U.S. Department of Energy
Hanford Site

MAR 16 2020

20-TPD-0012

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State
Department of Ecology
3100 Port of Benton Blvd.
Richland, Washington 99354

Dear Ms. Smith:

THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION, TRANSMITTAL OF RPP-PLAN-63020, "SAMPLING AND ANALYSIS PLAN FOR WMA A-AX FOCUS AREA 2 (SOUTHWESTERN AREA OF A FARM)," REV. 1

The purpose of this letter is to transmit the *Sampling and Analysis Plan for WMA A-AX Focus Area 2 (Southwestern Area of A Farm)*, RPP-PLAN-63020, Rev. 1 (SAP, Rev. 1), for Washington State Department of Ecology (Ecology) review. The *Sampling and Analysis Plan for WMA A-AX Focus Area 2 (Southwestern Area of A Farm)*, RPP-PLAN-63020, Rev. 0 (SAP, Rev. 0) was transmitted to Ecology on August 19, 2019. After review of the SAP, Rev. 0, Ecology requested that updates be made to the background section (Section 1.2) regarding the leak at Tank 241-A-105 and groundwater beneath A Farm. The SAP, Rev. 1, reflects this request as well as additional minor updates that do not affect field efforts. The primary additional update was made to Appendix B of the SAP, Rev. 1, to more accurately reflect Pacific Northwest National Laboratory methods and procedures. The document was also updated to identify that the location of the large diameter hole will be determined after construction work around the 242-A Evaporator has concluded (anticipated September 2021).

Field work for Focus Area 2 direct pushes was initiated in late December 2019, and status information has been provided to Ecology.

MAR 1 6 2020

If you have any questions, please contact me, or your staff may contact Becky Blackwell, Closure Project Manager, Tank Farms Programs Division, Office of River Protection, on (509) 376-0058.

Sincerely,

Brian A. Hankins for

Robert G. Hastings, Assistant Manager
Tank Farms Project
Office of River Protection

TPD:RIB

Attachment:
RPP-PLAN-63020

cc w/attach:
M. Barnes, Ecology
D. R. Einan, EPA
S. Leckband, HAB
J. J. Lyon, Ecology
K. Niles, ODOE
J. K. Perry, MSA
P. L. Rutland, WRPS
C. L. Tabor, WRPS
Administrative Record
Environmental Portal
WRPS Correspondence

cc w/o attach:
J. Bell, NPT
A. Buck, Wanapum
L. Contreras, YN
P. Mills, CTUIR
M. Murphy, CTUIR

Attachment
20-TPD-0012

Sampling and Analysis Plan for WMA A-AX Focus Area 2
(Southwestern Area of A Farm),
RPP-PLAN-63020, Rev. 1

(113 Pages Including Cover Sheet)

DOCUMENT RELEASE AND CHANGE FORM

Prepared For the U.S. Department of Energy, Assistant Secretary for Environmental Management
By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08RV14800

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Release Stamp

DATE:
Mar 05,2020
HANFORD RELEASE

1. **Doc No:** RPP-PLAN-63020 **Rev.** 01

2. **Title:**
Sampling and Analysis Plan for WMA A-AX Focus Area 2 (Southwestern Area of A Farm)

3. **Project Number:** T2R02 ☐N/A

4. **Design Verification Required:** ☐Yes ☒No

5. **USQ Number:** ☒ N/A RPP-27195

6. **PrHA Number** **Rev.** ☒ N/A

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Title	Name	Signature	Date
Clearance Review	Raymer, Julia R	*Raymer, Julia R*	03/05/2020
Document Control Approval	Meinecke, Kathryn R	*Meinecke, Kathryn R*	03/05/2020
Originator	Tabor, Cindy L	*Tabor, Cindy L*	03/03/2020
Other Approver	McKinney, Jo M	*McKinney, Jo M*	03/03/2020
Other Approver	Snyder, Susan	*Snyder, Susan*	03/03/2020
Responsible Manager	Rutland, Paul L	*Rutland, Paul L*	03/03/2020

8. **Description of Change and Justification**

Minor updates based on Ecology comments and refinement to PNNL methods identifed in Appendix B.

9. **TBDs or Holds** ☒N/A

10. **Related Structures, Systems, and Components**

a. **Related Building/Facilities** ☒N/A	b. **Related Systems** ☒N/A	c. **Related Equipment ID Nos. (EIN)** ☒N/A

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Document Number	Rev.	Title

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Childress, Ryan D	CLOSURE & INTERIM MEASURES
Gassman, Paul L	PROCESS CHEMISTRY
McKinney, Steve G	INTEGRATION & CONTROL
Tabor, Cindy L	CLOSURE & INTERIM MEASURES
Withrow, Steve M	TANK FARM SAMPLING

INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

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Title: Sampling and Analysis Plan for WMA A-AX Focus Area 2 (Southwestern Area of A Farm)

Publish to OSTI? ☐ Yes ☑ No

Information Category:
☐ Abstract ☐ Journal Article ☐ Summary
☐ Internet ☐ Visual Aid ☐ Software
☐ Full Paper ☐ Report ☑ Other Sampling and Analysis Plan

Trademark/Copyright "Right to Use" Information or Permission Documentation	Yes	NA
	☐	☑

Document Number: RPP-PLAN-63020 Revision 1 Date: February 2020

Author: Mesford, Timothy B

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Date of Conference: Conference Location:

Will Material be Handed Out? ☐ Yes ☑ No Will Information be Published? ☐ Yes ☑ No *(If Yes, attach copy of Conference format instructions/guidance.)*

Part III: WRPS Document Originator Checklist

Description	*Yes*	*N/A*	*Print/Sign/Date*
Information Product meets requirements in TFC-BSM-AD-C-01?	☐	☑	
Document Release Criteria in TFC-ENG-DESIGN-C-25 completed? (Attach checklist)	☐	☑	
If product contains pictures, safety review completed?	☑	☐	Roberts, Sheryl K IDMS workflow data attached

Part IV: WRPS Internal Review

Function	*Organization*	*Date*	*Print Name/Signature/Date*
Subject Matter Expert	WRPS	02/26/2020	Mesford, Timothy B Workflow data attached
Responsible Manager	WRPS	02/13/2020	Rutland, Paul L Workflow data attached
Other:			

Part V: IRM Clearance Services Review

Description	*Yes*	*No*	*Print Name/Signature*
Document Contains Classified Information?	☐	☒	If Answer is "Yes," ADC Approval Required Print Name/Signature/Date
Document Contains Information Restricted by DOE Operational Security Guidelines?	☐	☒	Reviewer Signature: Print Name/Signature/Date
Document is Subject to Release Restrictions? *If the answer is "Yes," please mark category at right and describe limitation or responsible organization below:*	☐	☒	Document contains: ☐ Applied Technology ☐ Protected CRADA ☐ Personal/Private ☐ Export Controlled ☐ Proprietary ☐ Procurement – Sensitive ☐ Patentable Info. ☐ OUO ☐ Predecisional Info. ☐ UCNI ☐ Restricted by Operational Security Guidelines ☐ Other (Specify)
Additional Comments from Information Clearance Specialist Review?	☐	☒	Information Clearance Specialist Approval APPROVED By Lynn M. Ayers at 10:01 am, Feb 26, 2020 Print Name/Signature/Date

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INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part VI: Final Review and Approvals

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WRPS External Affairs	☒	☐	McCune, Hal C - IDMS workflow data attached
WRPS Office of Chief Counsel	☒	☐	Cherry, Steve - IDMS workflow data attached
DOE – ORP Public Affairs/Communications	☒	☐	Levardi, Yvonne & Tyree, Geoff - Workflow data attached
Other: DOE OCC	☒	☐	Zelen, Ben J - IDMS workflow data attached
Other: DOE-ORP SME	☒	☐	Blackwell, Rebecca - IDMS workflow data attached

Comments Required for WRPS-Indicate Purpose of Document:

This sampling and analysis plan presents the sample design and field sampling requirements, quality assurance plan, and laboratory methods for vadose zone soil characterization of the southwestern area of 241-A Tank Farm (Focus Area 2).

APPROVED
By Lynn M. Ayers at 10:01 am, Feb 26, 2020

Approved for Public Release; Further Dissemination Unlimited

Information Release Station

Was/Is Information Product Approved for Release? ☒ Yes ☐ No

If Yes, what is the Level of Releaser? ☑ Public/Unrestricted ☐ Other (Specify) _____

Date Information Product Stamped/Marked for Release: 02/26/2020

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RPP-PLAN-63020
Revision 1

Sampling and Analysis Plan for WMA A-AX Focus Area 2 (Southwestern Area of A Farm)

Prepared by

C. L. Tabor
Washington River Protection Solutions, LLC

K. Schuyler
Freestone Environmental Services, Inc.

Date Published
February 2020

Prepared for the U.S. Department of Energy
Office of River Protection

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ACRONYMS

bgs	below ground surface
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy Office of River Protection
DQA	data quality assessment
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDDPro	Electronic Data Deliverable Processor
EPA	U.S. Environmental Protection Agency
ERT	electrical resistivity tomography
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QC	quality control
RFI	*Resource Conservation and Recovery Act of 1976* facility investigation
SAP	sampling and analysis plan
SMO	Sample Management Office
WMA	Waste Management Area
WRPS	Washington River Protection Solutions

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1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the sample design and field sampling requirements, quality assurance plan, and laboratory methods for vadose zone soil characterization of the southwestern area of A Farm (Focus Area 2). Focus Area 2 is shown in Figure 1-1. The work performed under this SAP is expected to provide information to meet this focus area's data needs identified in Revision 1 of RPP-RPT-60227, *Data Quality Objectives for Vadose Zone Characterization at Waste Management Area A-AX* (the Data Quality Objectives [DQO] Report).

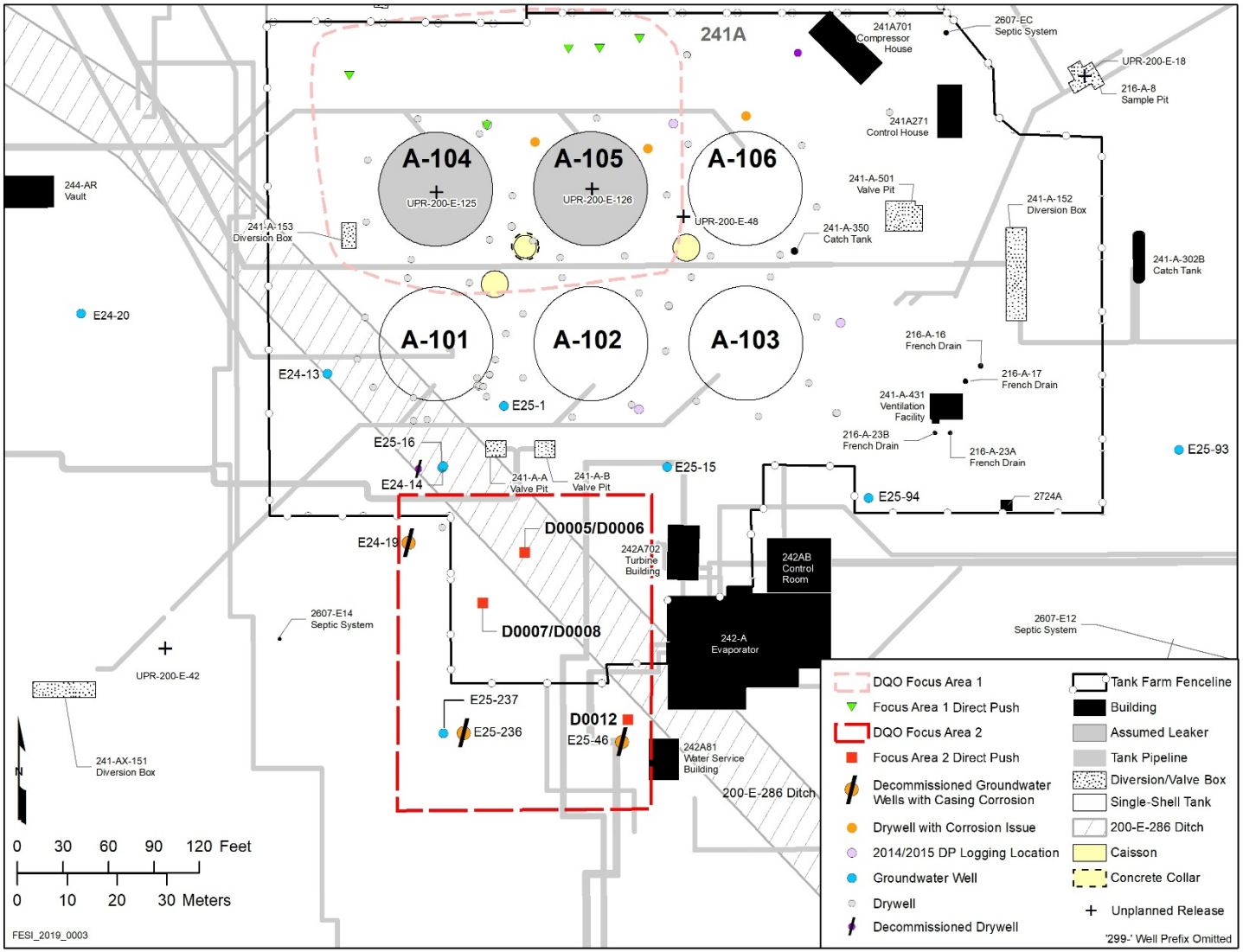
As described in the DQO Report, characterization activities will be undertaken in an iterative manner, with SAPs being prepared to address each focus areas, as identified. After the boundary of Waste Management Area (WMA) A-AX is defined, all focus areas are identified, and all sampling locations pertaining to WMA A-AX characterization are agreed upon, a *Resource Conservation and Recovery Act of 1976* facility investigation (RFI)/corrective measures study work plan will be developed. The work plan will present the preliminary conceptual site model; summarize focus area-specific data needs for WMA A-AX; and provide the context for this SAP within the overall decision-making process for the WMA A-AX performance assessment and closure. Completion of this SAP before the work plan facilitates timely initiation of field characterization activities at WMA A-AX.

This SAP supports vadose zone data collection in Focus Area 2. If the decision makers determine other focus areas should be investigated, then additional SAPs will be developed. Each SAP will be a stand-alone document to support field and laboratory efforts. This SAP is comprised of the following components:

- Introduction (Section 1.0)
- Project Organization (Section 2.0)
- Quality Assurance and Quality Control Requirements (Section 3.0)
- Field Sampling Plan (Section 4.0)
- Sample Analysis Requirements (Section 5.0)
- Data Management (Section 6.0)
- Change Control (Section 7.0)
- Documents and Records (Section 8.0)
- Management of Waste (Section 9.0)
- Health and Safety Plan (Section 10.0)
- References (Section 11.0).

Appendix A provides the characterization deviation form, which is further discussed in Section 7.0. Appendix B provides information about "Special Study" testing and evaluations performed by Pacific Northwest National Laboratory (PNNL).

Figure 1-1. Study Boundary for WMA A-AX Focus Area 2



Note: The location of the large diameter hole (D0012) will be finalized after construction in the area is completed (anticipated September 2021)

Much of the rationale and background material for characterization work and focus area selection are contained in the DQO Report. The DQO principal study questions, decision statements, and estimation statements developed for WMA A-AX are also contained in the DQO Report.

1.1 PURPOSE AND SCOPE

The purpose of this SAP is to specify the requirements for field characterization (i.e., sampling and geophysical logging), laboratory analysis, and data reporting for soil samples that will be collected within the southwestern section of A Farm. The requirements are based on objectives developed using a DQO process documented in the DQO Report. The State of Washington Department of Ecology (Ecology), the U.S. Department of Energy (DOE), and its contractors participated in the DQO process. This SAP and the future work plan provide and will provide information that is consistent with guidelines described in WAC 173-340-820, "Model Toxics Control Act – Cleanup," "Sampling and Analysis Plans." Furthermore, this SAP provides requirements for soil characterization that will be performed to support development of an RFI report and subsequent corrective measures studyfor WMA A-AX.

The scope of this SAP consists of collecting vadose zone soil samples, performing geophysical logging, and installing electrical resistivity tomography (ERT) electrodes. This work will consist of two direct push locations and one large diameter borehole in the area around the southwestern area of A Farm to support:

- Preparation of the WMA A-AX RFI report and corrective measures study including assessment of risk to human health and the environment
- Development and refinement of the WMA A-AX conceptual site model
- Process of risk-informed tank waste retrieval at WMA A-AX.

Information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*, as amended) is not provided in this SAP for the purpose of regulating the radiation hazards of such components under the authority of this SAP or the Hazardous Waste Management Act (RCW 70.105, "Hazardous Waste Management"), but is provided for informational purposes only.

1.2 FOCUS AREA BACKGROUND INFORMATION

This focus area is being investigated to determine if corrosion of wells in the southwestern area of A Farm is associated with tank waste releases from A Farm (e.g., Tank A-105 release). Wells in the southwestern area of WMA A-AX, 299-E-24-19, 299-E25-46, and 299-E25-236 (Figure 1-1), were decommissioned due to corrosion of their casings (DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management*

Area A-AX). These groundwater wells are located approximately 61 m (200 ft) to the south of Tanks A-104 and A-105, nonetheless, there has been speculation by Ecology that the cause of the corrosion might be due to Tank A-104 and/or Tank A-105 waste releases. The DQO Report identifies that approximately 500 to 2,500 gallons of waste have been released from Tank A-104 and any where from 2,000 to 277,000 gallons from Tank A-105. Both the *Tank 241-A-105 Leak Assessment Report* (WHC-MR-0264) and the *Hanford 241-A and 241-AX Tank Farms Leak Inventory Assessment Report* (RPP-ENV-37956) indicate that the release from Tank A-105 was more than likely to be 40,000 gallons or less.

There have been three possible causes for corrosion identified including: use of an annulus sealing agent that became corrosive in the high moisture environment at the corroded wells; exposure to corrosive fluids present in the vadose zone as a result of past releases to a waste site near the corroded wells; and exposure to corrosive fluids contaminated by tank releases. The *Fate and Transport of Constituents Leaked from Tank 241-A-105* (WHC-EP-0412) identifies that data from groundwater wells in and around A Farm indicate groundwater was contaminated before the operation of most tanks in the farm and before leaks were reports. Available records indicate that the volume of liquids discharged by PUREX cribs, french drains and trenches exceeded 3.6 billion gallons, much more than the estimate of about 40,000 gallons of fluids that leaked from Tank A-105.

In 2003, it was determined that two wells (299-E24-19 and 299-E25-46) in the vicinity of WMA A-AX had failed as a result of rapid corrosion of the stainless steel casing. These two wells were decommissioned in fiscal year 2004 (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*). Due to concern regarding the cause of the well corrosion in WMA A-AX, PNNL was asked to perform a detailed analysis of vadose zone samples collected in the vicinity of the well casings during their decommissioning to diagnose cause of rapid well casing corrosion. The resulting report (PNNL-15141, *Investigation of Accelerated Casing Corrosion in Two Wells at Waste Management Area A-AX*) recommended using Portland cement as an annulus sealing agent in groundwater monitoring wells in zones with high moisture content or that have the potential to accumulate perched water, such as well 299-E25-236.

