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Sampling and Analysis Plan for the 100-K Decision Unit Remedial Investigation/Feasibility Study

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

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



CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

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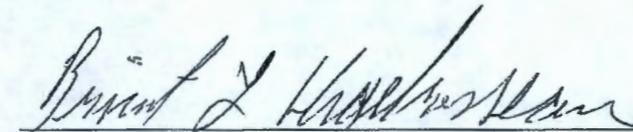
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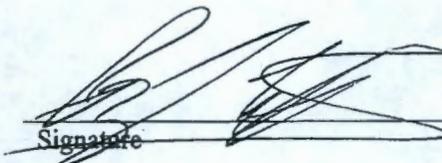
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U.S. Department of Energy, Richland Operations Office


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U.S. Environmental Protection Agency


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Terms

ALARA	as low as reasonably achievable
CFR	<i>Code of Federal Regulations</i>
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DQA	data quality assessment
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
gal./day	gallons per day
HASQARD	Hanford Analytical Services Quality Assurance Requirements Documents
HEIS	Hanford Environmental Information System
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>
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 the 100-K Decision Unit. The 100-K Decision Unit is located on the Hanford Site in southeastern Washington State and is associated with two source operable units: 100-KR-1 and 100-KR-2. The 100-KR-4 Groundwater Operable Unit underlies the two source operable units. This SAP describes the sampling and analysis to be performed associated with environmental investigation borings (boreholes), groundwater monitoring wells, and aquifer tubes. Figure 1-1 shows the location of the planned and existing boreholes, groundwater monitoring well network, and aquifer tubes within the scope of this SAP. Table 1-1 presents the intersection of data needs presented in Addendum 2 and the sampling and analysis activities. Chapter 2 of DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 2*, describes the site background and environmental setting of the 100-K Decision Unit.

Table 1-1. Plan Activities and Data Needs

Planned Activity	100-K Area		
	Quantity	Location	Data Needs No.
New boreholes (vadose zone)*	2	116-K-2 Trench West 116-K-2 Trench East	2, 3, 12
New wells to characterize deep vadose zone and unconfined aquifer*	9	Well #1 Well #2 Well #3 Well #4 Well #5 Well #6 Well #7 Well #8 Well #9	5, 10
New wells to characterize deep vadose zone, unconfined aquifer and Ringold upper mud unit*	4	Well R1 Well R2 Well R3 Well R4	7, 9, 10, 12
New aquifer tubes	3 tubes at 1 location	Location #1	5
Sample spatial/temporal uncertainty groundwater monitoring wells	18 existing locations		13

NOTE: This sampling and analysis plan may be in addition to other scheduled field activities.

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

1.1 Vadose Zone Characterization

This SAP describes the activities planned to characterize the vadose zone beneath the 116-K-2 Trench. Groundwater wells drilled as part of the 100-K Decision Unit RI also will have deep vadose zone soil samples collected during drilling at 13 groundwater monitoring well locations. Samples will be collected and analyzed to evaluate the nature and extent of contamination. The aquifer tubes will not have soil samples collected during drilling.

1.2 Groundwater Characterization

Groundwater samples will be collected and analyzed from new and existing groundwater monitoring wells 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.

1.3 Target Analytes and Contaminants of Potential Concern

Method-based analysis addresses the suites of analytical methods that will yield results for the target analytes or contaminants of potential concern (COPCs) needed. This method of laboratory analysis provides an umbrella effect in that analyses are provided for the target analytes or COPCs, as well as for any related constituents. Method based analysis will be performed for all chemical soil/aquifer sediment and water samples analyzed for the 100-K Decision Unit.

As presented in Appendix A, the standard laboratory method reporting lists that are used when running Hanford Site samples under current contractual agreements will be reported in the Hanford Environmental Information System (HEIS) database. The tables in Appendix A have been provided to define the analytes which will be reported when using a method based analysis approach. In addition, tentatively identified compounds will be reported for SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Method 8260.

