

# Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study

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



U.S. DEPARTMENT OF  
**ENERGY**

Richland Operations  
Office

P.O. Box 550  
Richland, Washington 99352

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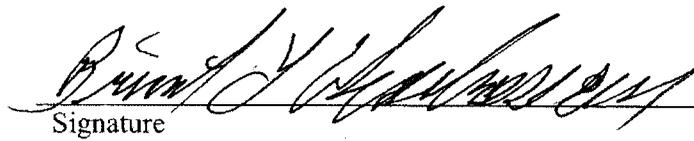
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## Terms

ALARA	as low as reasonably achievable
ASTM	American Society for Testing and Materials
CFR	<i>Code of Federal Regulations</i>
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DQA	data quality assessment
Ecology	Washington State Department of Ecology
EQL	estimated quantitation limit
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Documents</i>
HEIS	Hanford Environmental Information System
OU	operable unit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
SAP	sampling and analysis plan
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
VOA	volatile organics analysis
VOC	volatile organic compound
WAC	<i>Washington Administrative Code</i>

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## 1 Introduction

This sampling and analysis plan (SAP) supports the remedial investigation (RI)/feasibility study (FS) process for 100-BC. The 100-BC Area is located on the Hanford Site in southeastern Washington and is associated with two source operable units (OUs), 100-BC-1 OU and 100-BC-2 OU. The 100-BC-5 Groundwater OU underlies the two-source operable units. This SAP describes the sampling and analysis to be performed associated with environmental investigation borings (boreholes), test pits, and groundwater monitoring wells. Figure 1-1 shows the location of the planned and existing boreholes, test pits, and groundwater monitoring wells within the scope of this SAP. Table 1-1 presents the intersection of data gaps discussed in the addendum and sampling and analysis activities. The 100-BC RI/FS Work Plan, Chapter 2, describes the site background and, environmental setting of 100-BC (DOE/RL-2008-46-ADD3, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 3: 100 BC-1, 100-BC-2, and 100-BC-5 Operable Units*).

**Table 1-1. Plan Activities and Data Gaps**

Planned Activity	100-BC		Data Needs No.
	Quantity	Location	
Soil sample collection – Leach test	1*	100-C-7	1, 7
New boreholes (vadose zone)**	7	100-B-5 Trench 116-B-5 Crib 116-B-14 Trench 116-C-5 Retention Basin 118-B-6 Burial Ground 118-B-8:1 Reactor Fuel Storage Basin 118-C-3 Reactor Fuel Storage Basin	2, 3
New test pits (vadose zone)	3	116-B-6B Crib 116-B-9 French Drain 118-B-8:3 Process Sewer	2
New wells (unconfined aquifer)**	5	Well No. 1 Well No. 2 Well No. 3 Well No. 4 Well No. 5	4, 7
New well (Water-bearing Ringold Upper Mud Unit)**	1	Well No. 6	4, 6
Groundwater upwelling (pore water) samples	10	10 existing locations, with additional locations possible based on results	5
Sample spatial/temporal uncertainty groundwater monitoring wells	18	18 existing locations (includes 4 monitoring wells installed under DOE/RL-2009-61)	8

**Notes:**

\* Samples will be collected during the remediation of 100-C-7. More than one sample may be collected for leach testing as necessary.

\*\* Boreholes and groundwater monitoring wells will be logged with a neutron moisture tool and the high resolution, spectral gamma ray logging system. Geologic samples also will be logged.

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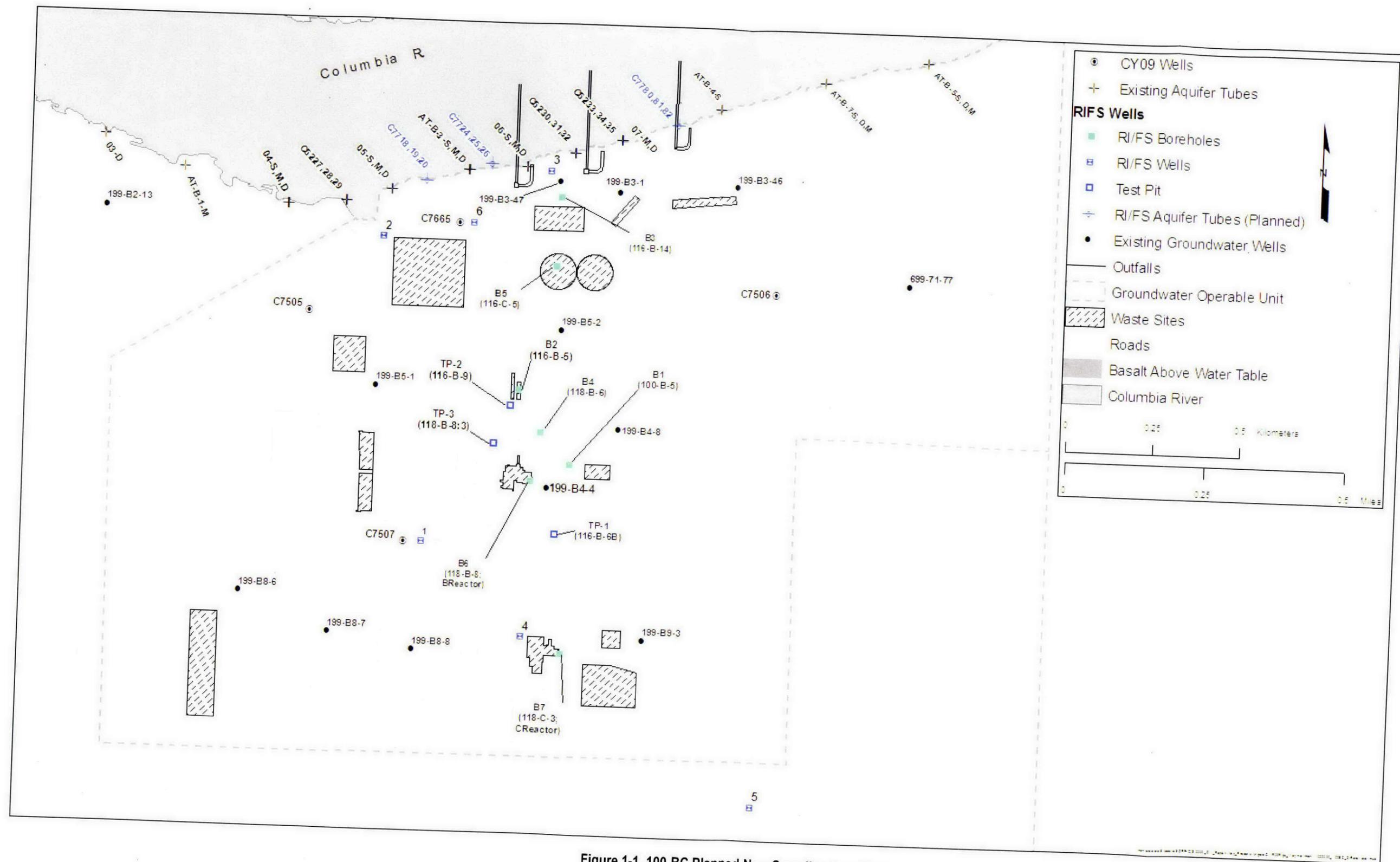


Figure 1-1. 100-BC Planned New Sampling Locations

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## 1.1 Vadose Zone Characterization

This SAP describes activities planned to characterize the vadose zone at 10 waste sites within 100-BC, and at six groundwater monitoring well locations. In addition, soil will be collected from the 100-C-7 waste site for leach testing, in support of Data Gap Nos. 1 and 7, as described in Table 3-1. The following waste sites will be characterized by drilling a borehole to groundwater within the waste site boundary.

- 100-B-5 Trench
- 116-B-5 Crib
- 116-B-14 Trench
- 116-C-5 Retention Basin
- 118-B-6 Burial Ground
- 118-B-8 Reactor Fuel Storage Basin
- 118-C-3 Reactor Fuel Storage Basin

Additionally, the following waste sites will be characterized by test pit excavations.

- 116-B-6B Crib
- 116-B-9 French Drain
- 118-B-8:3 Process Sewer

Groundwater wells drilled as part of the 100-BC RI also will have vadose zone soil samples collected during drilling. Samples will be collected and analyzed to evaluate the nature and extent of contamination at the subject waste sites.

## 1.2 Groundwater Characterization

Groundwater samples will be collected and analyzed from new and existing groundwater monitoring wells. The groundwater monitoring wells will be sampled and analyzed to define the extent of contamination and to support evaluation of contaminant transport. Where possible, new well locations and construction have been selected to satisfy multiple project data needs, such as delineating vadose zone and groundwater contamination. In addition, pore water will be sampled as presented in Section 3.5.2.

## 1.3 Target Analytes and Contaminants of Potential Concern

This section presents the master soil and groundwater contaminant lists.

### 1.3.1 Soil Target Analytes

Table 1-2 presents the soil target analytes. The detailed bases of target analyte selection is provided in Appendix D. Waste site-specific constituents for analysis are based on the master list.

**Table 1-2. Master Soil Target Analyte List for the 100-BC OUs**

<b>Radionuclides</b>	<b>Non-radionuclides</b>		
Americium-241	Butylbenzylphthalate	Lindane (Gamma-BHC) (1,2,3,4,5,6-hexachlorocyclo-hexane)	Nickel
Cobalt-60	Carbazole	Heptachlor	Selenium

Table 1-2. Master Soil Target Analyte List for the 100-BC OUs

Radionuclides	Non-radionuclides		
Cesium-137	Dibenzofuran	Heptachlor epoxide	Silver
Europium-152	Diethylphthalate	Methoxychlor	Strontium
Europium-154	Di-n-octylphthalate	Technical chlordane (alpha and gamma)	Thallium
Europium-155	Isophorone	Acenaphthene	Tin
Carbon-14	Methylnaphthalene; 2-	Anthracene	Titanium
Nickel-63	Methylphenol; 4- (p-cresol)	Benzo(a)anthracene	Vanadium
Technetium-99	N-nitrosodiphenyl-amine	Benzo(a)pyrene	Zinc
Tritium	Pentachlorophenol	Benzo(b)fluoranthene	Benzene
Plutonium-238	Phenol	Benzo(k)fluoranthene	1,1-Dichloroethene
Plutonium-239/240	Trichlorobenzene; 1,2,4-	Benzo(g,h,i)perylene	1,1,2,2-Tetrachloroethane
Plutonium-241	Dalapon	Chrysene	Carbon tetrachloride
Uranium-233/234	DB;2,4- [4-(2,4-dichlorophenoxy)butanoic acid] (Butoxone)	Dibenzo(a,h) anthracene	Chloroform
Uranium-235	Dicamba	Fluoranthene	Methyl isobutyl ketone (4-Methyl-2-pentanone)
Uranium-238	Dichlorophenoxy-acetic acid; 2,4-	Fluorene	Tetrachloroethene
Iodine-129	Dichloroprop	Indeno(1,2,3-cd)pyrene	Trichloroethene
Strontium-90	Dinoseb	Naphthalene	Toluene
	Picloram	Phenanthrene	Vinyl chloride
	TP-; 2,4,5-(2,4,5-Trichlorophenoxy) Propionic acid, 2 ]	Pyrene	Xylenes (total)
	Trichlorophenoxy-acetic acid; 2,4,5- (2,4,5-T)	Aluminum	Nitrate
	4,4'-Dichlorodiphenyldi-chlorethane	Antimony	Nitrite
	4,4-Dichlorodiphenyldi-chloro-ethylene	Arsenic	Asbestos
	4,4-Dichlorodiphenyltri-chloro-ethane	Barium	Chromium (hexavalent)
	Aldrin	Beryllium	Mercury
	Hexachlorocyclo-hexane; alpha (alpha-BHC, HCH)	Boron	Aroclor-1016 (PCB)
	Hexachlorocyclohexane; beta (beta-BHC, HCH)	Cadmium	Aroclor-1221 (PCB)

**Table 1-2. Master Soil Target Analyte List for the 100-BC OUs**

<b>Radionuclides</b>	<b>Non-radionuclides</b>		
	Dieldrin	Chromium (total)	Aroclor-1232 (PCB)
	Endosulfan I	Cobalt	Aroclor-1242 (PCB)
	Endosulfan II	Copper	Aroclor-1248 (PCB)
	Endosulfan sulfate	Lead	Aroclor-1254 (PCB)
	Endrin	Lithium	Aroclor-1260 (PCB)
	Endrin aldehyde	Manganese	Total petroleum hydrocarbons
	Endrin ketone	Molybdenum	Uranium (total)

Notes:

BHC = Benzenehexachloride

OUs = operable units

HCH = Hexachlorocyclohexane

PCB = polychlorinated biphenyl

**1.3.2 Groundwater COPCs**

Table 1-3 presents the groundwater contaminants of potential concern (COPCs). Chapter 4 of the 100-BC RI/FS Work Plan (DOE/RL-2008-46-ADD3) presents the approach used for development of the COPCs. The detailed bases of COPC selection is provided in Appendix D of the 100-BC work plan (DOE/RL-2008-46-ADD3).

**Table 1-3. Groundwater COPCs for the 100-BC OUs**

<b>Radionuclides</b>	<b>Non-radionuclides</b>	
Carbon-14	Antimony	Selenium
Cesium-137	Arsenic	Thallium
Cobalt-60	Beryllium	Zinc
Europium-155	Cadmium	1,1-Dichloroethene
Iodine-129	Chromium	1,1,2,2-Tetrachloroethane
Nickel-63	Cobalt	Benzene
Radium-228	Copper	Carbon Tetrachloride
Strontium-90	Hexavalent Chromium	Chloroform
Technetium-99	Lead	Tetrachloroethene
Tritium	Manganese	Trichloroethene
Uranium (total)	Mercury	Vinyl Chloride
	Nickel	Nitrate
		TPH – Diesel range

**Table 1-3. Groundwater COPCs for the 100-BC OUs**

Radionuclides	Non-radionuclides
---------------	-------------------

Notes:

OUs = operable units

TPH = Total Petroleum Hydrocarbons

## 1.4 Data Gaps

A systematic planning process was used to identify 100-BC problem statements and data gaps. The identified data needs resulting from the planning process are discussed in Chapter 4 of 100-BC RI/FS Work Plan (DOE/RL-2008-46-ADD3).

## 1.5 Sampling Design

The type of sampling design is judgmental (e.g., based on prior knowledge and professional judgment/expertise). The locations of waste sites and groundwater monitoring were defined to address the uncertainties and data gaps identified during planning. Figure 1-1 shows the locations of borcholes and groundwater monitoring wells described in this SAP. Tables 2-2 through 2-15 present the analytical methods selected to meet the estimated quantitation limits (EQLs) and the analytical performance requirements.

## 1.6 Project Schedule

The 100-BC RI field efforts are planned to occur between approximately March 2010 and December 2010, depending on the date of work plan approval. The drilling lead will prepare the relative borehole and groundwater well schedule for new installations. A spatial and temporal uncertainty sample round, or event, will be collected from each of the following: a seasonal high water level, a seasonal low water level, and a mid-point water level, for a total of three samples per well. Each round of monitoring in the network of wells for this area will be completed within 30 consecutive calendar days to minimize statistical variability in water levels. The RI report will document the results provided by sampling and analysis in this plan.

## 2 Quality Assurance Project Plan

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis. This QAPjP complies with the requirements of the following:

- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD)
- DOE O 414.1C, *Quality Assurance*
- 10 CFR 830, “Nuclear Safety Management,” Subpart A, “Quality Assurance Requirements”
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5

Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b) (Tri-Party Agreement Action Plan), require that quality assurance (QA)/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal units, as well as past practice processes. Therefore, this QAPjP follows the QA elements of QA/R-5 (EPA/240/B-01/003). The QAPjP demonstrates conformance to Part B requirements of ANSI/ASQ E4-2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use*.

In addition to the requirements cited above, the following reference also was used as a resource for identifying QAPjP elements:

- EPA-505-B-04-900A, *Intergovernmental Data Quality Task Force Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 1: UFP-QAPP Manual* (UFP-QAPP Manual).

The UFP-QAPP Manual (EPA-505-B-04-900A) is not imposed through the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). However, the UFP-QAPP Manual is a valuable resource and provides a comprehensive treatment of quality elements that should be addressed in any SAP. The UFP-QAPP Manual also was designed to be compatible with QA/R-5 (EPA/240/B-01/003), which forms the basis for this QAPjP.

The QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to this investigation.

**Section 2.1 Project Management** – This section addresses project management, including the project history and objectives, roles, and responsibilities of the participants. These elements ensure the project has a defined goal, participants understand the goal and the approach to be used, and planning outputs are documented.

**Section 2.2 Data Generation and Acquisition** – This section addresses aspects of project design and implementation. Implementing these elements ensures appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and properly documented.

**Section 2.3 Assessment and Oversight** – This section addresses the activities for assessing the effectiveness of implementing the project and associated QA/QC activities. The purpose of assessment is to ensure the QAPjP is implemented as prescribed.

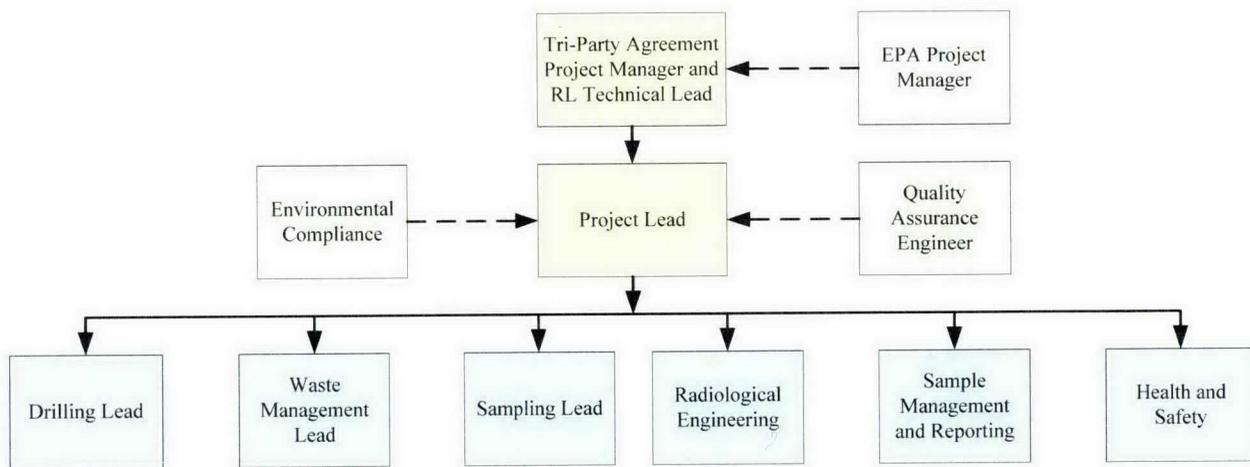
**Section 2.4 Data Validation and Usability** – This section addresses the QA activities occurring after the data collection or generation phase of the project is completed. Implementing these elements ensures data conform to the specified criteria, thus achieving the project objectives.

## 2.1 Project Management

The following sections address the basic aspects of project management, ensuring that the project has defined goals, the project team understands the goals and the approaches used, and the planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities covered under the SAP.