Starting in 2012, technetium-99 exceeded the drinking water standard in well 299-E25-236. In November 2012, review of a video survey completed within well 299-E25-236 revealed accelerated corrosion between 80 and 81 m (263 and 267 ft) below ground surface (bgs), despite the change in annulus sealing agent. Black staining from the corroded casing extended downward an additional ~8.5 to 9.8 m (28 to 32 ft) to groundwater at 90 m (295 ft) bgs. The surface of the groundwater was covered with various particles. The increase in technetium-99 activity at this well may have been associated with liquid seeping through the corroded casing and migrating down the inside of the casing to the groundwater. Elevated technetium-99 activity had also occurred at wells 299-E24-19 and 299-E25-46 (PNNL-15141). Well 299-E25-236 was decommissioned and replaced with well 299-E25-237 in 2013. When wells 299-E24-19, 299-E25-46, and 299-E25-236 were still in service, they also showed elevated levels of nickel, a product of stainless steel well casing corrosion, along with manganese, iron, and chromium. These constituents in groundwater monitored by stainless steel wells are indicators of well corrosion.

At the three corroded and decommissioned wells, the corrosion occurred above the water table at (or slightly above) a fine-grained geologic unit (the Cold Creek silt-dominated unit). Document DOE/RL-2015-49 stated, "It is unlikely that SSTs and other liquid waste facilities in WMA A-AX leaked or discharged a large enough volume that contained the corrosive constituents necessary to corrode the three wells. The most likely source of the corrosion is chloride-bearing effluent from the 200 East Area powerhouse (284-E Powerhouse) that was discharged to an unlined ditch (200-E-286 Ditch) that traversed the southwest end of what later became" A Farm (Figure 1-1). This ditch was active from 1946 to 1953. In 1978, a 60,000 gal leak from a ruptured water line southeast of the 241-A-501 Valve Pit (Occurrence Report 78-24, *Release of Raw Water in 241-A Tank Farm*) and other water releases could have served as a driving force to move contamination toward the groundwater well casings.

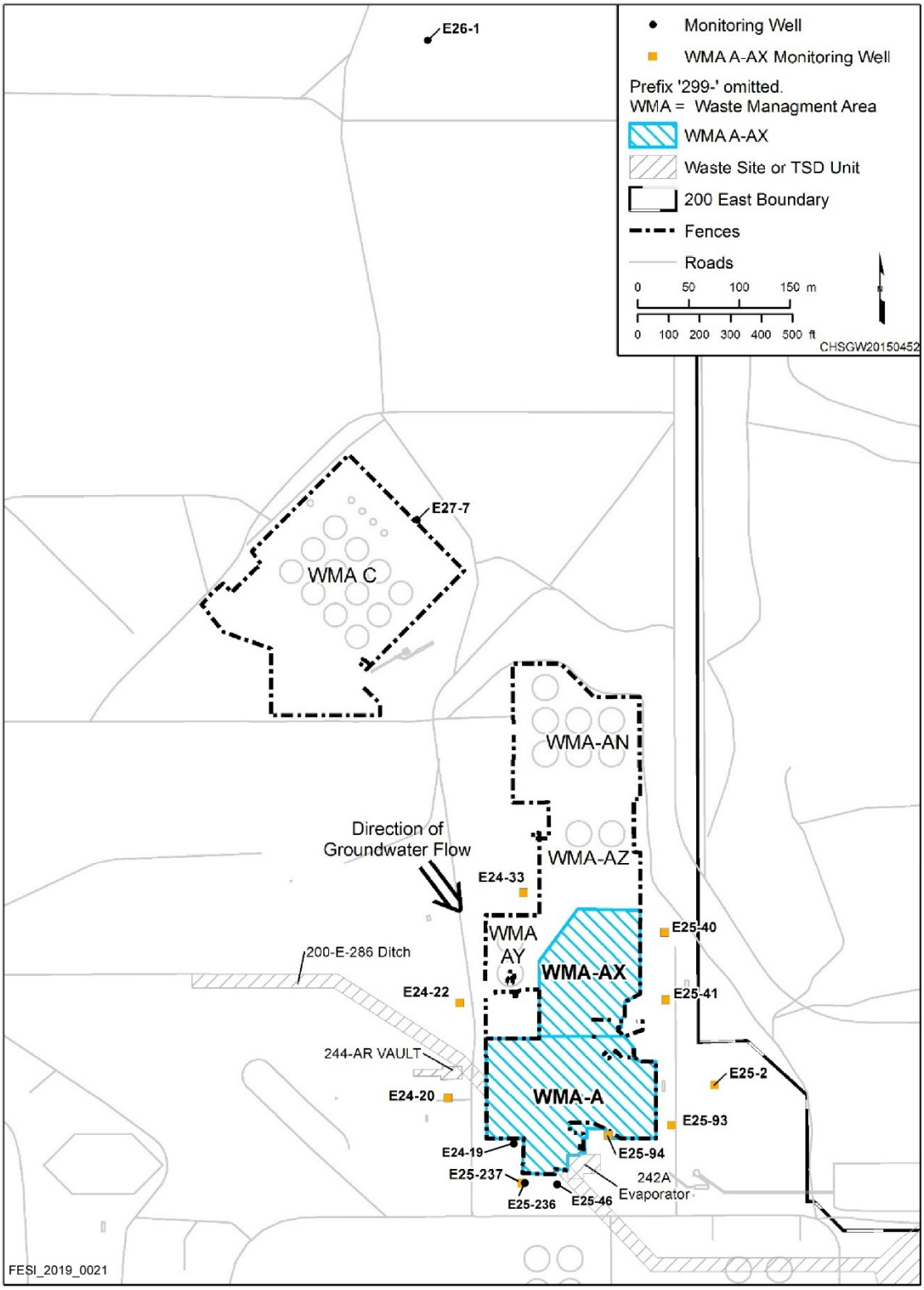
Regardless of the source of chloride, it is believed that the advanced well casing corrosion found at wells 299-E24-19 and 299-E25-46 was caused by chloride-facilitated crevice corrosion and stress corrosion cracking (PNNL-15070). In the neutral pH environments typically found in the vadose zone at the Hanford Site, 100 mg/L chloride is the critical threshold concentration beyond which stainless steel experiences pitting or stress corrosion cracking problems (Sedriks 1996, *Corrosion of Stainless Steel*). Additionally a silts lens, located between 88.6 and 91.9 m (290.7 and 301.5 ft) bgs, likely exacerbated this process by providing a continual source of moisture in contact with the chloride source, which generated localized porewater with high chloride concentrations. Archived soil samples from 299-E24-19 and 299-E25-46 calculated chloride porewater concentrations from 28.8 to 589 mg/L (PNNL-15141). However, the archived soil samples were subject to moisture loss via evaporation during the archival period. Therefore, it is thought that the chloride porewater concentrations of the archived soil samples do not accurately represent in-situ conditions (PNNL-15141).

Another proposed cause of the well corrosion is the release of tank waste. Well drilling logs indicate that the sediments underlying Tanks A-104 and A-105 are highly conductive, indicating that fluids would preferentially flow vertically through the vadose zone. A slow leak of waste directly between the tank laterals could percolate downward through the soil with little horizontal spreading, resulting in the detection of only localized contamination or none at all (WHC-MR-0264, *Tank 241-A-105 Leak Assessment*). Gamma and temperature scans of the laterals indicate only limited contaminant movement horizontally through the vadose zone near the laterals. The infiltration of evaporative cooling water lost from the tanks could transport already-released technetium-99 deep into the vadose zone. Laboratory experiments on flow and transport resulting from tank leaks indicate that under certain conditions, releases can potentially transport contaminants rapidly through the unsaturated zone to groundwater (PNNL-23586, *Intermediate-Scale Laboratory Experiments of Subsurface Flow and Transport Resulting from Tank Leaks*). Horizontal spreading at depth could have occurred if the liquid encountered a lower-permeability lithologic unit (e.g., the Cold Creek silt-dominated unit beneath WMA A-AX), which could account for technetium-99 at the corroded wells southwest of WMA A-AX.

Ratios between chemical concentrations can aid in the determination of contamination sources. For example, comparison of the technetium-99 to nitrate ratios in the sidewall cores samples collected from wells 299-E24-19 and 299-E25-46 indicates that the contamination is likely from

multiple sources. The sidewall core samples from well 299-E24-19 had an average nitrate to technetium-99 ratio of 6.43E+05 (µg nitrate/µg technetium-99), while the sidewall core samples from well 299-E25-46 had an average nitrate to technetium-99 ratio of 1.01E+07 (µg nitrate/µg technetium-99) (PNNL-15141). The disparity in the nitrate to technetium-99 ratios of the sidewall core samples from the two wells could possibly be explained by a leak/discharge of high nitrate containing waste from the 242-A Evaporator, which lies directly northeast of well 299-E25-46. Under this scenario, the two waste streams, 242-A-Evaporator and liquid waste from tanks, could have commingled to create the higher nitrate to technetium-99 ratio measured in the sidewall core samples from well 299-E25-46 (PNNL-15141). The groundwater flow in WMA A-AX is east-southeast (Figure 1-2), which puts well 299-E24-19 directly upgradient of well 299-E25-46 (Figure 1-1).

Figure 1-2. Location of WMA A-AX, A and AX Tank Farms, and Wells in the WMA A-AX Monitoring Network



Modified from DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX.*

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2.0 PROJECT ORGANIZATION

The project organization information is presented in the following sections and in Figure 2-1.

2.1 PROJECT MANAGER

The Project Manager (or designee) is responsible for the project-related activities including coordinating with DOE, regulators, and contactors in support of field activities to ensure work is performed safely and cost effectively. The Project Manager (or designee) coordinates the preparation and updates to the DQO, work plan, and SAPs, as required. In addition, the Project Manager (or designee) is also responsible for managing sampling documents and requirements, field activities, subcontracted tasks, and for ensuring the project file is properly maintained.

2.2 WASTE MANAGEMENT

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

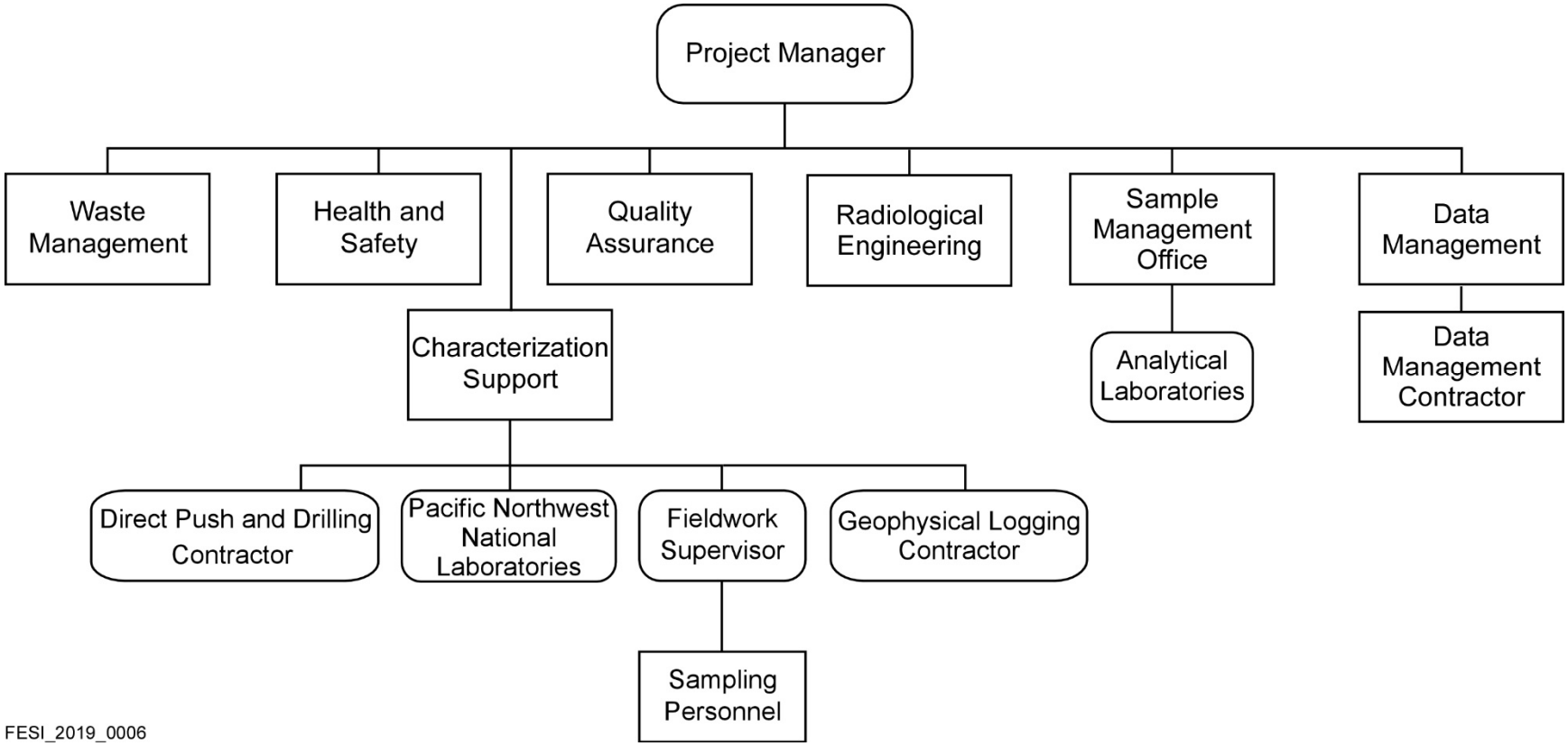
2.3 HEALTH AND SAFETY

The Health and Safety organization is responsible for coordinating industrial health and safety support within the project per the health and safety plan, job hazard analyses, and other pertinent safety documents; providing assistance to ensure compliance with applicable health and safety standards/requirements; and coordinating with Radiological Engineering to determine personal protective clothing requirements.

2.4 QUALITY ASSURANCE

The quality assurance (QA) point of contact provides independent oversight and is responsible for addressing QA issues on the project. The QA point of contact performs assessments and surveillance, as necessary; reviews documentation generated through implementation of field, data management, and/or laboratory activities; and identifies quality assurance hold points or best management practices, as needed.

Figure 2-1. Project Organization



2.5 RADIOLOGICAL ENGINEERING

Radiological Engineering is responsible for conducting As Low As Reasonably Achievable reviews, exposure and release modeling, and radiological control optimization; identifying that appropriate controls are implemented to maintain worker safety; interfacing with Health and Safety; and planning and directing radiological control technicians that support field activities.

2.6 SAMPLE MANAGEMENT OFFICE

The Sample Management Office (SMO) coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. SMO also coordinates with Data Management and associated contractor if issues arise with performing analyses.

The analytical laboratories analyze samples in accordance with established procedures and the requirements of this plan, and provide necessary laboratory data reports containing analytical and quality control (QC) results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues, and coordinate with the SMO and the Data Management Lead.

2.7 DATA MANAGEMENT

Data Management and associated contractor are responsible for generating field sampling documents, labels, and instructions for field sampling personnel and developing the sample authorization form, which provides information and instruction to the analytical laboratories. Data Management and the associated contractor ensure that field sampling documents are revised to reflect approved changes and coordinates with the SMO on project requirements.

Data Management and the associated contractor receive analytical data from the laboratories, ensure it is appropriately reviewed, perform data entry into the Hanford Environmental Information System (HEIS) database, and arrange for data validation and recordkeeping. Data Management and the associated contractor are also responsible for resolving sample documentation deficiencies or issues associated with field activities, laboratories, or other entities. The Data Management Lead or designee is responsible for informing the Project Manager of any issues reported by the analytical laboratories.

2.8 CHARACTERIZATION SUPPORT

Characterization Support personnel convey field requirements and schedule information to various supporting organizations including the Direct Push and Drilling Contractor, PNNL, and the Field Work Supervisor (FWS). The Direct Push, Drilling, and Geophysical Logging Contractors will work under the supervision of Characterization Support personnel.

The Characterization Support personnel will also act as the Sampling Lead and coordinate with nuclear chemical operators (sampling personnel), as necessary.

The PNNL will provide characterization support by performing additional tests and evaluations identified as "Special Study" in the DQO Report. PNNL will also store samples not needed for standard analysis. A field geologist will provide support at the large diameter hole as part of the "Special Study." Refer to Appendix B for additional details on the "Special Study."

The FWS directs the sampling personnel, who collect samples in accordance with this SAP, corresponding standard methods, work packages, and procedures. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that sampling personnel are appropriately trained and available. Sampling personnel collect samples in accordance with sampling documentation; complete field logbooks, chain-of-custody forms, and any necessary shipping paperwork; and deliver samples to the analytical laboratory.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL REQUIREMENTS

Quality assurance plan objectives are met through implementation of all sections of this SAP. This SAP establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis. This SAP has been developed to comply with the requirements of the following:

- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD)
- DOE O 414.1D, *Quality Assurance*
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plan*.

This SAP is also compliant with Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order* (HFFACO) *Action Plan*, Section 6.5, "Quality Assurance."

The HASQARD establishes the quality requirements for environmental data collection, including sampling and analysis, in support of the single-shell tank *Resource Conversation and Recovery Act of 1976* Corrective Action Program. The HASQARD applies to field and laboratory activities and identifies the QC requirements for environmental data collection, including sampling, field measurements, and laboratory analysis.

Hanford Site onsite laboratories performing analyses in support of this SAP will have approved and implemented QA plans. These QA plans will meet the minimum requirements of HASQARD as the baseline for laboratory quality systems. Any analytical work subcontracted to a commercial laboratory off the Hanford Site shall comply with the DOE Consolidated Audit Program Quality Systems manual. A commercial laboratory off the Hanford Site and national laboratory, such as PNNL, is subject to Washington River Protection Solutions (WRPS) audit and QA Program approval.

Project management and QA may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, procedures, and regulatory requirements. Deficiencies identified by these assessments shall be reported in accordance with existing programmatic requirements. Corrective actions will be implemented as required by WRPS policy and procedures. Management will be made aware of deficiencies identified by assessments and surveillances and subsequent corrective actions.

All sampling and analysis activities will be performed using approved methods, procedures, work packages, and plans. The methods, procedures, work packages, and plans are written to meet regulatory, operational, and/or laboratory QA plan requirements.

Sampling and analysis activities shall be performed by qualified personnel using properly maintained and calibrated equipment. Sampling and laboratory personnel shall complete the necessary training and must receive appropriate certification to perform assigned tasks in support

of the project. The environmental safety and health training program provides workers with the knowledge and skills necessary to safely execute assigned duties. Field personnel typically will have completed, at a minimum, the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Radiological worker training (as required).

A graded approach is used to ensure workers receive a level of training commensurate with their responsibilities, which complies with applicable DOE orders and government regulations. Specialized employee training includes pre-job briefings, on-the-job training, emergency preparedness, plan-of-the-day activities, and facility/worksite orientations.

3.1 QUALITY CONTROL REQUIREMENTS FOR FIELD SAMPLING

Prior to conducting sampling activities, the sampling equipment shall be cleaned using a procedure that is consistent with SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, sampling equipment cleaning protocol. Only new (unused), pre-cleaned, quality assured sample containers shall be used for sample collection. Quality control samples shall be collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability. Quality control samples will include the collection of field duplicates, field blanks, equipment rinsate blanks, field split samples where appropriate. Sampling personnel or laboratory personnel will prepare QC samples.

3.1.1 Field Duplicates

Field duplicates are independent samples collected as close as possible to the same time and same location, and intended to be identical. Field duplicates are used to determine precision for both sampling and laboratory requirements. It is not possible to collect field duplicates for direct push. For this reason, field duplicates will not be required for subsurface samples; however, field duplicates will be collected for surface soil samples (i.e., first 31 cm [12 in.]).

The duplicate samples shall be shipped to the laboratory in the same manner as the primary samples. Per HASQARD, field duplicates are normally collected at a frequency of 5 to 10% of the samples collected per matrix (e.g., soil). The DQO Report identified that field duplicates for surface samples will be collected at a frequency of 25%.

