the SAP ADD2 (DOE/RL-2011-104-ADD2) was to provide supplemental characterization for the shallow portion of 200-DV-1 OU waste sites. While data obtained under the SAP (DOE/RL-2011-104) include samples from within the 0 to 3.0 m (0 to 10 ft) bgs and 0 to 4.6 m (0 to 15 ft) bgs intervals, insufficient numbers of samples are available at some of the waste sites to calculate the 95% upper confidence level on the mean concentration. The 95% upper confidence level is needed to characterize risks for the 0 to 3.0 m (0 to 10 ft) bgs and 0 to 4.6 m (0 to 15 ft) bgs intervals, necessitating additional characterization.

The PSQ relating to characterization of shallow soils identified in Section 1.4 of the SAP (DOE/RL-2011-104) was amended in the SAP ADD2 (DOE/RL-2011-104-ADD2) by adding the need to characterize the 0 to 3 m (0 to 10 ft) bgs interval, as follows:

- **PSQ #1:** Do chemical and/or radiological contaminants in the shallow (0 to 3 m [0 and 10 ft] and 0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to HHE under current and/or potential future land use?

The two DSs identified in Section 1.4 of the SAP (DOE/RL-2011-104) were also amended for the SAP ADD2 (DOE/RL-2011-104-ADD2) to include the 0 to 3.0 m (0 to 10 ft) bgs depth interval, as follows:

- **DS #1:** Determine whether the chemical and/or radiological contaminants within the upper 3 and 4.6 m (10 and 15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for HHE.
- **DS #2:** For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 3 and 4.6 m (10 and 15 ft) sufficiently for remedy selection.

6 Completeness

The SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2) were reviewed to identify data requirements. Laboratory tests providing analytical nonradiological and radiological results are within the scope of this DUA. This chapter summarizes the number and location of all soil samples identified in the SAP and SAP ADD2 and verifies that the required samples have been collected and all required measurements and analyses were performed.

6.1 Sampling Design

The type of sampling design described in the SAP (DOE/RL-2011-104) is judgmental sampling (e.g., based on prior knowledge, professional judgment, and expertise). Soil sampling was performed at the boreholes identified in Table 2. The target sampling depths for deep boreholes are identified in Tables 3-2 through 3-18 in the SAP. The sampling depths listed in the SAP were later modified based on safety concerns and examination of the sample cores. These depths were selected based on the need to confirm the conceptual site model and reduce the uncertainty associated with the nature and extent of contamination. The type of sampling design described in the SAP ADD2 (DOE/RL-2011-104-ADD2) included five boreholes with a judgmental design and 23 boreholes with randomly selected sampling locations within the waste sites. The target sampling depths for shallow boreholes are identified in Table 5 of the SAP ADD2. The locations and depths selected for sampling were chosen during the supplemental DQO process based on the existence (or lack) of potential contamination sources to the shallow zone and previous characterization of the vertical extent of shallow contamination. Table 3 summarizes the expected number of sample intervals at each borehole.

Not all contaminants of potential concern (COPCs) were required for analysis at all sampling locations. Table 4 identifies a subset of waste sites with associated boreholes and COPCs.

6.2 Implementation of the Sample Design

Three separate drilling campaigns were required to collect all necessary data identified in the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2). Soil samples were collected while drilling the boreholes using techniques consistent with the methods identified in the SAP. The first campaign conducted between July 2015 and July 2016, included all of the deep boreholes, with the exception of C9497, C9498, C9503, C9513, and C9555. The remaining deep boreholes were drilled and sampled from May 2017 to October 2017. The shallow boreholes were drilled and sampled from January 9 to March 13, 2018.

Table 3. Sample Design Implementation and Completion Evaluation for 200-DV-1 OU Characterization Boreholes

Borehole ID	Soil Samples			All Required Analyses Performed?	(Number of Missing Intervals) Missing Constituent		
	Number of Sample Intervals Identified in the SAP	Number of Sampled Intervals[a]	Percent Actual Sampled Intervals				
Deep Boreholes[b]							
C8706	10	11	100+	Yes	—		
C9487	8	11	100+	Yes	—		
C9488	6	9	100+	No	(2) Uranium-233/234		
C9489	7	10	100+	Yes	—		
C9490	7	9	100+	Yes	—		
C9491	6	8	100+	Yes	—		
C9497	10	17	100+	Yes	—		
C9549 (C8707, C9548)[c]	10	12	100+	No	(3) Ammonia (3) Cesium-137 (3) Cobalt-60 (3) Europium-152	(3) Europium-154 (3) Europium-155 (3) Hexavalent chromium (3) Iodine-129	(1) Mercury (3) Strontium-90
C9550 (C8711)[c]	10	13	100+	No	(3) Americium-241 (3) Ammonia (3) Cesium-137 (3) Cobalt-60	(3) Europium-152 (3) Europium-154 (3) Europium-155 (3) Hexavalent chromium	(2) Iodine-129 (2) Mercury (2) Strontium-90
C9552 (C8709)[c]	10	11	100+	No	(2) Uranium-233/234		
C9512	7	9	100+	No	(1) Uranium-233/234		
C9513	11	18	100+	No	(4) Total petroleum hydrocarbons–kerosene range		
C9514	7	9	100+	Yes	—		
C9492	6	8	100+	Yes	—		
C9499	7	8	100+	No	(2) Uranium-233/234		

Table 3. Sample Design Implementation and Completion Evaluation for 200-DV-1 OU Characterization Boreholes

Borehole ID	Soil Samples			All Required Analyses Performed?	(Number of Missing Intervals) Missing Constituent		
	Number of Sample Intervals Identified in the SAP	Number of Sampled Intervals[a]	Percent Actual Sampled Intervals				
C9503	11	16	100+	Yes	—		
C9505	5	6	100+	No	(1) Uranium-233/234		
C9506	6	8	100+	No	(1) Uranium-233/234		
C9507	9	16	100+	No	(1) Chloride (1) Fluoride (1) Nitrate	(1) Nitrite (1) Phosphate (1) Sulfate	(1) Uranium-233/234
C9510	7	8	100+	No	(1) Ammonia (1) Iodine-129		
C9511	7	8	100+	No	(1) Ammonia (1) Hexavalent chromium (1) Iodine-129		
C9555 (C9498)[c]	10	16	100+	Yes	—		
Shallow Boreholes[d]							
C9558 (C9839)[c]	6	6	100	Yes	—		
C9559 (C9840)[c]	4	4	100	Yes	—		
C9560 (C9845)[c]	4	4	100	Yes	—		
C9841	4	4	100	No	(1) Aluminum (1) Antimony (1) Cadmium (1) Chromium	(1) Copper (1) Lead (1) Manganese (1) Mercury	(1) Nickel (1) Selenium (1) Silver (1) Uranium
C9842	4	4	100	Yes	—		
C9843	4	4	100	Yes	—		

Table 3. Sample Design Implementation and Completion Evaluation for 200-DV-1 OU Characterization Boreholes

Borehole ID	Soil Samples			All Required Analyses Performed?	(Number of Missing Intervals) Missing Constituent
	Number of Sample Intervals Identified in the SAP	Number of Sampled Intervals[a]	Percent Actual Sampled Intervals		
C9844	4	4	100	Yes	—
C9846	4	4	100	Yes	—
C9847	4	4	100	Yes	—
C9848	6	6	100	Yes	—
C9850	6	6	100	Yes	—
C9851	6	6	100	Yes	—
C9852	6	6	100	Yes	—
C9853	4	4	100	Yes	—
C9854	4	4	100	Yes	—
C9939 (C9849)[c]	6	6	100	Yes	—
C9855	4	4	100	Yes	—
C9856	4	4	100	Yes	—
C9860	4	4	100	Yes	—
C9861	4	4	100	Yes	—
C9862	4	4	100	Yes	—
C9863	4	4	100	Yes	—
C9940 (C9857)[c]	4	4	100	Yes	—
C9941 (C9858)[c]	4	4	100	Yes	—
C9942 (C9859)[c]	4	4	100	Yes	—
C9943 (C9864)[c]	6	6	100	Yes	—

Table 3. Sample Design Implementation and Completion Evaluation for 200-DV-1 OU Characterization Boreholes

Borehole ID	Soil Samples			All Required Analyses Performed?	(Number of Missing Intervals) Missing Constituent		
	Number of Sample Intervals Identified in the SAP	Number of Sampled Intervals[a]	Percent Actual Sampled Intervals				
C9944 (C9865)[c]	6	5	83	No	(1) Aluminum (1) Americium-241 (1) Ammonia (1) Antimony (1) Cadmium (1) Carbon-14 (1) Cesium-137 (1) Chloride (1) Chromium (1) Cobalt-60 (1) Copper (1) Cyanide (1) Europium-152	(1) Europium-154 (1) Europium-155 (1) Fluoride (1) Hexavalent chromium (1) Iodine-129 (1) Lead (1) Manganese (1) Mercury (1) Neptunium-237 (1) Nickel (1) Nickel-63 (1) Nitrate (1) Nitrite	(1) Phosphate (1) Plutonium-238 (1) Plutonium-239/240 (1) Selenium (1) Silver (1) Strontium-90 (1) Sulfate (1) Technetium-99 (1) Tritium (1) Uranium (1) Uranium-235 (1) Uranium-238 (1) Uranium-233/234
C9945 (C9866)[c]	6	6	100	Yes	—		

a. The number of intervals sampled do not include depths associated with samples collected only for testing and evaluation of physical properties.

b. Estimated number of samples per Tables 3-2 through 3-18 in DOE-RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

c. Boreholes in parentheticals did not reach the required total depth for sampling identified in the SAP (DOE/RL-2011-104) or SAP Addendum 2 (DOE/RL-2011-104-ADD2, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 2: Supplemental Shallow Soil Risk Characterization Sampling*). Replacement borehole(s) was/were required at these locations.

d. Estimated number of samples per Table 5 in DOE/RL-2011-104-ADD2.