### 2.1.1 Project and Task Organization

The Plateau Remediation Contractor and River Corridor Closure Contractor, or its approved subcontractor, are responsible for planning, coordinating, collecting, preparing, packaging, and shipping samples to the laboratory. The following sections describe the project organization concerning sampling and characterization, also shown in Figure 2-1. The project lead maintains a list of individuals or organizations as points of contact for each functional element shown in Figure 2-1. For each functional primary contractor role, a corresponding oversight role exists within the U.S. Department of Energy (DOE).



EPA = United States Environmental Protection Agency  
 RL = U.S. Department of Energy, Richland Operations Office  
 Tri-Party Agreement = Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*

**Figure 2-1. Project Organization**

**EPA Project Manager.** The U.S. Environmental Protection Agency (EPA) has assigned project managers responsible for overseeing cleanup projects and activities. The EPA has approval authority as the lead regulatory agency for the work being performed under this SAP. The EPA will work with the U.S. Department of Energy, Richland Operations Office (RL) to resolve concerns over the work as described in this SAP in accordance with the Tri-Party Agreement (Ecology et al., 1989a).

**Tri-Party Agreement Project Manager and RL Technical Lead.** The Tri-Party Agreement Project Manager is responsible for authorizing RI/FS activities for the 100 Area. The Tri-Party Agreement Project Manager also is responsible for obtaining lead regulatory approval of the work plan and SAP that authorize the RI/FS activities under the Tri-Party Agreement (Ecology et al., 1989a). The RL technical lead is responsible for overseeing the contractor in performing the work scope, working with the

contractor and the regulatory agencies to identify and work through issues, and providing technical input to the Tri-Party Agreement Project Manager.

**Environmental Compliance.** The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and develops appropriate mitigation measures with a goal of minimizing adverse environmental impacts. The environmental compliance officer also reviews plans, procedures, and technical documents to ensure environmental requirements have been addressed; identifies environmental issues affecting operations and develops cost-effective solutions; and responds to environmental and regulatory issues or concerns raised by RL and/or the regulatory agencies. The environmental compliance officer also may oversee project implementation for compliance with applicable internal and external environmental requirements.

**Project Lead.** The project lead is responsible for managing sampling documents and requirements, field activities, and subcontracted tasks and for ensuring the project file is properly maintained. The project lead ensures the sampling design requirements are converted into field instructions (e.g., work packages) providing specific direction for field activities. The project lead works closely with QA, Health and Safety, the drilling lead, and the sampling lead to integrate these and the other lead disciplines in planning and implementing the work scope. The project lead maintains a list of individuals or organizations filling each of the functional elements of the project organization (Figure 2-1). In addition, the project lead is responsible for version control of the SAP to ensure personnel are working to the most current job requirements. The project lead also coordinates with RL and the primary contractor management on sampling activities. The project lead supports RL in coordinating sampling activities with the regulators.

**Quality Assurance Engineer.** The QA engineer is matrixed to the project lead and is responsible for QA issues on the project including overseeing implementation of the project QA requirements; reviewing project documents, including data needs summary reports, field sampling plan, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA engineer must be independent of the unit generating the data.

**Drilling Lead.** The drilling lead has overall responsibility for the planning, coordinating, and executing drilling activities. Specific responsibilities include coordinating with the geological and drilling contractors. The drilling lead also communicates with the project lead designee to identify field constraints or emergent conditions affecting sampling design and execution, and directs the procurement and installation of materials and equipment needed to support fieldwork.

**Waste Management Lead (Waste Coordinator).** The waste management lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe, cost-effective manner. In addition, Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance, interpreting the characterization data to generate waste designations and profiles, and preparing and maintaining other documents that confirm compliance with waste acceptance criteria.

**Sampling Lead.** The sampling lead has overall responsibility for planning, coordinating, and executing sampling activities. Specific responsibilities include converting the sampling design requirements into field task instructions providing specific direction for field activities, as well as directing training, mock-ups, and practice sessions with field personnel to ensure the sampling design is understood and can be performed as specified. The sampling lead also communicates with the project lead designee to identify field constraints or emergent conditions affecting sampling design and execution, directs the procurement and installation of materials and equipment needed to support fieldwork, and prepares data packages based on instructions from the project lead designee and information contained in this SAP. The

shipping lead reports to the sampling lead for shipment authorization. No sample material will be transported on or off the Hanford Site without permission from an authorized shipper or designee.

**Radiological Engineering.** The Radiological Engineering lead is responsible for the radiological/health physics support within the project. Specific responsibilities include conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for work planning. In addition, the Radiological Engineering lead identifies radiological hazards and implements appropriate controls to maintain worker exposures ALARA (e.g., requiring personal protective equipment). The radiological engineering lead also interfaces with the project Health and Safety contact, and plans and directs radiological control technician support for activities.

**Sample Management and Reporting.** Sample Management and Reporting coordinates laboratory analytical work, ensuring the laboratories conform to Hanford Site internal laboratory QA requirements, or their equivalent, as approved by DOE, EPA, and Washington State Department of Ecology (Ecology). Sample Management and Reporting receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS), and arranges for data validation. Sample Management and Reporting is responsible for informing the project lead of any issues reported by the analytical laboratory. Sample Management and Reporting develops and oversees the implementation of the letter of instruction to the analytical laboratories, oversees data validation, and works with the project lead to prepare a characterization report on the sampling and analysis results.

The Sample Management and Reporting organization is also responsible for the performance of the data needs process, or equivalent. Additional related responsibilities include development of the SAP, including documentation of the data needs and the sampling design, preparation of associated presentations, resolution of technical issues, and any revisions to the SAP. Samples collected in the field and released to River Corridor Closure Contractor for shipping and analysis, as well as the resulting data, will be managed in accordance with applicable procedures, and work plans.

**Laboratories.** The laboratories analyze samples in accordance with established procedures, provide necessary sample reports, and explain results in support of data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

**Health and Safety.** Health and Safety is responsible for coordinating industrial safety and health support for the project through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulation or by internal primary contractor work requirements. In addition, Health and Safety assists project personnel in complying with applicable health and safety standards and requirements. Health and Safety coordinates with Radiological Engineering to determine personal protective clothing requirements.

### 2.1.2 Problem Definition and Background

This SAP describes the sampling and analysis to be performed associated with boreholes and groundwater monitoring wells. The specific problems to be solved, background information, and general information are provided in the work plan. Media to be sampled include water, aquifer sediment, and soil. Figure 1-1 shows the locations of the planned and existing boreholes and groundwater monitoring wells within the scope of this SAP. Regulatory drivers and reference to agreement documents for the activity are provided in the work plan.

### 2.1.3 Project and Task Description

Chapter 3 presents the field sampling plan. Tables 1-2 and 1-3 present the target analytes and COPCs. Section 1.6 provides guidance on the implementation schedule.

#### 2.1.4 Quality Objectives and Criteria

The QA objective of this plan is to develop implementation guidance for providing data of known and appropriate quality. Data quality indicators describe data quality, by evaluation against identified data needs, and by evaluation against the work activities identified in this SAP. The applicable QC guidelines, EQLs, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. The principal data quality indicators are precision, bias or accuracy, representativeness, comparability, completeness, and sensitivity. These data quality indicators are defined for the purposes of this document in Table 2-1. The data quality indicators will be evaluated during the data quality assessment (DQA) process (Section 2.4).

Analytical performance requirements for samples collected are presented in Tables 2-2 through 2-15. Laboratory operations and analytical services shall comply with Volume 4 of HASQARD (DOE/RL-96-68, *Laboratory Technical Requirements*) and any specific criteria identified in Tables 2-2 through 2-15 below. Criteria in Tables 2-2 through 2-15 take precedence over similar criteria in HASQARD. In consultation with the laboratory, the project lead, and/or others as appropriate, Sample Management and Reporting can approve changes to analytical methods as long as the method is based upon a nationally recognized standard (e.g., EPA, American Society for Testing and Materials [ASTM]) method, the new method achieves project data quality objectives (DQOs) as well or better than the replaced method, and the new method is required due to the nature of the sample (e.g., high radioactivity).

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Precision	<p>The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated either as the range or as the standard deviation.</p> <p>May also be expressed as a percentage of the mean of the measurements, such as relative range, relative percent difference, or relative standard deviation (coefficient of variation).</p>	<p>Use the same analytical instrument to make repeated analyses on the same sample.</p> <p>Use the same method to make repeated measurements of the same sample within a single laboratory or have two or more laboratories analyze identical samples with the same method.</p> <p>Split a sample in the field and submit both for sample handling, preservation and storage, and analytical measurements.</p> <p>Collect, process, and analyze co-located samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.</p>	<p>Field precision: At randomly selected locations, duplicate samples will be taken 1 per 20 samples per media.</p> <p>Laboratory precision: analysis of laboratory duplicate or matrix spike duplicate samples.</p>	<p>If duplicate data do not meet objective:</p> <ul style="list-style-type: none"> <li>• Evaluate apparent cause (e.g., sample heterogeneity)</li> <li>• Request reanalysis or re-measurement</li> <li>• Qualify the data before use</li> </ul>
Accuracy	<p>A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of sampling and analytical operations.</p>	<p>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); usually expressed either as percent recovery or as percent bias.</p>	<p>Laboratory accuracy determination based on matrix spikes and matrix spike duplicate results.</p>	<p>If recovery does not meet objective:</p> <ul style="list-style-type: none"> <li>• Qualify the data before use</li> <li>• Request reanalysis or re-measurement</li> </ul>

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Representativeness	A qualitative term expressing "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" (ANSI/ASQC S2-1995).	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.	Samples will be collected as described in the sampling design.  Judgment sampling ensures areas most likely to be contaminated, based on current information, will be evaluated.	If results are not representative of the system sampled: <ul style="list-style-type: none"> <li>• Identify the reason result is not representative</li> <li>• Reject the data, or, if data are otherwise usable, qualify the data for limited use and define the portion of the system the data represent</li> <li>• Redefine sampling and measurement requirements and protocols</li> <li>• Resample and reanalyze</li> </ul>
Comparability	A qualitative term expressing the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.	Compare sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.	Sampling personnel will use the same sampling protocols.  Samples will be submitted to the same laboratories when possible (based on laboratory contracts) for analysis by the same methods, thus data results will be comparable.	If data are not comparable to other data sets: <ul style="list-style-type: none"> <li>• Identify appropriate changes to data collection and/or analysis methods</li> <li>• Identify quantifiable bias, if applicable</li> <li>• Qualify the data as appropriate</li> <li>• Resample and/or reanalyze if needed</li> <li>• Revise sampling/analysis protocols to ensure future comparability</li> </ul>

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's data needs.	The percent complete will be determined during data validation.	<p>If data set does not meet completeness objective:</p> <ul style="list-style-type: none"> <li>• Identify appropriate changes to data collection and/or analysis methods</li> <li>• Identify quantifiable bias, if applicable</li> <li>• Qualify the data as appropriate</li> <li>• Resample and/or reanalyze if needed</li> <li>• Revise sampling and analysis protocols to ensure future comparability</li> </ul>
Sensitivity	The capability of a method or instrument to discriminate among measurement responses representing different levels of the variable of interest.	Determine the minimum concentration or attribute to be measured by a method (method detection limit), by an instrument (instrument detection limit), or by a laboratory (quantitation limit). The practical quantitation limit is the lowest level that can be routinely quantified and reported by a laboratory.	Ensure that sensitivity, as measured by detection limits, is appropriate for the action levels.	<p>If sensitivity does not meet objective:</p> <ul style="list-style-type: none"> <li>• Request reanalysis or re-measurement</li> <li>• Qualify or reject the data before use</li> </ul>

Notes:

\* Field sampling requirements are noted. Laboratories will follow requirements for use and interpretation of laboratory control samples.

ANSI/ASQC S2-1995, *Introduction to Attribute Sampling*

QA = quality assurance

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Isotopic – Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g			
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC – Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)			
			Direct Exposure	Groundwater Protection	River Protection						
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>			
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>											
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>			
7440-36-0	Antimony	6 mg/kg <sup>j</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD						
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg						
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV						
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg						
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg						
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV						
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg						
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg						
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg						
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg						
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg						
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg						
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg						
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg						
18540-29-9	Hexavalent Chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD				EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>

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Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg			
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>l</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>l</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud)	N/A	N/A
—						ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)		

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. Precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- j. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- k. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- l. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.
- m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.

ASTM D422-63, *Standard Test Method For Particle-Size Analysis of Soils*

**Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	= Chemical Abstracts Service		GEA	= gamma energy analysis		N/A	= not applicable	
cm <sup>2</sup>	= square centimeters		IC	= ion chromatography		NV	= no value	
Cr(VI)	= hexavalent chromium		ICP	= inductively coupled plasma		pCi/g	= average picocuries per gram	
dpm	= disintegrations per minute		LSC	= liquid scintillation counter		PRG	= preliminary remediation goals	
EQL	= estimated quantitation limit		mg/kg	= milligrams per kilogram		RESRAD	= RESidual RADioactivity (dose model)	
EPA	= Environmental Protection Agency		MS	= mass spectroscopy		TBD	= to be determined	

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
10045-97-3	Cesium-137 <sup>e</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g			
10198-40-0	Cobalt-60 <sup>e</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>			
10098-97-2	Strontium-90 <sup>e,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC – Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>e</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10028-17-8	Tritium <sup>e</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	125.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>

2-14

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7440-36-0	Antimony	6 mg/kg <sup>i</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>

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Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)			
			Direct Exposure	Groundwater Protection	River Protection						
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg						
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg						
71-43-2	Benzene	0.005 mg/kg <sup>l</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg						
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg						
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg						
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg						
75-01-4	Vinyl chloride	0.005 mg/kg <sup>l</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg						
<b>Performance Requirements for Physical Properties</b>											
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A				Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A				Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A			
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A			

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**Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area, Revision 6*.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. Precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- j. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- k. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- l. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.
- m. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

ASTM D422-63, *Standard Test Method For Particle-Size Analysis of Soils*

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<i>ASTM D2434-68, Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
<i>ASTM D2937-04, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
<i>ASTM D5084-03, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	=	Chemical Abstracts Service	GEA	=	gamma energy analysis	N/A	=	not applicable
cm <sup>2</sup>	=	square centimeters	IC	=	ion chromatography	NV	=	no value
Cr(VI)	=	hexavalent chromium	ICP	=	inductively coupled plasma	pCi/g	=	average picores per gram
dpm	=	disintegrations per minute	LSC	=	liquid scintillation counter	RESRAD	=	RESidual RADioactivity (dose model)
EPA	=	Environmental Protection Agency	mg/kg	=	milligrams per kilogram	TBD	=	to be determined
EQL	=	estimated quantitation limit	MS	=	mass spectroscopy			

Table 2-4. Analytical Performance Requirements for Soil Samples from 116-B-6B Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g			
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic - Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC – Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>

Table 2-4. Analytical Performance Requirements for Soil Samples from 116-B-6B Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7440-36-0	Antimony	6 mg/kg <sup>j</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg <sup>j</sup>	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>

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Table 2-4. Analytical Performance Requirements for Soil Samples from 116-B-6B Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>l</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl Chloride	0.005 mg/kg <sup>ll</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
<b>Performance Requirements for Physical Properties</b>								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A

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Table 2-4. Analytical Performance Requirements for Soil Samples from 116-B-6B Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud)  ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- j. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

Table 2-4. Analytical Performance Requirements for Soil Samples from 116-B-6B Crib

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<p>k. A task is included in DOE/RL-2008-46, <i>Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan</i> to re-evaluate arsenic and hexavalent chromium cleanup levels.</p> <p>l. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.</p> <p>m. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.</p> <p>ASTM D422-63, <i>Standard Test Method For Particle-Size Analysis of Soils</i>                      ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>                      ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>                      ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>                      ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i></p>								
CAS	=	Chemical Abstracts Service	GEA	=	gamma energy analysis	N/A	=	not applicable
cm <sup>2</sup>	=	square centimeters	IC	=	ion chromatography	NV	=	no value
Cr(VI)	=	hexavalent chromium	ICP	=	inductively coupled plasma	pCi/g	=	average picores per gram
dpm	=	disintegrations per minute	LSC	=	liquid scintillation counter	RESRAD	=	RESidual RADioactivity (dose model)
EQL	=	estimated quantitation limit	mg/kg	=	milligrams per kilogram	TBD	=	to be determined
EPA	=	Environmental Protection Agency	MS	=	mass spectroscopy			

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Table 2-5. Analytical Performance Requirements for Soil Samples from 116-B-9 French Drain

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic – Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic – Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC – Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>

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Table 2-5. Analytical Performance Requirements for Soil Samples from 116-B-9 French Drain

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC – Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7440-36-0	Antimony	6 mg/kg <sup>j</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-93-2	Lithium	2.5 mg/kg	160 mg/kg	192 mg/kg	NV			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

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Table 2-5. Analytical Performance Requirements for Soil Samples from 116-B-9 French Drain

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>li</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>l</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A

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Table 2-5. Analytical Performance Requirements for Soil Samples from 116-B-9 French Drain

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud)  ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values for were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

**Table 2-5. Analytical Performance Requirements for Soil Samples from 116-B-9 French Drain**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
j.	To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.							
k.	A task is included in DOE/RL-2008-46, <i>Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan</i> to re-evaluate arsenic and hexavalent chromium cleanup levels.							
m.	Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.							
l.	Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.							
m.	Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.							
ASTM D422-63, <i>Standard Test Method For Particle-Size Analysis of Soils</i>								
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	=	Chemical Abstracts Service	GEA	=	gamma energy analysis	MS	=	mass spectroscopy
Cr(VI)	=	hexavalent chromium	IC	=	ion chromatography	N/A	=	not applicable
dpm	=	disintegrations per minute	ICP	=	inductively coupled plasma	NV	=	no value
EQL	=	estimated quantitation limit	LSC	=	liquid scintillation counter	RESRAD	=	RESidual RADioactivity (dose model)

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Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g			
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC – Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic-Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>

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Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>l</sup>	70-130 <sup>f</sup>
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	Isotopic-Uranium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
14797-55-8	Nitrate (as Nitrogen)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg			
7440-36-0	Antimony	6 mg/kg <sup>j</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

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Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>l</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl Chloride	0.005 mg/kg <sup>l</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			

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Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
12674-11-2	Aroclor-1016 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.094 mg/kg	0.000447 mg/kg	EPA 8082 (PCB by GC)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
11104-28-2	Aroclor-1221 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
11141-16-5	Aroclor-1232 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
53469-21-9	Aroclor-1242 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.0394 mg/kg	0.000187 mg/kg			
12672-29-6	Aroclor-1248 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.0386 mg/kg	0.000183 mg/kg			
11097-69-1	Aroclor-1254 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.0664 mg/kg	0.000315 mg/kg			
11096-82-5	Aroclor-1260 (PCB)	0.017 mg/kgl	0.5 mg/kg	0.721 mg/kg	0.00342 mg/kg			
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A

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Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- j. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- k. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- l. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.
- m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.

**Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-14 Trench**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<i>ASTM D422-63, Standard Test Method For Particle-Size Analysis of Soils</i>								
<i>ASTM D2216-05, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
<i>ASTM D2434-68, Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
<i>ASTM D2937-04, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
<i>ASTM D5084-03, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.</i>								
CAS	= Chemical Abstracts Service	IC	= ion chromatography	NWTPH-D	= Northwest total petroleum hydrocarbon – diesel			
Cr(VI)	= hexavalent chromium	ICP	= inductively coupled plasma	PCB	= polychlorinated biphenyl			
dpm	= disintegrations per minute	LSC	= liquid scintillation counter	RESRAD	= RESidual RADioactivity (dose model)			
EQL	= estimated quantitation limit	MS	= mass spectroscopy	TPH	= total petroleum hydrocarbon			
GC	= gas chromatography	N/A	= not applicable					
GEA	= gamma energy analysis	NV	= no value					

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-5 Retention Basin

CAS Number	Analyte	Preliminary Cleanup Goals				Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
		EQL <sup>a</sup>	Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g			
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic-Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Nickel	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-5 Retention Basin

CAS Number	Analyte	Preliminary Cleanup Goals				Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
		EQL <sup>a</sup>	Direct Exposure	Groundwater Protection	River Protection			
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	Isotopic-Uranium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
Performance Requirements for Laboratory Measurements (Nonradiological)								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7440-36-0	Antimony	6 mg/kg <sup>j</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>j</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>j</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>j</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>j</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>

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Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-5 Retention Basin

CAS Number	Analyte	Preliminary Cleanup Goals				Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
		EQL <sup>a</sup>	Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>i</sup>	70-130 <sup>i</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>l</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg			
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>l</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>l</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>l</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>l</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>l</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
56-55-3	Benzo(a)anthracene	0.015 mg/kg	1.37 mg/kg	0.856 mg/kg	0.04 mg/kg			
50-32-8	Benzo(a)pyrene	0.015 mg/kg	0.137 mg/kg	2.33 mg/kg	0.109 mg/kg			
205-99-2	Benzo(b)fluoranthene	0.015 mg/kg	1.37 mg/kg	2.95 mg/kg	0.138 mg/kg	EPA 8310 (polynuclear aromatic hydrocarbons)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
218-01-9	Chrysene	0.1 mg/kg <sup>l</sup>	13.7 mg/kg	9.56 mg/kg	0.0446 mg/kg			
206-44-0	Fluoranthene	0.05 mg/kg	3,200 mg/kg	631 mg/kg	178 mg/kg			
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV	NWTPH-D	≤20 <sup>m</sup>	80-120 <sup>m</sup>
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A

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DOE/RL-2009-44, REV. 0

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-5 Retention Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- j. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.

**Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-5 Retention Basin**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<p>k. A task is included in DOE/RL-2008-46, <i>Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan</i> to re-evaluate arsenic and hexavalent chromium cleanup levels.</p> <p>l. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.</p> <p>m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Methods 8260 and 8270.</p> <p>ASTM D422-63, <i>Standard Test Method For Particle-Size Analysis of Soils</i></p> <p>ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i></p> <p>ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i></p> <p>ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i></p> <p>ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i></p>								
CAS	= Chemical Abstracts Service	IC	= ion chromatography	NV	= no value			
Cr(VI)	= hexavalent chromium	ICP	= inductively coupled plasma	NWTPH-D	= Northwest total petroleum hydrocarbon – diesel			
dpm	= disintegrations per minute	LSC	= liquid scintillation counter	RESRAD	= RESidual RADioactivity (dose model)			
EQL	= estimated quantitation limit	MS	= mass spectroscopy	TPH	= total petroleum hydrocarbon			
GEA	= gamma energy analysis	N/A	= not applicable					

Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
10028-17-8	Tritium <sup>e</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>e,g</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>h</sup>	70-130 <sup>h</sup>
7439-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>h</sup>	70-130 <sup>h</sup>
7440-36-0	Antimony	6 mg/kg <sup>i</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic <sup>j</sup>	10 mg/kg	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg <sup>i</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			

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Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-93-2	Lithium	2.5 mg/kg	160 mg/kg	192 mg/kg	NV			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>i</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>i</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium <sup>i</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>h</sup>	70-130 <sup>h</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>h</sup>	70-130 <sup>h</sup>
75-35-4	1,1-Dichloroethene	0.01 mg/kg <sup>k</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>l</sup>	70-130 <sup>l</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>k</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>k</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>k</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>k</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>k</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			

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Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Physical Properties</b>								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area, Revision 6*.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. Strontium-90 will be assessed as total radioactive strontium.



Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g			
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic-Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC-Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13966-29-5	Uranium-234	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	Isotopic-Uranium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15117-96-1	Uranium-235	0.5 pCi/g <sup>i</sup>	0.61 pCi/g	0.185 pCi/g	0.185 pCi/g			
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g			

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Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
18540-29-9	Hexavalent chromium <sup>i</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-36-0	Antimony	6 mg/kg <sup>l</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-38-2	Arsenic <sup>j</sup>	10 mg/kg	TBD	TBD	TBD			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>l</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>l</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>l</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>l</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

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Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
75-35-4	1,1-Dichlorethene	0.01 mg/kg <sup>i</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>i</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>i</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>i</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>i</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>i</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
12674-11-2	Aroclor-1016 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.094 mg/kg	0.000447 mg/kg			
11104-28-2	Aroclor-1221 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
11141-16-5	Aroclor-1232 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
53469-21-9	Aroclor-1242 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0394 mg/kg	0.000187 mg/kg			
12672-29-6	Aroclor-1248 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0386 mg/kg	0.000183 mg/kg			
11097-69-1	Aroclor-1254 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0664 mg/kg	0.000315 mg/kg			
11096-82-5	Aroclor-1260 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.721 mg/kg	0.00342 mg/kg			

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Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
56-55-3	Benzo(a)-anthracene	0.015 mg/kg	1.37 mg/kg	0.856 mg/kg	0.04 mg/kg	EPA 8310 (polynuclear aromatic hydrocarbons)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
50-32-8	Benzo(a)pyrene	0.015 mg/kg	0.137 mg/kg	2.33 mg/kg	0.109 mg/kg			
205-99-2	Benzo(b)-fluoranthene	0.015 mg/kg	1.37 mg/kg	2.95 mg/kg	0.138 mg/kg			
191-24-2	Benzo(ghi)perylene	0.03 mg/kg	2,400 mg/kg	25,700 mg/kg	7,070 mg/kg			
207-08-9	Benzo(k)-fluoranthene	0.015 mg/kg	1.37 mg/kg	21.5 mg/kg	0.138 mg/kg			
218-01-9	Chrysene	0.1 mg/kg <sup>i</sup>	13.7 mg/kg	9.56 mg/kg	0.0446 mg/kg			
206-44-0	Fluoranthene	0.05 mg/kg	3,200 mg/kg	631 mg/kg	178 mg/kg			
193-39-5	Indeno(1,2,3-cd)-pyrene	0.03 mg/kg	1.37 mg/kg	8.33 mg/kg	0.389 mg/kg			
91-20-3	Naphthalene	0.1 mg/kg	1,600 mg/kg	4.46 mg/kg	275 mg/kg			
85-01-8	Phenanthrene	0.05 mg/kg	24,000 mg/kg	1,140 mg/kg	9,100 mg/kg			
129-00-0	Pyrene	0.05 mg/kg	2,400 mg/kg	655 mg/kg	2,620 mg/kg			
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV	NWTPH-D	≤20 <sup>m</sup>	80-120 <sup>m</sup>
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A

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**Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA/600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.
- j. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- k. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- l. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.

**Table 2-9. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8 Reactor Fuel Storage Basin**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
ASTM D422-63, <i>Standard Test Method for Particle-Size Analysis of Soils</i>								
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma	NV	=	no value
Cr(VI)	=	hexavalent chromium	LSC	=	liquid scintillation counter	NWTPH-D	=	Northwest total petroleum hydrocarbon – diesel
dpm	=	disintegrations per minute	IC	=	ion chromatography	PCB	=	polychlorinated biphenyl
EQL	=	estimated quantitation limit	N/A	=	not applicable	RESRAD	=	RESidual RADioactivity (dose model)
GEA	=	gamma energy analysis	MS	=	mass spectroscopy	TPH	=	total petroleum hydrocarbon
GC	=	gas chromatography						

Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic-Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC-Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13966-29-5	Uranium-234	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	Isotopic-Uranium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15117-96-1	Uranium-235	0.5 pCi/g <sup>i</sup>	0.61 pCi/g	0.185 pCi/g	0.185 pCi/g			
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g			

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Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
18540-29-9	Hexavalent chromium <sup>l</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-36-0	Antimony	6 mg/kg <sup>l</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-38-2	Arsenic <sup>l</sup>	10 mg/kg	TBD	TBD	TBD			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>l</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>l</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>l</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>l</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

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Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
75-35-4	1,1-Dichlorethene	0.01 mg/kg <sup>i</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>i</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>i</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>i</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>i</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>i</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
12674-11-2	Aroclor-1016 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.094 mg/kg	0.000447 mg/kg	EPA 8082 (PCB by GC)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
11104-28-2	Aroclor-1221 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
11141-16-5	Aroclor-1232 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
53469-21-9	Aroclor-1242 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0394 mg/kg	0.000187 mg/kg			
12672-29-6	Aroclor-1248 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0386 mg/kg	0.000183 mg/kg			
11097-69-1	Aroclor-1254 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0664 mg/kg	0.000315 mg/kg			
11096-82-5	Aroclor-1260 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.721 mg/kg	0.00342 mg/kg			

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Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
56-55-3	Benzo(a)-anthracene	0.015 mg/kg	1.37 mg/kg	0.856 mg/kg	0.04 mg/kg	EPA 8310 (polynuclear aromatic hydrocarbons)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
50-32-8	Benzo(a)pyrene	0.015 mg/kg	0.137 mg/kg	2.33 mg/kg	0.109 mg/kg			
205-99-2	Benzo(b)-fluoranthene	0.015 mg/kg	1.37 mg/kg	2.95 mg/kg	0.138 mg/kg			
191-24-2	Benzo(ghi)perylene	0.03 mg/kg	2,400 mg/kg	25,700 mg/kg	7,070 mg/kg			
207-08-9	Benzo(k)-fluoranthene	0.015 mg/kg	1.37 mg/kg	21.5 mg/kg	0.138 mg/kg			
218-01-9	Chrysene	0.1 mg/kg <sup>l</sup>	13.7 mg/kg	9.56 mg/kg	0.0446 mg/kg			
206-44-0	Fluoranthene	0.05 mg/kg	3,200 mg/kg	631 mg/kg	178 mg/kg			
193-39-5	Indeno(1,2,3-cd)-pyrene	0.03 mg/kg	1.37 mg/kg	8.33 mg/kg	0.389 mg/kg			
91-20-3	Naphthalene	0.1 mg/kg	1,600 mg/kg	4.46 mg/kg	275 mg/kg			
85-01-8	Phenanthrene	0.05 mg/kg	24,000 mg/kg	1,140 mg/kg	9,100 mg/kg			
129-00-0	Pyrene	0.05 mg/kg	2,400 mg/kg	655 mg/kg	2,620 mg/kg			
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV	NWTPH-D	≤20 <sup>m</sup>	80-120 <sup>m</sup>
<b>Performance Requirements for Physical Properties</b>								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A

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Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA/600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.
- j. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- k. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- l. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.

**Table 2-10. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-8:3 Process Sewer**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
ASTM D422-63, <i>Standard Test Method for Particle-Size Analysis of Soils</i>								
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	= Chemical Abstracts Service	ICP	= inductively coupled plasma	NV	= no value			
Cr(VI)	= hexavalent chromium	LSC	= liquid scintillation counter	NWTPH-D	= Northwest total petroleum hydrocarbon – diesel			
dpm	= disintegrations per minute	IC	= ion chromatography	PCB	= polychlorinated biphenyl			
EQL	= estimated quantitation limit	N/A	= not applicable	RESRAD	= RESidual RADioactivity (dose model)			
GEA	= gamma energy analysis	MS	= mass spectroscopy	TPH	= total petroleum hydrocarbon			
GC	= gas chromatography							

Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Americium-241/ Curium-244	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10045-97-3	Cesium-137 <sup>g</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>g</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Iodine-129, Low Energy	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10098-97-2	Strontium-90 <sup>g,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	Isotopic-Plutonium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV <sup>e</sup>	NV <sup>e</sup>	LSC-Carbon-14	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13981-37-8	Nickel-63 <sup>g</sup>	30 pCi/g	4,026 pCi/g	83 pCi/g	166 pCi/g	LSC-Nickel-63	≤30 <sup>f</sup>	70-130 <sup>f</sup>
14133-76-7	Technetium-99 <sup>g</sup>	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.92 pCi/g	LSC-Technetium-99	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10028-17-8	Tritium <sup>g</sup>	10 pCi/g	510 pCi/g	12.6 pCi/g	25.2 pCi/g	LSC-Tritium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
13966-29-5	Uranium-234	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	Isotopic-Uranium	≤30 <sup>f</sup>	70-130 <sup>f</sup>
15117-96-1	Uranium-235	0.5 pCi/g <sup>i</sup>	0.61 pCi/g	0.185 pCi/g	0.185 pCi/g			
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g			

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Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
18540-29-9	Hexavalent chromium <sup>l</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Mercury cold vapor)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-36-0	Antimony	6 mg/kg <sup>l</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>k</sup>	70-130 <sup>k</sup>
7440-38-2	Arsenic <sup>l</sup>	10 mg/kg	TBD	TBD	TBD			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV			
7440-43-9	Cadmium	0.5 mg/kg <sup>l</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>l</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>l</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>l</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	EPA 300.0 (Anions by IC)	≤30 <sup>k</sup>	70-130 <sup>k</sup>

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Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
75-35-4	1,1-Dichlorethene	0.01 mg/kg <sup>i</sup>	1.67 mg/kg	0.0005 mg/kg	0.0008 mg/kg	EPA 8260 (volatile organics)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
79-34-5	1,1,2,2-Tetrachloroethane	0.005 mg/kg <sup>i</sup>	5 mg/kg	0.0012 mg/kg	0.0019 mg/kg			
71-43-2	Benzene	0.005 mg/kg <sup>i</sup>	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg <sup>i</sup>	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
127-18-4	Tetrachloroethene	0.005 mg/kg	1.85 mg/kg	0.008 mg/kg	0.008 mg/kg			
79-01-6	Trichloroethene	0.005 mg/kg <sup>i</sup>	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
75-01-4	Vinyl chloride	0.005 mg/kg <sup>i</sup>	0.667 mg/kg	0.00018 mg/kg	0.0252 mg/kg			
12674-11-2	Aroclor-1016 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.094 mg/kg	0.000447 mg/kg			
11104-28-2	Aroclor-1221 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
11141-16-5	Aroclor-1232 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.00920 mg/kg	0.0000437 mg/kg			
53469-21-9	Aroclor-1242 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0394 mg/kg	0.000187 mg/kg			
12672-29-6	Aroclor-1248 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0386 mg/kg	0.000183 mg/kg			
11097-69-1	Aroclor-1254 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.0664 mg/kg	0.000315 mg/kg			
11096-82-5	Aroclor-1260 (PCB)	0.017 mg/kg <sup>i</sup>	0.5 mg/kg	0.721 mg/kg	0.00342 mg/kg			

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Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
56-55-3	Benzo(a)-anthracene	0.015 mg/kg	1.37 mg/kg	0.856 mg/kg	0.04 mg/kg	EPA 8310 (polynuclear aromatic hydrocarbons)	≤30 <sup>m</sup>	70-130 <sup>m</sup>
50-32-8	Benzo(a)pyrene	0.015 mg/kg	0.137 mg/kg	2.33 mg/kg	0.109 mg/kg			
205-99-2	Benzo(b)-fluoranthene	0.015 mg/kg	1.37 mg/kg	2.95 mg/kg	0.138 mg/kg			
191-24-2	Benzo(ghi)perylene	0.03 mg/kg	2,400 mg/kg	25,700 mg/kg	7,070 mg/kg			
207-08-9	Benzo(k)-fluoranthene	0.015 mg/kg	1.37 mg/kg	21.5 mg/kg	0.138 mg/kg			
218-01-9	Chrysene	0.1 mg/kg	13.7 mg/kg	9.56 mg/kg	0.0446 mg/kg			
53-70-3	Dibenz[a,h]anthracene	0.03 mg/kg	1.37 mg/kg	4.29 mg/kg	0.2 mg/kg			
206-44-0	Fluoranthene	0.05 mg/kg	3,200 mg/kg	631 mg/kg	178 mg/kg			
193-39-5	Indeno(1,2,3-cd)-pyrene	0.03 mg/kg	1.37 mg/kg	8.33 mg/kg	0.389 mg/kg			
129-00-0	Pyrene	0.05 mg/kg	2,400 mg/kg	655 mg/kg	2,620 mg/kg			
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV	NWTPH-D	≤20 <sup>m</sup>	80-120 <sup>m</sup>
<b>Performance Requirements for Physical Properties</b>								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A

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Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. Calculated cleanup goals are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.
- j. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.
- k. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- l. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- m. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Methods 8260 and 8270.

ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils*

**Table 2-11. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-C-3 Reactor Fuel Storage Basin**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>								
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>								
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>								
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>								
CAS	= Chemical Abstracts Service		ICP	= inductively coupled plasma		NV	= no value	
Cr(VI)	= hexavalent chromium		LSC	= liquid scintillation counter		NWTPH-D	= Northwest total petroleum hydrocarbon – diesel	
dpm	= disintegrations per minute		IC	= ion chromatography		PCB	= polychlorinated biphenyl	
EQL	= estimated quantitation limit		MS	= mass spectroscopy		RESRAD	= RESidual RADioactivity (dose model)	
GEA	= gamma energy analysis		N/A	= not applicable		TPH	= total petroleum hydrocarbon	
GC	= gas chromatography							

Table 2-12. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
<b>Performance Requirements for Field Measurements</b>								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	≤50	— <sup>c</sup>
—	Gross alpha	100 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
—	Gross beta	5,000 dpm/ 100 cm <sup>2</sup>	N/A	N/A	N/A	Portable contamination detector	≤50	— <sup>c</sup>
<b>Performance Requirements for Laboratory Measurements (Radiological)<sup>d</sup></b>								
10045-97-3	Cesium-137 <sup>e</sup>	0.1 pCi/g	6.2 pCi/g	1,465 pCi/g	2,930 pCi/g	GEA	≤30 <sup>f</sup>	70-130 <sup>f</sup>
10198-40-0	Cobalt-60 <sup>e</sup>	0.05 pCi/g	1.4 pCi/g	13,900 pCi/g	27,800 pCi/g			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV <sup>g</sup>	NV <sup>g</sup>			
10098-97-2	Strontium-90 <sup>e,h</sup>	1 pCi/g	4.5 pCi/g	27.6 pCi/g	55.2 pCi/g	Strontium-90	≤30 <sup>f</sup>	70-130 <sup>f</sup>
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>								
7440-36-0	Antimony	6.0 mg/kg <sup>i</sup>	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 or 200.8 (ICP or ICP/MS metals)	≤30 <sup>j</sup>	70-130 <sup>j</sup>
7440-38-2	Arsenic <sup>k</sup>	10 mg/kg	TBD	TBD	TBD			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg <sup>i</sup>	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			

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Table 2-12. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg <sup>i</sup>	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg <sup>i</sup>	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg <sup>i</sup>	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium <sup>k</sup>	0.5 mg/kg	TBD	TBD	TBD	EPA 7196 (Cr(VI))	≤30 <sup>i</sup>	70-130 <sup>i</sup>
—	Distribution coefficient for EPA 6010/6020/7196/7470 or 200.8 metals	N/A	N/A	N/A	N/A	Desorption distribution coefficient using 1:1 water extract and acid leach	N/A	N/A
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216-05	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084-03 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434-68 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A

**Table 2-12. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937-04	N/A	N/A

Notes:

- a. The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- b. Equivalent methods may be substituted. For EPA Method 200.8, see EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Field measurements have no specific QC requirements for accuracy except to perform checks to verify manufacturer's expected performance.
- d. The PRG for the total of all radiological analytes is <15 mRem per year.
- e. The groundwater protection and river protection preliminary cleanup goal values were established in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Revision 6.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. Precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years. However, site-specific modeling will be performed, as necessary, to determine whether preliminary cleanup goals have been met.
- h. Strontium-90 will be assessed as total radioactive strontium.
- i. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if EQLs are met.
- j. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- k. A task is included in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan* to re-evaluate arsenic and hexavalent chromium cleanup levels.