Due to the sampling methodology of intact core samples at the large diameter borehole, it is not possible to collect a representative field duplicate. Duplicate samples may be obtained in the laboratory after the soil in the intact core has been removed and homogenized. For this project, the field duplicate to be prepared by the laboratory will be collected for every 20 samples (i.e., frequency of 5%) at the large diameter borehole.

3.1.2 Field Blanks

Field blank samples are samples prepared in the field at the sample collection site and returned to the laboratory with the samples to be analyzed. They are primarily used to test for contamination from the atmosphere. Field blank samples shall consist of deionized water. Field blank samples are samples prepared in the field at the sample collection site and returned to the laboratory with the samples to be analyzed. HASQARD does not identify a frequency for collection of field blanks but does suggest a frequency of not less than 5%. For this project, field blank samples will be collected for every 20 samples (i.e., frequency of 5%) at the direct push sampling locations and large diameter borehole.

3.1.3 Equipment Rinsate Blanks

Equipment rinsate blanks are prepared after the sampling equipment is cleaned; they are used to verify the adequacy of sampling equipment decontamination procedures and shall be collected for each sampling method or type of equipment used. Equipment rinsate blank samples shall consist of deionized water washed over or through decontaminated sampling equipment. Per HASQARD, equipment rinsate blanks shall be collected in the field and at the rate specified by the project. For this project, equipment rinsate blanks will be collected for every 20 samples (i.e., frequency of 5%) at the direct push sampling locations and large diameter borehole.

3.1.4 Field Split Samples

Split samples are a variation of field duplicate samples. Split samples are collected to compare data from different laboratories. Usually, the sample is homogenized and subsequently placed in separate, identically prepared containers, numbered uniquely, and forwarded to separate laboratories for analysis using the same method/protocol. The data generated by field split samples is used during the data assessment process to evaluate the data from the analyses performed by the primary laboratory on samples from the same source. Per HASQARD, field split samples will be collected at the rate specified by the project. For this project, field split samples to be prepared by the laboratory will be collected for every 20 samples (i.e., frequency of 5%) at the large diameter borehole.

3.1.5 Prevention of Cross-Contamination

Special care shall be taken to prevent cross-contamination of samples. Particular care will be exercised to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting them on or near potential contamination sources, such as uncovered ground (samples shall not be collected or stored in the presence of exhaust fumes.)

- Handling bottles or equipment with dirty hands (sample containers shall be filled with care to prevent any portion of the collected sample from coming in contact with the sampling personnel's gloves.)

- Improperly decontaminating equipment before sampling or between sampling events.

3.2 REQUIRED QUALITY CONTROL FOR ANALYSIS

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality and that are suitable for the intended use. Data quality is assessed, in part, by evaluation of precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These terms (i.e., data quality indicators) are defined in Table 3-1.

Table 3-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/ replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, and surrogates)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or remeasurement.

Table 3-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.
Comparability (field duplicate, field split sample, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.

Table 3-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Completeness (no QC element; addressed in data quality assessment)	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, field blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling practices to limit preferential selection or loss of sample media. • Use sample handling practices, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias.

Table 3-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
			• Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (most current methods are preferred).

a. QC acceptance requirements are provided in Table 5-2.

b. For purposes of this sampling plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

Laboratories performing analyses in support of this SAP shall have approved and implemented QA plans. These QA plans shall meet HASQARD minimum requirements.

The laboratory shall also use calibration blanks and calibration check standards appropriate for the analytical instrumentation being used (see HASQARD for definitions of QC samples and standards). The criteria presented are goals for demonstrating reliable method performance. The laboratory will use its internal QA system for addressing any QC failures. Quality Control failures will be brought to the immediate attention of the SMO and the Data Management Lead. Additionally if the QC failures are systematic and cannot be resolved by the internal protocols, the SMO and the Data Management Lead shall be consulted to determine the proper action. The laboratory should suggest a course of action at that time. Data not meeting the QC requirements shall be properly noted, and the associated QC failures shall be discussed in the narrative of the laboratory data report.

3.2.1 Laboratory Quality Control

Laboratory QC samples estimate precision and accuracy of the analytical data. The laboratory method blanks, duplicates, laboratory control sample/blank spike, and matrix spikes are defined in Chapter 1 of SW-846. In the event that sample material is not sufficient to perform all analyses, analyses will be prioritized and sample material allocated to complete as many analyses as possible in priority order (refer to Section 5.2). If insufficient sample is available for completion of laboratory QC analyses, the laboratory will make note of the condition in the data package (i.e., laboratory data report) narrative, and the associated data results will have laboratory qualifiers added as appropriate. If sample volume is insufficient to run all method-required QC, where spike duplicates are required, duplicates do not need to be analyzed, and where duplicates are required, spike duplicates are not required. Minimally, a duplicate and spike (or spike duplicate) is required per laboratory batch.

3.2.2 Instrument/Equipment Testing, Inspection, and Maintenance

Measurement and testing equipment used in the field or in the laboratory, which directly affects the quality of analytical data, will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment as specified by the manufacturer or other applicable guidelines. Maintenance requirements (such as parts lists and documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures (as appropriate). Analytical laboratory instruments are calibrated in accordance with the laboratory’s QA plan and applicable Hanford Site requirements.

Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements. Supplies and consumables are checked and accepted by users prior to use. Supplies and consumables procured by the analytical laboratories are procured, checked, and used in accordance with the laboratory's QA plan.

4.0 FIELD SAMPLING PLAN

This section provides direction for the field activities associated with soil sampling at three locations in Focus Area 2 (Figure 1-1).

- Two direct pushes will be placed at each of two locations. The first push at each location will be for geophysical logging and placement of ERT electrodes, and the second for collecting soil samples. When referring to samples collected at the direct push locations, sampling components are described as "liners" and "shoe."

- The third location is comprised of one large diameter borehole for geophysical logging, collecting soil samples using an intact core sampling method, and placement of ERT electrodes. Samples from the large diameter borehole are collected using a different method. Sampling components from the large diameter borehole are described as "intact core samples" in "Lexan liners." If Lexan™ liners are not available, alternate polycarbonate liners may be used upon approval by the Project Manager.

All field sampling activities shall be conducted in accordance with this SAP and the appropriate procedures and work packages to ensure data is of known and appropriate quality. Soil sampling services for this work will be performed by sampling personnel (e.g., nuclear chemical operators). The sampling personnel shall follow sampling protocols and procedures.

4.1 SAMPLING DESIGN AND STRATEGY

As identified in the DQO Report, a random sampling strategy cannot be applied in WMA A-AX because of the extensive amount of interferences and obstructions. Based on constraints associated with doing work in and around a tank farm, the sampling approach for WMA A-AX will be, in general, judgmental. A judgmental sampling strategy targets locations based on existing knowledge. This approach provides the highest potential for confirming and characterizing known and suspected releases in and around WMA A-AX, and will help refine the WMA A-AX conceptual site models.

Direct push locations in A Farm are limited primarily due to other tank farm activities and subsurface interferences identified by ground penetrating radar surveys. The two direct push locations (identified as D0005/D0006 and D0007/D0008) are depicted in Figure 1-1 and are inside the A Farm fenceline (the fenceline is defined as the TSD Unit Boundary DOE Operating Area in WA7 89000 8967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 9, for the Treatment, Storage, and Disposal of Dangerous Waste*, Part V [Dangerous Waste Permit Application Part A Form, Closure Unit Group 4, Single Shell Tank System]). The target depth for the direct push locations is as close as possible to the capillary fringe (approximately 88 m [290 ft] bgs); the intent is to push to target depths or refusal. Direct push location D0005/D0006 is within the footprint of the

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former 200-E-286 Ditch. Direct push location D0007/D0008 is outside of the 200-E-286 Ditch footprint, which allows for a comparison of the vertical distribution of constituents with sampling Borehole D0006. Direct push location D0007/D0008 is also near well 299-E24-19, a decommissioned well with casing corrosion. The target depth at the direct push locations is as close as possible to the capillary fringe (approximately 88 m [290 ft] bgs); the intent is to drill to target depths or refusal. The direct push location D0007/D0008 allows for investigation of cemented sand encountered at 58 m (189 ft) bgs in well 299-E24-19 that "could possibly be a barrier to contaminant transport" as described by a geologist in a borehole log.

Field activities at two direct push locations include:

- Soil sampling at ground surface (i.e., first 31 cm [12 in.])
- Soil sampling using a vertical push with direct push technology
- Geophysical logging (gross gamma, spectral logging, neutron moisture, and temperature).

The large diameter borehole (identified as D0012) is shown on Figure 1-1. The target depth for Borehole D0012 is as close as possible to the capillary fringe (approximately 88 m [290 ft] bgs); the intent is to drill to target depth or refusal. Conventional drilling technologies such as sonic, routinely drill and sample to depths greater than 88 m (290 ft) bgs on the Hanford Site Central Plateau and the probability of refusal is low. Borehole D0012 is located approximately 110 m (360 ft) south of Tanks A-104 and A-105 and in an area not currently known to have high-level tank waste contamination. This location was chosen due to its close proximity to two wells with casing corrosion (299-E25-46 and 299-E25-236). The location is also relatively free of surface and subsurface obstructions.

Field activities at one large diameter borehole include:

- Soil sampling at ground surface (i.e., first 31 cm [12 in.])
- Soil sampling using an intact core method with sonic drilling technology
- Geophysical logging (gross gamma, spectral logging, neutron moisture, and temperature).

Direct push and large diameter borehole locations, a summary of sampling rationale, and targeted depths are included in Table 4-1. Modifications may be required after field walk downs are conducted, during work package development, and/or if an obstruction occurs during pushing. Changes in sample locations will require notification and approval of the Project Manager or designee. If a direct push meets refusal prior to achieving total depth, the Direct Push Contractor will temporarily suspend work and will contact Characterization Support personnel. The Characterization Support personnel will determine the appropriate path forward. Changes to the SAP will be documented as noted in Section 7.0.

Table 4-1. Sample Location Strategy for Focus Area 2

Borehole ID	Approximate Location	Input Factors Associated with Location Reason for Sampling	Target Depth (bgs)
Direct Push			
D0005/D0006	East of decommissioned well 299-E24-19 (Vertical push)	• Within the previous footprint of 200-E-286 Ditch • Downgradient of Tanks A-104 and A-105 • Quantify contaminant mobility, if contamination is found. **Assess magnitude of contamination for modeling, risk, and nature and extent and quantify contaminant mobility, if contamination is found ("Special Study")**	290 ft
D0007/D0008	Southeast of decommissioned well 299-E24-19 (Vertical push)	• Downgradient of Tanks A-104 and A-105 • Near well (299-E24-19) with casing corrosion • Investigate dark reddish brown (rust colored) sand and low level radiological contamination at 57 m (187 ft) bgs seen at well 299-E24-19 • Investigate cemented sand that "could possibly be a barrier to contaminant transport" from 57.6 to 57.9 m (189 to 190 ft) bgs seen at well 299-E24-19 • Quantify contaminant mobility, if contamination is found. **Assess magnitude of contamination for modeling, risk, and nature and extent and Quantify contaminant mobility, if contamination is found ("Special Study")**	290 ft
Large Diameter Borehole			
D0012	Southwest of decommissioned well 299-E25-46 (Vertical borehole)	• Downgradient of Tanks A-104 and A-105 • Outside A Farm • Near two wells (299-E25-46 and 200-E25-236) with casing corrosion • Investigate zones of cementation with carbonate matrix, "limonite staining", and "confining layer" noted in borehole log from well 299-E25-46 at 84 m (275 ft) bgs • Determine "Special Study" physical properties for primary lithologic units	291 ft

Table 4-1. Sample Location Strategy for Focus Area 2

Borehole ID	Approximate Location	Input Factors Associated with Location Reason for Sampling	Target Depth (bgs)
		• Quantify contaminant mobility, if contamination is found.	
		Assess magnitude of contamination for modeling, risk, and nature and extent. Determine "Special Study" physical properties for primary lithologic units and Quantify contaminant mobility, if contamination is found ("Special Study")	

4.2 SOIL SAMPLE COLLECTION INFORMATION

Field work in WMA A-AX Focus Area 2 involves placement of two vertical direct pushes (D0005/D0006 and D0007/D0008) for geophysical logging, soil sampling, and ERT electrode placement. There will be two direct pushes at each of these locations, the first for geophysical logging and placement of ERT electrodes, and the second for collecting soil samples. Field work at Focus Area 2 will also include intact core sample collection from one large diameter borehole. This work will be performed by the Direct Push Contractor, under the supervision of Characterization Support personnel. The contractor will maintain procedures and calibration certifications to ensure quality data collection.

Geophysical logging data, available quick turnaround analysis results ("quick turn") for two mobile contaminants (technetium-99 and nitrate) along with a geologic summary of the area, operational history, and historical characterization data at that site may be used to aid in determining subsurface sample depths (deep samples from >4.6 m [15 ft] bgs) for direct push. The subsurface sampling horizons for direct push will be selected in an open meeting to which WRPS staff, DOE Office of River Protection (DOE-ORP), Ecology, U.S. Environmental Protection Agency (EPA), and other site contractors shall be invited. An additional back to back sample for direct push will be collected immediately following each deep sample collected for standard analysis. This additional sample interval will be used for the "Special Study."

Intact core sample collection using the sonic drilling method provides a unique opportunity to retrieve numerous quality samples with minimal disturbance to natural formation (Figure 4-1). The sonic drilling method will collect the intact core samples in 1.5 m (5 ft) intervals, producing five separate 0.3 m (1-ft) Lexan liners per sample interval (Figure 4-2). Intact core samples in Lexan liners are collected above and below the planned intervals to bound the target investigation interval and allow some adjustment of sample depths based on the actual conditions encountered during drilling. This will allow for refinement of final sample depths based on the recovered material. Additional samples also allow for flexibility in the event of an incomplete recovery, unusual soil characteristics are observed, or the feature of interest is encountered at a different depth than was expected. Any unused intact core samples may be archived, as

determined by the project. The planned subsurface sampling intervals at the large diameter borehole were predetermined during Revision 1 of the DQO Report and are identified in Section 4.2.3. These predetermined depths from >4.6 m (15 ft) bgs to a depth of approximately 88.7 m (291 ft) bgs were used to identify the intact core sample intervals. Refer to Table 4-2 for predetermined depths.

Figure 4-1. Undisturbed Soil in Intact Core Sample

Figure 4-2. Intact Core Samples in Lexan Liners

Table 4-2. Intact Core Sample Intervals for Large Diameter Borehole

Depth Intervals (ft bgs)				
7-12	50-55	135-140	195-200	271-276
12-17	55-60	140-145	200-205	276-281
17-22	90-95	159-164	251-256	281-286
22-27	95-100	164-169	256-261	286-291
27-32	100-105	169-174	261-266	-
45-50	130-135	190-195	266-271	

ft bgs = feet below ground surface

Additional sample criteria for direct push and the large diameter borehole are identified below.

- At the direct push locations, shallow samples will be collected at ground surface and at approximately 2.1 to 2.7 m (7 to 9 ft) bgs and 3.7 to 4.3 m (12 to 14 ft) bgs. Approximately seven deep sample intervals (>4.6 m [15 ft] bgs) will be determined in meetings with WRPS staff, DOE-ORP, Ecology, EPA, and other site contractors. Back to back samples for each deep sample interval will be collected for "Special Study" testing and evaluation. The result is a total of 14 deep samples and three shallow samples per direct push location.

- At the large diameter borehole, shallow samples will be collected at ground surface and approximately 2.1 to 2.7 m (7 to 9 ft) bgs and 3.7 to 4.3 m (12 to 14 ft) bgs. Twenty-eight deep intact core sample intervals will be collected from predetermined depths >4.6 m (15 ft) bgs to a depth of approximately 88.7 m (291 ft) bgs. Intact core samples in Lexan liners will be collected from the intervals identified in Table 4-2.

- One duplicate sample will be collected at one of the surface sample locations. The field duplicate will be a co-located sample and shall be analyzed for the constituents identified in Table 4-3.

The DQO Report describes the process by which chemical and radiological constituents and physical properties were identified and retained for further evaluation in this focus area. Table 4-3 identifies those constituents and physical properties, referred to as standard analysis, that are to be analyzed and measured in vadose zone soil samples at the direct push locations and the large diameter borehole. Table 4-3 also identifies those constituents that the laboratory will analyze or measure as "quick turn."

Deionized water QC samples (field blanks and equipment rinsate blanks), which are associated with surface and subsurface sampling, will be collected as identified in Sections 3.1.2 and 3.1.3, respectively. These blanks will be collected to evaluate for potential cross-contamination and laboratory performance. Table 4-4 shows the required analysis, sample preservation, containers, and holding times for these field QC samples. Based on the sample frequency for these QC samples, it is anticipated that three field blanks and three equipment rinsate blanks will be collected for this focus area.

The following subsections provide additional sample collection information:

- Surface sample collection (Section 4.2.1)
- Subsurface sample collection for direct push locations (Section 4.2.2).
- Subsurface sample collection for the large diameter borehole (Section 4.2.3).

4.2.1 Surface Sample Collection

Prior to ground surface sampling, sampling tools shall be vendor-certified cleaned or cleaned in accordance with procedures compliant with SW-846 protocol. The cleaned samplers shall be kept in the wrapping until they are used for sampling.

Surface soil samples will be collected at the locations where direct push samples and the large diameter borehole are planned. Soil in the top 31 cm (12 in.) will be collected using spatula, scoop, or miniature core samplers and placed in two 500 mL (16 oz) glass jars.

Table 4-3. Soil Sampling Requirements for WMA A-AX Focus Area 2[a]

Analysis Type	Primary Method[b]	Constituent/Physical Properties	Holding Time
"Quick Turn"[k]	ICP/MS (water extraction)	Technetium-99	6 months
	9056 Ion chromatography	Nitrate[c], Sulfate	48 hours
	9045	pH	24 hours (or as soon as possible) after receipt by laboratory
	9050	Specific Conductance	28 days
Standard	6010 ICP/AES	Aluminum, Barium, Beryllium, Bismuth, Boron, Calcium, Cerium, Chromium, Copper, Iron, Lanthanum, Lead, Lithium, Magnesium, Manganese, Molybdenum, Neodymium, Phosphorous, Potassium, Rhodium, Silicon, Sodium, Strontium, Sulfur, Tantalum, Thorium, Tin, Tungsten, Zinc, Zirconium	6 months
	6020 ICP/MS	Antimony, Arsenic, Cadmium, Cobalt, Nickel, Selenium, Silver, Thallium, Uranium, Vanadium	6 months
	Calculation	Uranium[d]	6 months
	7471 Cold vapor atomic absorption	Mercury	28 days
	7196 Colorimetric	Hexavalent Chromium	30 days
	9056 Ion chromatography	Bromide, Chloride, Fluoride, Nitrate[c], Nitrite[c], Phosphate, Sulfate, Acetate, Formate, Glycolate, Oxalate	28 days/48 hours[e]
	Ion chromatography EPA 300.7	Ammonium	7 days/28 days[f]
	9014 Spectrophotometric	Cyanide	14 days
	9060	Total Organic Carbon	28 days

Table 4-3. Soil Sampling Requirements for WMA A-AX Focus Area 2[a]

Analysis Type	Primary Method[b]	Constituent/Physical Properties	Holding Time
Standard con't	8081 GC/ECD	4,4′-DDD, 4,4′-DDE, 4,4′-DDT, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, Chlordane, Dieldrin, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene,	14 days/40 days[g]
	8082 GC/ECD	Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260	None
	8270 GC/MS	bis(2-Ethylhexl)phthalate, Tributyl phosphate	14 days/40 days[g]
	Gamma energy analysis	Antimony-125, Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155, Radium-226	6 months
	Low energy gamma counting	Iodine-129	6 months
	ICP/MS (acid extraction)	Neptunium-237, Technetium-99, Tin-126, Thorium-232, Uranium-233, Uranium-234, Uranium-235, Uranium-236, Uranium-238	6 months
	Liquid scintillation	Carbon-14, Nickel-63, Plutonium-241, Selenium-79, Tritium	6 months
	Alpha energy analysis	Americium-241, Curium-242, Curium-243/244, Plutonium-238, Plutonium-239/240	6 months
	Beta gas proportional counting	Strontium-90	6 months
	Gravimetric[h]	Percent solids	None
	Gravimetric[h]	Percent water	None
	Gravimetric[i]	Bulk (sediment) density	None
	ASTM D7928 ASTM D6913	Particle size distribution[j]	None

Note: The most current version/revision of methods and/or test plans are preferred.