ID = identification

SAP = sampling and analysis plan

Table 4. Summary of 200-DV-1 OU Sampling and Analysis Design

Radiological Constituents (All Boreholes)			
Americium-241	Europium-154	Plutonium-238	Uranium-233/234
Carbon-14	Europium-155	Plutonium-239/240	Uranium-235
Cesium-137	Iodine-129	Strontium-90	Uranium-238
Cobalt-60	Neptunium-237	Technetium-99	
Europium-152	Nickle-63	Tritium	
Nonradiological Constituents (All Boreholes)			
Aluminum	Copper	Mercury	Silver
Ammonia/ammonium	Cyanide (total)	Nickel	Sulfate
Antimony	Fluoride	Nitrate	Uranium
Cadmium	Hexavalent chromium	Nitrite	
Chloride	Lead	Phosphate	
Chromium	Manganese	Selenium	
For Boreholes at Waste Sites 216-B-43 Through 216-B-50, 216-B-42, 216-T-18, 216-T-19, 216-S-9, 216-S-13, 216-S-21 **Deep boreholes: C8706, C9497, C9549, C9550, C9552, C9512, C9513, C9514, C9506, and C9507** **Shallow boreholes: C9848, C9850, C9851, C9852, C9853, C9854, C9939, C9861, C9862, and C9863**			
Normal paraffin hydrocarbon (kerosene)* Tributyl phosphate			
For Deep Borehole C9507 at Waste Site 216-T-19 Only			
1,1,1-Trichloroethane	Carbon tetrachloride	Methyl isobutyl ketone (hexone or 4-methyl-2-pentanone)	trans-1,2-Dichloroethylene
1,1-Dichloroethane	Chlorobenzene	n-Butyl benzene	Trichloroethylene
1,2-Dichloroethane	cis-1,2-Dichloroethylene	Phenol	Trichloromethane (chloroform)
Acetone	Dichloromethane (methylene chloride)	Polychlorinated biphenyls	Xylene
Arsenic	Ethyl benzene	Tetrachloroethylene	
Benzene	Methyl ethyl ketone (2-butanone)	Toluene	
For Deep Borehole C9513 at Waste Site 216-S-13 Only			
Arsenic	Barium	Methyl isobutyl ketone (hexone or 4-methyl-2-pentanone)	Polychlorinated biphenyls

Notes: Modified from Table 1-2 in DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*.

The same contaminants of potential concern apply to the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2), as amended by a Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) change notice TPA-CN-668 (*Tri-Party Agreement Change Notice Form: DOE/RL-2011-104, Rev. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*), which removed radium-226, radium-228, and thorium-232 from the list of contaminants of potential concern for the 200-DV-1 Operable Unit.

*Analyzed as total petroleum hydrocarbons–kerosene range.

SAP = sample and analysis plan

Due to the possibility of high radiological contamination, the drilling method was restricted to either a direct-push type of drilling or sonic technology with a split core barrel. If a borehole could not be drilled to the required total depth, a replacement borehole was drilled. Table 3 provides the identification number for the initial drilling and sampling borehole and the identification number of the replacement borehole(s). The sampling design was implemented as described in the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2). Minor exceptions occurred based on actual conditions encountered during drilling and safety concerns identified before drilling began.

Of the 307 planned sample intervals, 99.7% were collected. The planned sample interval from 4 to 4.6 m (13 to 15 ft) bgs at C9944 (C9865) could not be collected due to the coarse- to very coarse-grained gravel backfill of the crib and the absence of fine material required for analysis. Additional opportunistic samples were collected, resulting in collecting more sample intervals than the required by the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2). Not all analyses could be performed on every sample. Missing analyses could be due to incomplete sample recovery, inadequate amount of fine material for analysis, or mistaken omission. Table 3 summarizes the sample design implementation and deviations from the sample interval or analyses.

7 Data Requirements

This section discusses the laboratory analytical requirements specified by the SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2) for soil samples. It also discusses the purpose of the types of laboratory batch QC samples that are required by the SAP. The batches of QC sample types defined in this chapter are evaluated in Chapter 10. When the laboratories detect failures in batch QC samples, the laboratories usually apply a QC laboratory qualifier to the data (as noted in Section 7.3).

7.1 Analytical Requirements

Soil analytical laboratory data from deep and shallow borehole characterization in the 200-DV-1 OU were evaluated against the updated SAP (DOE/RL-2011-104) specifications included in Tables 7 and 8 in SAP ADD2 (DOE/RL-2011-104-ADD2), which specify the required laboratory precision and accuracy. Table 5 in this DUA includes the analytical performance requirements for laboratory analysis of soil samples collected for the 200-DV-1 OU characterization boreholes.

7.2 Laboratory Quality Assurance and Quality Control

The quality assurance (QA)/QC) requirements govern nearly all aspects of analytical laboratory operation, including instrument procurement, maintenance, calibration, and operation. Laboratory requirements for internal QC checks are performed as appropriate for the analytical method at a rate of one per analytical batch or one in 20 (5%), whichever is more frequent. Laboratory internal QC checks include the following:

- **Laboratory contamination:** Each analytical batch contains a laboratory (method) blank (material of composition similar to that of the samples with known/minimal contamination from the analytes of interest) carried through the complete analytical process. The method blank is used to evaluate false-positive results in samples caused by contamination during handling at the laboratory.

Table 5. Analytical Performance Requirements for Soil Samples from Boreholes in the 200-DV-1 OU

Analyte	CAS Number	Preliminary Action Level			MDA[c] (pCi/g) or PQL[d] (mg/kg)	Analytical Method[e]	Precision Requirements[f] (%)	Accuracy Requirements[f] (%)
		Direct Contact, WAC 173-340 Method C Industrial RBL[a]	Outdoor Worker RBL	Ecological Protection[b]				
Performance Requirements for Laboratory Measurements (Radiological) (pCi/g)								
Americium-241	14596-10-2	—	61[g]	3,890[h]	1	Alpha energy analysis	≤30	70-130
Carbon-14	14762-75-5	—	57,013[g]	32	2	Liquid scintillation counter		
Cesium-137	10045-97-3	—	1.1[g]	21[h]	0.1	Gamma energy analysis		
Cobalt-60	10198-40-0	—	0.57[g]	692[h]	0.1			
Europium-152	14683-23-9	—	0.68[g]	1,520[h]	0.1			
Europium-154	15585-10-1	—	0.82[g]	1,290[h]	0.1			
Europium-155	14391-16-3	—	60[g]	15,800[h]	0.1			
Iodine-129	15046-84-1	—	157[g]	—	2	Low-energy photon spectroscopy		
Neptunium-237	13994-20-2	—	2.4[g]	3,860[h]	1	Alpha energy analysis		
Nickle-63	13981-37-8	—	59,952[g]	—	10	Liquid scintillation counter		
Plutonium-238	13981-16-3	—	344[g]	5,270[h]	1	Alpha energy analysis		
Plutonium-239/240	Pu-239/240	—	297[g]	6,110[h]	1			
Strontium-90	10098-97-2	—	119[g]	22.5[h]	2	Gas-flow proportional counting		
Technetium-99	14133-76-7	—	11,705[g]	4,490[h]	5	Liquid scintillation counter		
Tritium	10028-17-8	—	1,259[g]	420	30			
Uranium-233/234[i]	U-233/234	—	220[g]	5,130[h]	1	Alpha energy analysis		
Uranium-235	15117-96-1	—	3.6[g]	2,770[h]	1			
Uranium-238	7440-61-1	—	17[g]	1,580[h]	1			
Performance Requirements for Laboratory Measurements (Nonradiological) (mg/kg)								
1,1,1-Trichloroethane	71-55-6	7,000,000	3,825[j]	82[h]	0.005	EPA Method 8260	≤20	70-130
1,1-Dichloroethane	75-34-3	23,000	15[j]	83[h]	0.01			
1,2-Dichloroethane	107-06-2	1,440	1.8[j]	84[h]	0.005			
Acetone	67-64-1	3,150,000	74,616[j]	-	0.02			
Aluminum	7429-90-5	3,500,000	130,000[j]	3,988[k]	5	EPA Method 6020 or 6010	≤35	80-120
Ammonia/ammonium	7664-41-7	—	—	—	0.5	EPA Method 350.1		
Antimony	7440-36-0	1,400	52[j]	0.27[h]	0.5	EPA Method 6020 or 6010		
Arsenic	7440-38-2	87.5	20[j]	10[h]	1	EPA Method 6020		
Barium	7440-39-3	700,000	25,918[j]	102[h]	2	EPA Method 6020 or 6010	≤35	80-120
Benzene	71-43-2	2,390	3[j]	7[h]	0.005	EPA Method 8260	≤20	70-130
Cadmium	7440-43-9	3,500	11[j]	0.36[h]	0.2	EPA Method 6020	≤35	80-120
Carbon tetrachloride	56-23-5	1,880	3[j]	82[h]	0.005	EPA Method 8260	≤20	70-130

Table 5. Analytical Performance Requirements for Soil Samples from Boreholes in the 200-DV-1 OU