1.3.1 Soil/Aquifer Sediment Target Analytes

Table 1-2 presents the soil/aquifer sediment master list of target analytes. WCH-326, *100-K Decision Unit Target Analyte List Development for Soil* presents the approach used for development of the master list and waste site-specific target analytes. Waste site-specific constituents for analysis are based on the master list.

Table 1-2. Master Soil/Aquifer Sediment Target Analytes

Radionuclides	Nonradionuclides		
Americium-241	1,1-Dichloroethene	Benzo(ghi)perylene	Lead
Carbon-14	1,4-Dichlorobenzene	Benzo(k)fluoranthene	Manganese
Cesium-137	Acenaphthene	Beryllium	Mercury
Cobalt-60	Aluminum	Bis (2-ethylhexyl) phthalate	Methylene chloride
Europium-152	Anthracene	Cadmium	Nickel
Europium-154	Antimony	Carbazole	Nitrate (as N)
Europium-155	Aroclor-1016 (PCB)	Carbon tetrachloride	Nitrite (as N)
Nickel-63	Aroclor-1221 (PCB)	Chloroform	Pentachlorophenol
Plutonium-238	Aroclor-1232 (PCB)	Hexavalent Chromium	Phenanthrene
Plutonium-239/240	Aroclor-1242 (PCB)	Chromium (total)	Pyrene
Strontium-90	Aroclor-1248 (PCB)	Chrysene	Selenium
Technetium-99	Aroclor-1254 (PCB)	Cobalt	Silver
Tritium	Aroclor-1260 (PCB)	Copper	Tetrachloroethene
Uranium-233/234	Arsenic	Dibenz(a,h)anthracene	Thallium
Uranium-235	Barium	Di-n-butylphthalate	Toluene
Uranium-238	Benzene	Ethylene glycol	Total petroleum hydrocarbon
	Benzo(a)anthracene	Fluoranthene	Trichloroethylene
	Benzo(a)pyrene	Fluoride	Vanadium
	Benzo(b)fluoranthene	Indeno(1,2,3-c,d)pyrene	Zinc

PCB = polychlorinated biphenyl

1.3.2 Groundwater COPCs

Table 1-3 presents the groundwater COPCs. Chapter 4 of the work plan presents the approach used for development of the COPCs.

Table 1-3. Groundwater Contaminants of Potential Concern

Radionuclides	Nonradionuclides		
Carbon-14	1,1,2-Trichloroethane	Chromium	Nitrite (as N)
Tritium	1,1-Dichloroethene	Cobalt	Selenium
Strontium-90	Antimony	Copper	Sulfate
	Arsenic	Fluoride	Tetrachloroethene
	Barium	Hexavalent Chromium	Thallium
	Benzene	Lead	Trichloroethene
	Beryllium	Manganese	Uranium
	Cadmium	Mercury	Vanadium
	Carbon tetrachloride	Nickel	Vinyl chloride
	Chloride	Nitrate (as N)	Zinc
	Chloroform		

1.4 Data Needs

A systematic planning process was used to identify 100-K Decision Unit problem statements and data gaps. The identified data needs resulting from the systematic planning process are discussed in Chapter 4 of 100-K Decision Unit RI/FS Work Plan (Addendum 2).

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, groundwater monitoring wells, and aquifer tubes were defined to address the uncertainties and data needs identified during systematic planning. Figure 1-1 shows the locations of boreholes, groundwater monitoring wells, and aquifer tubes described in this SAP. Tables 2-2 through 2-4 present the selected analytical methods to meet the required detection limits and the analytical performance requirements.

1.6 Project Schedule

The 100-K Area RI field efforts will occur between October 2009 and June 2010. 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 the 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 and aquifer tubes for this decision unit 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.

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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. The work performed under this plan is conducted in accordance with:

- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)*
- DOE O 414.1C, *Quality Assurance*
- 10 CFR 830, Subpart A, "Nuclear Safety Management, 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), 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 EPA/240/B-01/003. The QAPjP demonstrates conformance to Part B requirements of ANSI/ASQC E4-1994, *Quality Systems for Environmental Data Collection and Environmental Technology Programs: Requirements with Guidance for Use*.