[a] Sampling personnel will place the shoe material in a 500 mL (16 oz) glass jar. The samples will be cooled to ≤6°C (≤43°F).

[b] Equivalent methods may be used by the laboratory with prior approval by the Data Management Lead.

[c] Analysis for nitrate (CAS number 14797-55-8) and nitrite (CAS number 14797-65-0) will be performed by the laboratory. Nitrogen in nitrate and nitrogen in nitrite will be determined from nitrate and nitrite results.

Table 4-3. Soil Sampling Requirements for WMA A-AX Focus Area 2[a]

Analysis Type	Primary Method[b]	Constituent/Physical Properties	Holding Time

[d] Total uranium result will be calculated using isotopic uranium analysis results. The holding time listed is applicable to the analysis of samples for isotopic uranium.

[e] 48-hour hold time is for nitrate, nitrite, and phosphate.

[f] Holding time is 7 days from collection to extraction/distillation and 28 days from distillation to analysis of preserved distillate.

[g] Holding time is 14 days from collection to extraction and 40 days from extraction to analysis.

[h] Performed using ASTM D2216 with minor modification of the target temperature to 105°C (221°F) and a 1% criteria for final mass difference (Method A).

[i] Bulk (sediment) density will be measured on only subsurface samples and will be determined as described in LAB-PLN-18-00004, "Test Plan for Sample Breakdown and Analysis of Sediment Samples Obtained as Part of the Vadose Zone Project." Bulk density cannot be determined using ASTM D2937 due to the compaction that occurs using the direct push sampling technique. The reported results using LAB-PLN-18-00004 will not be a true bulk density, but rather, a sediment density measurement.

[j] Particle size distribution will be performed by the laboratory, if sample volume is sufficient.

[k] "Quick turn" analyses will be prepared using a 1:1 water digest method. Around 50 g of soil sample is leached using a ratio of one part water to one part soil. The amount of water added to the soil sample is adjusted based on the percent moisture of the soil to maintain the 1:1 ratio of water to soil. The resultant slurries are place on a shaker table for around an hour, transferred to a centrifuge at 4,000 rpm for 30 minutes and filtered. The filtrates are transferred to a sample bottle and analyzed for nitrate and sulfate by ion chromatography and technetium-99 by ICP/MS. A separate unfiltered aliquot of the digest is analyzed for conductivity and pH.

ASTM = American Society for Testing and Materials
CAS = Chemical Abstracts Service
GC/ECD = gas chromatography/electron capture detector
GC/MS = gas chromatography/mass spectrometry
ICP/AES = inductively coupled plasma/atomic emission spectrometry
ICP/MS = inductively coupled plasma/mass spectrometry

References:

ASTM D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.*

ASTM D2937, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*.

ASTM D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*.

ASTM D7928, *Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis*.

EPA/600/S4-86/024, *Development of Standard Methods for the Collection and Analysis of Precipitation,* "Method 300.7, Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography."

LAB-PLN-18-00004, "Test Plan for Sample Breakdown and Analysis of Sediment Samples Obtained as Part of the Vadose Zone Project."

SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*.

Table 4-4. Field Quality Control Requirements for Field Blanks and Equipment Rinsate Blanks for WMA A-AX Focus Area 2 (Deionized Water Samples)

Primary Method[a]	Constituent	Container	Preservative	Holding Time
6010 Inductively coupled plasma/atomic emission spectrometry	Aluminum, Barium, Beryllium, Bismuth, Boron, Calcium, Cerium, Chromium, Copper, Iron, Lanthanum, Lead, Lithium, Magnesium, Manganese, Molybdenum, Neodymium, Phosphorous, Potassium, Rhodium, Silicon, Sodium, Strontium, Sulfur, Tantalum, Thorium, Tin, Tungsten, Zinc, Zirconium	Glass/plastic 500 mL	HNO_3 to pH<2	6 months (28 days for Mercury)
6020 Inductively coupled plasma/mass spectrometry	Antimony, Arsenic, Cadmium, Cobalt, Nickel, Selenium, Silver, Thallium, Uranium, Vanadium			
Calculation	Uranium[b]			
Inductively coupled plasma/ mass spectrometry	Neptunium-237, Techenetium-99, Tin-126, Thorium-232, Uranium-233, Uranium-234, Uranium-235, Uranium-236, Uranium-238			
7470 Cold vapor atomic absorption	Mercury			
Ion chromatography EPA 300.7	Ammonium	Glass/plastic 250 mL	H_2SO_4 to pH<2/ Cool to ≤6°C	28 days
9056 Ion chromatography	Bromide, Chloride, Fluoride, Nitrate[c], Nitrite[c], Phosphate, Sulfate, Acetate, Formate, Glycolate, Oxalate	Glass/plastic 500 mL	Cool to ≤6°C	28 days/ 48 hours[d]
7196 Colorimetric	Hexavalent Chromium	Glass/plastic 500 mL	Cool to ≤6°C	24 hours
9014 Spectrophotometric	Cyanide	Glass/plastic 60 mL	NaOH to pH≥12/ Cool to ≤6°C	14 days

Table 4-4. Field Quality Control Requirements for Field Blanks and Equipment Rinsate Blanks for WMA A-AX Focus Area 2 (Deionized Water Samples)

Primary Method[a]	Constituent	Container	Preservative	Holding Time
9060	Total Organic Carbon	Amber glass 500 mL	H_2SO_4 to pH<2/ Cool to ≤6°C	28 days
8081 GC/ECD	4,4′-DDD, 4,4′-DDE, 4,4′-DDT, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, Chlordane, Dieldrin, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene	Amber glass 2 x 1,000 mL	Cool to ≤6°C	7 days/ 40 days[e]
8082 GC/ECD	Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260	Amber glass 2 x 1,000 mL	Cool to ≤6°C	1 year
8270 GC/MS	bis(2-Ethylhexl)phthalate, Tributyl phosphate	Amber glass 2 x 1,000 mL	Cool to ≤6°C	7 days/ 40 days[e]
Gamma energy analysis	Antimony-125, Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155, Radium-226	Glass/plastic 2×1,000 mL	HNO_3 to pH<2	6 months
Alpha energy analysis	Americium-241, Curium-242, Curium-243/244, Plutonium-238, Plutonium-239/240			
Liquid scintillation	Nickel-63, Plutonium-241, Selenium-79			
Beta gas proportional counting	Strontium-90			
Liquid scintillation	Carbon-14, Tritium	Glass/plastic 1,000 mL	None	6 months
Low energy gamma counting	Iodine-129			

Note: The most current version/revision of methods and/or test plans are preferred.

[a] Equivalent methods may be used by the laboratory with prior approval by the Data Management Lead.

[b] Total uranium result will be calculated using isotopic uranium analysis results.

Table 4-4. Field Quality Control Requirements for Field Blanks and Equipment Rinsate Blanks for WMA A-AX Focus Area 2 (Deionized Water Samples)

Primary Method[a]	Constituent	Container	Preservative	Holding Time

[c] Analysis for nitrate (CAS number 14797-55-8) and nitrite (CAS number 14797-65-0) will be performed by the laboratory. Nitrogen in nitrate and Nitrogen in nitrite will be determined from nitrate and nitrite results.

[d] 48-hour hold time is for nitrate, nitrite, and phosphate.

[e] Holding time is 7 days from collection to extraction and 40 days from extraction to analysis.

CAS = Chemical Abstracts Service

GC/ECD = gas chromatography/electron capture detector

GC/MS = gas chromatography/mass spectrometry

References:

EPA/600/S4-86/024, *Development of Standard Methods for the Collection and Analysis of Precipitation*, Method 300.7, "Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography."

SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*.

The gravel surface in tank farms may prevent collection of a sample because larger soil particles (i.e., gravel/rocks greater than 6.4 mm [0.25 in.] in diameter), typically cannot be used for analysis. Therefore, larger soil particles should not be included in the sample. Preferably, soil particles less than 2 mm (0.08 in.) in diameter (i.e., fine material), should be collected. As sample material is collected, samplers may remove rock and stones to maximize the amount of soil captured for analysis. Additionally, sample material may be sieved, as needed.

If a sample cannot be collected because there is not enough fine material for analysis (full 500 mL [16 oz] glass jars), then Characterization Support personnel will be contacted by the FWS for directions. If a sample is not collected, then pictures of the sampling site will be taken to show the gravelly nature of the land surface. Additionally, the reason a sample could not be collected will be documented in direct push completion reports and noted in the logbook.

4.2.2 Subsurface Sample Collection for Direct Push Locations

Subsurface sampling will be conducted using hydraulic hammer direct push rig technology with dual-string sampling system consisting of inner and outer strings deployed by small-diameter push rods. When the target sampling depth is reached, the rods are pulled back and the "dummy" tip is removed from the inner rods. A sampler is attached to the inner string, returned to the bottom of the outer casing/push tubing, and positioned against the inner receiver face of the drive shoe. The inner and outer tubing strings are "locked" together using a proprietary method. The entire assembly is advanced approximately 10% deeper than the targeted sample interval in order to secure the material in the sampler.

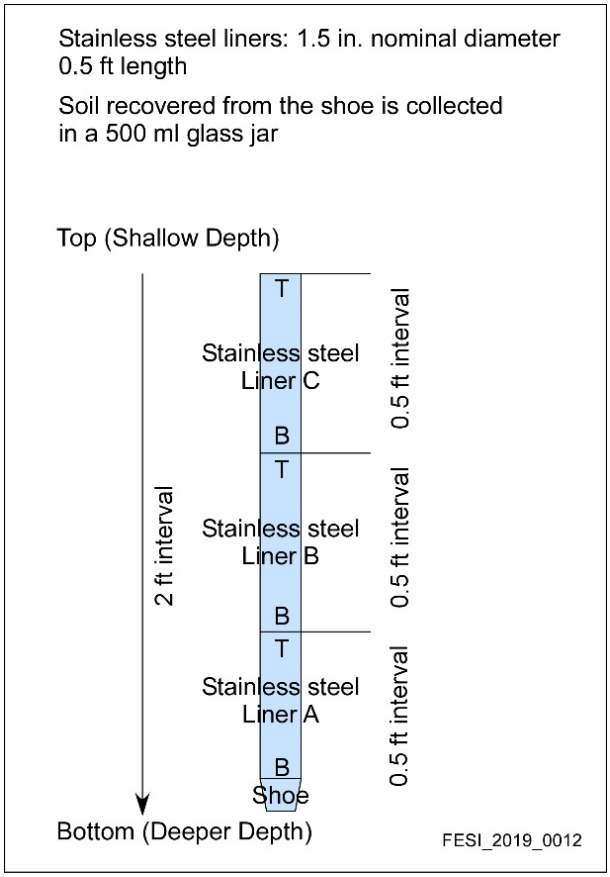
The sampler body holds three stainless steel liners. After sample collection, the liners will be removed from the sampler body and surveyed. Sampling personnel document recovery, sample condition, and estimated volume recovery percent. The sample is then packaged and transported under chain-of-custody control to the laboratory for analysis. The "dummy" tip is reattached to the inner string, placed in the casing shoe, and the entire assembly is advanced to the next sample depth. This process is repeated until all samples are collected or the tubing meets refusal. If an insufficient amount of soil is recovered (approximately less than 75% of expected volume), Characterization Support personnel will be contacted to determine if additional back-to-back samples will be collected to achieve the necessary sample volume for the laboratory analyses.

After sample collection, the liners are removed from the sampler body and surveyed. The material in the shoe shall be placed in a 500 mL (16 oz) glass jar. Stainless steel Liner A is the liner closest to the shoe. The next or middle liner is Liner B, and the topmost stainless steel liner is Liner C. Figure 4-3 provides a diagram of the labeling convention to be used. Each liner shall be marked to indicate its bottom (labeled B) and top (labeled T) to signify the position of the sample prior to shipping and transport. Sampling personnel will cap the liners and label the samples in accordance with Section 4.3. The sample is then packaged and transported under chain-of-custody control to the laboratory for analysis.

Upon completion of the final sample extraction, or upon meeting refusal, the dummy tip or sampler is removed, and the sampling direct pushes are decommissioned per requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Electrodes

will be installed into direct push logging locations at the time of decommissioning to allow for their use in the future. The grout for sealing electrode-equipped direct pushes must be high-strength, low-permeability, and low-conductivity cement. The materials pre-approved for decommissioning wells in accordance with WAC 173-160 have a high electrical conductivity that interferes with electrode measurements. The project will request a variuance from the Washington State Department of Ecology for the decommissioning requirements of WAC 173-160. Once approved, the direct push logging locations with electrodes will be decommissioned using a custom grout mixture consisting of Portland neat cement and ground pumice.

Figure 4-3. Diagram of Labeling Convention for Direct Push Locations



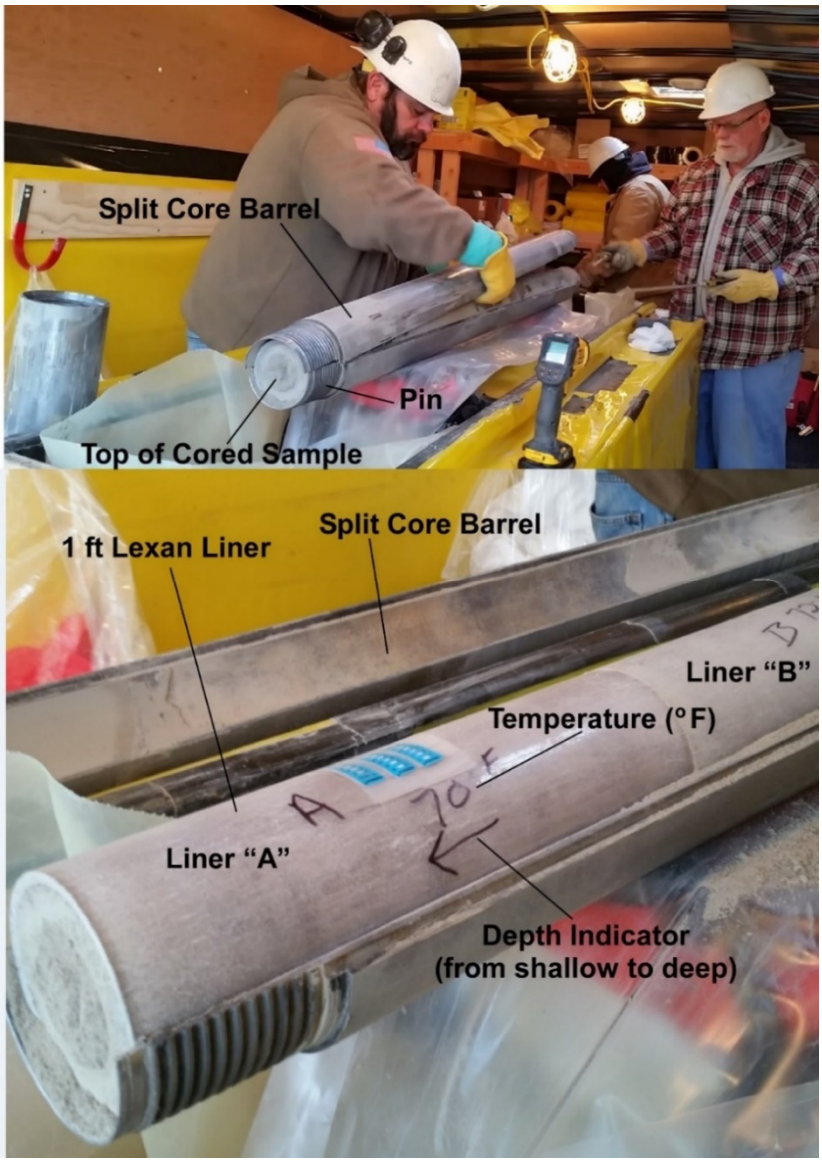
4.2.3 Subsurface Sample Collection for the Large Diameter Borehole

A sonic drilling technology will be used to collect intact core samples and achieve the required total depth. The sonic drilling technique has the capability to provide the necessary sample volumes to perform all required analyses and offers a reduced collection time compared to conventional drilling methods.

Soil will be retrieved as a core sample with minimal disturbance to the sample material (Figure 4-1). The sample apparatus collecting the cores will use a split-barrel design similar to a typical split spoon. The top of the split core barrel (referred to as the “pin”) is held together with a

modified tool that secures the split core barrel to the drill string (Figure 4-4). The bottom of the split core barrel is held together by a modified drill bit called the "shoe."

Figure 4-4. Split Core Barrel and Intact Core Samples

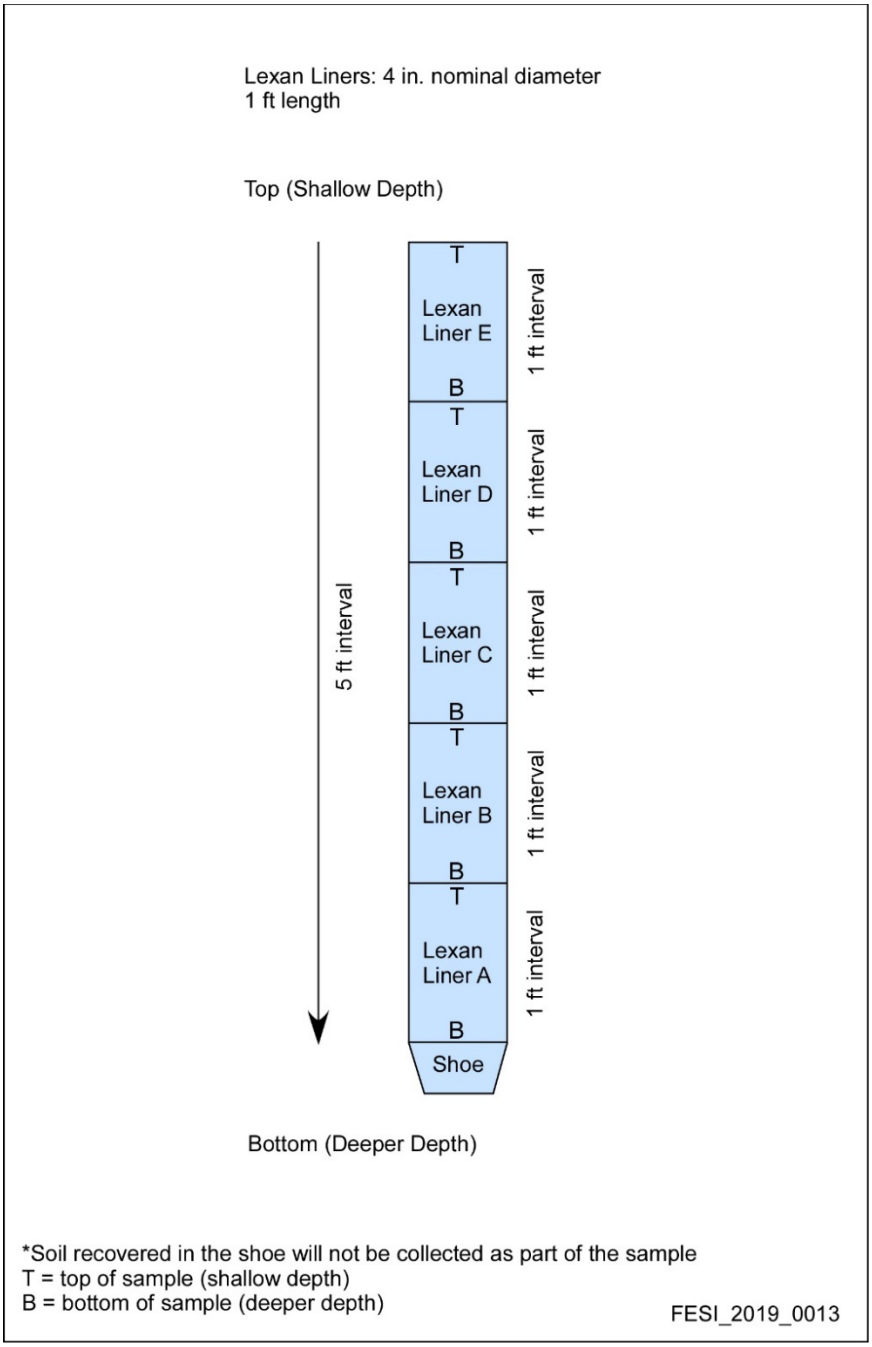


Each split core barrel device will be equipped with five 0.3 m (1 ft) Lexan liners. To collect the intact core sample, the hollow, split core barrel is driven 1.5 m (5 ft) into the undisturbed formation, filling the Lexan liners in the body of the split core barrel, and then brought to the surface.