ASTM D422-63, Standard Test Method for Particle-Size Analysis of Soils

ASTM D2216-05, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D2434-68, Standard Test Method for Permeability of Granular Soils (Constant Head)

ASTM D2937-04, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

**Table 2-12. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells**

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
ASTM D5084-03, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter								
CAS	=	Chemical Abstracts Service	GEA	=	gamma energy analysis	N/A	=	not applicable
Cr(VI)	=	hexavalent chromium	ICP	=	inductively coupled plasma	NV	=	no value
dpm	=	disintegrations per minute	MS	=	mass spectroscopy	RESRAD	=	RESidual RADioactivity (dose model)
EQL	=	estimated quantitation limit						

Table 2-13. Analytical Performance Requirements for Soil/Aquifer Sediment Leach Tests

CAS Number	Analyte	EQL <sup>a</sup>	Preliminary Cleanup Goals			Analytical Method <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7440-47-3	Chromium	10 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
18540-29-9	Hexavalent chromium	3.7 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	≤30 <sup>c</sup>	70-130 <sup>c</sup>

Notes:

- The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- Equivalent methods may be substituted. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

CAS # = Chemical Abstracts Service Number

ICP = inductively coupled plasma

EQL = estimated quantitation limit

N/A = not applicable

Table 2-14. Analytical Performance Requirements for Groundwater Samples

CAS Number	Analyte	Analytical Method <sup>a</sup>	EQL <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
<b>Performance Requirements for Field Measurements</b>							
—	Oxidation reduction potential	REDOX PROBE	N/A	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	pH measurement	PROBE	0.5 pH unit	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Specific conductance	PROBE	1 µS/cm	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Temperature	PROBE	--	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Dissolved oxygen	PROBE	--	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Turbidity	PROBE	0.1 NTU	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
<b>Performance Requirements for Laboratory Measurements (Radiological)</b>							
15046-84-1	Iodine-129	Iodine-129 – Low Level	1 pCi/L	≤30 <sup>d</sup>	70-130 <sup>d</sup>	1 pCi/L	40 CFR 141.66
10098-97-2	Strontium-90 <sup>e</sup>	Strontium-90	2 pCi/L	≤30 <sup>d</sup>	70-130 <sup>d</sup>	8 pCi/L	40 CFR 141.66
10028-17-8	Tritium	LSC-Tritium	400 pCi/L	≤30 <sup>d</sup>	70-130 <sup>d</sup>	20,000 pCi/L	40 CFR 141.66
12587-46-1	Gross alpha	GPC	3 pCi/L	≤30 <sup>d</sup>	70-130 <sup>d</sup>	15 pCi/L	Federal MCL
12587-47-2	Gross beta	GPC	4 pCi/L	≤30 <sup>d</sup>	70-130 <sup>d</sup>	N/A	4 mrem/year Federal MCL
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>							
7440-36-0	Antimony	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	5 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	5.6 µg/L	Human Health for the Consumption of Water + Organism
7440-38-2	Arsenic	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L <sup>g,h</sup>	≤20 <sup>f</sup>	80-120 <sup>f</sup>	0.018 µg/L	Human Health for the Consumption of Water + Organism
7440-41-7	Beryllium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	4.0 µg/L	40 CFR 141.62

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Table 2-14. Analytical Performance Requirements for Groundwater Samples

CAS Number	Analyte	Analytical Method <sup>a</sup>	EQL <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
7440-43-9	Cadmium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L <sup>g,h</sup>	≤20 <sup>f</sup>	80-120 <sup>f</sup>	0.25 µg/L	Freshwater CCC
7440-47-3	Chromium	EPA 6010 (ICP metals)	10 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	74 µg/L	Freshwater CCC
7440-48-4	Cobalt	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	4.8 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)
7440-50-8	Copper	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	8 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	9 µg/L	Freshwater CCC
18540-29-9	Hexavalent chromium	EPA 7196 (Cr(VI))	3.7 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	10 µg/L	Freshwater CCC
7439-92-1	Lead	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	2.1 µg/L	WAC 173-201A
7439-97-6	Mercury	EPA 7470 or 200.8 (mercury)	0.5 µg/L <sup>g</sup>	≤20 <sup>f</sup>	80-120 <sup>f</sup>	0.05 µg/L	WAC 173-21A Freshwater CCC
7439-96-5	Manganese	EPA 6010 (ICP metals)	5 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	50 µg/L	Secondary MCL
7440-02-0	Nickel	EPA 6010 (ICP metals)	40 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	52 µg/L	Freshwater CCC
7782-49-2	Selenium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	5 µg/L	Freshwater CCC
7440-28-0	Thallium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L <sup>g,h</sup>	≤20 <sup>f</sup>	80-120 <sup>f</sup>	0.24 µg/L	Human Health for the Consumption of Water + Organism
7440-66-6	Zinc	EPA 6010 (ICP metals)	10 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	91 µg/L	WAC 173-201A
7440-61-1	Uranium	Total Uranium (chemical)	1 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	30 µg/L	40 CFR 141.62
75-35-4	1,1-Dichloroethene	EPA 8260 (VOCs)	2 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.073 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)
79-34-5	1,1,2,2-Tetrachloroethane	EPA 8260 (VOCs)	1.5 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.17 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)

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Table 2-14. Analytical Performance Requirements for Groundwater Samples

CAS Number	Analyte	Analytical Method <sup>a</sup>	EQL <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
71-43-2	Benzene	EPA 8260 (VOCs)	1.5 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.795 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)
56-23-5	Carbon tetrachloride	EPA 8260 (VOCs)	1 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.23 µg/L	Human Health for the Consumption of Water + Organism
67-66-3	Chloroform	EPA 8260 (VOCs)	5 µg/L	≤20 <sup>i</sup>	80-120 <sup>i</sup>	5.7 µg/L	Human Health for the Consumption of Water + Organism
127-18-4	Tetrachloroethene	EPA 8260 (VOCs)	5 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.081 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)
79-01-6	Trichloroethene	EPA 8260 (VOCs)	1 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.49 µg/L	WAC 173-340-720 (4)(b)(iii)(A) and (B)
75-01-4	Vinyl chloride	EPA 8260 (VOCs)	5 µg/L <sup>h</sup>	≤20 <sup>i</sup>	80-120 <sup>i</sup>	0.029 µg/L	Human Health for the Consumption of Water + Organism
14797-55-8	Nitrate (as Nitrogen)	EPA 300.0 (anions by IC)	250 µg/L	≤20 <sup>f</sup>	80-120 <sup>f</sup>	10,000 µg/L	40 CFR 141.62

## Notes:

- Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA/600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Tentatively identified compounds will be reported for SW-846 Method 8260.
- The EQL is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- Field measurements have no specific QC requirements except to perform checks to verify manufacturer's expected performance.
- Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- Strontium-90 will be assessed as total radioactive strontium.
- Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on

**Table 2-14. Analytical Performance Requirements for Groundwater Samples**

CAS Number	Analyte	Analytical Method <sup>a</sup>	EQL <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis	
statistical control limits for analytical batch laboratory control samples is also performed. The precision criteria shown is for batch laboratory replicate matrix spike or replicate sample relative percent differences.								
g. To meet or approach calculated action levels, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/MS methods if EQLs are met.								
h. Action levels are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.								
i. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control limits, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for SW-846 Method 8260.								
40 CFR 141.62, "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Inorganic Contaminants."								
40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides."								
WAC 173-340-720(4), "Model Toxics Control Act-Cleanup," "Ground Water Cleanup Standards."								
WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."								
CAS #	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma	MS	=	mass spectrometry
CCC	=	criterion continuous concentration	LSC	=	liquid scintillation counter	N/A	=	not applicable
Cr(VI)	=	hexavalent chromium	MCL	=	maximum contaminant level	NTU	=	nephelometric turbidity unit
EQL	=	estimated quantitation limit	MDL	=	method detection limit	VOC	=	volatile organic compound
IC	=	ion chromatography						

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Table 2-15. Analytical Performance Requirements for Pore Water Samples

CAS Number	Analyte	Analytical Method <sup>a</sup>	EQL <sup>b</sup>	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
<b>Performance Requirements for Field Measurements</b>							
—	Oxidation reduction potential	REDOX PROBE	N/A	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	pH measurement	PROBE	0.5 pH unit	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Specific conductance	PROBE	1 µS/cm	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Temperature	PROBE	--	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Dissolved oxygen	PROBE	--	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
—	Turbidity	PROBE	0.1 NTU	— <sup>c</sup>	— <sup>c</sup>	N/A	N/A
<b>Performance Requirements for Laboratory Measurements (Nonradiological)</b>							
7440-47-3	Chromium	EPA 6010 (ICP metals)	10 µg/L	≤20 <sup>d</sup>	80-120 <sup>d</sup>	74 µg/L	Freshwater CCC
18540-29-9	Hexavalent chromium	EPA 7196 (Cr(VI))	10 µg/L	≤20 <sup>d</sup>	80-120 <sup>d</sup>	10 µg/L	Freshwater CCC

Notes:

- a. Equivalent methods may be substituted. See SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Tentatively identified compounds will be reported for SW-846 Methods 8260 and 8270.
- b. The estimated quantitation limit (EQL) is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the method detection limit. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve.
- c. Field measurements have no specific QC requirements except to perform checks to verify manufacturer's expected performance.
- d. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples is also performed. The precision criteria shown is for batch laboratory replicate matrix spike or replicate sample relative percent differences.

CAS = Chemical Abstracts Service

CCC = criterion continuous concentration

Cr(VI) = hexavalent chromium

ICP = inductively coupled plasma

N/A = not applicable

NTU = nephelometric turbidity unit

### 2.1.5 Special Training and Certification

A graded approach is used to ensure workers receive a level of training commensurate with responsibilities and complies with applicable DOE orders and government regulations. The sampling lead and drilling lead, in coordination with line management, will ensure that field personnel meet special training requirements.

Typical training requirements or qualifications have been instituted by the primary contractor management team to meet training requirements imposed by the contract, regulations, DOE orders, DOE contractor requirements documents, the American National Standards Institute, the American Society of Mechanical Engineers, and *Washington Administrative Code*. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel typically will have completed 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)
- Hanford general employee radiation training
- Hanford general employee training
- Radiological worker training

Project-specific safety training, geared specifically to the project and the day's activity, will be provided. Project-specific training includes the following:

- Training requirements or qualifications needed by sampling personnel will be in accordance with QA requirements.
- Samplers are required to have training and/or experience in the type of sampling being performed in the field, soil/aquifer sediment sampling and water sampling.
- The Radiation Protection Program establishes qualification requirements for radiological control technicians. Radiological control technicians assigned to these activities will be qualified through the prescribed training program and will undergo ongoing training and qualification activities.

In addition, pre-job briefings will be performed to evaluate an activity and its hazards by considering many factors, including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety procedures applicable to the job
- Training requirements for individuals assigned to perform the work
- Level of management control
- Proximity of emergency contacts

Training records are maintained for each individual in an electronic training record database. The contractor training organization maintains the training records system. Line management will be used to confirm an individual employee's training is appropriate and up-to-date before performing any fieldwork.

### 2.1.6 Documents and Records

The project lead is responsible for ensuring the current version of the SAP is being used and for providing any updates to field personnel. Version control is maintained through the administrative document control process. Before implementation, DOE and the regulatory agency will review and approve changes to the sampling plan that affect the data needs. Information pertinent to sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols in accordance with HASQARD (DOE/RL-96-68).

The sampling lead or drilling lead is responsible for ensuring the field instructions are maintained up-to-date and aligned with any revisions to the SAP. The sampling lead or drilling lead will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook, on nonconformance report forms) in accordance with internal corrective action procedures.

The project lead, drilling lead, sampling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities. Table 2-16 presents the change control for this project.

**Table 2-16. Change Control for the 100-BC Project**

Type of Change	Action	Documentation
By drilling lead or sampling lead: <ul style="list-style-type: none"> <li>Increasing sampling frequency based on field screening results or visual observations</li> </ul>	No SAP revision necessary	Field logbooks or operational records
By project management: <ul style="list-style-type: none"> <li>Change in target analytes or contaminants of potential concern</li> <li>Adding/removing wells</li> <li>Significant increases or decreases in sampling frequency</li> </ul>	Revise SAP (can be accomplished with Tri-Party Agreement Change Notice); obtain regulatory approval; distribute plan	Revised plan or approved Tri-Party Agreement Change Notice

Logbooks are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for logbooks will be listed. Only authorized persons may make entries in logbooks. Logbooks will be signed by the sampling lead, drilling lead, 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.

Logbook entries will be made in indelible ink. Corrections will be made by marking the erroneous data through with a single line, entering the correct data, and initialing and dating the changes.

The project lead is responsible for ensuring a project file is properly maintained. The project file will contain the records or references to their storage locations. The project file will include the following, as appropriate:

- Field logbooks or operational records
- Data forms

- Global Positioning System data
- Chain-of-custody forms
- Sample receipt records
- Inspection or assessment reports and corrective action reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract
- Laboratory data packages
- RI report
- Verification and validation report

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

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

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

## **2.2 Data Generation and Acquisition**

The following sections address data generation and acquisition to ensure the project methods for sampling, measurement, and analysis, data collection or generation, data handling, and QC activities are appropriate and documented.

### **2.2.1 Sampling Process Design (Experimental Design)**

The sampling design is judgmental sampling. In judgmental sampling, sampling unit selection (e.g., the number, location, and/or timing of sample collection) is based on knowledge of the feature or condition under investigation and professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory. Therefore, conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment. Probabilistic statements about parameters are not possible. Section 3.5 provides the types, number, and location of samples.

### **2.2.2 Sampling Methods**

Section 3.6 describes the sampling methods. The specific information includes the following:

- Field sampling methods
- Corrective actions for sampling activities (the task lead will be responsible for corrective action)

- Decontamination of sampling equipment
- Radiological field data

### 2.2.3 Sample Handling and Custody

A sampling and data tracking database is used to track the samples from the point of collection through the laboratory analysis process. Samplers should note any anomalies (e.g., sample appears unusual, sample is sludge) with the samples to prevent batching across dissimilar matrices. If anomalies are found, the samplers should write "DO NOT BATCH" on the chain-of-custody form and inform Sample Management and Reporting.

Laboratory analytical results are entered and maintained in HEIS. The HEIS sample numbers are issued to the sampling organization for the project. Each chemical, radiological, and physical properties sample is identified and labeled with a unique HEIS sample number.

Section 3.7 provides the following specific sample handling information:

- Container packaging
- Container labeling
- Sample custody requirements
- Sample transportation

Sample custody during laboratory analysis is addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Storage of samples at the laboratory will be consistent with laboratory instructions prepared by Sample Management and Reporting.

### 2.2.4 Analytical Methods

Tables 2-2 through 2-15 provide information on analytical methods. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor, or vadose zone contractor as applicable, participates in oversight of offsite analytical laboratories to qualify them for performing Hanford Site analytical work.

If the laboratory uses a nonstandard or unapproved method, the laboratory must provide method validation data to confirm the method is adequate for the intended use of the data. This includes information such as determination of detection limits, quantitation limits, typical recoveries, and analytical precision and bias. Deviations from the analytical methods noted in Tables 2-2 through 2-15 must be approved by Sample Management and Reporting in consultation with the project lead.

Laboratories providing analytical services in support of this SAP will have in place a corrective action program addressing analytical system failures and documenting the effectiveness of corrective actions. Issues affecting analytical results are to be resolved by Sample Management and Reporting in coordination with the project lead.

Batch leaching tests will be performed on soil and aquifer sediment samples. Standardized batch leach tests are done using a leach procedure based on ASTM D3987-06, *Standard Test Method for Shake Extraction of Solid Waste with Water*. The procedure recommends using soil screened through 9.5 mm (3/8-inch) mesh. Demineralized water will be used as the leaching liquid. Selected soil samples will be leached at soil to water weight ratios of 1 to 1, 1 to 2.5, and 1 to 5 with one test in each series duplicated. Soil/water mixtures are placed in clean, watertight sample containers (extraction vessels) and rotated end-over-end through the vessel centerline at a rate of about 30 rotations per minute for 18 hours. Following

18 hours of mixing, the soil/water slurry is pressure-filtered using a 0.45- $\mu\text{m}$  filter. The leachate will be analyzed for pH, conductivity, and metals or other contaminants of interest. Details of the test will be discussed with the laboratory personnel before analysis.

Desorption distribution coefficient determinations using reagent water extract aliquots and results of soil analysis from EPA SW-846 Methods 6010, 6020, 7196, 7470, or 200.8 metals as applicable will support modeling needs. Details of the test will be discussed with the laboratory personnel before analysis.

### 2.2.5 Quality Control

QC procedures must be followed in the field and laboratory to ensure reliable data are obtained. Field personnel will collect QC samples to evaluate the potential for cross contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of field duplicate, trip or field transfer blank, equipment rinsate blank, and field split samples. Laboratory QC samples estimate the precision and bias of the analytical data. Table 2-17 summarizes field and laboratory QC samples.

**Table 2-17. Project Quality Control Checks**

QC Sample Type	Purpose	Frequency
<b>Field Quality Control</b>		
Full trip blank	Assess contamination from containers or transportation.	One per 20 samples <i>per media sampled</i> .
Field transfer blank	Assess contamination from sampling site.	One per day when volatile organic components are sampled <i>per media sampled</i> .
Equipment rinsate blank	Verify adequacy of sampling equipment decontamination.	As needed. <sup>a</sup> If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment rinsate blank is not required. Otherwise, 1 per 20 samples <i>per media sampled</i> .
Field duplicates	Estimate precision, including sampling and analytical variability.	One per batch, <sup>b</sup> 20 samples maximum, <i>per media sampled</i> .
Field split	Estimate precision, including sampling, analytical, and inter-laboratory variability.	One for every analytical method, except for Pacific Northwest National Laboratory specific tests, <i>per media sampled</i> .
<b>Laboratory Quality Control<sup>b</sup></b>		
Method blank	Assess response of an entire laboratory analytical system.	One per batch, <sup>b</sup> 20 samples maximum, or as identified by method guidance <i>per media sampled</i> .
Matrix spike	Identify analytical (preparation and analysis) bias; possible matrix affect on the analytical method used.	One per batch, <sup>b</sup> 20 samples maximum, or as identified by the method guidance <i>per media sampled</i> .
Matrix duplicate or matrix spike duplicate	Estimate analytical bias and precision.	One per batch, <sup>b</sup> 20 samples maximum, or as identified by the method guidance <i>per media sampled</i> .
Laboratory control samples	Assess method accuracy.	One per batch, <sup>b</sup> 20 samples maximum, or as identified by the method guidance <i>per media sampled</i> .
Surrogates	Estimate recovery/yield.	As identified by the method guidance <i>per media sampled</i> .