In addition to the requirements cited above, the following reference was also 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*.

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, EPA-505-B-04-900A is a valuable resource and provides a comprehensive treatment of quality elements that should be addressed in any SAP. EPA-505-B-04-900A was designed to be compatible with 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 are properly documented.

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

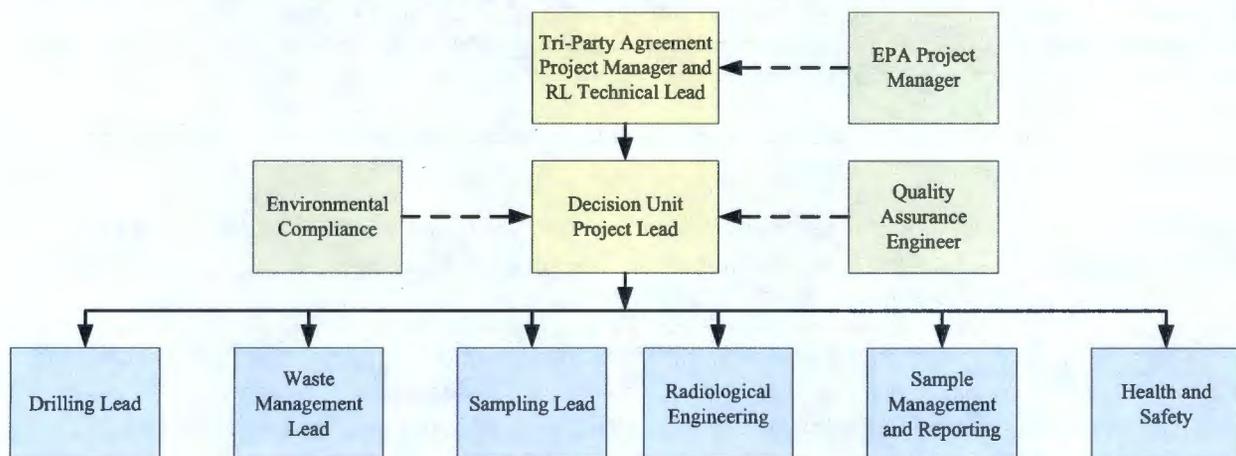
Section 2.4 Data Validation and Usability – This section addresses the QA activities occurring after the data collection or generation phase of the project is completed. Implementing these elements ensures data conform to the specified criteria, thus achieving the project objectives.

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, is responsible for planning, coordinating, sampling, 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 in the figure. For each functional primary contractor role, there is a corresponding oversight role within the U.S. Department of Energy (DOE).



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

Figure 2-1. Project Organization

EPA Project Manager. The U.S. Environmental Protection Agency (EPA) has assigned project managers responsible for oversight of cleanup projects and activities. EPA has approval authority as lead regulatory agency for the work being performed under this SAP. EPA will work with the DOE, 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 the RI/FS activities for the 100 Area decision units. 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. 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 that environmental requirements have been addressed; identifies environmental issues affecting operations and develops cost-effective solutions; and responds to environmental/regulatory issues or concerns raised by RL and/or the regulatory agencies. The environmental compliance office also oversees project implementation for compliance with applicable internal and external environmental requirements.

Decision Unit Project Lead. The project lead is responsible for direct managing of sampling documents and requirements, field activities, and subcontracted tasks, and for ensuring that the project file is properly maintained. The project lead ensures that 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 workscope. 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 point of contact is matrixed to the project lead and is responsible for QA issues on the project. Responsibilities include overseeing implementation of the project QA requirements; reviewing project documents, including data needs summary reports, SAPs, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA point of contact must be independent of the unit that is generating the data.

Drilling Lead. The drilling lead has overall responsibility for planning, coordinating, and executing drilling activities. Specific responsibilities include coordinating with the geological and drilling contractors. The drilling lead will also communicate with the decision unit project lead designee to identify field constraints or emergent conditions affecting sampling design/execution, and direct 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 and 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 confirming 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 to provide 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 decision unit 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 the Washington State Department of Ecology (Ecology). Sample Management and Reporting receives the analytical data from the laboratories, performs the data entry into the HEIS database, 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 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.