Because sample retrieval methods may inadvertently increase core barrel temperature, thermal measurements will be collected and recorded from the drill shoe and the liners to ensure that potential temperature-related effects on sediment surface chemistry are documented.

Upon retrieval, each 0.3 m (1 ft) Lexan liner will be labeled regarding its position in the split core barrel (i.e., A, B, C, D, or E, with the bottom/deepest liner being "A" to the uppermost liner being "E"). Figure 4-5 provides a diagram of the labeling convention to be used. Soil recovered in the shoe will not be collected as part of the sample and managed in accordance with Section 9.0. Each liner shall be marked to indicate its bottom (labeled B) and top (labeled T) to signify the position of the sample prior to shipping and transport. Sampling personnel will cap the liners and label the samples in accordance with Section 4.3. They will then package and transport the sample under chain-of-custody control to the laboratory for analysis.

Figure 4-5. Diagram of Labeling Convention for the Large Diameter Borehole



4.3 SAMPLE IDENTIFICATION

The HEIS database is the electronic repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project in accordance with onsite organizational procedures. Each sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampling personnel's field logbook. The shoe material from the direct push locations is placed in a 500 mL (16 oz) glass jar and the three to five liners will each have a unique HEIS number. Each sample container will be labeled with the following information using a waterproof marker on firmly affixed water-resistant labels:

- Sample identification number
- Sample collection date and time
- Name or initials of person collecting the sample
- Preservation method (if applicable)
- Sample location (direct push location identification number and depth of collection).

Due to limited space on sample labels, it is not possible to list all analytes; however, the laboratory is provided all necessary information to complete analysis. This information is provided in Section 5.0, which identifies the full list of analytes, appropriate analysis methods, and additional analysis information (e.g., "quick turn" analyses).

Additionally, coordinate and elevation information for each sample location will be stored in HEIS. Vertical survey data are recorded using NAVD88, *North American Vertical Datum of 1988* and the horizontal coordinates are recorded using the Washington State Plane (South Zone) NAD83, *North American Datum of 1983*, with the 1991 adjustment for horizontal coordinates. The coordinates and elevations (e.g., ground surface, sample depths) will be in metric units.

4.4 SAMPLE CUSTODY

Sampling personnel shall initiate a chain-of-custody form for each sample. The chain-of-custody form shall accompany each sample. At a minimum, the following sampling information shall be included on the chain-of-custody form:

- Project name
- Signature of the collector
- Date and time of collection
- Sample type (e.g., soil)
- Sample preservation information

- Requested analysis or provide a reference for sample analysis
- Signatures of persons involved in the chain of possession
- Date and time relinquished to the laboratory
- Unique HEIS sample identification number assigned to the sample
- Sample location (direct push location or borehole identification number and depth of collection)
- A notation of pertinent sampling information including unusual characteristics or sampling problems
- A brief description of the sample matrix, such as color or consistency, if possible.

Any pertinent sampling information (recovery, unusual characteristics, or sampling problems) shall be recorded in the sampling logbook. Each sample will be shipped in an approved shipping container in accordance with approved procedures. Each sample will be sealed with a sample seal to demonstrate that the samples have reached the laboratory without alteration.

4.5 SAMPLE HANDLING AND SHIPPING

All samples shall be stored and shipped at a temperature of ≤ 6°C (43°F). To meet applicable holding time requirements, the samples shall be shipped to the laboratory as soon as possible, typically the same day as collected. However, some samples may have elevated levels of radioactivity that require storage and transport in shielded shipping containers, which may prevent maintaining temperatures of ≤ 6°C (43°F). Sample shipments not meeting temperature or holding time requirements will be identified and brought to the immediate attention of the Data Management Lead, and discussed in the laboratory data report. The impact on subsequent use or interpretation of these data will be evaluated by the Project Manager.

Radiological control technician(s) will measure the dose rates of each sample container (i.e., glass jar and liners). The radiological control technician(s) also will measure radiological activity on the outside of the sample container (through the container) and will document the highest contact radiological reading in millirem per hour. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, “Transportation”), and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory’s acceptance criteria.

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5.0 SAMPLE ANALYSIS REQUIREMENTS

This section provides direction to the laboratory for sample preparation and analytical requirements for samples collected from the surface and subsurface depths identified for standard analysis in Table 5-1. The analytical methods are identified in Table 5-2. This section also identifies the samples need to be shipped to PNNL for "Special Study" testing and evaluations. Appendix B provides more details on the "Special Study" to be performed by PNNL.

Table 5-1. Approximate Sample Depths and Testing Requirements for the Large Diameter Borehole

Intact Core Sample Interval (ft bgs)	Sample Depths for Standard Analysis (ft bgs)[a, b]	Depths of Intact Core Samples in Lexan Liners Shipped to PNNL (ft bgs)
Surface	Surface	-
7-12	7-8	8-12
12-17	12-13	13-17
17-22	-	17-22
22-27	22-23	23-27
27-32	-	27-32
45-50	-	45-50
50-55	-	50-55
55-60	-	55-60
90-95	-	90-95
95-100	95-96	96-100
100-105	-	100-105
130-135	-	130-135
135-140	-	135-140
140-145	-	140-145
159-164	-	159-164
164-169	164-165	165-169
169-174	-	169-174
190-195	-	190-195
195-200	195-196	196-200
200-205	-	200-205
251-256	-	251-256
256-261	256-257	257-261
261-266	-	261-266
266-271	-	266-271

Table 5-1. Approximate Sample Depths and Testing Requirements for the Large Diameter Borehole

Intact Core Sample Interval (ft bgs)	Sample Depths for Standard Analysis (ft bgs)[a, b]	Depths of Intact Core Samples in Lexan Liners Shipped to PNNL (ft bgs)
271-276	(c)	Remaining intact core sample liners
276-281	-	276-281
281-286	(d)	Remaining intact core sample liners
286-291	-	286-291

a. Depths may be adjusted based on sampling technique and actual field conditions.

b. Standard analysis identified in Table 5-2.

c. Target the Cold Creek silt-dominated unit. For standard analysis, the geologist will select the 0.3 m (1-ft) intact core sample in Lexan liner representative of the Cold Creek silt-dominated unit, identified as containing the most silt or clay. Based on available borehole logs, the tentative sample depth for standard analysis is 82.9 to 83.2 m (272 to 273 ft) bgs.

d. Target the Cold Creek gravel-dominated unit. For standard analysis, the geologist will select the first 0.3 m (1-ft) intact core samples in Lexan liners representative of the Cold Creek gravel unit, identified as containing gravel or sandy gravel. Based on available borehole logs, the tentative sample depth for standard analysis is 86.6 to 86.9 m (284 to 285 ft) bgs. The remaining Lexan liners from this sample interval will be used by PNNL for the “Special Study” as described in Appendix B.

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Aluminum	2.75	6010 ICP/AES (acid)	6020 ICP/MS (acid)	80-120%	75-125%	≤30%	6 months
Barium	10.2						
Beryllium	0.5						
Calcium	6.25						
Chromium	0.15						
Copper	1						
Iron	5						
Lead	5						
Lithium	0.9						
Magnesium	26.3						
Manganese	0.55						
Molybdenum	0.47[e]						
Phosphorus	9.8						
Potassium	157						
Silicon	5.05						
Sodium	22.4						
Strontium	0.55						
Sulfur	11.4						
Tantalum	25.5						
Thorium	4.85						
Tin	6						
Tungsten	42.9						
Zinc	1						

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Zirconium	1.2	6010 ICP/AES (acid)	6020 ICP/MS (acid)	80-120%	75-125%	≤30%	6 months
Bismuth	25.8		NA				
Boron	6						
Cerium	10.5						
Lanthanum	2.75						
Neodymium	5.05						
Rhodium	25.8						
Antimony	0.13[f]	6020 ICP/MS (acid)	6010 ICP/AES (acid)	80-120%	75-125%	≤30%	6 months
Arsenic	0.2						
Cadmium	2.02E-2						
Cobalt	2						
Nickel	3						
Selenium	0.02						
Silver	6.00E-04						
Thallium	4.00E-04						
Vanadium	6.00E-03						
Uranium	0.5						
Uranium[g]	0.5	Calculated from Isotopic Uranium Results	NA	80-120%	75-125%	≤30%	6 months
Mercury	0.01[f]	7471 Cold vapor atomic absorption (acid)	6020 ICP/MS (acid)	80-120%	75-125%	≤30%	28 days
Hexavalent Chromium	0.09	7196 Colorimetric (water)	NA	80-120%	75-125%	≤30%	30 days

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Ammonium	0.5	Ion Chromatography EPA 300.7 (distillation)	NA	80-120%	75-125%	≤30%	7 days/28 days[h]
pH	-	9045	NA	± 0.1 pH units	NA	NA	24 hours (or as soon as possible) after receipt by laboratory
Bromide	1	Ion Chromatography 9056 (water)	NA	80-120%	75-125%	≤30%	28 days
Chloride	0.3						
Fluoride	2.81[f]						
Nitrate[i]	2.5						48 hours
Nitrite[i]	2.5						
Phosphate	0.785[f]						
Sulfate	2.7						28 days
Acetate	4.5						
Formate	10.0	Ion Chromatography 9056 (water)	NA	80-120%	75-125%	≤30%	28 days
Glycolate	3.8						
Oxalate	2						
Cyanide	0.5	9014 Spectrophoto-metric (distillation)	9012 Colorimetric	80-120%	75-125%	≤30%	14 days
Total Organic Carbon	20	9060	NA	85-115%	70-130%	≤30%	28 days

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
4,4′-DDD	0.025[j]	8081 GC/ECD (acid)	8270 GC/MS	70-130%	70-130%	≤30%	14 days/ 40 days[k]
4,4′-DDE	0.025[j]						
4,4′-DDT	0.025[j]						
Aldrin	0.01						
alpha-BHC[l]	NA						
beta-BHC[l]	NA						
gamma-BHC[l]	0.6						
Chlordane	0.1						
Dieldrin	0.007						
Endrin	0.02						
Heptachlor	0.04						
Heptachlor epoxide	0.04						
Hexachlorobenzene	1.70						

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Aroclor-1016	0.02	8082 GC/ECD (acid)	NA	70-130%	70-130%	≤30%	None
Aroclor-1221	0.02						
Aroclor-1232	0.02						
Aroclor-1242	0.02						
Aroclor-1248	0.02						
Aroclor-1254	0.02						
Aroclor-1260	0.02						
bis(2-Ethylhexyl)phthalate	2.95	8270 GC/MS (acid)	NA	70-130%	70-130%	≤30%	14 days/ 40 days[k]
Tributyl phosphate	3.3						
Antimony-125 – ^{125}Sb	0.3	Gamma energy analysis (direct)	NA	80-120%	N/A	≤30%	6 months
Cesium-137 – ^{137}Cs	0.1						
Cobalt-60 – ^{60}Co	0.01[f]						
Radium-226 – ^{226}Ra	0.2[f]			NA	75-125%		
Europium-152 – ^{152}Eu	0.1[f]				NA		
Europium-154 – ^{154}Eu	0.03[e,f]						
Europium-155 – ^{155}Eu	0.05[e,f]						
Iodine-129 – ^{129}I	2	Low energy gamma counting (fusion)	ICP/MS (acid)	80-120%	NA	≤30%	6 months
Technetium-99^{m}– ^{99}Tc	1	ICP/MS (water)	NA	80-120%	75-125%	≤30%	6 months

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Technetium-99[m]– ^{99}Tc	1	ICP/MS (acid)	Liquid scintillation (acid)	80-120%	75-125%	≤30%	6 months
Tin-126[n]– ^{126}Sn	400		NA				
Uranium-233 – ^{233}U	0.174			NA	NA		
Uranium-234 – ^{234}U	3.75E-02						
Uranium-235 – ^{235}U	4.32E-05			80-120%	75-125%		
Uranium-236 – ^{236}U	5.18E-04			NA	NA		
Uranium-238 – ^{238}U	4.37E-04			80-120%	75-125%		
Thorium-232 – ^{232}Th	4.40E-05						
Neptunium-237 – ^{237}Np	3.80E-02		Alpha energy analysis (acid)				
Tritium – ^{3}H	30	Liquid scintillation (water[o])	NA	80-120%	75-125%	≤30%	6 months
Carbon-14 – ^{14}C	1	Liquid scintillation (acid)	NA	80-120%	75-125%	≤30%	6 months
Nickel-63 – ^{63}Ni	30			80-120%	NA		
Selenium-79 – ^{79}Se	10			NA	NA		
Plutonium-241 – ^{241}Pu	1.65E+04		Calculation (from ^{238}Pu and $^{239/240}$Pu)	80-120%	75-125%		
Plutonium-238 – ^{238}Pu	1	Alpha energy analysis (acid)	ICP/MS (acid)	NA	NA	≤30%	6 months
Plutonium-239/240 – $^{239/240}$Pu	0.03[f]			80-120%			
Americium-241 – ^{241}Am	1						
Curium-242 – ^{242}Cm	1			NA		NA	
Curium-243/244 – $^{243/244}$Cm	1						

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	
Strontium-90 – ^{90}Sr	0.18[f]	Beta gas proportional counting (acid)	NA	80-120%	75-125%	≤30%	6 months
Percent water	-	Gravimetric[p]	NA	NA	NA	≤30%	None
Percent solids	-	Gravimetric[p]	NA	NA	NA	NA	None
Specific Conductance	-	9050	NA	NA	NA	NA	28 days
Bulk (sediment) density[q]	-	Gravimetric[q]	NA	NA	NA	≤30%	None
Particle size distribution[r]	-	ASTM D7928 ASTM D6913	NA	NA	NA	NA	None

Note 1: All standard analysis is performed on composite samples. The laboratory data report will be provided by the laboratory in Format VI. "Quick turn" analyses will be provided via e-mail to the Data Management Lead and will also be available in the laboratory data report for loading into HEIS.

Note 2: The most current version/revision of methods and/or test plans are preferred.

Note 3: **Bold** constituents are "quick turn" constituents. These constituents are also analyzed as part of standard analysis. Technetium-99 is listed twice in the table because the preparation method is different for "quick turn" and standard analysis. "Quick turn" analyses will be prepared using a 1:1 water digest method. Around 50 g of soil sample is leached using a ratio of one part water to one part soil. The amount of water added to the soil sample is adjusted based on the percent moisture of the soil to maintain the 1:1 ratio of water to soil. The resultant slurries are place on a shaker table for around an hour, transferred to a centrifuge at 4,000 rpm for 30 minutes and filtered. The filtrates are transferred to a sample bottle and analyzed for nitrate and sulfate by ion chromatography and technetium-99 by ICP/MS. A separate unfiltered aliquot of the digest is analyzed for conductivity and pH.

Note 4: Detection limits may be lower than achievable. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards. Detection limits that were not achieved will be documented in the laboratory data report (e.g., narrative).

[a] Detection limits for non-radiological constituents are in mg/kg, and detection limits for radiological constituents are in pCi/g.

[b] Equivalent methods may be used by the laboratory with prior approval by the Data Management Lead.

[c] Sampling personnel will place the shoe material in a 500 mL (16 oz) glass jar. The samples will be cooled to ≤6°C (≤43°F). Directions for sample preparation are provided in Section 5.1.

[d] Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and WHL-MP-1011.

[e] QC failures will be brought to the immediate attention of SMO and the Data Management Lead and will be discussed in the laboratory data report narrative. The associated result(s) qualified appropriately in the laboratory data report.

[f] Detection limit listed is Hanford Site background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

[g] Total uranium result will also be calculated using isotopic uranium analysis results. The QC Acceptance Requirements and holding time listed is applicable to the analysis of samples for isotopic uranium.

[h] Holding time is 7 days from collection to extraction/distillation and 28 days from distillation to analysis of preserved distillate.

[i] Analysis for nitrate (CAS number 14797-55-8) and nitrite (CAS number 14797-65-0) will be performed by the laboratory. Nitrogen in nitrate and Nitrogen in nitrite will be determined from nitrate and nitrite results.

[j] In support of the ecological risk assessment, the detection limit identified in the DQO Report has been lowered.

Table 5-2. Analytical and Quality Control Requirements for Standard Analysis at WMA A-AX Focus Area 2

Constituent/Physical Properties	Required Detection Limit[a]	Primary Method[b, c] (prep)	Alternative Method[b] (prep)	QC Acceptance Requirements[d,e]			Holding Times
				LCS %Recovery	Spike %Recovery	RPD	

[k] Holding time is 14 days from collection to extraction and 40 days from extraction to analysis.

[l] CAS number 319-84-6 is for alpha-Hexachlorocyclohexane and alpha-BHC. CAS number 319-85-7 is for beta-Hexachlorocyclohexane and beta-BHC (also known as beta-1,2,3,4,5,6-Hexachlorocyclohexane [beta-BHC] in HEIS). CAS number 58-89-9 is for gamma-Hexachlorocyclohexane (Lindane) and gamma-BHC.

[m] The laboratory shall differentiate between water extraction and acid extraction ^{99}Tc results in both hard copy and electronic (HEIS) reporting. For HEIS upload, the extraction (WE [water] or AE [acid]) will be appended to the method name.

[n] The acceptance requirements listed are those for Tin-117 (^{117}Sn), which is used as a surrogate to estimate precision and accuracy of the method for ^{126}Sn.

[o] RPP-RPT-60227, *Data Quality Objectives for Vadose Zone Characterization at Waste Management Area A-AX,* erroneously identified acid as the sample preparation method.

[p] Performed using ASTM D2216 with minor modification of the target temperature to 105°C (221°F) and a 1% criteria for final mass difference (Method A).

[q] Bulk (sediment) density will be measured on only subsurface samples and will be determined as described in LAB-PLN-18-00004, "Test Plan for Sample Breakdown and Analysis of Sediment Samples Obtained as Part of the Vadose Zone Project." Bulk density cannot be determined using ASTM D2937 due to the compaction that occurs using the direct push sampling technique. The reported results using LAB-PLN-18-00004 will not be a true bulk density, but rather, a sediment density measurement.