Table 2-17. Project Quality Control Checks

QC Sample Type	Purpose	Frequency
Notes:		
a. When a new type of non-dedicated equipment is used, an equipment rinsate blank will be collected every time sampling occurs until it can be shown that less-frequent collection of equipment rinsate blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.		
b. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).		

### 2.2.5.1 Field QC Samples

The Field QC sample types are discussed within this section.

**Full trip blanks** are samples prepared by the sampling team before traveling to the sampling site. The preserved bottle set is identical to the set collected in the field, but it is filled with reagent water or silica sand, as appropriate to the primary sample media. The bottles are sealed and transported, unopened, to the field in the same storage container used for samples collected the same day. Full trip blanks are typically analyzed for the same constituents as the samples from the associated sampling event. However, the analytical list for full trip blanks on soil may be limited to volatile organic analysis (VOA), semi-volatile organic analysis, and total petroleum hydrocarbons, depending on resolution/determination of the target analyte list. Full trip blanks are not required on aquifer sediments being analyzed for metals, mercury, and hexavalent chromium.

**Field transfer blanks** are preserved VOA sample containers filled at the sample collection site with reagent water or silica sand transported to the field. The samples are prepared during the sampling to evaluate potential contamination caused by field conditions. After collection, field transfer blank bottles are sealed and placed in the same storage container with the samples from the associated sampling event. Field transfer blank samples are analyzed for volatile organic compounds (VOCs) only.

A minimum of one field transfer blank will be collected at each borehole where the samples will undergo VOA. The field transfer blank will consist of reagent water or silica sand, as appropriate to the primary sample media, added to clean sample containers at the location where the VOC sample was collected. The field transfer blank will be batch analyzed with samples for which VOA is being requested.

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

For the field blanks (e.g., full trip blank, field transfer blank, and equipment rinsate blank), results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit. For radiological data, blank results are flagged if they are greater than two times the total minimum detectable activity.

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

A minimum of one soil and one aquifer sediment field duplicate will be collected for each day of sampling. The duplicate should be collected generally from an area expected to have some contamination, so valid comparisons between the samples can be made (e.g., at least some of the constituents will be above the detection limit). When sampling is performed from a split spoon, VOC samples and VOC duplicate samples are collected directly from the sampler. The remaining soil/aquifer sediment is then composited in a stainless steel mixing bowl. The soil/aquifer sediment sample and duplicate sample are collected from this composited material.

Evaluation of the results can provide an indication of intra-laboratory variability. Large relative percent differences can be an indication of laboratory performance problems and should be investigated. Only those field duplicates with at least one result greater than five times the method detection limit or minimum detectable activities are evaluated.

A **field split** is a representative sample from a sampling event sent to a third party laboratory (i.e., reference laboratory). Evaluation of the results can provide an indication of inter-laboratory variability. Large relative percent differences can be an indication of laboratory performance problems and should be investigated. Only those results greater than five times the method detection limit or minimum detectable activity at both laboratories are evaluated.

### **2.2.5.2 Laboratory QC Samples**

The laboratory QC samples (e.g., method blanks, laboratory control sample/blank spike, and matrix spike) are defined for three digit EPA methods (EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*, and EPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*) and four digit EPA methods (SW-846), and will be run at the frequency specified in the respective reference. QC checks outside of control limits will be reflected in the data validation process and during the DQA described in Section 2.4.

### **2.2.5.3 QC Requirements**

If only disposable equipment is used or equipment is dedicated to a particular well, an equipment rinse blank is not required. If no VOC samples are collected, a field transfer blank is not required.

Field duplicates must agree within 20 percent, as measured by the relative percent difference, to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results also are flagged with a "Q" qualifier in the HEIS database.

For chemical analyses, the acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are stated in Tables 2-2 through 2-15.

Holding time is the elapsed time period between sample collection and analysis, or sample collection to extraction and sample extraction to analysis, as applicable to the method. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the analytical method, as specified for three- and four-digit EPA methods (EPA-600/4-79-020; EPA-600/R-94-111; SW-846). Data associated with exceeded holding times are flagged.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The laboratories participate in national studies such as the EPA sanctioned water pollution and water supply performance evaluation studies. The Soil and Groundwater Remediation Project periodically audits the analytical laboratories to identify and solve quality problems or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and

performance evaluation studies are presented in the annual groundwater monitoring report (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). Failure of QC will be determined and evaluated during data validation and the DQA process. Data will be qualified as appropriate.

### **2.2.6 Instrument and Equipment Testing, Inspection, and Maintenance**

Equipment used for collection, measurement, and testing should meet the applicable standards (e.g., American Society for Testing and Materials) or have been evaluated as acceptable and valid in accordance with the procedures, requirements, and specifications. The sampling lead or equivalent will ensure that the data generated from instructions using a software system are backed up and/or downloaded regularly. Software configuration will be acceptance tested before use in the field.

Measurement and testing equipment used in the field or in the laboratory that 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. Maintenance requirements (such as documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with three- and four-digit EPA methods (EPA-600/4-79-020; EPA-600/R-94-111; SW-846), or with auditable Hanford Site and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

### **2.2.7 Instrument and Equipment Calibration and Frequency**

Section 3.4 provides specific field equipment calibration information. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's QA plan.

### **2.2.8 Inspection and Acceptance of Supplies and Consumables**

Supplies and consumables used in support of sampling and analysis activities will be procured in accordance with internal work requirements and processes described in the contractor acquisition system. Responsibilities and interfaces necessary to ensure items are procured or acquired for the contractor to meet the specific technical and quality requirements must be in place. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users before use. Supplies and consumables procured by the analytical laboratories are procured, checked, and used in accordance with the laboratories' QA plans.

### **2.2.9 Non-Direct Measurements**

Non-direct measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. Non-direct measurements will not be evaluated as part of the activities within the scope of this SAP.

### **2.2.10 Data Management**

Sample Management and Reporting, in coordination with the project lead, is responsible for ensuring analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management procedures. Electronic data access, when appropriate, will be through a database (e.g., HEIS or a project specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to Sample Management and Reporting routinely. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with contractor procedures. This process is used to document analytical errors and establish resolution with the project lead. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

Planning for sample collection and analysis will be in accordance with the programmatic requirements governing fixed laboratory sample collection activities, as discussed in the sampling procedures. If specific procedures do not exist for a particular work evolution, or it is determined additional guidance is needed to complete certain tasks, a work package will be developed to control the activities, as appropriate. Examples of the sampling procedure requirements include activities associated with the following:

- Chain-of-custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks
- Checklists
- Sample packaging and shipping

When this SAP is implemented, approved work control packages and procedures will be used to document field activities, including radiological and nonradiological measurements. Field activities will be recorded in the field logbook. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection."
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of primary contractor radiological records.
- Minimum standards and practices necessary for preparing, performing, and retaining radiological related records.
- Indoctrination of personnel on the development and implementation of sample plans.
- Requirements associated with preparing and transporting regulated material.
- Daily reports of radiological surveys and measurements collected during field investigation activities. Data will be cross referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results.

## **2.3 Assessment and Oversight**

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

### **2.3.1 Assessments and Response Actions**

Contractor management, regulatory compliance, quality, and/or Health and Safety organizations may conduct random surveillance and assessments to verify compliance with the requirements outlined in this

SAP, project work packages, the QAPjP, procedures, and regulatory requirements. Section 2.4 discusses the only planned assessment, a DQA, for the activities identified in this SAP. The results of the DQA will be provided to the project lead.

If circumstances arise in the field dictating the need for additional assessment activities, then additional assessments would be performed. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions and/or deficiencies in accordance with the contractor QA program, the corrective action management program, and associated procedures that implement these programs.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The contractor conducts oversight of offsite analytical laboratories and qualifies the laboratories for performing Hanford Site analytical work.

### **2.3.2 Reports to Management**

Reports to management on data quality issues will be made if these issues are identified. Issues reported by the laboratories are communicated to Sample Management and Reporting, which initiates a sample issue resolution form in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the project lead. At the end of the project, a DQA report will be prepared to determine whether the type, quality, and quantity of collected data met the quality objectives described in this SAP.

## **2.4 Data Validation and Usability**

The elements under data validation and usability address the QA activities occurring after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying the project objectives.

### **2.4.1 Data Review, Verification, and Validation**

The criteria for verification include, but are not limited to, review for completeness (samples were analyzed as requested), use of the correct analytical method/procedure, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

Data validation will be performed to ensure that the data quality goals established during the planning phase have been achieved. Data validation will be in accordance with internal procedures. The criteria for data level validation are based on a graded approach. The primary contractor has defined five levels of validation, Level A through Level E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of data (e.g., calibration data or calculations of representative samples from the dataset). Validation will be performed to contractor Level C, which is a review of the QC data. Level C validation specifically requires verification of deliverables; requested versus reported analyses; and qualification of the results based on analytical holding times, method blank results, matrix spike/matrix spike duplicate sample results, surrogate spike recoveries, and duplicate sample results. Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. Analyte group refers to categories, such as radionuclides, VOCs, semi-volatile organic compounds, polychlorinated biphenyls, metals, and anions. The goal is to cover the various analyte groups and matrices during the validation.

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

## 2.4.2 Verification and Validation Methods

Validation activities will be based on EPA functional guidelines. Validation will be performed on target and non-target analytes from each method as part of the methods-based analysis. Data validation may be performed by the analytical laboratory, Sample Management and Reporting, and/or by a party independent of both the data collector and the data user. Data validation qualifiers must be compatible with the HEIS database.

When outliers or questionable results are identified, additional data validation will be performed. The additional validation will be performed for up to 5 percent of the statistical outliers and/or questionable data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure data are usable. Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the dataset. Data validation will be documented in data validation reports. An example of questionable data is if the positive detections are greater than the practical quantitation limit or reporting limit in soil/aquifer sediment from a site that should not have exhibited contamination. Similarly, results below background would not be expected and could trigger a validation inquiry. The determination of data usability will be conducted and documented in a DQA report. Data validation will be documented in data validation reports, which will be included in the project file.

## 2.4.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The results of the DQA will be used in interpreting the data and determining whether the objectives of this activity have been met. The DQA will be in accordance with EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide*, and EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners*.

## 2.4.4 Corrective Actions

The responses to data quality defects identified through the DQA process will vary and may be data- or measurement-specific. Some pre-identified corrective actions are identified in Table 2-1.

### 3 Field Sampling Plan

The following sections provide additional details regarding field-specific sample and data collection requirements.

#### 3.1 Site Background and Objectives

Site background information is contained in DOE/RL-2008-46-ADD3. The target analytes and COPCs are presented in Tables 1-2 and 1-3. Section 1.6 of this SAP provides a schedule for implementation. The objective of the field sampling plan is to identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the systematic planning process and presents the design to identify sampling locations, the total number of samples to be collected, and analyses to be performed.

#### 3.2 Documentation of Field Activities

Logbooks or data forms are required for field activities. Section 2.1.6 provides logbook requirements. Data forms may be used to collect field information. However, the data forms must be referenced in logbooks and must follow the same requirements as those for logbooks presented below. The following is a summary of information to be recorded in logbooks:

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

#### 3.3 Sampling Design

As Section 2.2.1 presents, the sampling design is judgmental sampling.

### 3.4 Calibration of Field Equipment

The sampling lead is responsible for ensuring field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with manufacturer operating instructions, internal work requirements and processes, and/or work packages that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from instrument calibration activities are recorded in logbooks and/or work packages. Hard copy or electronic versions are acceptable.

Calibrations must be performed as follows:

- Before initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or procedure, or as required by regulations
- Upon failure to meet specified QC criteria

Field instrumentation, calibration, and QA checks will be performed in accordance with the following:

- As specified in its program documentation, Pacific Northwest National Laboratory calibrates radiological field instruments on the Hanford Site.
- Daily calibration checks will be performed and documented for each instrument used to characterize areas under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.

### 3.5 Sample Location and Frequency

The purpose of this section is to identify the sampling locations and frequencies and define the sampling and analysis requirements for samples and measurements to be collected. Figure 1-1 shows the approximate locations of boreholes and groundwater monitoring wells described in this SAP. The actual locations will be determined based on a field walk down of current site conditions to avoid Hanford Site National Historic restrictions, roads, and other obstructions.

#### 3.5.1 Vadose Zone Characterization

Samples will be collected from boreholes, test pits, and groundwater monitoring wells to support characterization of the vadose zone and groundwater as outlined in Table 1-1. The vadose zone will be characterized by performing intrusive investigations at ten waste sites: 100-B-5 Trench, 116-B-5 Crib, 116-B-14 Trench, 116-C-5 Retention Basin, 118-B-6 Burial Ground, 118-B-8 Reactor Fuel Storage Basin, 118-C-3 Reactor Fuel Storage Basin, 116-B-6B Crib, 116-B-9 French Drain, and 118-B-8:3 Process Sewer. Intrusive investigations consist mainly of collecting and analyzing samples from planned boreholes, from groundwater monitoring wells during drilling, and from test pits in areas of known or suspected contamination. Each groundwater well will also have deep vadose zone samples collected for vadose zone characterization. These activities are planned to characterize the nature and vertical extent of contamination in the vadose zone beneath waste sites, characterize the physical properties of soil/aquifer sediments, locate potential sources, and verify contaminant distribution coefficients to support modeling and an assessment of risk. The data from these activities will be used to verify the adequacy of interim remedial actions and refine the preliminary conceptual site model of 100-BC.

The scope of vadose zone characterization efforts includes field screening, collecting and analyzing soil samples from the vadose zone, collecting and analyzing aquifer sediment, performing groundwater sampling and analysis, and performing geophysical logging. The general intent of the borehole sampling design is to begin sample collection at the maximum depth of remedial action or bottom of the engineered

structure and sample at 1.5 m (5 ft) intervals. The soil sampling frequency will be continuous within 3.1 m (10 ft) of the expected water table. Vadose zone samples will be collected according to the sampling scheme shown in Table 3-1. The sampling scheme for each borehole and groundwater monitoring wells includes collecting soil samples periodically throughout the vadose zone, and collecting one sample of aquifer sediments 1.5 m (5 ft) into the water table. Groundwater samples will be collected from boreholes and wells as described in Section 3.5.2. Additional samples may be collected and drilling depth may be extended based on observations made in the field.

Physical property samples will be collected to provide site-specific values to support modeling efforts. The physical property samples will be collected from lithologies representing major facies in the vadose zone. The physical property samples will be collected in conjunction with split-spoon sample intervals, where possible.

#### **3.5.1.1 Field Screening**

Radiological field screening data, visual observation of lithologies, visual observation of contamination, or site geologist professional judgment may be used to adjust sampling points presented in Table 3-1, assist in determining sample shipping requirements, and support worker health and safety monitoring. Section 3.6.3 describes radiological field screening methods.

#### **3.5.1.2 Geophysical Logging**

The planned boreholes and groundwater monitoring wells will be geophysically logged with the high resolution, spectral gamma ray logging system to determine the vertical distribution and concentration of gamma emitting radionuclides. Soil moisture will be determined using a neutron logging tool. The boreholes and groundwater monitoring wells will be logged before the casing is telescoped and before the borehole is decommissioned. The starting point for logging will be recorded; this is usually at the ground surface or the top of the casing. Boreholes will be decommissioned with RL and EPA approval, in accordance with WAC 173-160 after geophysical logging and all sampling are completed.

**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
100-C-7	Depths to be determined. Sample(s) to be collected from areas where Cr(VI) is visually apparent, and where high concentrations are suspected.	Batch leach test in accordance with Table 2-13.	None	None
100-B-5 Trench One borehole to 5 ft below groundwater (approximately 73 ft bgs) Justification: The 100-B-5 Trench was selected for characterization because mercury and chromium are above screening levels for groundwater protection at a depth of 28 ft below surface. No other contaminants were above screening levels for protection of groundwater. Although, strontium and hexavalent chromium were detected below screening for groundwater protection, this site is also selected because it is located correlative to the two respective groundwater plumes. A portion of the 100-B-8 and 100-C-6 effluent pipelines are located adjacent to this site, therefore data will also be provided to characterize process pipelines.	28-30.5, 33-35.5, 38-40.5, 43-45.5, 48-50.5, 53-55.5, 58-60.5, 63-65.5, 65.5-68, 68-70.5, 70.5-73 (75.5-78 aquifer sediment sample <sup>b</sup> ) by split spoon (12 samples [estimated])  Major formation and lithology changes samples by split spoon (2 samples [estimated])	Target analytes and field screening parameters batch leach in accordance with Table 2-2.  Batch leach test in accordance with Table 2-13.  Aquifer sediment sample will only be analyzed for strontium-90, metals, hexavalent chromium, and mercury.	During drilling 75.5 ft to 78 ft bgs, collect one filtered groundwater sample from unconfined aquifer <sup>b</sup> (1 sample).  Expedited turnaround time for Cr(VI) analysis will be requested.	Table 1-3 constituents (in accordance with Table 2-14).  Field screening parameters (in accordance with Table 2-14).