Analyte	CAS Number	Preliminary Action Level			MDA[c] (pCi/g) or PQL[d] (mg/kg)	Analytical Method[e]	Precision Requirements[f] (%)	Accuracy Requirements[f] (%)
		Direct Contact, WAC 173-340 Method C Industrial RBL[a]	Outdoor Worker RBL	Ecological Protection[b]				
Chloride	16887-00-6	—	—	—	55[l]	EPA Method 300.0 or 9056	≤35	80-120
Chlorobenzene	108-90-7	70,000	75[j]	40[h]	0.005	EPA Method 8260	≤20	70-130
Chromium (total)	7440-47-3	5,250,000	195,000[j]	0.4[h]	1	EPA Method 6010 or 6020	≤35	80-120
cis-1,2-Dichloroethylene	156-59-2	7,000	260[j]	83[h]	0.005	EPA Method 8260	≤20	70-130
Copper	7440-50-8	140,000	5,191[j]	16[h]	1	EPA Method 6020	≤35	80-120
Cyanide (total)	57-12-5	2,100	18[j]	20,693[h]	0.25	EPA Method 9012		
Dichloromethane (methylene chloride)	75-09-2	21,000	344[j]	59[h]	0.005	EPA Method 8260	≤20	70-130
Ethyl benzene	100-41-4	11,900	12[j]	159	0.005			
Fluoride	16984-48-8	210,000	7,787[j]	556[h]	25[l]	EPA Method 300.0 or 9056	≤35	80-120
Hexavalent chromium	18540-29-9	10,500[m]	389[j]	104[h]	0.5	EPA Method 7196		
Lead	7439-92-1	1,000	—	11[h]	0.3	EPA Method 6020		
Manganese	7439-96-5	490,000	17,985[j]	220[h]	1	EPA Method 6020 or 6010		
Mercury	7439-97-6	1,050[m]	39[j]	0.03[h]	0.2	EPA Method 7471 (soil) or 7470 (water)		
Methyl ethyl ketone (2-butanone)	78-93-3	2,100,000	21,800[j]	312[h]	0.02	EPA Method 8260	≤20	70-130
Methyl isobutyl ketone (hexone or 4-methyl-2-pentanone)	108-10-1	280,000	13,900[j]	193[b]	0.02			
n-Butyl benzene	104-51-8	175,000	6,489[j]	193[h]	0.005			
Nickel	7440-02-0	70,000	2,593[j]	16.3[h]	0.5	EPA Method 6020	≤35	80-120
Nitrate (in nitrogen)	147-97-55-8	24,900,000	921,422[j]	12[h]	12.5[l]	EPA Method 300.0 or 9056		
Nitrite (in nitrogen)	147-97-65-0	1,050,000	42,827[j]	12[h]	12.5[l]			
Phenol	108-95-2	1,050,000	8,438[j]	0.2[h]	0.33	EPA Method 8270	≤30	70-130
Phosphate	14265-44-2	—	—	—	5	EPA Method 300.0	≤35	80-120
Polychlorinated biphenyls	1336-36-3	65.6	1[j]	0.27[h]	0.033	EPA Method 8082 (Aroclors only)	≤30	70-130
Selenium	7782-49-2	17,500	649[j]	0.3[h]	0.5	EPA Method 6020	≤35	80-120
Silver	7440-22-2	17,500	649[j]	2[h]	0.2	EPA Method 6020 or 6010		
Sulfate	14808-79-8	—	—	—	27.5[l]	EPA Method 300.0	≤35	80-120
Tetrachloroethylene	127-18-4	21,000	38[j]	14[h]	0.005	EPA Method 8260	≤20	70-130
Toluene	108-88-3	280,000	3,408[j]	195	0.005			
TPH–kerosene range	TPH, KEROSENE	2,000	—	35,638[h]	25	NWTPH[n]	≤30	70-130
trans-1,2-Dichloroethylene	156-60-5	70,000	—	83[h]	0.005	EPA Method 8260	≤20	70-130

Table 5. Analytical Performance Requirements for Soil Samples from Boreholes in the 200-DV-1 OU

Analyte	CAS Number	Preliminary Action Level			MDA[c] (pCi/g) or PQL[d] (mg/kg)	Analytical Method[e]	Precision Requirements[f] (%)	Accuracy Requirements[f] (%)
		Direct Contact, WAC 173-340 Method C Industrial RBL[a]	Outdoor Worker RBL	Ecological Protection[b]				
Tributyl phosphate	126-73-8	14,600	284[j]	—	0.33	EPA Method 8270	≤30	70-130
Trichloroethylene	79-01-6	1,750	1.6[j]	7[h]	0.005	EPA Method 8260	≤20	70-130
Trichloromethane (chloroform)	67-66-3	4,230	1[j]	83[h]	0.005			
Uranium (total)	7440-61-1	10,500	389[j]	4[h]	0.15	EPA Method 6020	≤35	80-120
Xylene	1330-20-7	700,000	122[j]	149	0.01	EPA Method 8260	≤20	70-130

a. The direct contact risk-based level is based on an excess lifetime cancer risk of 1 in 100,000 or a hazard quotient of 1.0. ECF-HANFORD-10-0453, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*.

b. CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*.

c. Highest allowable MDAs are specified in contracts with analytical laboratories. Actual MDAs vary by laboratory and may be lower. Where project-specific action levels are greater than contract-specified highest allowable MDAs, the contract-specified highest allowable MDA is given. Where project-specific action levels are less than contract-specified highest allowable MDAs, a highest allowable MDA that is lower than the action level is given, provided that the lower highest allowable MDA is technically achievable under routine operating conditions by laboratories under contract to CHPRC.

d. Highest allowable PQLs are specified in contracts with analytical laboratories. Actual PQLs vary by laboratory and may be lower. Where project-specific action levels are greater than contract-specified highest allowable PQLs, the contract-specific PQL is given. Where project-specific action levels are less than contract-specified highest allowable PQLs, a highest allowable PQL that is lower than the action level is given, provided that the lower highest allowable PQL is technically achievable under routine operating conditions by laboratories under contract to CHPRC.

e. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For EPA Method 350.1, 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.

f. Precision and accuracy requirements as defined in EPA procedures and implemented by laboratory analysis and quality assurance procedures. Precision criteria are for batch laboratory replicate sample analyses. Accuracy criteria are for associated batch laboratory control sample percent with additional evaluations also performed for matrix spikes, traces, and carriers, as appropriate to the method.

g. The outdoor worker RBL used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 100,000. ECF-HANFORD-16-0133, *Calculation of Soil Radiological Preliminary Remedial Goals for the Outdoor Worker Scenario*.

h. The ecological risk screening level listed in the SAP ADD2 (DOE/RL-2011-104-ADD2, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 2: Supplemental Shallow Soil Risk Characterization Sampling*) was updated in 2018.

i. Table 1-2 in DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*, notes that uranium-233 is a COPC only for waste site 216-S-13. Uranium-234 is a COPC for all waste sites in the 200-DV-1 Operable Unit.

j. The outdoor worker RBL used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 1,000,000 or a hazard quotient of 0.1. ECF-HANFORD-16-0134, *Calculation of Soil Nonradiological Preliminary Remediation Goals for the Outdoor Worker Scenario*.

k. Aluminum ecotoxicity is only identified in soils with pH <5.5 (OSWER Directive 9285.7-60, *Ecological Soil Screening Level for Aluminum Interim Final*). Most soil pH measures at the Hanford Site are >5.5 (DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment*; DOE/RL-2007-50, *Central Plateau Ecological Risk Assessment Data Package Report*; ECF-HANFORD-11-0158). Thus, aluminum at the Hanford Site does not present an ecological risk.

l. General chemistry analyses. Dilutions for certain ion chromatography constituents may have been necessary, potentially increasing the PQL above the limits established in this table.

m. Value was calculated after SAP ADD2 (DOE/RL-2011-104-ADD2) was finalized.

n. From Ecology Publication ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*. The Ecology methods use a modification to EPA Method 8015.

ADD2	=	Addendum 2	MDA	=	minimum detectable activity
CAS	=	Chemical Abstracts Service	NWTPH	=	Northwest total petroleum hydrocarbons
CHPRC	=	CH2M HILL Plateau Remediation Company	PQL	=	practical quantitation limit
COPC	=	contaminants of potential concern	RBL	=	risk-based level
Ecology	=	Washington State Department of Ecology	SAP	=	sampling and analysis plan
EPA	=	U.S. Environmental Protection Agency	TPH	=	total petroleum hydrocarbons

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- **Analytical accuracy:** For most analyses, a known quantity of representative analytes of interest (matrix spike [MS]) is added to a separate aliquot of a sample from the analytical batch. The known amount added is compared to the actual measured amount to calculate the percent recovery. The percent recovery of the added MS is used to evaluate analytical accuracy. For analyses not amenable to MS techniques (e.g., gamma energy analysis [GEA]) or where analytical recovery is evaluated from recovery of the tracers or carriers, the accuracy of laboratory preparation and analysis is evaluated using QC reference samples (e.g., laboratory control spike). In addition to MS recovery, surrogate compounds are used to evaluate accuracy in the volatile organic analysis (VOA). Surrogate compounds with instrumental responses that are typical of the other analytes are added to the blanks, samples, and MSs, and the recovery is evaluated.

- **Analytical precision:** Separate aliquots removed from the sample containers (duplicate samples) are analyzed for each analytical batch for radionuclides and metals. The duplicate sample results are compared to the original sample results, which are evaluated as relative percent differences (RPDs) and are used to assess analytical precision. Alternately, a matrix spike duplicate (MSD) may be used to assess precision of metals and organic parameters. For an MSD, a separate aliquot is removed from the same sample container and spike in the same manner as the MS. The results (not recoveries) from the MS/MSD are used to calculate an RPD and assess precision.

- **Laboratory control samples (LCSs) or QC reference samples (analytical accuracy):** An LCS is prepared from an independent standard at a concentration other than that used for calibration but within the calibration range. The LCS is taken through all of the preparation and analysis steps used in the method. The LCS or QC reference sample measures the accuracy of the analytical process. Laboratories are also subject to periodic and random audits of laboratory performance, systems, and overall program. Audits check that the laboratories are performing to laboratory contract requirements. Audits were not conducted with respect to the data analyses performed as part of this project.

The QC frequency is monitored through the data login and verification process and is not rechecked as a part of the DUA.

7.3 Qualification Flags

When generating environmental analytical data, any of several qualification flags may be assigned to an individual result. The HEIS database carries qualification flags applied by three sources: (1) the laboratory, (2) the third-party data validator, or (3) a data reviewer. Table 6 defines the data flags used to qualify results included in the deep and shallow borehole data set.

Table 6. Qualification Flags

Flag	Definition
Laboratory-Applied Flags	
*	Inorganics: Duplicate analysis not within control limits.
A	Organics: Valid for TICs only. The TIC is a suspected aldol condensation product.
B	Inorganics and Wetchem:* The analyte was detected at a value less than the reporting limit but ≥MDL. The data should be considered usable for decision making purposes. Organics: The analyte was detected in both the associated QC blank and in the sample. Radionuclides: The associated QC sample blank has a result ≥2 times the MDA and, after corrections, the result is ≥MDA for this sample.
C	Inorganics and Wetchem: The analyte was detected in both the sample and the associated QC blank, and the blank concentration was > 5% of the sample concentration.
D	All: Analyte was reported at a secondary DF, typically DF >1 (i.e., the primary preparation required dilution to either bring the analyte within the calibration range or to minimize interference). Required for organics/Wetchem if the sample was diluted.
E	Inorganics: Reported value is estimated because of interference. See comments in the laboratory data report or case narrative. Organics: Concentration exceeds the calibration range of the GC/MS.
J	Organics (estimated value): (1) Constituent detected at a level <PQL and ≥MDL, (2) estimated concentration for TICs.
M	Inorganics: Duplicate precision criteria not met.
N	All except GC/MS-based analysis: The matrix spike recovery is outside of control limits. The associated sample data may be biased.
o	All: The LCS is outside of control limits.
T	Organics (GC/MS-based analysis only): Spike and/or spike duplicate sample recovery is outside of control limits.
U	All: The constituent was analyzed for and was not detected. The data should be considered usable for decision-making purposes.
X, Y, Z	All: The result-specific translation of this qualifier code is provided in the laboratory data report or case narrative.
Third-Party Validation-Applied Flags	
U	The constituent was analyzed for but was not detected. The data should be considered usable for decision-making purposes.
UJ	The constituent was analyzed for and was not detected. Due to a QC deficiency identified during data validation, the value reported may not accurately reflect the reporting limit. The data should be considered usable for decision-making purposes.
J	Indicates the constituent was analyzed for and detected. The associated value is estimated due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.
J+	Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected positive bias due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.