[r] Particle size distribution will be performed by the laboratory, if sample volume is sufficient.

CAS = Chemical Abstracts Service
GC/ECD = gas chromatography/electron capture detector
GC/MS = gas chromatography/mass spectrometry
HEIS = Hanford Environmental Information System
ICP/AES = inductively coupled plasma/atomic emission spectrometry
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
NA = not applicable
RPD = relative percent difference

References:

ASTM D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.*

ASTM D2937, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*.

ASTM D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*.

ASTM D7928, *Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis*.

EPA/600/S4-86/024, *Development of Standard Methods for the Collection and Analysis of Precipitation*, "Method 300.7, Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography."

LAB-PLN-18-00004, "Test Plan for Sample Breakdown and Analysis of Sediment Samples Obtained as Part of the Vadose Zone Project."

RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*.

RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study*.

SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*.

WHL-MP-1011, *Quality Assurance Project Plan for 222-S Laboratory.*

As identified in Section 4.0, two methods are being used to collect samples; direct push and sonic drilling (i.e., large diameter borehole).

For direct push locations:

- Standard analysis will be performed on three shallow sample intervals: surface, 2.1 to 2.7 m (7 to 9 ft) bgs and 3.7 to 4.3 m (12 to 14 ft) bgs.

- Standard analysis will be performed on seven deep sample intervals determined in meetings with Ecology, DOE-ORP, and WRPS. The number of deep samples maybe adjusted with DOE-ORP and Ecology concurrence. An additional back to back sample will be collected for each deep sample interval, the liners and shoe will be sent to PNNL for "Special Study" testing and evaluation described in Appendix B.

For the large diameter borehole:

- Standard analysis will be performed on three shallow sample intervals: surface, 2.1 to 2.7 m (7 to 9 ft) bgs and 3.7 to 4.3 m (12 to 14 ft) bgs.

- Standard analysis will be performed on seven deep sample depth intervals identified in Table 5-1. The number and depth of deep samples maybe adjusted with DOE-ORP and Ecology concurrence. Additional intact core samples collected in Lexan liners will be sent to PNNL for "Special Study" testing and evaluation described in Appendix B.

After the samples are received at the laboratory, the samples for standard analysis will be prepared and analyzed in accordance with this SAP. Table 5-2 identifies the following information:

- Constituent (analyte)/physical properties
- Required detection limit
- Primary and alternative method of analysis
- QC acceptance requirements for the primary methods
- Holding times.

"Quick turn" constituents for soil samples are bolded in Table 5-2 and include technetium-99, nitrate, sulfate, pH, and specific conductance. Results for "quick turn" constituents will be reported for each sample, provided sufficient sample material is obtained to perform all analyses.

Changes to the approved laboratory analytical procedures or methods may be required to accommodate analysis of samples that are contaminated with Hanford Site tank waste and/or to reduce radiological exposure to the analysts. Documentation will be provided in the laboratory data report to reaffirm these changes will not affect the quality of the data or its intended use. The documentation of changes (e.g., substitutions, deviations, or modifications) to the methods shall be in writing, maintained at the laboratory, and available for inspection on request. Additional regulatory QA or HASQARD requirements for documenting procedure

modifications shall also be followed. Prior to deviating from the methods identified in Table 5-2, the Data Management Lead must be contacted.

5.1 DIRECTIONS FOR SAMPLE PREPARATION AND STANDARD ANALYSIS

Samples delivered to 222-S Laboratory are normally received from the field at door 13 of the Multicurie Section. Samples transported in coolers will be stored under refrigeration until they are processed. Upon receipt, the sample custodian will verify the identification number on each sample container and ensure it matches the sample seal on the sample container and the chain-of-custody form. Laboratory sample identification numbers will be affixed to each container that is retained past initial receipt. Residual sample material remaining after analysis will be maintained in refrigerated storage until directed otherwise by the Data Management Lead. This section pertains to standard analysis. "Special Study" testing and evaluations are described in Appendix B.

For surface and subsurface samples (liner or intact cores), a licensed geologist with Hanford Site experience will photograph, examine, and describe the material from each glass jar or liner from the direct push locations, and intact core samples identified for standard analysis in Table 5-2. The preferred methods of analysis are SW-846 or other approved standardized methods as applicable. The most recent revisions are preferred. Visual inspection and manual manipulations are performed to provide a geologic description of each sample. These descriptions shall provide estimates of the percentage of sand, fine sand, very fine sand, coarse to fine silt, and mud content per ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual–Manual Procedure)*. The soil descriptions are recorded and used to classify the sediment texture on a modified Folk/Wentworth diagram. Additional HEIS sample numbers will be assigned to the composite and "quick turn" samples, as needed.

Sections 5.1.1 and 5.1.2 describe surface and subsurface sample analysis, respectively. Particle size distribution will be performed per LAB-PLN-18-00004, "Test Plan for Sample Breakdown and Analysis of Sediment Samples Obtained as Part of the Vadose Zone Project" only if there is enough sample material.

5.1.1 Surface Sample Analysis

Surface samples will be photographed, geologically described, and subsampled per LAB-PLN-18-00004. Percent water and percent solids will also be determined per LAB-PLN-18-00004. Bulk (sediment) density will not be calculated on surface samples. Subsampled material will be used to perform the "quick turn" and standard analysis identified in Table 5-2.

Direction regarding insufficient sample material is provided in Section 5.2. Reporting of laboratory results is described in Section 6.0.

5.1.2 Subsurface Analysis

For the large diameter borehole, each sample interval will include five, 0.3 m (1-ft) intact cores, labeled in the field using the convention in Figure 4-5. The laboratory will select the intact core samples corresponding to the standard analysis depths identified in Table 5-1. Any other intact core samples (typically identified as "Liner A", "Liner B", "Liner C", or "Liner D") will be sent to PNNL. Figure 5-1 is a visual representation of the anticipated sampling depths at Borehole D0012. The intact core sample intervals identified in Figure 5-1 corresponds to the sample intervals identified in Table 5-1.

Subsurface samples are photographed, geologically described, and subsampled per LAB-PLN-18-00004. Percent water, percent solid, and bulk (sediment) density will also be determined per LAB-PLN-18-00004. Bulk (sediment) density is performed on the contents of only full liners or intact cores. A visual inspection will be performed to determine which liner contains the highest moisture content. The contents of this liner or intact core liner will be used for the "quick turn" analysis. Percent water and percent solids will be determined for the contents of this liner. The remaining material from this liner, the other liners, and the shoe (as appropriate) will be composited, and percent water and percent solids will also be determined from the composited material. Subsampled composited material will be used to perform the standard analysis identified in Table 5-2.

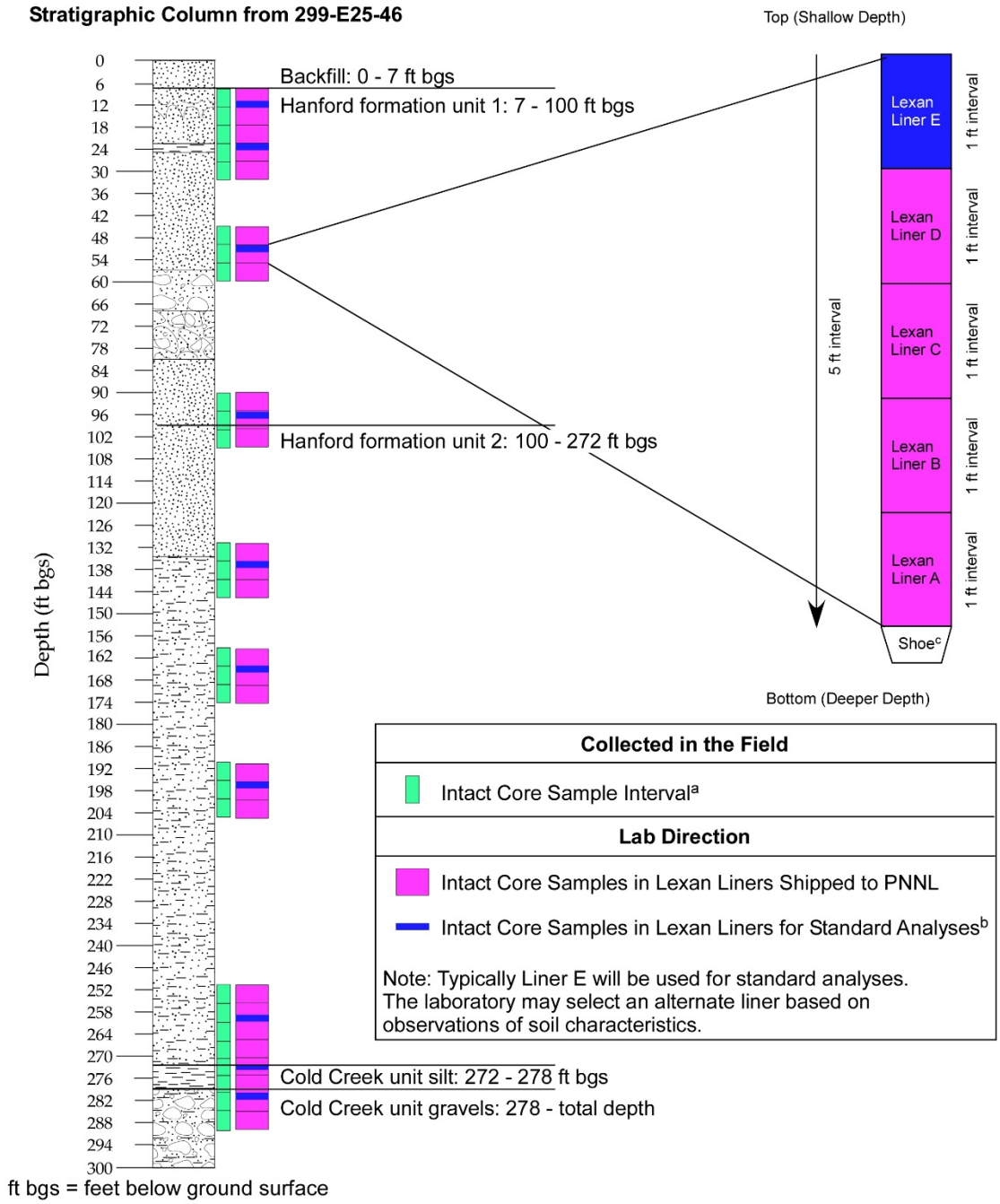
Due to the sampling methodology of intact core samples at the large diameter borehole, it is not possible to collect a representative field duplicate. One duplicate sample will be prepared by the laboratory after the soil in the intact core has been removed and homogenized. Additionally per the direction of SMO, one field split sample will be prepared by the laboratory after the soil in the intact core has been removed and homogenized.

Direction regarding insufficient sample material is provided in Section 5.2. Reporting of laboratory results is described in Section 6.0.

5.2 INSUFFICIENT RECOVERY OF SAMPLE MATERIAL

If the quantity of sample material is insufficient to perform the analyses required in this SAP, the laboratory and/or SMO shall notify the Data Management Lead within one working day to identify the path forward. The typical prioritization of analyses is listed in Table 5-3; however, changes may be made based on specific data needs. The Data Management Lead will identify the analysis priority based on available sample material and discussion with project personnel (e.g., Project Manager). Changes to this prioritization will be documented in the laboratory data report. Additionally, if there is not sufficient sample available to perform laboratory QC analyses, the laboratory will make note of the condition in the laboratory data report narrative, and the associated data results will have laboratory qualifiers added as appropriate.
Any analyses prescribed by this SAP, but not performed, shall be identified in the laboratory data report and through the characterization deviation form (refer to Section 7.0 and Appendix A).

Figure 5-1. Visual Representation of Anticipated Sampling Depths at the Large Diameter Borehole



a. Each intact core sample interval is 5 ft in length and produces five, 1-ft intact core samples in Lexan liners.
b. Standard analyses are identified in Table 5-2.
c. Soil recovered in the shoe will not be collected as part of the sample. This soil will be discarded in the field.

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Table 5-3. Analytical Priorities for WMA A-AX Focus Area 2

Priority	Analysis Type	Primary Method	Constituent/Physical Properties
1	"Quick Turn"	ICP/MS (water extraction)	Technetium-99
		9056 Ion chromatography	Nitrate, Sulfate
		9050	Specific Conductance
2		9045	pH
3	Standard	Gravimetric	Percent solids
		Gravimetric	Percent water
4		Gravimetric	Bulk (sediment) density
5		Gamma energy analysis	Antimony-125, Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155, Radium-226
6		ICP/MS (acid extraction)	Technetium-99
7		6010 ICP/AES and 6020 ICP/MS	Aluminum, Barium, Beryllium, Bismuth, Boron, Calcium, Cerium, Chromium, Copper, Iron, Lanthanum, Lead, Lithium, Magnesium, Manganese, Molybdenum, Neodymium, Phosphorous, Potassium, Rhodium, Silicon, Sodium, Strontium, Sulfur, Tantalum, Thorium, Tin, Tungsten, Zinc, Zirconium Arsenic, Cadmium, Cobalt, Nickel, Selenium, Silver, Thallium, Uranium, Vanadium Neptunium-237, Thorium-232, Uranium-233, Uranium-234, Uranium-235, Uranium-236, Uranium-238
8		Low energy gamma counting	Iodine-129
9		Liquid scintillation	Selenium-79
10		ICP/MS (acid extraction)	Antimony, Tin-126
11		Beta gas proportional counting	Strontium-90

Table 5-3. Analytical Priorities for WMA A-AX Focus Area 2

Priority	Analysis Type	Primary Method	Constituent/Physical Properties
12	Standard	Liquid scintillation	Nickel-63
13		Liquid scintillation	Tritium
14		Liquid scintillation	Carbon-14
15		Liquid scintillation	Plutonium-241
16		Alpha energy analysis	Americium-241, Curium-242, Curium-243/244, Plutonium-238, Plutonium-239/240
17		7471 Cold vapor atomic absorption	Mercury
18		7196 Colorimetric	Hexavalent Chromium
19		9056 Ion chromatography	Bromide, Chloride, Fluoride, Nitrate, Nitrite, Phosphate, Sulfate, Acetate, Formate, Glycolate, Oxalate
20		Ion chromatography EPA 300.7	Ammonium
21		9060	Total Organic Carbon
22		8270 GC/MS	bis(2-Ethylhexl)phthalate, Tributyl phosphate
23		8081 GC/ECD	4,4′-DDD, 4,4′-DDE, 4,4′-DDT, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, Chlordane, Dieldrin, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene
24		8082 GC/ECD	Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260
25		9014 Spectrophotometric	Cyanide
26		ASTM D7928 ASTM D6913	Particle size distribution

Table 5-3. Analytical Priorities for WMA A-AX Focus Area 2

Priority	Analysis Type	Primary Method	Constituent/Physical Properties

ASTM = American Society for Testing and Materials
CAS = Chemical Abstracts Service
GC/ECD = gas chromatography/electron capture detector
GC/MS = gas chromatography/mass spectrometry
ICP/AES = inductively coupled plasma/atomic emission spectrometry
ICP/MS = inductively coupled plasma/mass spectrometry

References:

ASTM D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*.

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EPA/600/S4-86/024, *Development of Standard Methods for the Collection and Analysis of Precipitation,* "Method 300.7, Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography."

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SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*.

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6.0 DATA MANAGEMENT

This section describes the reporting requirements for the WMA A-AX soil sample results. Section 6.1 identifies "quick turn" reporting requirements, and Section 6.2 identifies how all the analyses will be reported. "Quick turn" constituents are bolded in Table 5-2. Analytical results will be reported in Format VI data packages (i.e., laboratory data report).

It is anticipated that the 222-S Laboratory will perform the analyses identified in Table 5-2. If necessary, the laboratory and/or SMO may subcontract certain analyses to another qualified laboratory. The subcontracted laboratory shall meet all QA/QC requirements in this SAP. The 222-S Laboratory will prepare a statement of work authorizing the subcontracted laboratory to perform the analyses. The statement of work shall be reviewed and approved by the QA personnel and Data Management Lead prior to commencement of laboratory analysis.

"Special Study" testing and evaluations will also be performed by PNNL, as described in Appendix B.

6.1 "QUICK TURN" REPORTING

The "quick turn" analyses will be reported as preliminary results on an expedited time frame (within 7 days of the last sample received for a batch; however, upon request, they will be reported within a shorter period of time, as negotiated with the laboratory and/or SMO prior to sample delivery). The "quick turn" results will be transmitted via e-mail to the Data Management Lead. They will also be reported in the laboratory data report, and the information will be loaded into HEIS by the laboratory via Electronic Data Deliverable Processor (EDDPro).

6.2 FORMAT VI REPORTING AND DATA DELIVERABLES

Analysis performed by laboratories will be provided in Format VI laboratory data reports. A Format VI Report with QA verification includes the following:

- Narrative – contains a description of sample receipt, sample breakdown, and has a section corresponding to each method, describing any analytical/QC deviations

- Results Table (Data Summary Report) – printout containing sample and duplicate results, relative percent difference, standard and spike recoveries, blank results, and data qualifiers (flags)

- Sample section that contains sample breakdown diagrams, chain-of-custody forms, and geologist's descriptions

- Section that contains e-mail correspondence and/or characterization deviation forms (refer to Section 7.0 and Appendix A) that document issues that arose during sampling and analysis, and subsequent decisions that affected initial work instructions.

The laboratory will perform a QA review of the final report. Typical QA reviews require a minimum 10% review.

The laboratory data report will also include tentatively identified compounds found in the semi-volatile organic analyses. The tentatively identified compounds shall not be reported in HEIS unless directed by the Data Management Lead. A discussion of the tentatively identified compound evaluation process shall be provided in the narrative. A Format VI laboratory data report is subject to internal laboratory QA verification and review, including peer review prior to release.

The laboratory data report will be provided to the Data Management Lead. The laboratory shall issue the report within 180 calendar days following receipt of the last samples. Preliminary results for "quick turn" data shall be available within 7 days, unless an expedited turnaround time is requested. Preliminary results for the remaining data shall be within 60 days following receipt of the last sample, unless the Data Management Lead is informed of QC failures that require re-extraction and/or reanalysis (e.g., within two times holding times). As indicated in Section 3.2, laboratory changes will be communicated to the Data Management Lead and documented in the laboratory data report(s) narrative. Sample raw data will be provided, upon request, to the Data Management Lead. Additionally, documentation of deviations to the SAP analysis requirements shall be appended to the final laboratory data report (e.g., change in specified methods, characterization deviation form [refer to Section 7.0 and Appendix A]). The Project Manager will identify personnel to be included on the distribution list for the final laboratory data report.

In addition to the laboratory data report, an electronic version of the analytical results shall be uploaded to HEIS by the laboratory via EDDPro within 14 calendar days of release of the report. The electronic data shall be in the standard electronic format for HEIS.

6.3 DATA REVIEW AND USABILITY

This section addresses the data management and QA activities that occur after data collection. These activities will primarily be subcontracted. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives. The Data Management Lead or designee will be responsible for ensuring the completeness of the data report(s), reviewing results against any existing knowledge, and assessing the data to determine if they are adequate for the intended use. A review will also be performed to verify all data were correctly loaded into HEIS.

6.3.1 Data Review and Verification

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

The criteria for verification include, but are not limited to, use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results will be reviewed to ensure they are usable.

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

6.3.2 Data Validation

Data validation is an independent assessment to ensure the reliability of the data. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation may also include verification of instrument calibrations, evaluation of analytical results based upon method blanks, recovery of various internal standards, correctness of uncertainty calculations, correctness of identification and quantification of analytes, and the effect of quality deficiencies on data reliability. The contractor follows the data validation process described in EPA-540-R-2017-001, *National Functional Guidelines for Inorganic Superfund Methods Data Review*; and EPA-540-R-2017-002, *National Functional Guidelines for Organic Superfund Methods Data Review*, adjusted for use with SW-846, HASQARD, and radiochemistry methods.