Sample Management and Reporting is also responsible for the performance of 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 preparation of any revisions to the SAP.

Samples taken in the field and released to the 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 within the project, as carried out 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 provides assistance to project personnel in complying with applicable health and safety standards and requirements. Health and Safety coordinates with Radiological Engineering to determine personnel protective equipment requirements.

2.1.2 Problem Definition and Background

This SAP describes the sampling and analysis to be performed associated with environmental investigation borings (boreholes), groundwater monitoring wells, and aquifer tubes. 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 location of the planned and existing boreholes, groundwater monitoring wells, and aquifer tubes within the scope of this SAP. The regulatory drivers and references 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 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, quantitative target limits, 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 2.4.3).

Table 2-2 presents soil/aquifer sediment analytical performance requirements by location, based on the master target analyte list in Table 1-2. Table 2-3 presents analytical performance requirements for deep vadose zone soil/aquifer sediment samples from groundwater wells. Table 2-4 presents analytical performance requirements for water samples. Laboratory operations and analytical services will be in compliance with Volume 4 of HASQARD (DOE/RL-96-98) and any specific criteria identified in Tables 2-2 through 2-4. Criteria in Tables 2-2 through 2-4 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.

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.</p>	<p>If duplicate data do not meet objective:</p> <ul style="list-style-type: none"> • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement • Qualify the data before use.
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 both 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 a percent bias.</p>	<p>Laboratory accuracy determination based on matrix spikes and matrix spike duplicates.</p>	<p>If recovery does not meet objective:</p> <ul style="list-style-type: none"> • Qualify the data before use • Request re-analysis or re-measurement.

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Representativeness	A qualitative term to express "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.	<p>Samples will be collected as described in the sampling design.</p> <p>Judgment sampling ensures areas most likely to be contaminated, based on current information, will be evaluated.</p>	<p>If results are not representative of the system sampled:</p> <ul style="list-style-type: none"> • Identify the reason for result not being representative • 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 • Redefine sampling and measurement requirements and protocols • Resample and reanalyze.
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.	<p>Sampling personnel will use the same sampling protocols.</p> <p>Samples will be submitted to the same laboratories when possible for analysis by the same methods, thus data results will be comparable.</p>	<p>If data are not comparable to other data sets:</p> <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability.

Table 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"> Identify appropriate changes to data collection and/or analysis methods Identify quantifiable bias, if applicable Qualify the data as appropriate Resample and/or reanalyze if needed Revise sampling/analysis protocols to ensure future comparability.
Sensitivity	The capability of a method or instrument to discriminate between 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"> Request reanalysis or re-measurement Qualify/reject the data before use.

* 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*.

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from the 116-K-2 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	— ^b
—	Gross alpha	100 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^b
—	Gross beta	5,000 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^b
Performance Requirements for Laboratory Measurements (Radiological)								
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV ^c	NV ^c	GEA	±30 ^d	70-130 ^d
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV ^c	NV ^c			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV ^c	NV ^c			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV ^c	NV ^c			
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV ^c	NV ^c	Isotopic-Pu	±30 ^d	70-130 ^d
10098-97-2	Strontium-90 ^e	1 pCi/g	4.5 pCi/g	NV ^c	NV ^c	Gas flow proportional counting	±30 ^d	70-130 ^d
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV ^c	NV ^c	LSC – C-14	±30 ^d	70-130 ^d
13981-37-8	Nickel-63	30 pCi/g	4,026 pCi/g	NV ^c	NV ^c	LSC – Ni-63	±30 ^d	70-130 ^d
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g	LSC – Tc-99	±30 ^d	70-130 ^d
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g	LSC – Tritium	±30 ^d	70-130 ^d