Table 6. Qualification Flags

Flag	Definition
J-	Indicates the constituent was analyzed for and detected. The associated value is estimated with a suspected negative bias due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes
UR	Indicates the constituent was analyzed for and not detected; however, due to an identified QC deficiency the data should be considered unusable for decision-making purposes.
Data Reviewer-Applied Flags	
A	Indicates an issue with the chain-of-custody that could affect data usability.
H	Laboratory holding time was exceeded before the sample was analyzed.
R	Do not use. Further review indicates that the result is not valid.
Y	Result is suspect. Review had insufficient evidence to show the result is valid or invalid.

*Wetchem is a group of analytical methods that do not use instrumentation but are associated with "wet" chemical reactions.

DF = dilution factor
GC/MS = gas chromatography/mass spectrometry
MDA = minimum detectable activity
MDL = method detection limit
PQL = practical quantitation limit
QC = quality control
TIC = tentatively identified compound

8 Results

Collected samples were packaged and sent to three laboratories for analysis: GEL, TARL, and TASL. Soil samples were submitted to GEL for chemical and radiochemical analyses, TARL for select chemical and radiochemical analyses, and TASL for select chemical analyses. Material collected from designated sample intervals was analyzed using the analytical methods specified in Table 5. Sample material designated for a particular analysis by the selected laboratory is tracked by a unique HEIS database number.

Analytical requests for chemical and radiochemical services to be completed by the laboratories were documented on chain-of-custody forms. Analytical results provided by the laboratories were tracked and documented by sample delivery groups in data packages.

8.1 Nondetect Data Exceeding Highest Allowable Detection Limits

Laboratories were not able to meet the minimum detectable activity (MDA) or practical quantitation limit (PQL) identified in the SAP ADD2 (DOE/RL-2011-104-ADD2) for some of the collected samples. Nondetect values were identified and the corresponding reporting limit, MDA, or method detection limit (MDL) (as appropriate) was compared to the highest allowable MDAs and highest allowable PQLs identified in Table 5. A total of 119 results for deep boreholes and 68 results for shallow boreholes, representing 17 analytes had reported nondetect values greater than the MDA or PQL. A total of 54 selenium and 72 antimony samples exceeded the PQL identified in the SAP ADD2, of which 50 and 67 samples respectively, were diluted prior to analysis.

The ecological risk screening levels listed in the SAP (DOE/RL-2011-104) were updated in 2018. As a result, the MDA or PQL may exceed the new ecological risk screening levels. The revised ecological risk screening levels identified in Table 5 were compared to the nondetect results from the 200-DV-1 OU deep and shallow borehole data set. A total of 181 results for deep boreholes and 132 results for shallow boreholes, representing three analytes, had reported nondetect values greater than or equal to the new ecological risk screening levels. The three analytes with the nondetect results greater than the new ecological risk screening levels (antimony, aroclors, and selenium) will be treated as uncertainties in the risk assessment.

Nondetect results were also compared to the human health risk-based levels (RBLs) identified in Table 5. A total of two results for deep boreholes, representing two analytes, had reported nondetect values greater than or equal to the outdoor worker RBL. The two analytes with nondetect results greater than the outdoor worker RBL (europium-154 and cobalt-60) will be treated as uncertainties in the risk assessment. None of the nondetect values in the deep or shallow borehole data set were greater than or equal to the WAC 173-340, "Model Toxics Control Act–Cleanup," Method C RBLs identified in Table 5.

Table 7 summarizes the nondetect sample results exceeding the highest allowable MDA, PQL, RBL, or ecological risk screening level.

Table 7. Nondetect Data Exceeding Preliminary Screening Levels

Nondetect Data Exceeding Highest Allowable MDA or PQL		
Deep Boreholes		
Antimony (35 samples)	Cobalt-60 (1 sample)	Phosphate (1 sample)
Aroclors (9 samples)	Europium-152 (2 samples)	Selenium (33 samples)
Arsenic (5 samples)	Europium-154 (3 samples)	Silver (17 samples)
Carbon-14 (1 sample)	Europium-155 (5 samples)	Technetium-99 (2 samples)
Cesium-137 (1 sample)	Nickel-63 (1 sample)	Tributyl phosphate (3 samples)
Shallow Boreholes		
Antimony (37 samples)	Europium-155 (3 sample)	Uranium-235 (2 samples)
Carbon-14 (3 samples)	Selenium (21 samples)	
Europium-154 (1 sample)	Total petroleum hydrocarbons–kerosene range (1 sample)	
Nondetect Values Exceeding Outdoor Worker RBL		
Deep Boreholes		
Europium-154 (1 sample)	Cobalt-60 (1 sample)	
Nondetect Values Exceeding Ecological Protection Values		
Deep Boreholes		
Antimony (119 samples)	Selenium (54 samples)	Aroclors (9 samples)
Shallow Boreholes		
Antimony (110 samples)	Selenium (22 samples)	

MDA = minimum detectable activity
PQL = practical quantitation limit
RBL = risk-based level

8.2 Summary of Unusable/Rejected Analytical Results

A number of sample results were marked by data reviewer as unusable or rejected. The qualifier "R" denotes that the result is considered rejected (not valid) based on further review. A total of 70 analytical results representing 10 COPCs were identified as rejected ("R" flagged) based on combinations of laboratory and review qualifiers.

Results marked as rejected ("R" flagged) consisted of six radionuclides, one nonradionuclide, and two organic analytes (cesium-137, cobalt-60, europium-152, europium-154, europium-155, iodine-129, cyanide, total petroleum hydrocarbons (TPH)–kerosene range, and tributyl phosphate) from 53 shallow soil and 17 deep soil samples. Table 8 summarizes the number of results by decision zone and analyte for results flagged as rejected based on laboratory and review qualifiers.

Table 8. Summary of Rejected Results by COPC and Decision Zone

Analyte	Shallow Borehole Rejected Data (R)	Deep Borehole Rejected Data (R)
Cobalt-60	—	1
Cyanide	2	—
Total petroleum hydrocarbons–kerosene range	—	1
Tributyl phosphate	—	1
Cesium-137	3	1
Cobalt-60	—	1
Europium-152	2	—
Europium-154	1	2
Europium-155	40	10
Iodine-129	5	1
Total number of samples	**53**	**17**

R = do not use; further review indicates result is not valid

Any analytical results flagged in combination with the "R" qualifier should not be used for decision-making purposes.

8.3 Data Validation

Data validation was performed by Analytical Quality Associates, Inc., of Albuquerque, New Mexico, as documented in the following data validation reports:

- AQA, 2017, *Data Validation Report for CH2M HILL Plateau Remediation Company VSR17-002 Project 200-DV-1 Chemical and Radiochemical Validation – Level C*
- AQA, 2018a, *Data Validation Report for CH2M HILL Plateau Remediation Company VSR18-006 Project 200-DV-1 Chemical and Radiochemical Validation – Level C*
- AQA, 2018b, *Data Validation Report for CH2M HILL Plateau Remediation Company VSR18-010 Project 200-DV-1 Chemical and Radiochemical Validation – Level C*

All data flags assigned resulting from data validation were entered into the HEIS database.

8.3.1 Validation Summary

The SAP (DOE/RL-2011-104) specifies that at least 5% (by matrix and analyte group) of all chemical and radiochemical data must undergo Level C data validation. Validation of selected laboratory data was performed by Analytical Quality Associates, Inc. Table 9 summarizes the laboratory methods and number of samples that were independently validated for the 200-DV-1 OU characterization. As shown in the table, the 5% SAP requirement was satisfied.

Table 9. 200-DV-1 OU Samples Validated by Analyte Group

Analyte Group	Total Samples Analyzed	Total Samples Validated	Percent Validated
Anions	484	41	8
Nonradioactive metals	709	57	8
Volatile organic compounds	67	6	9
Polychlorinated biphenyls	49	10	20
Semivolatile organic compounds	175	27	15
Total petroleum hydrocarbons	164	27	16
Radionuclides	394	23	6

8.3.1.1 Major Deficiencies

A major deficiency results in the qualification of sample data as unusable for decision-making purposes. Major deficiencies were noted for one tributyl phosphate sample (B39WP8), resulting in the qualification as unusable due to lack of MS, LCS, and precision data. Two cyanide results (B3FLM9 and B3FLN2) were qualified as unusable nondetect results because the samples were analyzed beyond the hold time but within two times the hold time. A major deficiency was also found that resulted in the qualification of one TPH–kerosene range sample (B320W0) as unusable due to a very low LCS recovery. Section 11.2 provides further discussion on these samples.

*8.3.1.2 Minor Deficiencies**

A minor deficiency results in qualification of sample data as nondetected or estimated; however, the data should be considered usable for decision-making purposes.

A variety of minor deficiencies were identified for inorganics (metals), general chemistry, radiochemistry and organics (VOAs), semivolatile organic analysis (SVOAs), polychlorinated biphenyls (PCBs), and TPH. These deficiencies led to results being qualified as estimated or as nondetected, as summarized in Tables 10 and 11. A total of 6,908 samples were collected, and 377 (5%) of these samples were included in third-party validation packages (VSR17-002, VSR18-006, and VSR18-010).

8.3.2 Qualification Flags Applied to the Data Set

Tables 10 and 11 list the qualification flags applied to the data set as a result of the data validation process conducted by Analytical Quality Associates, Inc.