Data validation will be performed to Level C, which is a review of the QC data. Level C validation consists of a review of the QC data and specifically requires verification of deliverables; requested versus reported analytes; and qualification of the results based on evaluation of analytical holding times, method blank results, MS/MSD results, surrogate recoveries, and duplicate sample results. Level C data validation is generally equivalent to Level 2A in EPA 540-R-08-005, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*. Level C data validation will be performed on up to 50% of this focus area's soil sample results by a party independent of both the data collector and the data user.

6.3.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. 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 (usability). The DQA process uses the entirety of the collected data to determine usability for decision making. For judgmental (focused) sampling designs, data quality indicators such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets (individual laboratory data packages) are evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation*. Data verification and data validation are integral to both the statistical DQA data evaluation process and the data quality indicator evaluation process. Guidelines from EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide,* and data assessment requirements and specifications in HASQARD will be followed, as applicable. Results of the DQA/data quality indicator processes will be used by the Project Manager to interpret the data and determine if the DQOs for this SAP have been met.

7.0 CHANGE CONTROL

Field activity and laboratory work scope changes may be required based on unexpected field conditions, new information, health and safety concerns, or other circumstances. Changes to work scope may result in modifications to this SAP. Work scope changes that do not result in deviation from the SAP requirements can be made in the field or laboratory with the approval of the Project Manager or designee. These work scope changes will be documented in the sampling work package and/or Format VI laboratory data report(s). Changes will also be summarized in SAP revisions, if revisions are needed. Justification for the changes to work scope shall be provided in sufficient detail to explain the basis for the change.

Version control is maintained by the administrative document control process. Three types of changes during the accomplishment of sampling and analysis that could affect compliance with the requirements in the SAP are as follows.

- A **fundamental change** is a change that does not meet the requirements set forth in the SAP or that incorporates characterization activities not defined in the scope of the SAP.

- A **significant change** generally involves a significant change to a component of the characterization that does not fundamentally alter the overall test approach.

- A **minor change** will not have a significant impact on the scope, schedule, or cost of the characterization. Minor field changes can be made by the person in charge of the field activity. These minor changes should be documented in the project file (for example, through interoffice memoranda or logbooks). Insignificant changes will not impact the requirements of the SAP.

The Project Manager will discuss the change with DOE-ORP. DOE-ORP will then discuss significant changes with Ecology, as needed, including changes described in Sections 9.3 and 12.0 of the HFFACO Action Plan. Appropriate documentation will follow, in accordance with the requirements for the type of change. The Project Manager or designee is responsible for communicating field corrective action requirements and ensuring immediate corrective actions are applied to field activities.

Characterization Support personnel are responsible for tracking all changes. Characterization Support personnel are also responsible for ensuring the field instructions are maintained and aligned with any revisions or approved changes to the SAP; for ensuring the current version of the SAP is being used; and for providing any updates to field personnel. Characterization Support personnel and/or the Data Management Lead will also ensure deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook or characterization deviation form). Appendix A provides a copy of the characterization deviation form.

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8.0 DOCUMENTS AND RECORDS

All information pertinent to field sampling will be recorded in bound logbooks in accordance with existing sample collection protocols. Sampling personnel will be responsible for recording all relevant sampling information. Entries made in the logbook will be dated and signed by the individual who made the entry. Program requirements for managing the generation, identification, transfer, protection, storage, retention, retrieval, and disposition of records will be followed.

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

The Project Manager is responsible for ensuring project information is properly maintained. The following information will be maintained, as appropriate:

- Field logbooks
- Change notices
- Final reports (e.g., direct push completion and logging reports)
- Laboratory data report
- Verification and validation reports.

The laboratory will follow their own procedures with respect to documents and records. Audits will be periodically conducted by WRPS QA to ensure their practices are following requirements.

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure the accuracy and retrievability of stored records. Records required by the HFFACO, will be managed in accordance with the HFFACO requirements.

The results from the "Special Study" laboratory testing and evaluations will be provided in published PNNL report(s), which will, at a minimum, contain information on the following:

- Sample collection
- Geologic interpretation of the collected samples
- Results of laboratory physical, hydrologic, and chemical analyses
- Results of contaminant mobility and transport evaluation
- Quality assurance

- Interpretation of laboratory data in the context of subsurface conditions and contaminant distribution and mobility.

Qualified electronic data for laboratory analysis results and calculations will also be delivered with the report. Collectively, this information will be used to support simulations and analysis of the WMA A-AX subsurface.

9.0 MANAGEMENT OF WASTE

Waste generated by field activities will be managed consistent with the applicable waste management requirements. Waste handling will comply with requirements of WAC 173-303, "Dangerous Waste Regulations." Waste handling practices are based on minimizing the exposure of field personnel to both radiation and chemical pollutants to as low as reasonably achievable and comply with regulatory requirements.

If unused samples and associated laboratory waste for analysis are to be dispositioned, the process must adhere with the laboratory contract and agreements. In accordance with 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," the Data Management Lead's approval is required before unused samples or waste is returned from offsite laboratories. Additionally, the Data Management Lead's approval is required before disposal of unused sample material at onsite laboratories.

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10.0 HEALTH AND SAFETY PLAN

Field operations will be performed in accordance with health and safety requirements identified in appropriate procedures and plans. Work control documents will be prepared to provide further control of site operations. Safety documentation will include a job hazard analysis and, as applicable, radiological work permits. The sampling procedures and associated activities will implement as low as reasonably achievable practices to minimize the radiation exposure to the sampling and analytical teams, consistent with the requirements defined in 10 CFR 835, "Occupational Radiation Protection."

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Note: The most current version/revision of methods and/or test plans are preferred.

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APPENDIX A

CHARACTERIZATION DEVIATION FORM

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CHARACTERIZATION DEVIATION FORM

Document: _____ **Change Number:** _____ **ECN to SAP Required?** Y / N

Requestor: _____ **Date:** _____

Original Requirement:

Samples Impacted:

Proposed Change:

Reason for Change:

Date Change Effective:

Schedule Impact:

Authorization:
Project Manager (Print/Sign): **Date:**

Quality Assurance (Print/Sign): **Date:**

222-S Sample Management Office (Print/Sign): **Date:**

Laboratory Project Coordinator (Print/Sign): **Date:**

Other (Optional, Print/Sign): **Date:**

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APPENDIX B

"SPECIAL STUDY" PHYSICAL PROPERTY TESTS AND CONTAMINANT AND GEOCHEMICAL EVALUATIONS

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B1.0 INTRODUCTION

This appendix identifies the requirements for testing and evaluations defined as a "Special Study in Revision 1 of RPP-RPT-60227, *Data Quality Objectives for Vadose Zone Characterization at Waste Management Area A-AX* (the Data Quality Objectives [DQO] Report) for Focus Area 2. Additional background information on the "Special Study" portion of Focus Area 2 is discussed in Appendix D of the DQO Report. This appendix is comprised of the following sections:

- B2.0 Special Study
- B3.0 Number of Samples, Sample Size, Sample Depths, and Analytes.

B2.0 SPECIAL STUDY

The purpose of the Waste Management Area (WMA) A-AX "Special Study" is to:

- Define and estimate chemical and physical properties of vadose zone soil that can influence contaminant movement through the soil (principal study question [PSQ] #2).

- Determine naturally occurring vadose zone soil constituents that could be altered by contact with tank waste (PSQ #4).

- Determine tank waste constituents that may remain in soil at detectable levels after the bulk of the waste has passed through portions of the vadose zone (PSQ #4).

- Estimate the concentration and distribution between aqueous and sediment phases of naturally occurring vadose zone soil constituents and tank waste found in the vadose zone (PSQ #4).

Additionally, the purpose of the "Special Study" is to obtain subsurface information to support the WMA A-AX conceptual site model and associated fate and transport modeling effort.

Focus Area 2 samples for the "Special Study" will be collected from a large diameter hole and two direct pushes (Refer to Figure 1-1).

For the large diameter borehole:

- Standard analysis (Table 5-2) will be performed on three shallow sample intervals: surface, 2.1 to 2.7 m (7 to 9 ft) below ground surface (bgs), and 3.7 to 4.3 m (12 to 14 ft) bgs.

- Standard analysis will be performed on seven pre-determined deep sample depth intervals. The number and depth of deep samples maybe adjusted with U.S. Department of Energy, Office of River Protection (DOE-ORP) and Washington State Department of Ecology (Ecology) concurrence. Additional sample intervals and intact core samples

collected in Lexan liners will be sent to Pacific Northwest National Laboratory (PNNL) for "Special Study" testing and evaluation.

For direct push locations:

- Standard analysis will be performed on three shallow sample intervals: surface, 2.1 to 2.7 m (7 to 9 ft) bgs and 3.7 to 4.3 m (12 to 14 ft) bgs.

- Standard analysis will be performed on seven deep sample intervals determined in meetings with Ecology, DOE-ORP, and WRPS. The number of deep samples maybe adjusted with DOE-ORP and Ecology concurrence. An additional back to back sample for "Special Study" will be collected for each deep sample interval, the liners and shoe are sent to PNNL for additional testing and evaluations.

The following information is included in Section B2.0:

- Physical Properties (Section B2.1)
- Contaminant and Geochemical Properties associated with Contaminant Mobility (B2.2).

B2.1 PHYSICAL PROPERTIES

Contaminant mobility is related to physical properties that control water movement and interactions of contaminants and soils. Existing data for the physical properties in the 200 East Area (PNNL-23711, *Physical, Hydraulic, and Transport Properties of Sediments and Engineered Materials Associated with Hanford Immobilized Low-Activity Waste*) need to be augmented with data for the WMA A-AX vicinity. This will be accomplished by collecting a vertical profile of physical property measurements with samples from the primary lithologic units. The vertical profile will be established from samples collected from a large diameter borehole (refer to Figure 1-1, D0012).

Intact core samples from D0012 will be collected from within the following major lithologic units present in the vadose zone beneath Focus Area 2:

- Hanford formation unit 1
- Hanford formation unit 2
- Cold Creek unit silt
- Cold Creek unit gravels.

Additional intact core samples will be collected from depths with apparent unique physical properties (e.g., zones with calcium carbonate cementation).

The physical properties measured as part of this "Special Study" and identified in Table B-1, will be considered representative of the targeted subsurface lithologic units in WMA A-AX for the purpose of fate and transport modeling. The other physical properties identified in Table 5-2,

which are part of the standard analysis will also be performed at all sample depths including the samples collected for "Special Study."

Table B-1. Physical Properties to be Measured for "Special Study" at Focus Area 2

Parameter	Method	Purpose
Soil pictures and description[a]	Geologist inspection of soil samples	Used to describe the hydrogeologic setting.
Bulk Density[b], Particle Density, and Porosity	Bulk density and porosity using ASTM D7263, particle density using ASTM D5550 (gas pycnometer) or ASTM D854 (water pycnometer), consistent with Flint and Flint 2002, *Particle Density,* Methods of Soil Analysis, Part 4: Physical Methods.	Used in evaluating soil texture needed to support lithologic interpretation, interpretation of physical and chemical testing data, and provide parameter inputs to fate and transport modeling.
Total Carbon and Total Inorganic Carbon	EPA 9060 (Soil and WE)	Used for interpretation of the carbonate concentration for use in geochemical data interpretation.
Particle Size Distribution[b]	ASTM B822 (Laser for < 2mm) and ASTM D6913 (sieving for >2 mm)	Used in evaluating soil texture needed to support lithologic interpretation and interpretation of physical and chemical testing data.
Saturated and unsaturated hydraulic properties	Methods from PNNL-27846, *Physical and Hydraulic Properties of Sediments from the 200-DV-1 Operable Unit*, ASTM D6836, ASTM D5856, ASTM D5084, Hopmans et al., 2002.	These data support lithologic interpretation and provide parameter inputs to fate and transport modeling.

Note: Complete reference citations are provided in Section B4.0.

a. Although this activity is not identified in Table 5-2, these activities are conducted as part of the standard analysis. This activity will also be performed as part of the "Special Study."

b. These parameters are also determined as part of the standard analysis identified in Table 5-2. These parameters will also be measured using the method identified in this table as part of the "Special Study."

WE = water extract (1:1 soil: water), PNNL-18800, *Characterization of Sediments from the Soil Desiccation Pilot Test (SDPT) Site in the BC Cribs and Trenches Area*, and PNNL-17031, *A Site-Wide Perspective on Uranium Geochemistry at the Hanford Site*

B2.2 CONTAMINANT AND GEOCHEMICAL PROPERTIES ASSOCIATED WITH CONTAMINANT MOBILITY

Contaminant mobility will be determined for a subset of samples using a tiered approach. Because this evaluation is contingent on having samples where contaminants are present, results from "quick turn" analysis identified in Table 5-2 will be reviewed. If these "quick turn" results show elevated concentrations for technetium-99, nitrate, sulfate, specific conductance, or pH > 8 and the WRPS Project Lead, in consultation with subject matter experts, determine that additional evaluations under Tier I are needed, then they will be performed. The "quick turn"

constituents are considered good indicators to identify the need for Tier I analysis. These constituents are considered mobile and their presence in samples above background concentrations could indicate that waste passed through those portions of the soil.

The constituents in Table B-2 were selected for Tier I evaluation based on being potential indicators of tank waste releases and having varying distribution coeffient (K_d) factors. In addition, detection of technetium-99 and elevated sulfate levels relative to background or natural conditions, are potentially indicators for tank waste migration (PNNL-15503, *Characterization of Vadose Zone Sediments Below the C Tank Farm: Borehole C4297 and RCRA Borehole 299-E-27-22*). Technetium-99 is a significant tank waste marker because it is common to tank waste due to its high fission yield, is very long-lived, can be detected at very low concentrations, and is soluble and mobile in the subsurface. Elevated sulfate in samples could be related to Tank A-105 sluicing that used sulfuric acid as a sluicing agent. Chloride concentrations from this study may be compared to results from Focus Area 1 samples to determine if their sources are similar (e.g., tank waste).

Table B-2. Analyses Included in Tier I Evaluation

Parameter	Method	Purpose
Physical Properties		
Bulk density[a] and weight fraction >2 mm	ASTM D7263, D854	Used in evaluating soil texture needed to support lithologic interpretation, interpretation of physical and chemical testing data, and provide parameter inputs to fate and transport modeling
Percent water (moisture content)[a]	ASTM D2216	Used in interpreting physical and chemical testing data and provide parameter inputs to fate and transport modeling.
Soil pictures and description	-	Used to describe the hydrogeologic setting.
pH	Primary method identified in Table 5-2[b]	Measurements are additional indicators of potential impacts to water chemistry from the presence of tank waste.
Specific conductance	Primary method identified in Table 5-2[b]	
Particle size distribution[a]	ASTM B822 [Laser for <2 mm] and ASTM D6913 [sieving for >2 mm]	Used in evaluating soil texture needed to support lithologic interpretation and interpretation of physical and chemical testing data.
Constituent Analyses		
Chloride	Primary method identified in Table 5-2[b] WE	Elevated levels relative to background or natural conditions, may indicate an environment conducive to stainless steel corrosion
Fluoride	Primary method identified in Table 5-2[b] WE	
Sulfate	Primary method identified in Table 5-2[b] WE	Elevated sulfate levels relative to background or natural conditions, would be significant indicators for tank waste migration

Table B-2. Analyses Included in Tier I Evaluation

Parameter	Method	Purpose
Nitrate	Primary method identified in Table 5-2[b] WE	Direct indicators of potential tank waste impact and represent a range of contaminant mobility.
Technetium-99[a]	Primary method identified in Table 5-2[b] using WE and AE	
I-129[a] and I-127	Iodine-129: Alternative method identified in Table 5-2 using WE. Iodine-127: EPA 6020 ICP/MS WE	
Total uranium and uranium (VI)[a]	Total uranium: Primary method identified in Table 5-2 using WE and AE. Uranium (VI): Brina and Miller 1992, "Direct detection of trace levels of uranium by laser induced kinetic phosphorimetry" (Kinetic Phosphorescence Analyzer) using WE and AE.	
Strontium-90[a]	Primary method identified in Table 5-2[b] using WE and AE	
Cesium-137[a]	Primary method identified in Table 5-2[b] using WE and AE	

Note: Complete reference citations are provided in Section B4.0.

a. These parameters are also determined as part of the standard analysis identified in Table 5-2. These parameters are also measured using the method identified in this table as part of the "Special Study" for the purpose of the Tier I analyses.

b. Methods in Table 5-2 will be used unless approval to use another method is granted by Project Manager.

AE = acid extract (1:3 soil:water, 8M HNO_3) conducted on the < 2 mm grain size fraction, PNNL-18800 and PNNL-17301

ICP/MS = inductively coupled plasma/mass spectrometry

WE = water extract (1:1 soil:water) conducted on the < 2 mm grain size fraction, PNNL-18800 and PNNL-17301

The Tier I analyses would be conducted on samples collected in the interval immediately proceeding the samples used for the quick turn analyses. The sample would be subsampled for Tier I constituent analyses, identified in Table B-2, on the < 2 mm particle size fraction of the sample. The subsample size for these analyses will be minimized to retain as much sample as possible for subsequent Tier II and III analyses.

The WRPS Project Lead, in consultation with subject matter experts, will review applicable test results from Tier I to determine if additional evaluations under Tier II are needed and to select the specific parameters to be evaluated for the sample of interest.

The Tier II analyses are used to support the determination of geochemical conditions and to provide evidence for contaminant associations with sediment phases. Tier II will include analysis for those parameters identified in Table B-3. Tier II extractions will include analysis for those parameters detected in Tier I. The geochemical conditions will be determined through analysis of major anions and cations, total carbon, total inorganic carbon, total organic carbon, alkalinity, and iodate and iodide (if present in a sample from Tier I analysis) using the methods identified in Table B-3. Evidence for contaminant associations with sediment phases will be determined through application of a six sequential extraction process (described below and in

Table B-3). These sequential extractions will be conducted at a 1:3 soil to liquid ratio at room temperature (20 °C to 25 °C [68 °F to 77 °F] or 95°C [203°F] for Extraction 6) and will only be performed for those constituents identified in Table B-2 that are detected in Tier I analyses.