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from the 116-K-2 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Laboratory Measurements (Nonradiological)								
16984-48-8	Fluoride	5 mg/kg	4,800 mg/kg	2,880 mg/kg	5,770 mg/kg	EPA 300.0 (anions by IC)	±30 ^f	70-130 ^f
14797-55-8	Nitrate (as N) ^g	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg			
14797-65-0	Nitrite (as N) ^g	2.5 mg/kg	8,000 mg/kg	4 mg/kg	8 mg/kg			
7440-36-0	Antimony	6 mg/kg ^{h,i}	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
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			
7440-43-9	Cadmium	0.5 mg/kg ⁱ	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 ^c			
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 ^j	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	EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7782-49-2	Selenium	10 mg/kg ^{h,i}	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg ^{h,i}	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg ⁱ	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 ^c			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from the 116-K-2 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
18540-29-9	Hexavalent Chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30 ^f	70-130 ^f
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 (Hg cold vapor)	±30 ^f	70-130 ^f
71-43-2	Benzene	0.005 mg/kg ^l	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg	EPA 8260 (VOCs)	±30 ^k	70-130 ^k
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
18540-29-9	Hexavalent Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30 ^f	70-130 ^f
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^f	70-130 ^f
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

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from the 116-K-2 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
—	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	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 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	N/A	N/A

- a. 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 the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- b. Field measurements have no specific accuracy quality control requirement except to perform checks to verify manufacturer's expected performance.
- c. Generic residual radioactivity 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.
- d. 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.
- e. Strontium-90 will be assessed as total radioactive strontium.
- f. 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.
- g. Nitrate/Nitrite may also be reported as nitrogen in nitrate/nitrite by Method 353.1/353.2/353.3 with the reporting limits specified in Appendix A.
- h. 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 required detection limits are met.
- i. Calculated cleanup goals are below 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. The manganese preliminary remediation goal groundwater and river protection values are not risk based. They are predicated on a secondary maximum

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from the 116-K-2 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			

contaminant level (taste and/or odor) and are based on Hanford site background.

- k. 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 Method SW-846 8260.

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,*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*

CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma
dpm	=	disintegrations per minute	LSC	=	liquid scintillation counter
EQL	=	estimated quantitation limit	N/A	=	not applicable
GEA	=	gamma energy analysis	NV	=	no value
IC	=	ion chromatography	VOC	=	volatile organic compound

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	— ^b
—	Gross alpha	100 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^b
—	Gross beta	5,000 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^b
Performance Requirements for Laboratory Measurements (Radiological)								
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV ^c	NV ^c	GEA	±30 ^d	70-130 ^d
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV ^c	NV ^c			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV ^c	NV ^c			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV ^c	NV ^c			
10098-97-2	Strontium-90 ^e	1 pCi/g	4.5 pCi/g	NV ^c	NV ^c	Gas flow proportional counting	±30 ^d	70-130 ^d
Performance Requirements for Laboratory Measurements (Nonradiological)								
7440-36-0	Antimony	6 mg/kg ^{f,g}	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
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 ^g	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 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-96-5	Manganese ⁱ	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 ^{f,g}	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg ^{f,g}	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg ^g	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 ^c			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
7439-97-6	Mercury ^j	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 (Hg cold vapor)	±30 ^g	70-130 ^g
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30 ^h	70-130 ^h
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30 ^h	70-130 ^h

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
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	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 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	N/A	N/A

- a. 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*.
- b. Field measurements have no specific accuracy quality control requirement except to perform checks to verify manufacturer's expected performance.
- c. Generic residual radioactivity 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.
- d. 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

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method ^a	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			

batch laboratory replicate sample relative percent differences.

- e. Strontium-90 will be assessed as total radioactive strontium.
- f. 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 required detection limits are met.
- g. Calculated cleanup goals are below 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.
- h. Accuracy criteria specified is 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.
- i. The manganese preliminary remediation goal groundwater and river protection values are not risk based. They are predicated on a secondary maximum contaminant level (taste and/or odor) and are based on Hanford site background.
- j. Mercury is to be analyzed for only at Wells R3 and R4.