Table 10. Summary of 200-DV-1 OU Deep Borehole Sample Results Data Validation Qualification Flags

Method/Analytes	Laboratory Qualifier	Affected Samples	Reason
VSR17-002			
Ammonia (EPA Method 350.1)			
Nitrogen in ammonia	J	B354H7, B35532	Laboratory blank contamination
Alpha Energy Analysis			
Uranium-235	J	B35N91	Low LCS recovery
Uranium-235	UJ	B35N89, B35N93	Low LCS recovery
ICP/MS Metals (EPA Method 6020)			
Chromium	J	B320W0	Low MS recovery and poor duplicate precision
Antimony	J+	B354H7, B35530, B35532, B35598, B35599	High LCS recovery
Manganese	J+	B354H7, B35530, B35532, B35598, B35599	High MS recovery
Selenium	J	B339Y9, B33B04	Low MS recovery
Uranium	J	B339Y9, B33B04	Poor duplicate precision
Polychlorinated biphenyls (EPA Method 8082)			
Aroclor 1260	UJ	B339Y9, B33B04	Poor MS/MSD precision
Semivolatile Organic Compounds (EPA Method 8270)			
Tributyl phosphate	J	B354H7, B35532, B35598	Lack of MS/MSD and LCS data
Total Petroleum Hydrocarbons (NWTPH)			
TPH–kerosene range	J	B339Y4, B339Y9, B33B04	Low MS and MSD recoveries
TPH–kerosene range	R	B320W0	Very low LCS recovery
Volatile Organic Compounds (EPA Method 8260)			
1,1,1-Trichloroethane 1,1-Dichloroethane 1,2-Dichloroethane 2-Butanone 4-Methyl-2-pentanone Acetone Benzene Carbon tetrachloride Chlorobenzene Chloroform Chloromethane Ethylbenzene Methylene chloride Tetrachloroethene Trichloroethene	J	B339Y8, B33B03	Lack of MS/MSD data

Table 10. Summary of 200-DV-1 OU Deep Borehole Sample Results Data Validation Qualification Flags

Method/Analytes	Laboratory Qualifier	Affected Samples	Reason
Toluene	UJ	B33B03	Lack of MS/MSD data
Xylenes (total)	UJ	B33B03	Lack of MS/MSD data
VSR18-006			
Anions (EPA Method 300.0 or 9056)			
Chloride	J+	B39LL8, B39LM1, B39LM4, B39LM7, B39LN0, B39WM8, B39WN3, B39WN8, B39WP3, B39WP8, B39WR3, B39WR8, B39WT3	Laboratory blank contamination
Sulfate	J+	B3D1M4	Laboratory blank contamination
ICP Metals (EPA Method 6010)			
Aluminum	J+	B3BMX4	High MS recoveries
ICP/MS Metals (EPA Method 6020)			
Manganese	J+	B39LL8, B39LM1, B39LM4, B39LM7, B39LN0, B39WM8, B39WN8, B39WP3, B39WP8, B39WR3, B39WT3, B3BMX3	High MS recovery
Polychlorinated Biphenyls (EPA Method 8082)			
Aroclor 1016 Aroclor 1221 Aroclor 1232 Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Aroclor 1262 Aroclor 1268	J	B39WN3, B39WN8, B39WP3, B39WP8, B39WR3, B39WR8	Lack of precision data
Semivolatile Organic Compounds (EPA Method 8270)			
Tributyl phosphate	J	B39LM1, B39LM7, B39LN0, B39WM8, B39WN3, B39WN8, B39WP3, B39WR3, B39WR8	Lack of MS, LCS. and precision data
Tributyl phosphate	J	B39LL8, B39LM4, B39WT3	Low surrogate recovery, lack of MS, LCS, and precision data
Tributyl phosphate	R	B39WP8	Very low surrogate recovery, lack of MS, LCS, and precision data

Table 10. Summary of 200-DV-1 OU Deep Borehole Sample Results Data Validation Qualification Flags

Method/Analytes	Laboratory Qualifier	Affected Samples	Reason
Volatile Organic Compounds (EPA Method 8260 or 5035)			
4-Methyl-2-pentanone	J	B39WV1, B39WX1	High MS recovery

EPA = Environmental Protection Agency
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike duplicate
NWTPH = Northwest total petroleum hydrocarbons
QC = quality control
TPH = total petroleum hydrocarbons

Laboratory qualifiers:

J = Indicates that the constituent was analyzed for and detected. The associated value is estimated due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.

J+ = Indicates that the constituent was analyzed for and detected. The associated value is estimated with a suspected positive bias due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.

R = Due to an identified QC deficiency, the data should be considered unusable for decision-making purposes.

UJ = The constituent was analyzed for and was not detected. Due to a QC deficiency identified during data validation, the value reported may not accurately reflect the reporting limit. The data should be considered usable for decision-making purposes.

Table 11. Summary of 200-DV-1 OU Shallow Borehole Sample Results Data Validation Qualification Flags

Method/Analytes	Laboratory Qualifier	Affected Samples	Reason
VSR18-010			
Ammonia (EPA Method 350.1)			
Nitrogen in ammonia	J	B3FLM9	Laboratory blank contamination Analysis outside of one times the hold time but within two times the hold time
Nitrogen in ammonia	J+	B3FL37, B3FLV1, B3FLV3, B3FLV6, B3FLV9, B3FMC3, B3FMC6, B3FMC9, B3FMD2, B3FMF3, B3FMF6, B3FMF9, B3FMH2, B3FMH5	Laboratory blank contamination
Anions (EPA Method 9056)			
Chloride Fluoride Nitrogen in nitrate Nitrogen in nitrite Phosphorus in phosphate Sulfate	J	B3FLH4, B3FLH7, B3FLJ0, B3FLK6	Lack of matrix-specific accuracy data

Table 11. Summary of 200-DV-1 OU Shallow Borehole Sample Results Data Validation Qualification Flags

Method/Analytes	Laboratory Qualifier	Affected Samples	Reason
Chloride	J	B3FLD7, B3FLF0	Lack of matrix-specific accuracy data; analysis outside of hold time
Fluoride Nitrogen in nitrate Nitrogen in nitrite Phosphorus in phosphate Sulfate	J	B3FLD4, B3FLD7, B3FLF0	Lack of matrix specific-accuracy data
Cyanide (EPA Method 9012)			
Cyanide	R	B3FLM9, B3FLN2	Nondetect result beyond the hold time but within two times the hold time
ICP/MS Metals (EPA Method 6020)			
Manganese	J+	B3FL37, B3FLM9, B3FLN2, B3FLN8, B3FLV1, B3FLV3, B3FLV6, B3FLV9, B3FMC3, B3FMC6, B3FMC9, B3FMD2, B3FMF3, B3FMF6, B3FMF9, B3FMH2, B3FMH5	High matrix spike recoveries

EPA = U.S. Environmental Protection Agency QC = quality control

ICP/MS = inductively coupled plasma/mass spectrometry

Laboratory qualifiers:

J = Indicates that the constituent was analyzed for and detected. The associated value is estimated due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.

J+ = Indicates that the constituent was analyzed for and detected. The associated value is estimated with a suspected positive bias due to a QC deficiency identified during data validation. The data should be considered usable for decision-making purposes.

R = Due to an identified QC deficiency the data should be considered unusable for decision-making purposes.

8.3.3 Holding Times and Preservation

Holding times are defined as the period of time from sample collection to sample analysis or extraction, and the period of time from sample extraction to sample analysis. Holding times are calculated from the date of sample collection as recorded on the chain-of-custody form to determine validity of the results. All samples were properly preserved, and analyses were performed within the prescribed holding times with the following exceptions:

- Analyses were performed outside of required holding times for 76 deep boreholes samples.
- Analyses were performed outside of required holding times for 53 shallow borehole samples.

Table 12 provides details regarding samples analyzed outside of holding times.

Table 12. Sample Analyses Performed Outside of Holding Times

Well Name	Sample Number	Analyte	Required Holding Time	Analyzed Within Two Times Holding Time
Deep Borehole Data				
C8706	B35N88, B35N90, B35N92, B35N94, B35N96, B35N98, B35NB0, B35NB2	TPH–kerosene range	14/40 days[a]	Yes
C9487	B362K0, B362K2, B362K4, B362K6	Cyanide	14 days	No
C9489	B37PT0, B37PT2, B37PT4, B37PT6, B37PT8, B37PV0, B37PV2	Hexavalent chromium	30 days	Yes
C9506	B36HH9, B36HJ1, B36HJ3	Cyanide	14 days	No
	B36HH9, B36HJ1, B36HJ3, B36HJ5, B36HJ7, B36HJ9	TPH–kerosene range	14/40 days[a]	Yes
C9507	B36852, B36854	Nitrogen in ammonia	28 days	Yes
	B36852, B36854, B36860	Nitrogen in nitrite	28 days/48 hours[b]	Yes
	B36852, B36854	TPH–kerosene range	14/40 days[a]	Yes
C9510	B33MF0	Cyanide	14 days	No
		Mercury	28 days	Yes
	B33MF1	Chloride	28 days/48 hours[b]	Yes
		Fluoride		
		Nitrogen in nitrate		
		Nitrogen in nitrite		
		Phosphorus in phosphate		
		Sulfate		
C9512	B37FH4	Phenol	14/40 days[a]	Yes
		Tributyl phosphate		
C9513	B39X19, B39X46, B39X60	4-Methyl-2-pentanone	14 days	Yes
	B3DCF8, B3DCH3, B3DCH8, B3DCJ3, B3DCJ8, B3DCK3, B3DCK8, B3DCL3, B3DCL8, B3DCM3, B3F941	Tributyl phosphate	14/40 days[a]	Yes
C9549	B352W8, B352X0, B352X2	Nitrogen in nitrate	28 days/48 hours[b]	Yes

Table 12. Sample Analyses Performed Outside of Holding Times

Well Name	Sample Number	Analyte	Required Holding Time	Analyzed Within Two Times Holding Time
C9552	B354H7	TPH–kerosene range	14/40 days[a]	Yes
	B35530	Bromide	28 days/48 hours[b]	Yes
		Chloride		
		Fluoride		
		Phosphate		
	B35530, B355V9, B355W2	Nitrogen in nitrate	28 days/48 hours[b]	Yes
		Sulfate		
	B35530, B355V9, B355W2, B355W4, B35JF2, B35JF4	Nitrogen in nitrite	28 days/48 hours[b]	Yes
	B354H7, B35532, B35598, B355V9, B355W1, B355W4, B35JF1, B35JF4	TPH–kerosene range	14/40 days[a]	Yes
C9555	B3FCL3	Cyanide	14 days	Yes
C9560	B3FLN2	Cyanide	14 days	Yes
Shallow Borehole Data				
C9841	B3FL93	Chloride	28 days/48 hours[b]	No
		Fluoride		
		Nitrogen in nitrate		
		Nitrogen in nitrite		
		Phosphorus in phosphate		
		Sulfate		
		Cyanide	14 days	No
		Hexavalent chromium	30 days	No
	B3FL85, B3FL87, B3FL93	Nitrogen in ammonia	28 days	No
C9842	B3FLB7, B3FLC0, B3FLC3	Chloride	28 days/48 hours[b]	No
		Fluoride		
		Nitrogen in nitrate		
		Nitrogen in nitrite		
		Phosphorus in phosphate		
		Sulfate		
	B3FLC0, B3FLC3	Cyanide	14 days	No
	B3FLB7, B3FLC0, B3FLC3	Hexavalent chromium	30 days	No