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**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
<p>116-B-5 Crib</p> <p>One borehole to 5 ft below groundwater (approximately 65 ft bgs)</p> <p>Justification: The 116-B-5 Trench was selected for characterization because tritium, mercury, and barium are above screening levels for groundwater protection at a depth of approximately 16 ft bgs. No other contaminants were above screening levels for protection of groundwater. This site is also located correlative to the tritium, hexavalent chromium, and Sr-90 groundwater plumes and the site is a likely source of the tritium groundwater contamination. Process information indicates that 2.6 million gallons of tritiated effluent containing hundreds of gallons of mercury along with solvents and degreasers such as carbon tetrachloride, methyl alcohol, and trichloroethylene were released to the soil column. The volume of effluent release was sufficient to affect the entire vadose zone beneath the waste site.</p>	<p>15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 57.5-60, 60-62.5, 62.5-65 (67.5-70 aquifer sediment sample<sup>b</sup>) by split spoon (13 samples [estimated])</p> <hr/> <p>Major formation and lithology changes samples by split spoon (2 samples [estimated])</p>	<p>Target analytes and field screening parameters, batch leach in accordance with Table 2-3.</p> <p>Batch leach test in accordance with Table 2-13. Aquifer sediment sample will only be analyzed for strontium-90, tritium, metals, hexavalent chromium, and mercury.</p> <hr/> <p>Physical properties in accordance with Table 2-4.</p>	<p>During drilling 67.5 ft to 70 ft bgs<sup>b</sup>, collect one filtered groundwater sample from unconfined aquifer (1 sample).</p> <p>Expedited turnaround time for Cr(VI) analysis will be requested.</p>	<p>Table 1-3 constituents (in accordance with Table 2-14).</p> <p>Field screening parameters (in accordance with Table 2-14).</p>

**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
<p>116-B-6B Crib One test pit.</p> <p>Justification: The 116-B-6B Crib was selected for characterization because it received 100 kg of sodium dichromate in 4,000 L of effluent. Based on the soil column pore volume of 198 m<sup>3</sup>, the volume discharged was not sufficient to affect groundwater. Thus, the volume of effluent discharged to the soil column remains in the vadose zone and may be a future source of groundwater contamination. Because the engineered structure is approximately 5 ft below the depth of remedial action, contamination above screening levels for protection of groundwater may be present near the bottom of the waste site at 15 ft. Verification data indicate contaminants did not exceed screening criteria for groundwater protection. This site is also located correlative to the Sr-90 and hexavalent chromium groundwater plumes.</p>	<p>16.4-18.4 (1 sample [estimated])</p> <p>19.4-21.4 (1 sample [estimated])</p>	<p>Target analytes and field screening parameters batch leach in accordance with Table 2-4.</p> <p>Batch leach test in accordance with Table 2-13.</p> <p>Physical properties in accordance with Table 2-4.</p>	N/A	N/A
<p>116-B-9 French Drain One test pit.</p> <p>Justification: This site was selected for characterization because data is not available to evaluate the concentration and distribution of tritium at this site. The site was part of the P-10 project and tritium was not included in the analysis list for the close out data.</p>	<p>8-10 (1 sample [estimated])</p> <p>11-13 (1 sample [estimated])</p>	<p>Target analytes and field screening parameters in accordance with Table 2-5.</p> <p>Batch leach test in accordance with Table 2-13.</p> <p>Physical properties in accordance with Table 2-5.</p>	N/A	N/A

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**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
<p>116-B-14 Trench</p> <p>One borehole to 5 ft below groundwater (approximately 45 ft bgs).</p> <p>Justification: This site received sludge from the 116-B-11 Retention Basin. There is no history of this site receiving a high volume liquid waste stream. This site is being characterized to support conceptual site model development of a low-volume liquid site; there is also a lack of polychlorinated biphenyl data at this site. Site is also located relative to the hexavalent chromium, tritium, and strontium groundwater plumes adjacent to the Columbia River.</p>	<p>20-22.5, 25-27.5, 30-32.5, 32.5-35, 35-37.5, 37.5-40 (45-47.5 aquifer sediment sample<sup>b</sup>) by split spoon (<u>7 samples [estimated]</u>)</p>	<p>Target analytes and field screening parameters batch leach in accordance with Table 2-6.</p> <p>Batch leach test in accordance with Table 2-13.</p> <p>Aquifer sediment sample only will be analyzed for strontium-90, metals, hexavalent chromium, and mercury.</p>	<p>During drilling 45 ft to 47.5 ft bgs, collect one filtered groundwater sample from unconfined aquifer<sup>b</sup> (<u>1 sample</u>).</p> <p>Expedited turnaround time for Cr(VI) analysis will be requested.</p>	<p>Table 1-3 constituents (in accordance with Table 2-14).</p> <p>Field screening parameters (in accordance with Table 2-14).</p>
	<p>Major formation and lithology changes samples by split spoon (<u>2 samples [estimated]</u>)</p>	<p>Physical properties in accordance with Table 2-6.</p>		
<p>116-C-5 Retention Basin</p> <p>One borehole to 5 ft below groundwater (approximately 45 ft bgs).</p> <p>Justification: This site was selected for characterization because hexavalent chromium, total chromium, lead, mercury, nickel-63 exceed remedial action goals in the deep zone. The site is also located relative to the hexavalent chromium, tritium, and strontium groundwater plumes adjacent to the Columbia River.</p>	<p>15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 37.7-40, 40-42.5, 42-5-45 (50-52.5 aquifer sediment sample<sup>b</sup>) by split spoon (<u>9 samples [estimated]</u>)</p>	<p>Target analytes and field screening parameters batch leach in accordance with Table 2-7.</p> <p>Batch leach test in accordance with Table 2-13.</p> <p>Aquifer sediment sample only will be analyzed for strontium-90, metals, hexavalent chromium, and mercury.</p>	<p>During drilling 50-52.5 ft bgs, collect one filtered groundwater sample from unconfined aquifer<sup>b</sup> (<u>1 sample</u>).</p> <p>Expedited turnaround time for Cr(VI) analysis will be requested.</p>	<p>Table 1-3 constituents (in accordance with Table 2-14).</p> <p>Field screening parameters (in accordance with Table 2-14).</p>
	<p>Major formation and lithology changes samples by split spoon (<u>2 samples [estimated]</u>)</p>	<p>Physical properties in accordance with Table 2-7.</p>		

**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
<p>118-B-6 Burial Ground</p> <p>One borehole to 5 ft below groundwater (approximately 71 ft bgs).</p> <p>Justification: The 118-B-6 Burial Ground was selected for characterization because tritium in the soil column at a depth of 23 ft is approximately 200 times the soil concentration that is protective of groundwater. This site is also located relative to the strontium-90 and hexavalent chromium groundwater plumes.</p>	<p>21-23.5, 26-28.5, 31-33.5, 36-38.5, 41-43.5, 46-48.5, 51-53.5, 56-58.5, 61-63.5, 63.5-66, 66-68.5, 68.5-71 (73.5-76 aquifer sediment sample<sup>b</sup>) by split spoon (13 samples [estimated])</p>	<p>Target analytes and field screening parameters batch leach in accordance with Table 2-8.</p> <p>Batch leach test in accordance with Table 2-13.</p> <p>Aquifer sediment sample only will be analyzed for strontium-90, tritium, metals, hexavalent chromium, and mercury.</p>	<p>During drilling 73.5 ft to 76 ft bgs, collect one filtered groundwater sample from unconfined aquifer<sup>b</sup> (1 sample).</p> <p>Expedited turnaround time for Cr(VI) analysis will be requested.</p>	<p>Table 1-3 constituents (in accordance with Table 2-14).</p> <p>Field screening parameters (in accordance with Table 2-14)</p>
	<p>Major formation and lithology changes samples by split spoon (2 samples [estimated])</p>	<p>Physical properties in accordance with Table 2-8.</p>		

**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
118-B-8 Reactor Fuel Storage Basin One borehole to 5 ft below groundwater (approximately 74 ft bgs) Justification: This site is selected because little or no data has been collected in the immediate vicinity of the reactor. The reactor fuel storage basin is known to have leak and contained fuel pool water, spent fuel and sludge. The site is also located relative to the hexavalent chromium, and strontium groundwater plumes adjacent to the Columbia River. Data are needed to evaluate the vertical extent of contamination at the 105-B reactor museum.	0-2.5, 5-7.5, 10-12.5, 12.5-15, 17.5-20, 22.5-25, 27.5-30, 32.5-35, 37.5-40, 42.5-45, 47.5-50, 52.5-55, 55-57.5, 57.5-60, 62.5-65, 65-67.5, 67.5-70, 70-72.5, 72.5-75 (80-82.5 aquifer sediment sample <sup>b</sup> ) by split spoon (20 samples [estimated])	Target analytes and field screening parameters in accordance with Table 2-9.  Batch leach test in accordance with Table 2-13.  Aquifer sediment sample only will be analyzed for strontium-90, tritium, metals, hexavalent chromium, and mercury.	During drilling 80 ft to 82.5 ft bgs, collect one filtered groundwater sample from unconfined aquifer <sup>b</sup> (1 sample).  Expedited turnaround time for Cr(VI) analysis will be requested.	Table 1-3 constituents (in accordance with Table 2-14).  Field screening parameters (in accordance with Table 2-14).
	Major formation and lithology changes samples by split spoon (2 samples [estimated])	Physical properties in accordance with Table 2-9.		

**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Masurement <sup>a</sup>		Water Sample/Masurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
<p>118-B-8:3 Process Sewer One test pit. Justification: This site was selected for characterization because the pipeline is located near the 118-B-8 Reactor. Samples will be collected from inside the pipe and below the pipe to evaluate risk and contaminant level below the 105-B reactor museum.</p>	<p>Inside pipe, at approximately 22 ft bgs, and at approximately 23 ft bgs. (3 samples <u>[estimated]</u>)</p>	<p>Target analytes and field screening parameters in accordance with Table 2-10. Batch leach test in accordance with Table 2-13. Physical properties in accordance with Table 2-10.</p>	<p>N/A</p>	<p>N/A</p>
<p>118-C-3 Reactor Fuel Storage Basin One borehole to 5 ft below groundwater (approximately 99 ft bgs) Justification: This site is selected because the reactor fuel storage basin is known to have leak and contained fuel pool water, spent fuel and sludge. Data are needed to evaluate the vertical extent of contamination at the reactor.</p>	<p>15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 60-62.5, 65-67.5, 70-72.5, 75-77.5, 80-82.5, 85-87.5, 87.5-90, 90-92.5, 92.5-95, 95-97.5, 97.5-100, (103-105.5 sediment sample) by split spoon <u>(21 samples [estimated])</u></p> <p>Major formation and lithology changes samples by split spoon <u>(2 samples [estimated])</u></p>	<p>Target analytes and field screening parameters in accordance with Table 2-11. Batch leach test in accordance with Table 2-13. Aquifer sediment sample only will be analyzed for strontium-90, tritium, metals, hexavalent chromium, and mercury. Physical properties in accordance with Table 2-11.</p>	<p>During drilling 103-105.5 ft bgs, collect one filtered groundwater sample from unconfined aquifer<sup>b</sup> (1 sample). Expedited turnaround time for Cr(VI) analysis will be requested.</p>	<p>Table 1-3 constituents (in accordance with Table 2-14). Field screening parameters (in accordance with Table 2-14).</p>

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**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 1 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in 100-BC.	During drilling, archive samples of drill cuttings will be grab collected every 5 ft, or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup>	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated <u>22 samples</u> ).	Table 1-3 constituents (in accordance with Table 2-14).  Field screening parameters (in accordance with Table 2-14).
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon ( <u>8 samples [estimated]</u> )	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, 5 ft below water table <sup>b</sup> ( <u>1 filtered groundwater sample</u> ).	Metals, hexavalent chromium, strontium-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon ( <u>6 samples [estimated]</u> )	Physical properties in accordance with Table 2-12.		

**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 2 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in 100-BC	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup>	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer ( <u>estimated 22 samples</u> ).	Table 1-3 constituents (in accordance with Table 2-14). Field screening parameters (in accordance with Table 2-14).
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer, and 5 ft into the RUM within a non-water-bearing unit by split spoon ( <u>8 samples [estimated]</u> )	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, 5 ft below water table <sup>b</sup> ( <u>1 filtered groundwater sample</u> ).	Metals, hexavalent chromium, strontium-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon ( <u>6 samples [estimated]</u> )	Physical properties in accordance with Table 2-13.		

**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 3 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in 100-BC	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup>	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer ( <u>estimated 22 samples</u> ).	Table 1-3 constituents (in accordance with Table 2-14). Field screening parameters (in accordance with Table 2-14).
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon ( <u>8 samples [estimated]</u> )	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, 5 ft below water table <sup>b</sup> ( <u>1 filtered groundwater sample</u> ).	Metals, hexavalent chromium, strontium-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes, and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon ( <u>6 samples [estimated]</u> )	Physical properties in accordance with Table 2-12.		

Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 4 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in 100-BC	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup>	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer ( <u>estimated 22 samples</u> ).	Table 1-3 constituents (in accordance with Table 2-14). Field screening parameters (in accordance with Table 2-14).
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non water-bearing unit by split spoon ( <u>8 samples [estimated]</u> )	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, 5 ft below water table <sup>b</sup> ( <u>1 filtered groundwater sample</u> ).	Metals, hexavalent chromium, strontium-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon ( <u>6 samples [estimated]</u> )	Physical properties in accordance with Table 2-12.		

Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 5 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in 100-BC	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup> .	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer ( <u>estimated 22 samples</u> ).	Table 1-3 constituents in accordance with Table 2-14.  Field screening parameters in accordance with Table 2-14.
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon ( <u>8 samples [estimated]</u> )	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, 5 ft below water table <sup>b</sup> ( <u>1 filtered groundwater sample</u> ).	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon ( <u>6 samples [estimated]</u> )	Physical properties in accordance with Table 2-12.		

**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Well No. 6 Install borehole reaching a total depth approximately 50 ft within the RUM and screened in the first water bearing unit of the RUM in 100-BC	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples <sup>c</sup>	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer and from water-bearing intervals of the RUM unit if sufficient water is available (24 samples).	Table 1-3 constituents (in accordance with Table 2-14).  Field screening parameters (in accordance with Table 2-14).
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer and from the top, middle, and bottom of the non-water-bearing units of the RUM unit by split spoon (10 samples [estimated])	In accordance with Tables 2-12 and 2-13: <ul style="list-style-type: none"> <li>• Batch leach test</li> <li>• Distribution coefficient</li> <li>• Radiological methods.</li> <li>• Physical properties</li> <li>• EPA Methods 7196 and 6010</li> </ul>	During drilling, from water-bearing unit in RUM <sup>b</sup> (1 filtered groundwater sample).	Metals, hexavalent chromium, strontium-90, and mercury in accordance with Table 2-14.
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples [estimated])	Physical properties in accordance with Table 2-13.		

**Table 3-1. Borehole and Groundwater Well Sample/Measurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Sample 18 spatial/temporal uncertainty monitoring wells (Table 3-2); multiple rounds (This includes existing wells and 4 groundwater monitoring wells installed under Sampling and Analysis Plan DOE/RL-2009-61).	None	None	Multiple sampling rounds to support remedial investigation (18 wells × 3 rounds = 54 samples).	Table 1-3 constituents at standard turnaround time in accordance with Table 2-14.  Field screening parameters in accordance with Table 2-14.
Sample pore water at 10 (minimum) locations selected for Phase III sampling under <i>Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River</i> (DOE/RL-2008-11)	None	None	A minimum of one round of sampling will occur. Exact locations to be identified in the field based on favorable flow, temperature, and conductivity measurements.  (10 locations x 1 round = 10 samples).	Total chromium and hexavalent chromium in accordance with Table 1-15. Additional analytes as agreed upon by DOE and EPA.
Estimated number of samples	<u>Soil/aquifer sediment chemical</u> : 152 <u>Physical property</u> : 57 <u>Geologic archive samples</u> : variable		<u>Water samples collected during drilling</u> : 147 <u>Spatial/temporal uncertainty samples</u> : 54 <u>Pore water samples</u> : 10	
Estimated minimum number of field QC samples	<u>Soil/aquifer sediment chemical</u> : 25 (8 equipment rinsate blank, 8 field blank, 8 duplicate, 1 split) <u>Physical property</u> : 0 <u>Geologic archive samples</u> : 0		<u>Water samples collected during drilling</u> : 25 (8 equipment rinsate blank, 8 field blank, 8 duplicate, 1 split) <u>Spatial/temporal uncertainty samples</u> : 10 (3 equipment rinsate blank, 3 field blank, 3 duplicate, 1 split) <u>Pore water samples</u> : 4 (1 equipment rinsate blank, 1 field blank, 1 duplicate, 1 split)	

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**Table 3-1. Borehole and Groundwater Well Sample/Masurement Locations and Depths**

Sampling Location	Soil/Aquifer Sediment Sample/Measurement <sup>a</sup>		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte Property List	Sample Interval Depth (ft bgs)	Analyte List
Total number of samples	<u>Soil/aquifer sediment chemical</u> : 177 <u>Physical property</u> : 57 <u>Geologic archive samples</u> : variable		<u>Water samples collected during drilling</u> : 172 <u>Spatial/temporal uncertainty samples</u> : 64 <u>Pore water samples</u> : 14	

Notes:

- a. Upon visual observation of contamination, a depth discrete sample will be collected for applicable analysis. For example, if hexavalent chromium contamination is observed at any interval other than those stated for sampling, a depth discrete sample would be collected for hexavalent chromium analysis.
- b. This aquifer sediment sample will be collected from the unconfined aquifer, 5 ft below the water table.
- c. Archive samples may be omitted at the discretion of the field geologist due to radiological field data.

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

bgs = below ground surface  
 GEA = gamma energy analysis  
 RUM = Ringold Fm Upper Mud

### **3.5.2 Groundwater Characterization**

Groundwater characterization, including well activities, identification of wells to be sampled, well depth and screen placement, and well drilling and completion procedures, is discussed in this section.

#### **3.5.2.1 New Groundwater Wells**

Table 3-1 summarizes groundwater monitoring well activities. From the new well screened in the Ringold Fm Upper Mud Unit, slug testing and pump testing will be performed to characterize hydraulic conductivity.

##### ***Well Depth and Screen Placement***

For the five new groundwater wells in the unconfined aquifer in 100-BC, the screen length and placement will be determined after initial aquifer samples are reviewed.

For the one new groundwater well in 100-BC to be drilled into the uppermost water-bearing unit within the Ringold Fm Upper Mud Unit, the screen length and placement will be determined based on the thickness and ability to produce water in the water-bearing Ringold Fm Upper Mud Unit.

##### ***Well Drilling and Completion Procedures***

Well drilling will be performed in accordance with WAC 173-160. The wells will be drilled using 25-cm (10 in.) diameter (or larger) casing to total depth. The drilling method will be determined based on discussions between the drilling lead and drilling contractor. The wells will be constructed as 15.24 cm (6-in.) wells with Schedule 10, Type 304 or 316 stainless steel, V-slot continuous wire wrap screen, atop a 0.6 m (2 ft) long stainless steel sump with end cap. A Schedule 10 stainless steel riser will be used to extend the permanent well into the vadose zone, with Schedule 10 stainless steel casing through the vadose zone to ground surface. Colorado silica sand will be used for the sand pack; sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or powdered bentonite will be used for bentonite sealing material; and Type I/II Portland cement will be used for cement grout.

Surface construction consisting of protective casing, protective guard posts, and cement pad must be in place before job completion. The protective casing will be a minimum of 5 cm (2 in.) larger in diameter than the permanent casing. Protective casing will rise approximately 0.9 m (3 ft) above the ground surface. Permanent casing will rise to approximately 0.3 m (1 ft) below the top of the protective casing. Protective casing will have a lockable well cap extending approximately 38.1 cm (15 in.) above the top of the protective casing.

Final well design, including screen placement and length, will be determined by concurrence of the field geologist, drilling lead, and operable unit lead based on field conditions.

##### ***Well Sampling During Drilling***

Soil samples will be collected during well drilling for vadose zone characterization, as described in Section 3.5.1. Groundwater samples will be collected during drilling of borings and groundwater monitoring wells as described in Table 3-1. Generally, samples will be collected at 5 ft intervals throughout the unconfined aquifer and below the water table.

After completion, samples will be collected from the groundwater wells installed under the scope of this SAP quarterly for the first year, with a reduction in frequency for subsequent years, if warranted. These sampling and analysis activities will be conducted as part of DOE/RL-2003-38, *100-BC-5 Operable Unit Sampling and Analysis Plan*, Rev 1.