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,*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*

CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma
dpm	=	disintegrations per minute	LSC	=	liquid scintillation counter
EQL	=	estimated quantitation limit	N/A	=	not applicable
GEA	=	gamma energy analysis	NV	=	no value
IC	=	ion chromatography			

Table 2-4. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL	Precision Requirement (%) ^b	Accuracy Requirement (%) ^b	Action Level	Action Level Basis
Performance Requirements for Field Measurements							
—	Oxidation reduction potential	REDOX PROBE	N/A	— ^c	— ^c	N/A	N/A
—	pH measurement	PROBE	0.5 pH unit	— ^c	— ^c	N/A	N/A
—	Specific conductance	PROBE	1 µS/cm	— ^c	— ^c	N/A	N/A
—	Temperature	PROBE	--	— ^c	— ^c	N/A	N/A
—	Dissolved oxygen	PROBE	--	— ^c	— ^c	N/A	N/A
—	Turbidity	PROBE	0.1 NTU	— ^c	— ^c	N/A	N/A
Performance Requirements for Laboratory Measurements (Radiological)							
14762-75-5	Carbon-14	LSC - Carbon-14	200 pCi/L	±30	70-130	2,000 pCi/L	40 CFR 141.66
10098-97-2	Strontium-90	Strontium 89/90 – Sr-90	2 pCi/L	±30	70-130	8 pCi/L	40 CFR 141.66
10028-17-8	Tritium	LSC - Tritium (H-3)	400 pCi/L	±30	70-130	20,000 pCi/L	40 CFR 141.66
Performance Requirements for Laboratory Measurements (Nonradiological)							
7440-36-0	Antimony	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	5 µg/L	±20	80-120	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 ^d	±20	80-120	0.018 µg/L	Human Health for the Consumption of Water + Organism
7440-39-3	Barium	EPA 6010 (ICP metal)	20 µg/L	±20	80-120	1,000 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	80-120	4.0 µg/L	40 CFR 141.62

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Table 2-4. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL	Precision Requirement (%) ^b	Accuracy Requirement (%) ^b	Action Level	Action Level Basis
7440-43-9	Cadmium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L ^d	±20	80-120	0.25 µg/L	Freshwater CCC
7440-47-3	Chromium	EPA 6010 (ICP metal)	10 µg/L	±20	80-120	74 µg/L	Freshwater CCC
7440-48-4	Cobalt	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	±20	80-120	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	80-120	9 µg/L	Freshwater CCC
18540-29-9	Hexavalent chromium	EPA 7196	10 µg/L	±20	80-120	10 µg/L	WAC 173-201A
7439-92-1	Lead	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L	±20	80-120	2.5 µg/L	Freshwater CCC
7439-96-5	Manganese	EPA 6010 (ICP metal)	5 µg/L	±20	80-120	50 µg/L	40 CFR 143.3
7439-97-6	Mercury	EPA 7470 or 200.8	0.5 µg/L ^d	±20	80-120	0.012 µg/L	WAC 173-201A
7440-02-0	Nickel	EPA 6010 (ICP metal)	40 µg/L	±20	80-120	52 µg/L	Freshwater CCC
7782-49-2	Selenium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	±20	80-120	5 µg/L	Freshwater CCC
7440-28-0	Thallium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L ^d	±20	80-120	0.24 µg/L	Human Health for the Consumption of Water + Organism
7440-61-1	Uranium	Total Uranium (chemical)	1 µg/L	±20	80-120	30 µg/L	40 CFR 141.62
7440-62-2	Vanadium	EPA 6010 (ICP metal)	25 µg/L	±20	80-120	112 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-66-6	Zinc	EPA 6010 (ICP metal)	10 µg/L	±20	80-120	120 µg/L	Freshwater CCC
75-35-4	1,1-Dichloroethene	EPA 8260 (VOCs)	2 µg/L ^d	±20	80-120	0.073 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)