Table 12. Sample Analyses Performed Outside of Holding Times

Well Name	Sample Number	Analyte	Required Holding Time	Analyzed Within Two Times Holding Time
C9843	B3FLD4, B3FLD7, B3FLF0	Chloride	28 days/48 hours[b]	Yes
		Fluoride		
		Nitrogen in Nitrate		
		Nitrogen in Nitrite		
		Phosphorus in phosphate		
		Sulfate		
C9845	B3FLM9	Cyanide	14 days	Yes
		Nitrogen in ammonia	28 days	Yes
C9853	B3H0F7, B3H0H0, B3H0H3, B3H0H5, B3H0H8	Cyanide	14 days	No
C9854	B3H0J9, B3H0K2, B3H0K5, B3H0K8	Cyanide	14 days	No
C9855	B3H0L9, B3H0M2, B3H0M5, B3H0M8	Cyanide	14 days	No
C9856	B3H180, B3H183, B3H185, B3H188, B3H191	Cyanide	14 days	Yes
C9857	B3H1B2, B3H1B5, B3H1C3	Cyanide	14 days	Yes
		Nitrogen in ammonia	28 days	Yes
C9858	B3H1D4, B3H1D7	Cyanide	14 days	Yes
		Nitrogen in ammonia	28 days	Yes
C9859	B3H1N0	Nitrogen in ammonia	28 days	Yes
C9860	B3H1T4, B3H1T7, B3H1V0	Nitrogen in ammonia	28 days	Yes
C9861	B3H1Y0	Nitrogen in ammonia	28 days	Yes
C9940	B3H1C6, B3H1C9	Cyanide	14 days	Yes
		Nitrogen in ammonia	28 days	Yes
C9941	B3H1F5	Cyanide	14 days	No
		Nitrogen in ammonia	28 days	No
C9942	B3H1N3, B3H1N9	Nitrogen in ammonia	28 days	Yes
C9943	B3H265, B3H268	Cyanide	14 days	No
		Mercury	28 days	Yes
		Nitrogen in ammonia	28 days	Yes
C9944	B3H294	Cyanide	14 days	No
		Mercury	28 days	Yes
		Nitrogen in ammonia	28 days	Yes

Table 12. Sample Analyses Performed Outside of Holding Times

Well Name	Sample Number	Analyte	Required Holding Time	Analyzed Within Two Times Holding Time
C9945	B3H2D0	Cyanide	14 days	No
		Mercury	28 days	Yes
		Nitrogen in ammonia	28 days	Yes

a. The first number shown is the number of days to extract, and the second number is the number of days to analyze the sample extraction.

b. The EPA Method 300.0 nitrate, nitrite, and phosphate holding time is 48 hours after sample extraction preparation. The holding time of 28 days applies to all other anions quantified by EPA Method 300.0.

EPA = U.S. Environmental Protection Agency

TPH = total petroleum hydrocarbons

Sections 8.3.3.1 through 8.3.3.4 address specific groups of analytes and analyses, providing additional details about the required sample preservation methods (where applicable) and holding-time requirements.

8.3.3.1 Inorganics

The holding-time requirements for metals are as follows:

- The holding-time requirements for inductively coupled plasma (ICP) and inductively coupled plasma/ mass spectrometry (ICP/MS) metals are analysis within 180 days of sample collection for both soil and water samples.
- Mercury requires analysis within 28 days of sample collection for both soil and water samples. Preservation of soil samples for mercury analysis requires chilling to 4(±2)°C. Preservation of water samples for metals analysis (including mercury) is acidification with nitric acid to pH <2 and chilling to 4(±2)°C.

8.3.3.2 General Chemistry

The holding-time requirements for general chemistry parameters are as follows:

- **All anions except nitrate, nitrite, and phosphate:** Analysis within 28 days of sample collection.
- **Nitrate, nitrite, and phosphate:** Analysis within 48 hours of collection for water samples; extraction within 28 days of collection and analysis within 48 hours of extraction for soil samples.
- **Cyanide:** Analysis within 14 days of sample collection for both soil and water samples.
- **Hexavalent chromium:** Analysis within 24 hours of collection for water samples and within 30 days for soil samples.

Sample preservation for anions requires chilling the groundwater and soil samples to 4(±2)°C. Cyanide requires preservation of water samples with sodium hydroxide to pH >12 and chilling to 4(±2)°C.

8.3.3.3 Radionuclides

The maximum holding-time for radiochemical analysis is 180 days for both soil and water samples. Sample preservation for water samples requires acid preservation with nitric acid to pH <2. There are no specific preservation requirements for radiochemical soil analysis.

All samples were properly preserved and analyzed within the prescribed holding times.

8.3.3.4 Organics

The holding times and preservation requirements for VOCs, semivolatile organic compounds (SVOCs), PCBs, polynuclear aromatic hydrocarbons, and pesticides are as follows:

- **VOCs (water):** Acidify with hydrochloric acid or sulfuric acid to pH <2, cool to 4(±2)°C, and analyze within 14 days of collection. If samples are not acidified but are cooled to 4(±2)°C, analyze within 7 days of collection.
- **VOCs (soil):** For low level, freeze samples and analyze within 14 days. For high level, preserve samples in methanol, cool to 4(±2)°C, and analyze within 14 days of collection. If samples (low or high level) are not frozen or preserved but are cooled to 4(±2)°C, analyze within 48 hours of collection.
- **SVOCs (water and soil):** Cool to 4(±2)°C, and extract within 14 days of collection. Analysis within 40 days from extraction.
- **PCBs by Methods 8082 and 1668A (water):** No preservation; analyze within one year of collection.
- **PCBs by Method 8082 (soil):** Cool to approximately 4°C; analyze within one year of collection.
- **Polynuclear aromatic hydrocarbons (water):** No preservation; extract within 7 days and analyze within 40 days of extraction.
- **Pesticides (water):** No preservation; extract within 7 days and analyze within 40 days of extraction.

9 Field Quality Control

This section discusses the project QC checks that are met by collecting different types of field QC samples. Section 9.1 defines the types of samples required by the SAP (DOE/RL-2011-104) and the required frequency of collection for each type of sample. Section 9.2 evaluates the results of the field QC samples collected.

9.1 Field Quality Control Sampling Requirements

The SAP (DOE/RL-2011-104) required collection of full trip blank (FTB) samples, field transfer blank (FXR) samples, equipment blank (EB) samples, and field duplicate samples. Table 13 summarizes the required frequency for each field QC sample type.

Table 13. Project QC Checks

QC Sample Type	Purpose	Frequency
Field QC		
Full trip blank	Assess contamination from containers or transportation	One per 20 borehole trips.
Field transfer blank	Assess contamination from sampling site	One per day when volatile organic compounds are sampled.
Equipment rinsate blank	Verify adequacy of sampling equipment decontamination	As needed. If only disposable equipment is used, then an equipment rinsate blank is not required. Otherwise, one per 20 soil samples collected.
Field duplicate	Estimate precision, including sampling and analytical variability	One per 20 soil samples collected.
Split sample	Estimate precision, including sampling, analytical, and interlaboratory variability	As needed.

QC = quality control

9.1.1 Field Blank Requirements

The FTB samples are samples prepared by the sampling team before traveling to the sampling site. The preserved bottle set is identical to the set collected in the field, but it is filled with reagent water or silica sand (as appropriate to the primary sample media). The bottles are sealed and transported, unopened, to the field in the same storage container used for samples collected the same day. FTBs are typically analyzed for the same constituents as the samples from the associated sampling event; however, the analytical list for FTBs on soil may be limited to VOAs, SVOAs, and TPH (depending on resolution/determination of the target analyte list). FTBs are not required on soils being analyzed for metals, mercury, and hexavalent chromium.

The FXR samples are preserved VOA sample containers filled at the sample collection site with reagent water or silica sand (as appropriate to the primary sample media) transported to the field. The samples are prepared during sampling to evaluate potential contamination caused by field conditions. After collection, FXR bottles are sealed and placed in the same storage container with samples from the associated sampling event. The FXR samples are analyzed for VOCs only and will be batched with samples for which VOA is being requested.

The EB samples are collected for sampling devices reused to assess decontamination process adequacy. EBs will consist of silica sand or reagent water poured over the decontaminated sampling equipment and placed in containers, as identified on the project sampling authorization form. If disposable (i.e., single-use) equipment is used, EBs will not be required.

For the field blanks (i.e., FTBs, FXRs, and EBs), results above two times the MDL are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and toluene, the limit is five times the MDL. For radiological data, blank results are flagged if they are greater than two times the total MDA.

9.1.2 Field Duplicate Requirements

Field duplicate samples are used to evaluate sample consistency and the precision of field sampling methods. Field duplicates are independent samples that are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

Duplicates are generally collected from an area with expected contamination so valid comparisons between the samples can be made (e.g., some of the constituents will be above the detection limit). When sampling is performed using a split-spoon sampler, VOC samples and VOC duplicate samples are collected directly from the sampler. The remaining soil is then composited in a stainless-steel mixing bowl. The soil sample and duplicate sample are collected from the composited material.

Evaluation of the results can provide an indication of intralaboratory variability. Large RPDs can be an indication of laboratory performance issues and should be investigated. Only the field duplicates with at least one result greater than five times the MDL or MDA are evaluated. Field duplicate sample results must agree within 30% for soils (as measured by the RPD) to be acceptable.

9.2 Field Quality Control Results

Section 9.2.1 summarizes the sample results for FTBs, FXRs, and EBs. Section 9.2.2 summarizes the duplicate sample results.

9.2.1 Field Blank Results

Field blank samples are analyzed to determine if positive results may be attributed to contaminants introduced when transferring samples from the field to the laboratory. Any analyte measured above the laboratory detection limit is evaluated for potential impacts to associated sample results.

A total of 21 FTB samples were collected from the 200-DV-1 OU characterization boreholes. Of the 279 nonradiological analytical results associated with the FTB samples, one of the results did not include a corresponding laboratory MDL, and approximately 16% of the results (44 samples) were greater than two times the MDLs. Of the 161 radiological analytical results associated with the FTB samples, one of the results did not include a corresponding laboratory MDA, and approximately 0.6% of the results (one sample) were greater than two times the MDA. Ten of the analytes were detected at values significant enough to impact the usability of 139 sample results.