### **Columbia River Pore Water Sampling**

Additional groundwater upwelling (pore water) samples will be collected in the Columbia River. Samples will be collected from established upwelling locations, and the focus will be on sites where contamination was detected in previous pore water sampling conducted under the *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (DOE/RL-2008-11). At a minimum, attempts will be made to collect samples at ten of the 100-BC locations that were selected for Phase III sampling under the RI Work Plan for the Hanford Site Releases to the Columbia River (DOE/RL-2008-11). Exact sample locations will be identified in the field using the procedures for identification of favorable flow conditions relating to temperature and conductivity, as outlined in the RI Work Plan for the Hanford Site Releases to the Columbia River (DOE/RL-2008-11). Additional sampling location requirements will be determined through a collaborative process with DOE and EPA.

Laboratory analysis from pore water will include, at a minimum, hexavalent chromium (Cr(VI)) and total chromium. Additionally, those contaminants detected above either aquatic protection levels or drinking water standards (whichever is most restrictive) during the Phase III sampling described above will be sampled for from selected locations as indicated by the Phase III results. This need for additional analytes will be determined through a collaborative process with DOE and EPA.

#### **3.5.2.2 Groundwater Network to Evaluate Spatial and Temporal Uncertainty**

Table 3-1 summarizes groundwater monitoring activities to address spatial and temporal uncertainties. Table 3-2 presents the wells to be sampled. Multiple rounds of groundwater samples will be collected for analysis to support the remedial investigation in the existing groundwater wells for each contaminant identified in Table 1-3.

**Table 3-2. Spatial and Temporal Uncertainty Groundwater Monitoring Well Network**

C7505 (new)	199-B3-46	199-B4-4	199-B5-1	C7665 (new)	199-B9-3	699-67-86
199-B2-13	199-B3-47	C7507 (new)	199-B5-2	699-65-83	699-65-72	699-71-77
199-B3-1	C7506 (new)	199-B4-8	199-B8-6			

To determine the spatial and temporal risk uncertainty for potential human and ecological receptors, the RI process requires that the groundwater be sampled, providing representative data of aquifer conditions, both spatially and temporally. It is required that the groundwater be sampled throughout an area without regard to the location of surface facilities or known groundwater plumes. If there are temporal changes in groundwater conditions, samples must be collected to capture these varying stages to properly delineate temporal risk uncertainties to potential receptors. The resulting well network data will be used to evaluate the groundwater risk information presented in DOE/RL-2007-21, *Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*. Observations and conclusions regarding the data collected and the DOE/RL-2007-21 evaluation will be documented in the RI report (e.g., risk uncertainties associated with temporal and spatial representativeness, verifying groundwater risk conclusions, ensuring no contaminants were inadvertently overlooked, and establishing a “present condition” dataset that can be used to measure the progress of future cleanup actions).

#### **Sampling Frequency**

To capture baseline aquifer conditions fully, it is required that samples represent not only spatial variations but also changes that occur over time. Near the river, these varying conditions are observed as changes in groundwater flow, both direction and rate, causing temporary movement of contaminants through different portions of the unconfined aquifer. For areas bordering on the Columbia River, the

changing aquifer conditions are caused by fluctuating river elevations associated with flood control and hydroelectric production. For representing baseline groundwater conditions, samples are required to represent these varying aquifer conditions associated with high, low and mid-point or transitional river elevations. The date and frequency of sample collection is based on measurements of the river elevation to optimize collection of samples representing these temporal changes in groundwater conditions.

### ***Effect of River Elevation on Groundwater Conditions***

Along the Columbia River, rapid, periodic or cyclic elevation fluctuations of the river occur in controlled response to flood conditions, hydroelectric production, and salmon spawning programs at a series of dams and reservoirs upriver of the Hanford site. These rapid elevation changes in the river cause periodic influences on flow conditions within the aquifer. For example, there are two times during a calendar year when the river elevation peaks and two times the river elevation is low. The highest river elevation occurs in early June when water is released from reservoirs that have reached capacity from the melting snow pack in the Cascade Mountains. The lowest river elevation is engineered in late September to early October to encourage salmon spawning in low pockets of the river bottom along the Hanford Reach.

When water is released upriver, the river elevation rises above the elevation of the local aquifer causing movement of water from the river into the aquifer. At this time, the flow direction in the aquifer is modified from the ambient condition and varies with local conditions along the river. This flow from the river brings cleaner river water into the groundwater causing a temporary reduction in contaminant levels in monitoring wells near the river.

When the river elevation is artificially lowered to a level below the aquifer by holding water back in the upriver reservoirs, groundwater moves from the aquifer into the river. The river then recharges from the aquifer, causing a change in the flow direction to roughly perpendicular to the river's edge, once again varying with specific locations along the river. These changes in direction may bring contaminated groundwater through observation wells at certain places and into the river. Thus, near the river/aquifer interface, the flow direction and rate change with time. The effect on aquifer conditions is greatest when the river peaks in June and, again, at its lowest level in late September to early October. To capture these temporal effects on contaminant plumes within the aquifer from the low river elevation, groundwater sampling should be conducted prior to late October.

Inland from the river, the rapid river elevation changes form a pressure pulse that appears to be transmitted along the free surface of the unconfined aquifer. This effect causes groundwater elevation changes in wells not affected by actual movement of aquifer water. For some places, the elevation increase may allow the groundwater to interact with contaminated soils located just above the water table. The timing of these periodic or cyclic river elevation changes determines the sampling frequency required to represent the temporal variations in groundwater conditions.

### ***Groundwater Sampling Dates***

Because the goal of the temporal uncertainty groundwater sampling is to determine groundwater conditions when the river has the maximum effect on flow rate and direction, sampling is scheduled for late May to mid-June during the highest peak and from late September to late October during the time of the lowest elevation. From the second week in June to mid-September, the river elevation is in transition, decreasing from the maximum elevation to the lowest elevation. Also from March through April, elevations change from low to the high that occur in the first week of June. Consequently, the best opportunity to capture transitional conditions occurs during the months of March and April or July and August.

Based on the previous discussion, three sampling events are recommended to represent the temporal fluctuations in groundwater conditions. One sampling event captures the effect on the aquifer when the

river stage is highest and the greatest increase in aquifer elevation occurs (May to mid June). The second sampling interval ranges from mid-September to mid-October when the river is at the lowest elevation for the year. This period is when contamination from the aquifer might be affecting the river. The third sampling point represents the mid-point or transitional aquifer conditions occurring from either March through April or July through August. Thus, the groundwater sampling schedules, which support the temporal uncertainty evaluation for the RI/FS at each area along the river, captures the maximum effects of changing river elevations on aquifer conditions as well as the transitional time between the maximum and minimum changing conditions.

### **3.6 Sampling Methods**

Soil/aquifer sediment sampling will be performed in accordance with approved procedures for soil and aquifer sediment sampling using a 10.2 cm (4-in.) split-spoon sampler. The split-spoon samplers will be equipped with separate stainless steel or polycarbonate liners. Site personnel will not overdrive the sampling device. Samples for VOCs will be packaged first. Next, the remaining soil/aquifer sediment will be transferred to a pre-cleaned, stainless steel mixing bowl or other suitable pre-cleaned container, homogenized, then containerized in accordance with the sampling procedure. If sample volume requirements cannot be met, samples will be collected according to the following priority: hexavalent chromium, metals (including mercury and uranium), batch leach test, tritium, nitrate, strontium-90, technetium-99, other radionuclides, polychlorinated biphenyls, semi-volatile organic compounds, hydraulic properties, and other anions. Sufficient volume should be available to perform these analyses. It is desirable to have a consistent priority for all samples.

Groundwater samples collected during drilling, before development, will be pumped from selected intervals. The pump will be operated long enough to provide stabilized field readings, but not necessarily three casing volumes.

For the groundwater monitoring well network, prior to sample capture, the pump will be operated for a period sufficient to provide stabilized field readings, and at least three casing volumes.

#### **3.6.1 Corrective Actions and Deviations for Sampling Activities**

The project lead, sampling lead, drilling lead, or designee must document deviations from procedures or other problems pertaining to sample collection, chain-of-custody, target analytes, COPCs, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action procedures. The project lead, sampling lead, drilling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

Sample location changes that are more significant but not affecting the data needs will require notification and approval of the project lead. Changes to sample locations resulting in impacts to meeting the data needs will require concurrence with DOE and regulatory project leads. Changes to the SAP will be documented as noted in Section 2.1.6.

#### **3.6.2 Decontamination of Sampling and Drilling Equipment**

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

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

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample container by setting the equipment/sample container on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events. Field decontamination (e.g., field washing and reuse) is not appropriate for sampling equipment

The drill rig derrick, all downhole equipment, and temporary casing will be field decontaminated (e.g., high pressure and temperature), at a minimum, before mobilization and demobilization.

### **3.6.3 Radiological Field Data**

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

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

- Instructions to radiological control technicians on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.
- Information regarding the Geiger-Müller, portable alpha meter, dual phosphors beta/gamma, and sodium iodide portable instruments, will include a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments are commonly used on the Hanford Site for obtaining measurements of removable surface contamination measurements and direct measurements of the total surface contamination.
- Information on the characteristics associated with the hand-held probes to be used in the performance of direct radiological measurements will include a physical description of the probe, the radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The hand-held probe is an alpha detection instrument commonly used on the Hanford Site for obtaining removable surface contamination measurements and direct measurements of the total surface contamination.

## **3.7 Sample Handling**

Sample handling, including container packaging, container labeling, sample custody, and sample transportation, is discussed in this section.

### **3.7.1 Container Packaging**

Level I EPA pre-cleaned sample containers will be used for soil/aquifer sediment and water samples collected for chemical analysis. Container sizes may vary depending on laboratory specific volumes and requirements for meeting analytical detection limits. Radiological Engineering will measure the

contamination levels and dose rates associated with the sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead, in consultation with Sample Management and Reporting, can send smaller volumes to the laboratory. Preliminary container types and volumes are identified in Tables 3-3 and 3-4.

**Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples**

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size <sup>a</sup>
Alpha energy analysis	None	6 months	G/P	10 g
Americium-241/Curium-244	None	6 months	G/P	5 g
Gamma energy analysis	None	6 months	G/P	750 g
Liquid scintillation counter	None	6 months	G	33 g
Isotopic – plutonium	None	6 month	G/P	5 g
Isotopic – uranium	None	6 months	G/P	5 g
Strontium-90	None	6 months	G/P	5 g
Iodine-129 – Low Level	None	6 months	G/P	150 g
EPA 200.8	None	6 months	G/P	15 g
EPA 6010	Cool ~4° C	6 months	G/P	15 g
EPA 7196	Cool ~4° C	30 days	G/P	50 g
EPA 7471	None	28 days	G/P	15 g
UKPA	None	6 months	G/P	10 g
EPA 8260 <sup>b</sup>	Cool ~4° C	14 days	G	50 g
EPA 8270	Cool ~4° C	14/40 days	aG	250 g
EPA 8082	Cool ~4° C	14/40 days	aG	50 g
EPA 8310	Cool ~4° C	14/40 days	aG	250 g
EPA 300.0	Cool ~4° C	48 hours/28 days	G/P	50 g
ASTM D2216-05	None	None	Moisture-proof container	200 g
ASTM D2937-04	None	None	G/P	1,000 g
ASTM D2434-68	None	None	P	1,000 g
ASTM D5084-03	None	None	P	1,000 g
Batch leaching test	Cool ~4° C	28 days from field to extraction	G	100 g/120 mL
Distribution coefficient	Cool ~4 °C		Moisture-proof container	250 g

**Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples**

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size <sup>a</sup>
Notes:				
a. Based on minimum QC requirements.				
b. Field preservation EPA 5035A also may be used.				
For EPA Method 300.0, see EPA-600/4-79-020, <i>Methods for Chemical Analysis of Water and Wastes</i> .				
For the four-digit EPA methods, see SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i> .				
ASTM D2216-05, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i>				
ASTM D2434-68(2006), <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i>				
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i>				
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i>				
48 hours/28 days = 48 hours for nitrate, nitrite, and phosphate; others, 28 days				
14/40 days = 14 days to extraction, then 40 days for analysis				
aG = amber glass				
G = glass				
P = plastic				
UKPA = total uranium by kinetic phosphorescence analysis				

**Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples**

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size <sup>a</sup>
Iodine-129 – Low Level	None	6 months	G/P	2000 mL
Strontium-90	HNO <sub>3</sub> to pH <2	6 months	G/P	2,000 mL
EPA 6020 or 200.8	HNO <sub>3</sub> to pH <2	6 months	G/P	300 mL
LSC – Tritium	None	6 months	G	60 mL
EPA 900.0	HNO <sub>3</sub> to pH <2	6 months	G/P	2,000 mL
EPA 6010	HNO <sub>3</sub> to pH <2	6 months	G/P	300 mL
EPA 7196	Cool ~4° C	24 hours	aG	500 mL
EPA 7470	HNO <sub>3</sub> to pH <2	28 days	G	500 mL
EPA 6020 or 200.8	HNO <sub>3</sub> to pH <2	28 days	G	300 mL
EPA 8260	Cool ~4° C, HCl or H <sub>2</sub> SO <sub>4</sub> to pH <2	14 days	aGs	40 mL
EPA 300.0	Cool ~4° C	48 hours/28 days	P	125 mL

**Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples**

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
Notes:				
* Based on minimum QC requirements.				
For EPA Method 200.8, see EPA-600/R-94-111, <i>Methods for the Determination of Metals in Environmental Samples, Supplement 1</i> .				
For EPA Method 300.0, see EPA-600/4-79-020, <i>Methods for Chemical Analysis of Water and Wastes</i> .				
For the four-digit EPA methods, see SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i> .				
48 hours/28 days = 48 hours for nitrate, nitrite, and phosphate; others, 28 days.				
aG = amber glass				
G = glass				
aGs = amber glass septum; no headspace				
P = plastic				

### 3.7.2 Container Labeling

The sample location, depth, and corresponding HEIS numbers are documented in the sampler's field logbook. A custody seal (e.g., evidence tape) is affixed to each sample container and/or the sample collection package in such a way as to indicate potential tampering. Each sample container will be labeled with the following information on firmly affixed, water resistant labels:

- HEIS number
- Sample collection date and time
- Analysis required
- Preservation method (if applicable)
- Sampling authorization form number

In addition to the above information, sample records must include the following:

- Analysis required
- Source of sample
- Matrix
- Field data (pH, radiological readings)

Except for VOA samples, a custody seal (i.e., evidence tape) will be affixed to the lid of each sample container. The custody seal will be inscribed with the sampler's initials and the date. Custody seals are not applied directly to VOA bottles collected because of a potential for affecting analytical results and/or fouling of laboratory equipment. Custody seals and any other required labels or documentation can be fixed to the exterior of a plastic bag holding vials in such a manner to detect potential tampering.

### 3.7.3 Sample Custody Requirements

Sample custody will be maintained in accordance with existing Hanford Site protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be

indicated on the accompanying chain-of-custody form. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to Sample Management and Reporting within 48 hours of shipping.

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

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

#### **3.7.4 Sample Transportation**

Sample transportation will be in compliance with the applicable regulations for packaging, marking, labeling, and shipping hazardous materials, hazardous substances, and hazardous waste mandated by the U.S. Department of Transportation (49 CFR 171, “General Information, Regulations, and Definitions,” through Part 177, “Carriage By Public Highway”) in association with the International Air Transportation Authority, DOE requirements, and applicable program specific implementing procedures.

### **3.8 Management of Waste**

All waste (including unexpected waste) generated by sampling activities will be managed in accordance with DOE/RL-2004-30, *Waste Control Plan for the 100-BC-5 Operable Unit*. Pursuant to 40 CFR 300.440, “National Oil and Hazardous Substances Pollution Contingency Plan,” “Procedures for Planning and Implementing Off-Site Response Actions,” approval from the lead regulatory agency Remedial Project Manager is required before returning unused samples or waste from offsite laboratories.

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## **4 Health and Safety**

Field operations will be performed in accordance with health and safety requirements and appropriate Soil and Groundwater Remediation Project requirements. Additionally, work control documents will be prepared to control site operations. Safety documentation will include an activity hazard analysis and, as applicable, radiological work permits. The sampling procedures and associated activities will implement ALARA practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in 10 CFR 835.

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## 5 References

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**Appendix A**  
**Laboratory Standard Compound List**

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## A1 Laboratory Standards Compound List

Tables A-1 through A-10 provide the laboratory standard compound list.

## A2 References

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**Table A-1. U.S. Environmental Protection Agency Method 300.0**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
24959-67-9	Bromide	250	2,500	≤20%/≤30%	80-120%/70-130%
16887-00-6	Chloride	200	2,000	≤20%/≤30%	80-120%/70-130%
16984-48-8	Fluoride	500	5,000	≤20%/≤30%	80-120%/70-130%
14797-55-8	Nitrate*	250	2,500	≤20%/≤30%	80-120%/70-130%
14797-65-0	Nitrite*	250	2,500	≤20%/≤30%	80-120%/70-130%
NO3-N	Nitrogen in nitrate*	75	750	≤20%/≤30%	80-120%/70-130%
NO2-N	Nitrogen in nitrite*	75	750	≤20%/≤30%	80-120%/70-130%
14265-44-2	Phosphate*	500	5,000	≤20%/≤30%	80-120%/70-130%
14808-79-8	Sulfate	500	5,000	≤20%/≤30%	80-120%/70-130%

Notes:

\* Nitrate, nitrite, and phosphate suite or nitrogen in nitrate, nitrogen in nitrite, and phosphorus in phosphate suite may either be reported.

EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*

CAS = Chemical Abstract Services

EQL = estimated quantitation limit

Table A-2. U.S. Environmental Protection Agency SW-846 Method 6010

CAS Number	Constituent	Water RDL (pCi/L)	Soil RDL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
7429-90-5	Aluminum	50	5,000	≤20%/≤30%	80-120%/70-130%
7440-36-0	Antimony	60	6,000	≤20%/≤30%	80-120%/70-130%
7440-38-2	Arsenic	100	10,000	≤20%/≤30%	80-120%/70-130%
7440-39-3	Barium	20	2,000	≤20%/≤30%	80-120%/70-130%
7440-41-7	Beryllium	2	500	≤20%/≤30%	80-120%/70-130%
7440-69-9	Bismuth	100	10,000	≤20%/≤30%	80-120%/70-130%
7440-42-8	Boron	20	2,000	≤20%/≤30%	80-120%/70-130%
7440-43-9	Cadmium	2	500	≤20%/≤30%	80-120%/70-130%
7440-70-2	Calcium	1,000	100,000	≤20%/≤30%	80-120%/70-130%
7440-47-3	Chromium	10	1,000	≤20%/≤30%	80-120%/70-130%
7440-48-4	Cobalt	4	2,000	≤20%/≤30%	80-120%/70-130%
7440-50-8	Copper	8	1,000	≤20%/≤30%	80-120%/70-130%
7439-89-6	Iron	50	5,000	≤20%/≤30%	80-120%/70-130%
7439-92-1	Lead	50	5,000	≤20%/≤30%	80-120%/70-130%
7439-93-2	Lithium	25	2,500	≤20%/≤30%	80-120%/70-130%
7439-95-4	Magnesium	750	75,000	≤20%/≤30%	80-120%/70-130%
7439-96-5	Manganese	5	5,000	≤20%/≤30%	80-120%/70-130%
7439-98-7	Molybdenum	20	2,000	≤20%/≤30%	80-120%/70-130%
7440-02-0	Nickel	40	4,000	≤20%/≤30%	80-120%/70-130%
7723-14-0	Phosphorus	100	50,000	≤20%/≤30%	80-120%/70-130%
7440-09-7	Potassium	4,000	400,000	≤20%/≤30%	80-120%/70-130%
7782-49-2	Selenium	100	10,000	≤20%/≤30%	80-120%/70-130%
7440-21-3	Silicon	20	2,000	≤20%/≤30%	80-120%/70-130%
7440-22-4	Silver	10	1,000	≤20%/≤30%	80-120%/70-130%
7440-23-5	Sodium	500	50,000	≤20%/≤30%	80-120%/70-130%
7440-24-6	Strontium (elemental)	10	1,000	≤20%/≤30%	80-120%/70-130%
7440-28-0	Thallium	50	5,000	≤20%/≤30%	80-120%/70-130%
7440-31-5	Tin	100	10,000	≤20%/≤30%	80-120%/70-130%
7440-62-2	Vanadium	25	2,500	≤20%/≤30%	80-120%/70-130%
7440-66-6	Zinc	10	10,000	≤20%/≤30%	80-120%/70-130%

## Notes:

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-3. U.S. Environmental Protection Agency Method 200.8 or SW-846 Method 6020**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
7440-36-0	Antimony	5	600	≤20%/≤30%	80-120%/70-130%
7440-38-2	Arsenic	4	1,000	≤20%/≤30%	80-120%/70-130%
7440-39-3	Barium	5	500	≤20%/≤30%	80-120%/70-130%
7440-41-7	Beryllium	2	200	≤20%/≤30%	80-120%/70-130%
7440-43-9	Cadmium	2	200	≤20%/≤30%	80-120%/70-130%
7440-47-3	Chromium	2	200	≤20%/≤30%	80-120%/70-130%
7439-92-1	Lead	2	500	≤20%/≤30%	80-120%/70-130%
7782-49-2	Selenium	4	1,000	≤20%/≤30%	80-120%/70-130%
7440-22-4	Silver	2	200	≤20%/≤30%	80-120%/70-130%
7440-28-0	Thallium	2	500	≤20%/≤30%	80-120%/70-130%

**Notes:**

For EPA Method 200.8, see EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*.

For Method 6020, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-4. U.S. Environmental Protection Agency SW-846 Method 8260**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
71-55-6	1,1,1-trichloroethane	5	5	≤20%/≤30%	80-120%/70-130%
79-34-5	1,1,2,2-tetrachloroethane	5	5	≤20%/≤30%	80-120%/70-130%
79-00-5	1,1,2-trichloroethane	2	5	≤20%/≤30%	80-120%/70-130%
75-34-3	1,1-dichloroethane	2	10	≤20%/≤30%	80-120%/70-130%
75-35-4	1,1-dichloroethene	10	10	≤20%/≤30%	80-120%/70-130%
107-06-2	1,2-dichloroethane	5	5	≤20%/≤30%	80-120%/70-130%
540-59-0	1,2-dichloroethene(total)	10	5	≤20%/≤30%	80-120%/70-130%
78-87-5	1,2-dichloropropane	5	5	≤20%/≤30%	80-120%/70-130%
78-93-3	2-butanone	10	10	≤20%/≤30%	80-120%/70-130%
591-78-6	2-hexanone	20	20	≤20%/≤30%	80-120%/70-130%

Table A-4. U.S. Environmental Protection Agency SW-846 Method 8260

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
108-10-1	4-methyl-2-pentanone	10	10	≤20%/≤30%	80-120%/70-130%
67-64-1	Acetone	20	20	≤20%/≤30%	80-120%/70-130%
71-43-2	Benzene	1.5	5	≤20%/≤30%	80-120%/70-130%
75-27-4	Bromodichloromethane	5	5	≤20%/≤30%	80-120%/70-130%
75-25-2	Bromoform	5	5	≤20%/≤30%	80-120%/70-130%
74-83-9	Bromomethane	10	10	≤20%/≤30%	80-120%/70-130%
75-15-0	Carbon disulfide	5	5	≤20%/≤30%	80-120%/70-130%
56-23-5	Carbon tetrachloride	2	5	≤20%/≤30%	80-120%/70-130%
108-90-7	Chlorobenzene	5	5	≤20%/≤30%	80-120%/70-130%
75-00-3	Chloroethane	10	10	≤20%/≤30%	80-120%/70-130%
67-66-3	Chloroform	5	5	≤20%/≤30%	80-120%/70-130%
74-87-3	Chloromethane	10	10	≤20%/≤30%	80-120%/70-130%
156-59-2	cis-1,2-Dichloroethylene	5	5	≤20%/≤30%	80-120%/70-130%
10061-01-5	cis-1,3-dichloropropene	5	5	≤20%/≤30%	80-120%/70-130%
124-48-1	Dibromochloromethane	5	5	≤20%/≤30%	80-120%/70-130%
100-41-4	Ethylbenzene	5	5	≤20%/≤30%	80-120%/70-130%
75-09-2	Methylene chloride	5	5	≤20%/≤30%	80-120%/70-130%
100-42-5	Styrene	5	5	≤20%/≤30%	80-120%/70-130%
127-18-4	Tetrachloroethene	5	5	≤20%/≤30%	80-120%/70-130%
108-88-3	Toluene	5	5	≤20%/≤30%	80-120%/70-130%
10061-02-6	trans-1,3-dichloropropene	5	5	≤20%/≤30%	80-120%/70-130%
79-01-6	Trichloroethene	1	5	≤20%/≤30%	80-120%/70-130%
75-01-4	Vinyl chloride	5	5	≤20%/≤30%	80-120%/70-130%
1330-20-7	Xylenes (total)	10	10	≤20%/≤30%	80-120%/70-130%

Notes:

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
120-82-1	1,2,4-Trichlorobenzene	10	330	≤20%/≤30%	80-120%/70-130%
95-50-1	1,2-Dichlorobenzene	10	330	≤20%/≤30%	80-120%/70-130%
541-73-1	1,3-Dichlorobenzene	10	330	≤20%/≤30%	80-120%/70-130%
106-46-7	1,4-Dichlorobenzene	5	330	≤20%/≤30%	80-120%/70-130%
95-95-4	2,4,5-Trichlorophenol	10	330	≤20%/≤30%	80-120%/70-130%
88-06-2	2,4,6-Trichlorophenol	10	330	≤20%/≤30%	80-120%/70-130%
120-83-2	2,4-Dichlorophenol	10	330	≤20%/≤30%	80-120%/70-130%
105-67-9	2,4-Dimethylphenol	10	330	≤20%/≤30%	80-120%/70-130%
51-28-5	2,4-Dinitrophenol	25	825	≤20%/≤30%	80-120%/70-130%
121-14-2	2,4-Dinitrotoluene	10	330	≤20%/≤30%	80-120%/70-130%
606-20-2	2,6-Dinitrotoluene	10	330	≤20%/≤30%	80-120%/70-130%
91-58-7	2-Chloronaphthalene	10	330	≤20%/≤30%	80-120%/70-130%
95-57-8	2-Chlorophenol	10	330	≤20%/≤30%	80-120%/70-130%
91-57-6	2-Methylnaphthalene	10	330	≤20%/≤30%	80-120%/70-130%
95-48-7	2-Methylphenol (cresol, o-)	10	330	≤20%/≤30%	80-120%/70-130%
88-74-4	2-Nitroaniline	10	330	≤20%/≤30%	80-120%/70-130%
88-75-5	2-Nitrophenol	20	660	≤20%/≤30%	80-120%/70-130%
91-94-1	3,3'-Dichlorobenzidine	10	330	≤20%/≤30%	80-120%/70-130%
65794-96-9	3+4 Methylphenol (cresol, m+p)*	10	330	≤20%/≤30%	80-120%/70-130%
99-09-2	3-Nitroaniline	10	330	≤20%/≤30%	80-120%/70-130%
534-52-1	4,6-Dinitro-2-methylphenol	10	330	≤20%/≤30%	80-120%/70-130%
101-55-3	4-Bromophenylphenyl ether	10	330	≤20%/≤30%	80-120%/70-130%
59-50-7	4-Chloro-3-methylphenol	10	330	≤20%/≤30%	80-120%/70-130%
106-47-8	4-Chloroaniline	10	330	≤20%/≤30%	80-120%/70-130%
7005-72-3	4-Chlorophenylphenyl ether	10	330	≤20%/≤30%	80-120%/70-130%
100-01-6	4-Nitroaniline	10	330	≤20%/≤30%	80-120%/70-130%
100-02-7	4-Nitrophenol	20	660	≤20%/≤30%	80-120%/70-130%
83-32-9	Acenaphthene	10	330	≤20%/≤30%	80-120%/70-130%
208-96-8	Acenaphthylene	10	330	≤20%/≤30%	80-120%/70-130%
120-12-7	Anthracene	10	330	≤20%/≤30%	80-120%/70-130%

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
56-55-3	Benzo(a)anthracene	10	330	≤20%/≤30%	80-120%/70-130%
50-32-8	Benzo(a)pyrene	10	330	≤20%/≤30%	80-120%/70-130%
205-99-2	Benzo(b)fluoranthene	10	330	≤20%/≤30%	80-120%/70-130%
191-24-2	Benzo(ghi)perylene	10	330	≤20%/≤30%	80-120%/70-130%
207-08-9	Benzo(k)fluoranthene	10	330	≤20%/≤30%	80-120%/70-130%
108-60-1	Bis(2-chloro-1-methylethyl)ether	10	330	≤20%/≤30%	80-120%/70-130%
111-91-1	Bis(2-Chloroethoxy)methane	10	330	≤20%/≤30%	80-120%/70-130%
111-44-4	Bis(2-chloroethyl) ether	10	330	≤20%/≤30%	80-120%/70-130%
117-81-7	Bis(2-ethylhexyl) phthalate	10	330	≤20%/≤30%	80-120%/70-130%
85-68-7	Butylbenzylphthalate	10	330	≤20%/≤30%	80-120%/70-130%
86-74-8	Carbazole	10	330	≤20%/≤30%	80-120%/70-130%
218-01-9	Chrysene	10	330	≤20%/≤30%	80-120%/70-130%
53-70-3	Dibenz[a,h]anthracene	10	330	≤20%/≤30%	80-120%/70-130%
132-64-9	Dibenzofuran	10	330	≤20%/≤30%	80-120%/70-130%
84-66-2	Diethylphthalate	10	330	≤20%/≤30%	80-120%/70-130%
131-11-3	Dimethyl phthalate	10	330	≤20%/≤30%	80-120%/70-130%
84-74-2	Di-n-butylphthalate	10	330	≤20%/≤30%	80-120%/70-130%
117-84-0	Di-n-octylphthalate	10	330	≤20%/≤30%	80-120%/70-130%
206-44-0	Fluoranthene	10	330	≤20%/≤30%	80-120%/70-130%
86-73-7	Fluorene	10	330	≤20%/≤30%	80-120%/70-130%
118-74-1	Hexachlorobenzene	10	330	≤20%/≤30%	80-120%/70-130%
87-68-3	Hexachlorobutadiene	10	330	≤20%/≤30%	80-120%/70-130%
77-47-4	Hexachlorocyclopentadiene	10	330	≤20%/≤30%	80-120%/70-130%
67-72-1	Hexachloroethane	10	330	≤20%/≤30%	80-120%/70-130%
193-39-5	Indeno(1,2,3-cd)pyrene	10	330	≤20%/≤30%	80-120%/70-130%
78-59-1	Isophorone	10	330	≤20%/≤30%	80-120%/70-130%
91-20-3	Naphthalene	10	330	≤20%/≤30%	80-120%/70-130%
98-95-3	Nitrobenzene	10	330	≤20%/≤30%	80-120%/70-130%
621-64-7	n-Nitrosodi-n-dipropylamine	10	330	≤20%/≤30%	80-120%/70-130%
86-30-6	n-Nitrosodiphenylamine	10	330	≤20%/≤30%	80-120%/70-130%

**Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
87-86-5	Pentachlorophenol	10	330	≤20%/≤30%	80-120%/70-130%
85-01-8	Phenanthrene	10	330	≤20%/≤30%	80-120%/70-130%
108-95-2	Phenol	10	330	≤20%/≤30%	80-120%/70-130%
129-00-0	Pyrene	10	330	≤20%/≤30%	80-120%/70-130%

## Notes:

\* May report as 3-Methylphenol (cresol, p-) and 4-Methylphenol (cresol, m-) or a 3+4 Methylphenol (cresol, m+P) total.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-6. U.S. Environmental Protection Agency SW-846 Method 8310**

Chemical Abstracts Service Number	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
83-32-9	Acenaphthene	20	100	≤20 / ≤30	80-120 / 70-130
208-96-8	Acenaphthylene	25	100	≤20 / ≤30	80-120 / 70-130
120-12-7	Anthracene	10	50	≤20 / ≤30	80-120 / 70-130
56-55-3	Benzo(a)anthracene	0.3	15	≤20 / ≤30	80-120 / 70-130
50-32-8	Benzo(a)pyrene	0.5	15	≤20 / ≤30	80-120 / 70-130
205-99-2	Benzo(b)fluoranthene	0.5	15	≤20 / ≤30	80-120 / 70-130
191-24-2	Benzo(ghi)perylene	1	30	≤20 / ≤30	80-120 / 70-130
207-08-9	Benzo(k)fluoranthene	0.5	15	≤20 / ≤30	80-120 / 70-130
218-01-9	Chrysene	5	100	≤20 / ≤30	80-120 / 70-130
53-70-3	Dibenz[a,h]anthracene	1	30	≤20 / ≤30	80-120 / 70-130
206-44-0	Fluoranthene	5	50	≤20 / ≤30	80-120 / 70-130
86-73-7	Fluorene	3	30	≤20 / ≤30	80-120 / 70-130
193-39-5	Indeno(1,2,3-cd)pyrene	1	30	≤20 / ≤30	80-120 / 70-130
91-20-3	Naphthalene	20	100	≤20 / ≤30	80-120 / 70-130
85-01-8	Phenanthrene	10	50	≤20 / ≤30	80-120 / 70-130
129-00-0	Pyrene	5	50	≤20 / ≤30	80-120 / 70-130

Table A-6. U.S. Environmental Protection Agency SW-846 Method 8310

Chemical Abstracts Service Number	Constituent	Water EQL ( $\mu\text{g/L}$ )	Soil EQL ( $\mu\text{g/kg}$ )	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
Notes:					
SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i>					
$\mu\text{g/L}$ = micrograms per liter					
$\mu\text{g/kg}$ = micrograms per kilogram					
CAS = Chemical Abstracts Service					
EQL = estimated quantitation limit					

Table A-7. U.S. Environmental Protection Agency SW-846 Method 8082

CAS Number	Constituent	Water EQL ( $\mu\text{g/L}$ )	Soil EQL ( $\mu\text{g/kg}$ )	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
12674-11-2	Aroclor-1016	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
11104-28-2	Aroclor-1221	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
11141-16-5	Aroclor-1232	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
53469-21-9	Aroclor-1242	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
12672-29-6	Aroclor-1248	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
11097-69-1	Aroclor-1254	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
11096-82-5	Aroclor-1260	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
37324-23-5	Aroclor-1262	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130
11100-14-4	Aroclor-1268	0.5	16.5	$\leq 20 / \leq 30$	80-120 / 70-130

Notes:

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B* $\mu\text{g/L}$  = micrograms per liter $\mu\text{g/kg}$  = micrograms per kilogram

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-8. Gamma Spectroscopy, Germanium High Energy Detectors (Gamma Energy Analysis)**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQLt (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
14234-35-6	Antimony-125	50	0.3	≤30	70-130
13966-02-4	Beryllium-7	50	0.3	≤30	70-130
13967-70-9	Cesium-134	15	0.1	≤30	70-130
10045-97-3	Cesium-137	15	0.1	≤30	70-130
10198-40-0	Cobalt-60	25	0.05	≤30	70-130
14683-23-9	Europium-152	50	0.1	≤30	70-130
15585-10-1	Europium-154	50	0.1	≤30	70-130
14391-16-3	Europium-155	50	0.1	≤30	70-130
13966-00-2	Potassium-40			≤30	70-130
13967-48-1	Ruthenium-106			≤30	70-130

## Notes:

- a. Where EQL is not specified, the EQLs attainable by the laboratories for the methods-based constituents using the same analytical conditions as for the contaminants of concern are applicable.

pCi/L = picocuries per liter

pCi/g = picocuries per gram

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-9. Isotopic Uranium**

CAS Number	Constituent	Water EQL (µg/L)	Soil EQLt (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
13966-29-5	Uranium-234	1	1	≤30	70-130
15117-96-1	Uranium-235	1	0.5	≤30	70-130
U-238	Uranium-238	1	1	≤30	70-130

## Notes:

pCi/L = picocuries per liter

pCi/g = picocuries per gram

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

**Table A-10. Plutonium**

<b>CAS Number</b>	<b>Constituent</b>	<b>Water EQL (µg/L)</b>	<b>Soil EQLt (µg/kg)</b>	<b>Precision Requirement Water/Soil (%)</b>	<b>Accuracy Requirement Water/Soil (%)</b>
13981-16-3	Plutonium-238	1	1	≤30	70-130
PU-239/240	Plutonium-239/240	1	1	≤30	70-130

## Notes:

pCi/L = picocuries per liter  
 pCi/g = picocuries per gram  
 CAS = Chemical Abstracts Service  
 EQL = estimated quantitation limit

**Table A-11. Gross Alpha/Beta by Gas Proportional Flow Counting Method 900.0**

<b>Chemical Abstracts Service Number</b>	<b>Constituent</b>	<b>Water Estimated Quantitation Limit (pCi/L)</b>	<b>Soil Estimated Quantitation Limit (pCi/g)</b>	<b>Precision Requirement Water/Soil (%)</b>	<b>Accuracy Requirement Water/Soil (%)</b>
12587-46-1	Gross Alpha Activity	3	NA	≤30	70-130
12587-47-2	Gross Beta Activity	4	NA	≤30	70-130

NA = not applicable  
 pCi/L = picocuries per liter  
 pCi/g = picocuries per gram

**Distribution**

	<u>MS</u>	<u>Quantity</u>
<u>U.S. Department of Energy, Richland Operations Office</u>		
G. L. Sinton	A6-38	60
DOE Public Reading Room	H2-53	1
 <u>CH2M HILL Plateau Remediation Company</u>		
J. V. Borghese	H3-21	15
Publications Technical Library	H3-21	1
 <u>Washington Closure Hanford, LLC</u>		
R. O. Ovink	H4-21	6
 <u>Pacific Northwest National Laboratory</u>		
J. S. Fruchter	K6-96	2
 <u>Administrative Record</u>		
	H6-08	1
 <u>Document Clearance</u>		
	H6-08	1

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