Table 2-4. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL	Precision Requirement (%) ^b	Accuracy Requirement (%) ^b	Action Level	Action Level Basis
79-00-5	1,1,2-Trichloroethane	EPA 8260 (VOCs)	2 µg/L ^d	±20	80-120	0.59 µg/L	Human Health for the Consumption of Water + Organism
71-43-2	Benzene	EPA 8260 (VOCs)	1.5 µg/L ^d	±20	80-120	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 ^d	±20	80-120	0.23 µg/L	Human Health for the Consumption of Water + Organism
67-66-3	Chloroform	EPA 8260 (VOCs)	5 µg/L	±20	80-120	5.7 µg/L	Human Health for the Consumption of Water + Organism
79-01-6	Trichloroethene	EPA 8260 (VOCs)	1 µg/L ^d	±20	80-120	0.49 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
127-18-4	Tetrachloroethene	EPA 8260 (VOCs)	5 µg/L ^d	±20	80-120	0.081 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-01-4	Vinyl chloride	EPA 8260 (VOCs)	5 µg/L ^d	±20	80-120	0.025 µg/L	Human Health for the Consumption of Water + Organism
16887-00-6	Chloride	EPA 300.0 (anions by IC)	200 µg/L	±20	80-120	230,000 µg/L	Freshwater CCC
16984-48-8	Fluoride	EPA 300.0 (anions by IC)	500 µg/L	±20	80-120	960 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
14797-55-8	Nitrate	EPA 300.0 (anions by IC)	250 µg/L	±20	80-120	10,000 µg/L	40 CFR 141.62
14797-65-0	Nitrite	EPA 300.0 (anions by IC)	250 µg/L	±20	80-120	1,000 µg/L	40 CFR 141.62
14808-79-8	Sulfate	EPA 300.0 (anions by IC)	500 µg/L	±20	80-120	250,000 µg/L	40 CFR 143.3

a. Equivalent methods may be substituted. For the three-digit EPA method, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*. Tentatively identified compounds will be reported for Method SW-846 8260.

b. Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation based on statistical control of laboratory control samples also is

Table 2-4. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL	Precision Requirement (%) ^b	Accuracy Requirement (%) ^b	Action Level	Action Level Basis
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performed. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analyses.

- c. Field measurements have no specific accuracy quality control requirement except to perform checks to verify manufacturer's expected performance.
- d. Calculated cleanup goals are below 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.

^a"National Recommended Water Quality Criteria" (EPA, 2009)

CAS	=	Chemical Abstract Services	ICP	=	inductively coupled plasma
CCC	=	criterion continuous concentration	MS	=	mass spectrometry
EQL	=	estimated quantitation limit	N/A	=	not applicable
GEA	=	gamma energy analysis	NTU	=	nephelometric turbidity units
IC	=	ion chromatography	VOC	=	volatile organic compound

2.1.5 Special Training and Certification

A graded approach is used to ensure that workers receive a level of training commensurate with responsibilities that 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, American National Standards Institute/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, including soil/aquifer sediment sampling and water sampling.
- The Radiation Protection Program establishes qualification requirements for radiological control technicians. The 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 that the current version of the SAP is being used and for providing any updates to field personnel. The administrative document control process maintains version control. Before implementation, DOE and the lead 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 DOE/RL-96-98.

The sampling lead or drilling lead is responsible for ensuring that the field instructions are maintained up-to-date and aligned with any revisions or other approved changes 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 or 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 2-5 presents the change control for this project.

Table 2-5. Change Control for 100-K Decision Unit Project

Type of Change	Action	Documentation
By drilling lead or sampling lead: <ul style="list-style-type: none"> • Increasing sampling frequency based on field screening results or visual observations. 	No SAP revision necessary	Field logbooks or operational records
By project management: <ul style="list-style-type: none"> • Change in target analytes or COPCs • Adding or removing wells • Significant increases or decreases in sampling frequency. 	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 that 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 the accuracy and availability 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 that the project's 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 and location, and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and on 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 (ultimately, 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 or sample is sludge) with the samples to prevent batching across similar 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. 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 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 2-4 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, then the laboratory must provide method validation data to confirm that 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 2-4 must be approved by Sample Management and Reporting in consultation with project lead.