Table B-3. Analyses Included in Tier II

Parameter	Method	Purpose
Major anions including carbonate[a]	Water extraction (WE) (1:1 soil: water), PNNL-18800 and PNNL-17031	Determination of geochemical conditions
Major cations[a]	WE and acid extraction (AE) (1:3 soil:water, 8M HNO_3), PNNL-18800 and PNNL-17031	
Total carbon, total inorganic carbon, total organic carbon	EPA 9060 (Soil and WE)	
Alkalinity	*Standard Methods for the Examination of Water and Wastewater* 2320B Titration Method[b]	
I-129 and I-127 as iodate and iodide (only if I-129 is present in Tier I analysis)	Adapted ICP/MS method using an ion chromatography column for separation of iodine species prior to ICP/MS analysis.	
Total I-129, total I-127 (only if I-129 is present in Tier 1 analysis)	Tetramethylammonium hydroxide (TMAH) extraction of sediment. Watts and Mitchell 2008, "A pilot study on iodine in soils of Greater Kabul and Nangarhar provinces of Afghanistan", Env. Geochem. Health 31(4).	
Extractions		
Extraction 1: aqueous contaminant fraction (using simulated porewater)	Conducted at a 1:3 soil:liquid ratio at room temperature (68°F to 77°F) using the approach described in PNNL-26208, *Contaminant Attenuation and Transport Characterization of 200-DV-1 Operable Unit Sediment,* with application of six different reagents[b]. Gleyzes et al. 2002, "Fractionation studies of trace elements in contaminated soils and sediments: a review of sequential extraction procedures"; Beckett 1989, "The use of extractants in studies on trace metals in soils, sewage sludges, and sludge-treated soils"; Larner et al. 2006, "Comparative study of optimized BCR sequential extraction scheme and acid leaching of elements in certified reference material NIST 2711"; Sutherland and Tack 2002, "Determination of Al, Cu, Fe, Mn, Pb, and Zn in certified reference materials using the optimized BCR sequential extraction procedure."	Evidence for contaminant associations with sediment phases identified in Tier 1 analysis.
Extraction 2: adsorbed contaminant fraction (ion exchangeable)		
Extraction 3: "rind-carbonate" contaminant fraction (using acetate solution)		
Extraction 4: total carbonate contaminant extraction fraction (using acetic acid solution)		
Extraction 5: iron-oxide contaminant fraction (using oxalate, oxalic acid)[c]		
Extraction 6: defined as the hard-to-extract contaminant fraction		

Table B-3. Analyses Included in Tier II

Parameter	Method	Purpose
(using nitric acid at 203°F) [c]		
1,000-hour carbonate extraction	Conducted at a 1:3 soil:liquid ratio at room temperature (68°F to 77°F) using the approach described in PNNL-17031; Kohler et al. 2004, "Methods for estimating adsorbed uranium (VI) and distribution coefficients of contaminated sediments"; PNNL-26208	

Note: Complete reference citations are provided in Section B4.0.

a. Though not identified as a "Special Study", this parameter will be measured using the method in this table on samples collected for the purpose of Tier I analyses.

b. Available at the Standard Methods for the Examination of Water and Wastewater website. https://www.standardmethods.org/doi/full/10.2105/SMWW.2882.023

c. If uranium is analyzed in Tier II, only total uranium will be reported because uranium (IV) will be oxidized too quickly in these acidic solutions.

AE = acid extract (1:3 soil:water, 8M HNO_3) conducted on the < 2 mm grain size fraction, PNNL-18800 and PNNL-17301

ICP/MS = inductively coupled plasma/mass spectrometry

WE = water extract (1:1 soil:water) conducted on the < 2 mm grain size fraction, PNNL-18800 and PNNL-17301

The extractions use Reagents 1 through 6 defined below.

- Reagent 1 – Simulated Porewater:

Order to Dissolve	Molarity (mol/L)	Reagent	Molecular Weight (g/mol)	Mass (g/L)
1	0.012	$CaSO_4 \cdot 2H_2O$	172.1723	2.0661
2	0.0017	NaCl	58.4430	0.0994
3	0.0004	$NaHCO_3$	84.0068	0.0336
4	0.0034	$NaNO_3$	84.9948	0.2890
5	0.0026	$MgSO_4$	120.3660	0.3130
6	0.0024	$MgCl_2 \cdot 6H_2O$	203.3034	0.4879
7	0.0007	KCl	74.5515	0.0522
Adjust pH to 7.0 to 7.2 with sodium hydroxide or sulfuric acid.				

Source: PNNL-24297, *Extended Leach Testing of Simulated LAW Cast Stone Monoliths*

Once the chemicals dissolved, an excess of calcium carbonate will be added to the solution and allowed to mix. After approximately 1 week, excess calcium carbonate will be filtered out using a 0.45-µm filter.

- Reagent 2 - 0.5 mol/L $Mg(NO_3)_2$: 128.2 g $Mg(NO_3)_2 \cdot 6H2O$ + 30 µL 2 mol/L NaOH to pH 8.0, balance deionized water to 1.0 L

- Reagent 3 - Acetate solution: 136.1 g sodium acetate•$3H_2O$ + 30 mL glacial acetic acid (17.4 mol/L), pH 5.0, balance deionized water to 2.0 L

- Reagent 4 - Acetic acid solution: concentrated glacial acetic acid, pH 2.3; 50.66 mL glacial acetic acid (17.4 mol/L) + 47.2 g $Ca(NO_3)_2$•$4H_2O$, pH 2.3, balance deionized water to 2.0 L

- Reagent 5 - Oxalate solution: 0.1 mol/L ammonium oxalate, 0.1 mol/L oxalic acid; 9.03 g anhydrous oxalic acid + 14.2 g ammonium oxalate•H_2O, balance deionized water to 1.0 L

- Reagent 6 - 8.0 mol/L HNO_3: 502 mL conc. HNO_3 (15.9 mol/L) + 498 mL deionized water

In the first extraction, 6 mL of simulated porewater (Reagent 1) will be mixed with 3.0 (±0.5) g of soil for 50 minutes in a centrifuge tube. The tube is then centrifuged at 3,000 revolutions per minute (rpm) for 10 minutes, and liquid will be drawn off the top of the soil and filtered (0.45 µm) for analysis. Extractions 2 and 3 are conducted with the same procedure except using Reagents 2 and 3, respectively. The fourth extraction uses the same procedure except with a contact time of 5 days and with use of Reagent 4. The fifth extraction is conducted the same as Extraction 1 except using Reagent 5. In the sixth extraction, 6 mL of nitric acid (Reagent 6) will be added to the soil and mixed for 2 hours at 90 °C (203 °F). The tube is then centrifuged at 3,000 rpm for 10 minutes, and liquid will be drawn off the top of the soil and filtered (0.45 µm) for analysis.

In addition, a 1,000-hour carbonate extraction will also be conducted. A carbonate solution (0.0144M $NaHCO_3$ + 0.0028M Na_2CO_3 (pH 9.3); 2.42 g $NaHCO_3$ + 0.592 g Na_2CO_3 + balance deionized water to 2.0 L) is used for the 1,000-hour carbonate extractions. Soil (3.0 ± 0.5 g) and 6.0 mL of the carbonate solution is placed in 45-mL Teflon or polycarbonate centrifuge tubes, mixed for 1,000 hours at 6 rpm, and centrifuged at 3,000 rpm for 10 minutes, and liquid will be drawn off the top of the soil and filtered (0.45 µm) for analysis.

The WRPS Project Lead, in consultation with subject matter experts, will review applicable test results from Tier I and Tier II to determine if additional evaluations under Tier III are needed and to select the specific analyses to be conducted for the selected sample.

The Tier III analyses are used to evaluate and quantify attenuation mechanisms and impacts from tank waste that affect contaminant mobility. The Tier III analyses will only be performed for those detected constituents and mechanisms of interest identified from Tier I and II analyses. Table B-4 provides a summary of tests, which may be performed during the Tier III analyses.

X-ray diffraction for mineral phase identification and sequential suite of electron microscopy analyses are used to determine associations of contaminants with elements indicative of precipitate forms (iron, phosphorus, calcium, silica, barium, and manganese).

Table B-4. Analyses Included in Tier III Evaluation

Parameter	Method	Purpose
Sediment mineralogy	X-ray diffraction	Major sediment mineral phase identification.
Contaminant solid mineral phases	Electron Microscope with EDS detector identification of contaminant solid phases on sediment thin section.	Map and then verify associations of contaminants with elements indicative of precipitate forms.
Contaminant sediment/water partitioning, release rate from sediment, and release rate change as the concentration of co-contaminants changes (i.e., in 1-D column leach as sediment is flushed with simulated porewater)	Batch and 1-D column leach tests. PNNL-26266, *Geochemical, Microbial, and Physical Characterization of 200-DV-1 Operable Unit B-Complex Cores from Boreholes C9552, C9487, and C9488 on the Hanford Site Central Plateau*; PNNL-26208; and PNNL-27524, *Contaminant Attenuation and Transport Characterization of 200-DV-1 Operable Unit Sediment Samples from Boreholes C9497, C9498, C9603, C9488, and C9513*	Quantify contaminant partitioning, release rate from sediments, and leaching characteristics.
Iron and Manganese Redox Species:		
Ferrous iron, ferric iron, and manganese	PNNL-26266, PNNL-26208, and PNNL-27524	Redox reactive iron and manganese species and ratio of reduced/oxic species that can potentially influence mobility of contaminants that are redox reactive.
EDS = energy dispersive x-ray spectrometer		

Note: Complete reference citations are provided in Section B4.0.

Soil may also be analyzed for iron and manganese redox species. Results of these analyses will be interpreted with respect to the redox capacity and potential of the soil. The analyses will use the following extractions in an anoxic chamber to quantify ferrous iron, ferric iron, and manganese, which are solubilized by different solutions as described below.

- Extraction 1 - soil samples (2.0 ± 0.5 g) will be mixed with 10.0 mL of ion exchange (1.0 M $CaCl_2$) solution for 50 minutes at 6 rpm, centrifuged (3,000 rpm, 10 minutes), and filtered (0.45 µm). The solution is then analyzed for iron (II) and manganese.

- Extraction 2 - soil samples (2.0 ± 0.5 g) will be mixed with 10.0 mL of 0.5M HCl for 24 hours at 6 rpm, centrifuged (3,000 rpm, 10 minutes), and filtered (0.45 µm). The solution is then analyzed for iron (II) and manganese.

- Extraction 3 - soil samples (2.0 ± 0.5 g) will be mixed with 10.0 mL of 5M HCl for 24 hours at 6 rpm, centrifuged (3,000 rpm, 10 minutes), and filtered (0.45 µm). The solution is then analyzed for iron (II), manganese, and total iron.

- Extraction 4 - soil samples (2.0 ± 0.5 g) will be mixed with 10.0 mL of 0.25M $NH_2OH•HCl$ solution for 30 minutes at 50 °C (122 °F), centrifuged (3,000 rpm, 10 minutes), and filtered (0.45 µm). The solution is then analyzed for total iron and manganese.

- Extraction 5 - soil samples (2.0 ± 0.5 g) will be mixed with 10.0 mL of dithionite-citrate-bicarbonate solution (0.3 mol/L sodium-citrate, 1.0 mol/L $NaHCO_3$, and 0.06 mol/L sodium dithionite), mixed for 30 minutes at 80 °C (176 °F), centrifuged (3,000 rpm, 10 minutes), and filtered (0.45 µm). The solution is then analyzed for total iron and manganese

Column or batch tests are performed to quantify contaminant partitioning and leaching characteristics. These tests are also performed to provide a data set for evaluating the configuration of the reactive transport component of the fate and transport model. Soil-column experiments will be conducted with one-dimensional, vertical, bottom-up flow of injected simulated porewater solution through contaminated soil. The concentration of target contaminants and constituents in the effluent will be measured. A non-sorbing, non-reactive tracer (bromide ion) will be included in the injection solution and its breakthrough is measured to assess column flow dynamics. For both column and batch tests, the sequential extraction process may be applied to determine pre- and post-leaching concentrations of contaminants in the extraction phases in order to aid in the interpretation of leaching test results.

B3.0 NUMBER OF SAMPLES, SAMPLE SIZE, SAMPLE DEPTHS, AND ANALYTES

This section summarizes the soil sampling identified for the "Special Study." As identified in Section B2.0, it is anticipated that seven deep samples each of the three investigation sites (i.e., a large diameter borehole and two direct push locations) will be provided to PNNL for the "Special Study." Further explanation is provided below for each sampling methodology.

B3.1 LARGE DIAMETER BOREHOLE

Table B-5 shows the predetermined sample intervals identified for various analysis and testing:

- Seven deep (>4.6 m [15 ft] bgs) sample intervals for standard analysis discussed in Section 5.0

- Five sample intervals for physical property tests discussed in Section B2.1

- Seven sample intervals for contaminant and geochemical properties evaluations discussed in Section B2.2 (the "tiered" analysis).

Based on actual drilling conditions, the number of samples or intervals at which they are analyzed or tested maybe adjusted with DOE-ORP and Ecology concurrence. Additional core intervals, supplementary to those identified for the analysis and testing above, will also be shipped to PNNL. These core intervals may be utilized if it is determined they better represent the targeted area identified in the Table B-5 "Rationale" column or if an unusual feature is identified.

Table B-5 shows the sample intervals that will be used for testing and evaluations in the "Special Study":

- Up to five 0.3 m (1-ft) intact core samples for physical property tests (Section B2.1).

- Up to four 0.3 m (1-ft) intact core samples for contaminant and geochemical properties (Section B2.2).

Each 0.3 m (1 ft) intact core sample is approximately 4 kg (8.8 lbs), assuming an average bulk density of 1.6 kg/L.

PNNL will be responsible for storage of samples they receive from the large diameter borehole. Any unused intact cores will be stored until the project has completed all testing and they are no longer needed for additional evaluations.

A geologist will be in the field during the drilling of the large diameter borehole. Activities performed will be consistent with procedures and will include activities like:

- Logging soil composition during drilling and field operations

- Recording the sequence of field activities

- Generating a daily email status report describing the interval drilled, samples collected, and other observations as appropriate

- Writing a project borehole summary report

- Providing a soil description and detailed digital photographs of soil visible at the ends of the Lexan liners and soil recovered between intact core sample intervals

- Collecting soil grab samples for archive purposes

- Recording maximum temperatures measured by infrared thermometer.

Table B-5. Approximate Sample Intervals and Testing Requirements for the Large Diameter Borehole

Lithology	Core Interval (ft bgs)	Sample Intervals for Standard Analysis (ft bgs)[a, b]	Sample Intervals for "Special Study" Contaminant and Geochemical Properties (ft bgs)[a, c]	Sample Intervals for "Special Study" Physical Property Tests (ft bgs)[a,d]	Rationale (from nearby borehole 299-E25-46)
Backfill	-	Surface	-	-	Shallow risk assessment, additional intact core sample, may not be needed for Special Study
H1	7-12	7-8	-	-	Shallow risk assessment, additional intact core sample, may not be needed for Special Study
	12-17	12-13	-	-	Shallow risk assessment, additional intact core sample, may not be needed for Special Study
	17-22	-	-	-	Additional intact core sample, may not be needed for testing
	22-27	22-23	23-27	-	Sandy silt lens
	27-32	-	-	-	Additional intact core sample, may not be needed for testing
	45-50	-	-	-	Additional intact core sample, may not be needed for testing
	50-55	-	-	50-55	"Silty pebble sand"
	55-60	-	-	-	Additional intact core sample, may not be needed for testing
	90-95	-	-	-	Additional intact core sample, may not be needed for testing
	95-100	95-96	96-100	-	Intermediate sample depth. Increase vertical profile of constituent distribution.
	100-105	-	-	-	Additional intact core sample, may not be needed for testing
H2	130-135	-	-	-	Additional intact core sample, may not be needed for testing
	135-140	-	-	135-140	"Silty sand", increase in gross gamma signature
	140-145	-	-	-	Additional intact core sample, may not be needed for testing
	159-164	-	-	-	Additional intact core sample, may not be needed for testing
	164-169	164-165	165-169	-	

Table B-5. Approximate Sample Intervals and Testing Requirements for the Large Diameter Borehole

Lithology	Core Interval (ft bgs)	Sample Intervals for Standard Analysis (ft bgs)[a, b]	Sample Intervals for "Special Study" Contaminant and Geochemical Properties (ft bgs)[a, c]	Sample Intervals for "Special Study" Physical Property Tests (ft bgs)[a,d]	Rationale (from nearby borehole 299-E25-46)
H2	169-174	-	-	169-174	Increase in total gamma, partially due to change in casing size, but there does appear to be an increase in silt content beginning at 50 m (164 ft) with calcium carbonate cementation noted in borehole log
	190-195	-	-	-	Additional intact core sample, may not be needed for testing
	195-200	195-196	196-200	-	Limonite staining, carbonate cementation
	200-205	-	-	-	Additional intact core sample, may not be needed for testing
	251-256	-	-	-	Additional intact core sample, may not be needed for testing
	256-261	256-257	257-261	-	Carbonate cementation
	261-266	-	-	-	Additional intact core sample, may not be needed for testing
	266-271	-	-	-	Additional intact core sample, may not be needed for testing
CCU	271-276	(e)	Remaining intact core samples[e]	-	"Silt" in CCUz
	276-281	-	-	276-281[e,g]	"Silt" in CCUz and "Silty pebble sand" in CCUg
	281-286	(f)	Remaining intact core samples[g]	-	"Silty pebble sand" in CCUg
	286-291	-	-	286-291[g]	"Silty pebble sand" in CCUg

a. Depths may be adjusted based on sampling technique and actual field conditions.

b. Analyses identified in Table 5-2.

c Testing and evaluations as appropriate, identified in Tables D-5, D-6, and D-7 (i.e., Tiered Analysis Approach) in Appendix D of the DQO Report.

d. Physical property tests identified in Table D-4 in Appendix D of the DQO Report and Table 5-2 of the plan.

e. Target the Cold Creek silt-dominated unit (CCUz). For standard analysis, the geologist will select the 0.3 m (1-ft) intact core sample in Lexan liner representative of the CCUz, identified as containing the most silt or clay. Based on available borehole logs, the tentative sample depth for standard analysis is 82.9 to 83.2 m (272 to 273 ft) bgs.

Table B-5. Approximate Sample Intervals and Testing Requirements for the Large Diameter Borehole

Lithology	Core Interval (ft bgs)	Sample Intervals for Standard Analysis (ft bgs)[a, b]	Sample Intervals for "Special Study" Contaminant and Geochemical Properties (ft bgs)[a, c]	Sample Intervals for "Special Study" Physical Property Tests (ft bgs)[a,d]	Rationale (from nearby borehole 299-E25-46)

Physical property and testing and evaluations for the "Special Study" will be performed using remaining available intact core samples representative of the CCUz. Based on borehole logs from well 299-E25-46, the CCUz is expected to be present from 82.9 to 84.7 m (272 to 278 ft) bgs.

f. Target the Cold Creek gravel-dominated unit (CCUg). For standard analysis, the geologist will select the first 0.3 m (1-ft) intact core samples in Lexan™ liners representative of the CCUg, identified as containing gravel or sandy gravel. Based on available borehole logs, the tentative sample depth for standard analysis is 86.6 to 86.9 m (284 to 285 ft) bgs. Physical property and testing and evaluations for the "Special Study" will be performed using remaining available intact core samples representative of the CCUg. Based on borehole logs from well 299-E25-46, the CCUg is expected to be present from 84.7 m (278 ft) bgs to total depth of the borehole at 88.7 m (291 ft) bgs.

CCU = Cold Creek unit
CCUg = Cold Creek gravel-dominated unit
CCUz = Cold Creek silt-dominated unit
H1 = Hanford formation unit 1
H2 = Hanford formation unit 2

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B3.2 DIRECT PUSH LOCATIONS

Standard analysis will be performed on approximately seven deep (>4.6 m [15 ft] bgs) sample intervals from the direct push locations. The number of deep samples maybe adjusted with DOE-ORP and Ecology concurrence.

It is anticipated that the direct push sample locations are more likely to encounter contamination than the large diameter borehole, given closer proximity to Tanks A-104 and A-105. Thus, an additional deep sample will be collected back-to-back at each sample depth to facilitate the tiered analysis approach used to determine contaminant and geochemical properties.

PNNL will be responsible for storage of samples received from the direct push locations. Each additional sample will be stored until "quick turn" results from the preceding sample are available. If "quick turn" results indicate contamination may be present, then the additional sample will be evaluated for testing in the "Special Study" as described in Section B2.0. Based on available sample material, the WRPS Project Lead in consultation with subject matter experts, will determine which evaluations to perform.

Soil in the liners and shoe from the direct push locations will be collected as described in Section 4.2.2 and delivered to PNNL. The direct push dual-string sampling system yields a limited volume of sample material; at 100% recovery, each sample produces approximately 594 g of soil sample material (described in Section 4.3 of the DQO Report).

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