In addition to FTBs, FXRs were collected specifically for VOA samples. A total of 19 FXR samples were collected from the 200-DV-1 OU characterization boreholes. Of the 214 results reported, 2% of the results (four samples) were greater than two times the MDL. Methyl isobutyl ketone was detected at a value significant enough to impact one sample result.

A total of two EB samples were collected from the 200-DV-1 OU characterization boreholes. Of the 43 analytical results associated with the EB samples, four nonradiological results (9%) were greater than two times the laboratory MDLs. Sulfate and chloride were detected at values significant enough to impact the usability of 14 sample results.

Table 14 lists the analytes exceeding two times the MDL (nonradiological constituents) or MDA (radiological constituents) in the field blanks. Table 15 identifies the field samples and analytes significantly impacted by field blank results greater than two times the laboratory detection limit.

Table 14. Field Blank Results Greater than Two Times the MDL or MDA

Aluminum (10 samples)	Copper (3 samples)	Nitrate (2 samples)
Ammonia (2 samples)	Hexavalent chromium (1 sample)	Sulfate (5 samples)
Antimony (1 sample)	Lead (1 sample)	Uranium (3 samples)
Barium (3 samples)	Manganese (7 samples)	Uranium-238 (1 sample)
Chloride (8 samples)	Methyl isobutyl ketone (4 samples)	
Chromium (1 sample)	Nickel (1 sample)	

Table 15. Field Sample Analyses Impacted by Field Blank Results

Full Trip Blank		
Ammonium (16)	Hexavalent chromium (2)	Uranium (8)
Antimony (3)	Lead (3)	Uranium-238 (3)
Chloride (45)	Nitrate (14)	
Chromium (12)	Sulfate (33)	
Field Transfer Blank		
Methyl isobutyl ketone (1)		
Equipment Blank		
Chloride (7)		
Sulfate (7)		

9.2.2 Field Duplicate Results

Field duplicate samples were obtained from the same sample interval using the same equipment and sampling technique as the corresponding primary field samples. The field duplicate samples were analyzed for the same COPCs at the same laboratory that analyzed the primary field samples. Duplicate pair results were evaluated if at least one of the two results was greater than five times the MDL or MDA. Soil characterization samples were collected from 66 boreholes at a total of 365 depth intervals. A total of 41 field duplicates were collected during the 200-DV-1 OU characterization sampling (at a rate of 11%), exceeding the required collection interval of one duplicate per 20 samples collected. Of the 2,038 data points evaluated, 87 exceeded the RPD criteria. Table 16 identifies the analytes exceeding the 30% RPD.

Table 16. Field Duplicate Results Exceeding RPD Requirement

Aluminum (6 samples)	Chloride (1 sample)	Nickel (5 samples)
Americium-241 (2 samples)	Chromium (12 samples)	Nitrate (5 samples)
Ammonia (1 sample)	Copper (4 samples)	Strontium-90 (1 sample)
Arsenic (7 sample)	Cyanide (1 samples)	Sulfate (1 sample)
Barium (7 samples)	Hexavalent chromium (1 sample)	Uranium (5 samples)
Cadmium (1 sample)	Lead (6 samples)	Uranium-233/234 (3 samples)
Cesium-137 (4 samples)	Manganese (11 samples)	Uranium-238 (3 samples)

10 Laboratory Quality Control

In addition to the evaluation performed for field QC data (discussed in Chapter 9), a broad review of the laboratory QC results was also conducted. Laboratory QC results were stored electronically in the HEIS database and were evaluated against the acceptance criteria using various database queries. Table 17 summarizes the SAP (DOE/RL-2011-104) acceptance criteria for laboratory QC samples.

Table 17. SAP Acceptance Criteria for Laboratory QC Samples

QC Element	Acceptance Criteria
Laboratory duplicate samples	Laboratory duplicate samples with at least one result >5 times the MDL or MDA must have an RPD ≤30% for solid matrixes to be considered acceptable.
Laboratory blank samples	The SAP does not have a QC requirement for laboratory blanks. In lieu of a SAP requirement, laboratory blanks exceeding the MDL or MDA were compared to associated batch samples. Laboratory blank results that exceeded 5% of any of the associated sample result concentrations were considered significant.
LCS/LCD	LCS percent recovery must be between the upper and lower control limits listed in the SAP and Table 5. In addition, where the sample result is ≤4 times the spiking concentration, the RPD for LCD samples must be ≤30% for soil matrices.
MS/MSD	Laboratory spike recoveries, where the sample result is ≤4 times the spiking concentration are evaluated by comparing the percent recovery with the minimum and maximum control limits provided by the laboratory. In addition, where the sample result is ≤4 times the spiking concentration, the MS/MSD RPD must be ≤30% for soil matrices.

Source: DOE/RL-2011-104, *Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

LCD = laboratory control sample duplicate
LCS = laboratory control sample
MDA = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference
SAP = sampling and analysis plan

10.1 Laboratory Contamination

Hanford Site laboratory contracts require laboratory method blanks to be analyzed with each batch of up to 20 samples. A total of 4,193 unique laboratory blank results were reported: 3,586 results for the deep borehole sample set, and 607 results for the shallow borehole sample set. COPCs were detected in 97 deep and 14 shallow laboratory blank results. These values were compared to detected COPC concentrations in the analytical data set corresponding to each QC batch where that COPC was detected in the blank. Any result where 5% of the standard value reported for an analyte was below the corresponding batch laboratory blank concentration was identified as not meeting evaluation criteria. A total of 195 analytical results did not meet the evaluation criteria: 149 deep borehole results, 39 shallow borehole results, and 7 field trip blank results. Table 18 summarizes the number of analytes impacted by laboratory blank contamination.

Table 18. Field Sample Analyses Impacted by Laboratory Blank Contamination

Deep Boreholes		
Ammonium (34 samples)	Chloride (37 samples)	Sulfate (6 samples)
Antimony (49 samples)	Copper (2 samples)	Technetium-99 (3 samples)
Arsenic (2 samples)	Silver (8 samples)	Uranium-233/234 (2 samples)
Cadmium (2 samples)	Strontium-90 (1 sample)	Uranium-238 (3 samples)
Shallow Boreholes		
Ammonia (38 samples)	Europium-153 (1 sample)	
Field Quality Control Blanks		
Ammonia (1 sample)	Chloride (3 samples)	
Barium (1 sample)	Manganese (1 sample)	
Copper (1 sample)		

10.2 Laboratory Precision

Precision is a measure of data spread when more than one measurement exists of the same sample. Laboratory precision is determined by evaluating laboratory duplicates and comparing the RPD between duplicate samples to accuracy requirements listed in Table 5. A total of 916 MS/MSD and LCS/ laboratory control sample duplicate (LCD) pairs and duplicate samples were evaluated for the deep borehole sample set, and 206 were evaluated for the shallow borehole sample set. Approximately 98% of the results satisfied evaluation criteria. A total of 28 sample pairs exceeded the RPD limits: 27 from the deep borehole samples, and one from the shallow borehole samples. Table 19 identifies the methods and constituents that exceeded SAP (DOE/RL-2011-104) precision requirements.

Table 19. Methods and Constituents that Exceeded SAP Precision Requirements

Anions (EPA Method 300.0)
Chloride (1 sample)
Ammonia (EPA Method 350.1)
Ammonia (2 samples)
Alpha Energy Analysis
Uranium-233/234 (3 samples) Uranium-238 (3 samples)
Cyanide (EPA Method 9012)
Cyanide (2 samples)

Table 19. Methods and Constituents that Exceeded SAP Precision Requirements

ICP/MS Metals (EPA Method 6020)		
Arsenic (1 sample)	Lead (3 samples)	Uranium (4 samples)
Chromium (6 samples)	Manganese (3 samples)	
Copper (4 samples)	Nickel (4 samples)	
Gamma Energy Analysis		
Cesium-137 (2 samples)		
Gas-Flow Proportional Counting		
Strontium-90 (2 samples)		
Mercury (EPA Method 7471)		
Mercury (2 samples)		
Polychlorinated Biphenyls (EPA Method 8082)		
Aroclor 1260 (1 sample)		
Semivolatile Organic Compounds (EPA Method 8270)		
Phenol (3 samples)		
Volatile Organic Compounds (EPA Method 8260)		
1,1,1-Trichloroethane (1 sample)	Carbon tetrachloride (1 sample)	Tetrachloroethene (1 sample)
1,1-Dichloroethane (1 sample)	Chlorobenzene (1 sample)	Toluene (1 sample)
1,2-Dichloroethane (1 sample)	Chloroform (1 sample)	trans-1,2-Dichloroethylene (1 sample)
2-Butanone (2 samples)	cis-1,2-Dichloroethylene (1 sample)	Trichloroethene (1sample)
4-Methyl-2-pentanone (4 samples)	Ethylbenzene (1 sample)	Xylenes (total) (1 sample)
Acetone (2 samples)	Methylene chloride (1 sample)	
Benzene (1 sample)	n-Butylbenzene (1 sample)	

Source: DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

EPA = U.S. Environmental Protection Agency
ICP/MS = inductively coupled plasma/ mass spectrometry
SAP = sampling and analysis plan

The RPD values reported outside of the SAP (DOE/RL-2011-104) analytical performance requirements were related to 117 field sample analyses (Table 20).

Table 20. Field Sample Analyses Impacted by RPD Results Outside of SAP Criteria

Chloride (4 samples)	Ethylbenzene (1 sample)	Manganese (2 samples)
Ammonia (5 samples)	Methylene chloride (1 sample)	Nickel (6 samples)
1,1,1-Trichloroethane (1 sample)	n-Butylbenzene (1 sample)	Uranium (4 samples)
1,1-Dichloroethane (1 sample)	Tetrachloroethene (1 sample)	Mercury (2 samples)
1,2-Dichloroethane (1 sample)	Toluene (1 sample)	Aroclor 1260 (2 samples)
2-Butanone (6 samples)	trans-1,2-Dichloroethylene (1 sample)	Phenol (6 samples)
4-Methyl-2-pentanone (18 samples)	Trichloroethene (1 sample)	Cyanide (3 samples)
Acetone (6 samples)	Xylenes (total) (1 sample)	Cesium-137 (5 samples)
Benzene (1 sample)	Arsenic (1 sample)	Total beta radiostrontium (3 samples)
Carbon tetrachloride (1 sample)	Chromium (7 samples)	Uranium-233/234 (7 samples)
Chlorobenzene (1 sample)	Copper (3 samples)	Uranium-238 (9 samples)
Chloroform (1 sample)	Lead (2 samples)	
cis-1,2-Dichloroethylene (1 sample)		

Source: DOE/RL-2011-104, *Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

10.3 Accuracy

Two types of QC are used to assess accuracy. The LCS is used to assess the performance of the laboratory with respect to the method and the accuracy of the laboratory preparation and analysis processes. The MS samples are used to assess the accuracy of the published method on the sample matrix and to evaluate matrix effects that may bias the data.

10.3.1 Laboratory Control Samples

A total of 3,309 LCS results were reported for the deep borehole data set, and 561 results were reported for the shallow borehole data set. Approximately 97% of the results satisfied evaluation criteria. The LCS values (94 from the deep borehole data set and 8 from the shallow borehole data set) were reported outside of the SAP (DOE/RL-2011-104) analytical performance requirements listed in Table 5. Of the LCS values that were outside the SAP requirements, 95 results were within the laboratory accuracy performance requirements. All of the LCS results for the shallow borehole data set met laboratory acceptance criteria, and 87 of the LCS results for the deep borehole data set met laboratory acceptance criteria. Two of the seven LCS results from the deep borehole data set that were outside of the laboratory accuracy performance requirements were flagged with "o" qualifiers. Table 21 identifies the methods and analytes for which LCS values were outside of the SAP accuracy requirements.

Table 21. Methods and Analytes that Exceeded SAP LCS Accuracy Requirements

Cyanide (EPA Method 9012)
Cyanide (2 samples)
ICP Metals (EPA Method 6010)
Aluminum (10 samples)
ICP/MS Metals (EPA Method 6020)
Aluminum (15 samples) Antimony (34 samples)
Mercury (EPA Method 7471)
Mercury (23 samples)
Polychlorinated Biphenyls (EPA Method 8082)
Aroclor 1016 (3 samples) Aroclor 1260 (1 samples)
Semivolatile Organic Compounds (EPA Method 8270)
Phenol (9 samples) Tributyl phosphate (1 samples)
Total Petroleum Hydrocarbons (NWTPH)
Total petroleum hydrocarbons–kerosene range (4 samples)

Source: DOE/RL-2011-104, *Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

EPA	=	U.S. Environmental Protection Agency	ICP	=	inductively coupled plasma
ICP	=	inductively coupled plasma	ICP/MS	=	inductively coupled plasma/mass spectrometry
LCS	=	laboratory control sample	NWTPH	=	Northwest total petroleum hydrocarbons

The LCS values reported outside of the SAP (DOE/RL-2011-104) analytical performance requirements were related to 397 field sample analyses (Table 22). However, the LCS values met laboratory performance requirements for 382 of the results.

Table 22. Field Sample Analyses Impacted by LCS Results Outside of SAP Criteria

Aluminum (97 results)	Phenol (29 results)
Antimony (119 results)	Tributyl phosphate (8 results)
Mercury (119 results)	Cyanide (7 results)
Aroclor 1016 (6 results)	Total petroleum hydrocarbons–kerosene range (6 results)
Aroclor 1260 (6 results)	

Source: DOE/RL-2011-104, *Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

10.3.2 Matrix Spike Recovery

The MS recovery is also used as a measure of analytical accuracy. A total of 2,041 MS sample results were reported: 1,719 for the deep borehole data set and 322 for the shallow borehole data set. Of these results, 167 results (8.2%) did not satisfy the laboratory analytical performance requirements described in the SAP (DOE/RL-2011-104). Three of the 167 results that did not meet SAP requirements met the control limits established by the laboratories. Table 23 lists the methods and analytes for which MS values were outside of the SAP accuracy requirements.

Table 23. Methods and Constituents that Exceeded SAP MS Accuracy Requirements

Anions (EPA Method 300.0 or 9056)		
Fluoride (2 samples) Nitrogen in Nitrite (12 samples)	Phosphate (2 samples) Phosphorus in phosphate (5 samples)	Sulfate (1 sample)
Ammonia (EPA Method 350.1)		
Ammonia (3 sample) Nitrogen in ammonia (28 samples)		
Volatile Organic Compounds (EPA Method 8260)		
1,1,1-Trichloroethane (1 sample) 1,1-Dichloroethane (1 sample) 1,2-Dichloroethane (3 samples) 2-Butanone (2 samples) 4-Methyl-2-pentanone (2 samples) Acetone (3 samples)	Benzene (1 sample) Carbon tetrachloride (1 sample) Chlorobenzene (2 sample) Chloroform (1 sample) cis-1,2-Dichloroethylene (1 sample) Ethylbenzene (2 samples) Methylene chloride (1 sample)	n-Butylbenzene (1 sample) Tetrachloroethene (2 samples) Toluene (2 samples) trans-1,2-Dichloroethylene (1 sample) Trichloroethene (2 samples) Xylenes (total) (2 samples)
ICP Metals		
Aluminum (3 samples) Antimony (1 sample) Arsenic (2 samples) Barium (6 samples)	Chromium (9 samples) Copper (7 samples) Lead (4 samples)	Manganese (4 samples) Nickel (7 samples) Selenium (10 samples)
Hexavalent Chromium (EPA Method 7196)		
Hexavalent chromium (12 samples)		
Mercury (EPA Method 7471)		
Mercury (1 sample)		
Cyanide (EPA Method 9012)		
Cyanide (2 samples)		
Liquid Scintillation Counter		
Carbon-14 (2 samples)	Technetium-99 (6 samples)	Tritium (1 sample)

Table 23. Methods and Constituents that Exceeded SAP MS Accuracy Requirements

Total Petroleum Hydrocarbons (NWTPH)
Total petroleum hydrocarbons–kerosene range (6 samples)

DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

EPA = U.S. Environmental Protection Agency
ICP = inductively coupled plasma
LCS = laboratory control sample
NWTPH = Northwest total petroleum hydrocarbons
SAP = sampling and analysis plan

11 Data Usability Conclusions

The assessment noted some deficiencies in the data. The deficiencies are summarized in the following sections.

11.1 Data Verification Considerations

Samples were collected at 306 of the 307 planned sample intervals; however, not all planned analyses were performed. Missing analyses were due to incomplete sample recovery, inadequate amounts of fine material for analysis, or samples mistakenly being omitted. A total of 119 constituents planned for data analysis were not analyzed in the deep and shallow boreholes sample set. Deep boreholes C9550 and C8711 were reported together and had 30 missed analytical results for certain COPCs. Deep boreholes C9549, C8707, and C9548 were reported together and had 28 missed analytical results for certain COPCs. Shallow boreholes C9944 and C9865 were reported together and had 39 missed analytical results for certain COPCs. Table 3 lists the specific COPCs and the number of intervals from which the constituent is missing.

A total of 16,523 results from borehole soil samples were generated as a result of field characterization, with only 70 results (<0.5%) flagged as "rejected" or unusable.

All samples and required field QC samples were collected in accordance with SAP (DOE/RL-2011-104) and SAP ADD2 (DOE/RL-2011-104-ADD2), with minor exceptions as noted in Section 9.2. In addition, the analyses were performed in accordance with the contractually required analytical methodology.

11.2 Data Validation Considerations

A minimum of 5% of the data collected were subject to a rigorous third-party validation. Most of the QC deficiencies observed during third-party validation were minor and were considered not to limit the use of the data for decision-making purposes. Values for those constituents flagged as "J," "UJ," "J+," or "J-" should be considered estimated but usable. The main validation observations were blank contamination; lack of LCS, LCD, MS, or MSD data; out-of-limits LCS, MS, or MSD recoveries; and samples analyzed outside of holding times. Table 10 summarizes the data flags assigned during third-party validation.

Four samples were noted for QC deficiencies that were considered by third-party validation to limit use of the data for decision-making purposes and resulted in "R" flags for some of the analytes. Nondetect sample B39WP8 was flagged as "R" due to lack of MS, LCS, and precision data. Nondetect sample B320W0 was flagged as "R" due to very low LCS recovery. The "R" flags were applied to cyanide sample results B3FLN2 and B3FLM9 because analyses were performed in excess of the holding time but within two times the holding time with nondetect results.

11.3 Field Quality Control Considerations

Field QC samples were collected and analyzed in accordance with the SAP (DOE/RL-2011-104). In general, results were within the precision requirements outlined in the SAP. Values exceeding the precision requirements were minimal, and no systemic issues were identified. No impacts to data usability were noted due to field QC issues.

11.4 Laboratory Quality Control Considerations

Laboratory QC samples were analyzed at the required frequency outlined in the SAP (DOE/RL-2011-104). A total of 2,041 MS sample results were reported. Of these results, 167 (8.2%) did not satisfy the laboratory analytical performance requirements described in the SAP. In many cases, the contamination was associated with nondetects in the actual samples. Under these conditions, the observed blank contamination minimally impacted sample results, and the values are considered adequate for their intended use. The LCS and MS performance demonstrated by the laboratory, while in some cases outside of those dictated by the SAP, should be considered as best achievable with current technology, and the associated results should be considered adequate for their intended use.

11.5 Conclusions

Based on the results of the DUA, the overall sample sets and associated analytical data are of sufficient quantity and have a sufficiently low overall degree of qualified (flagged) data points to be considered usable for DQOs for the 200-DV-1 OU remedy selection evaluation. Given the high degree of acceptable data, the analytical results (general chemistry, inorganic, organic, and radiochemical) are considered useable for the intended purposes stated in Chapter 3. Samples were collected and analyzed as specified in the SAP (DOE/RL-2011-104). Sample results accurately indicate the presence or absence of target analyte contamination at sample locations. Laboratory and matrix accuracy and precision are in control overall, and no systematic or general discrepancies were displayed. Sample results are considered to be representative of site conditions at the time of collection. Sample collection and analytical techniques followed approved, documented procedures (except as noted in this report and reflected in qualified data points). All results are reported in industry standard units.

Detection limits, precision, accuracy, and data completeness were evaluated to determine if any analytical data should be rejected as a result of QA/QC deficiencies. The conclusions of this DUA are that, with the exception of 70 results qualified as rejected (flagged as "R"), the collected data are of the right type, quality, and quantity for their intended use in the 200-DV-1 OU remedy selection evaluation.

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