Laboratories providing analytical services in support of this SAP will have in place a corrective action program that addresses analytical system failures and documents on 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 leach contacting tests will be performed on select soil and aquifer sediment samples. Standardized batch leach tests are done using a leach procedure based on ASTM D-3987-06, *Standard Test Method for Shake Extraction of Solid Waste with Water*. The procedure recommends using soil screened through 3/8-inch mesh. Demineralized water, pH adjusted according to EPA's West Coast recommendation, 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 water-tight 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 filtered using a 0.45- μ 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.

Grain-size (sieve) analysis may be performed as a field procedure or in the laboratory based on ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils*. Field grain size analysis may be used to select well screens for groundwater wells.

2.2.5 Quality Control

The QC procedures must be followed in the field and laboratory to ensure that 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 duplicates, trip or field transfer blanks, equipment blanks, and field splits. Laboratory QC samples estimate the precision and bias of the analytical data. Table 2-6 summarizes field and laboratory QC samples. Additional QC samples may be collected if conditions arise.

Table 2-6. Project Quality Control Checks

QC Sample Type	Purpose	Frequency
Field Quality Control		
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 compounds are sampled <i>per media sampled</i> .
Equipment rinsate	Verify adequacy of sampling equipment decontamination	As needed. ^a 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, ^b 20 samples maximum <i>per media sampled</i> .
Field split	Estimate precision, including sampling, analytical, and inter-laboratory variability	At a minimum, one per analytical method, <i>per media</i> for analyses performed where detection limit and precision and accuracy criteria have been defined in the Performance Requirements Tables.
Laboratory Quality Control^b		

Table 2-6. Project Quality Control Checks

QC Sample Type	Purpose	Frequency
Method blank	Assess response of an entire laboratory analytical system	One per batch, ^b 20 samples maximum, or as identified by the method guidance <i>per media sampled</i> .
Matrix spike	Identify analytical (preparation and analysis) bias; possible matrix affect on the analytical method used	When required by the method guidance, one per batch, ^b 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	When required by the method guidance, one per batch, ^b 20 samples maximum, or as identified by the method guidance, <i>per media sampled</i> .
Laboratory control samples	Assess method accuracy	One per batch, ^b 20 samples maximum, or as identified by the method guidance <i>per media sampled</i> .
Surrogates	Estimate recovery/yield	When required by the method guidance, as identified by the method guidance.

- a. Whenever a new type of non-dedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown less frequent collection of equipment 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, semivolatile 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 volatile organic analysis sample containers filled at the sample collection site with reagent water or silica sand, as appropriate to the primary sample media, transported to the field. The samples are prepared during 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. The 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 volatile organic analysis. 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 batched with samples for which volatile organic analysis is being requested.

Equipment rinsate blanks are collected for sampling devices reused to assess the adequacy of the decontamination process. Equipment 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 (i.e., single-use) equipment is used, equipment blanks will not be required.

For the field transfer blanks (i.e., full trip blanks, field transfer blanks, and equipment rinsate), 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(s) from a sampling event(s) 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 (see 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 for the four-digit EPA methods (see SW-846) and will be run at the frequency specified in 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, then an equipment rinsate blank is not required. If no VOC samples are collected, then a field transfer blank is not required. Field transfer blanks are not required when simply transferring samples to the field gas chromatograph for analysis.

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 are also 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 2-4.

Holding time is the elapsed time period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the analytical method, as specified for 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 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 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 the 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/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 this activity.

2.2.10 Data Management

Sample Management and Reporting, in coordination with the project lead, is responsible for ensuring analytical data is 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 *Hanford Federal Facility Agreement and Consent Order 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 to establish resolution with the project lead. The sample issue resolution forms become a permanent part of the analytical data package for future reference and for 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 sampling procedures. If specific procedures do not exist for a particular work evolution, or if it is determined that additional guidance is needed to complete certain tasks, a work package will be developed to adequately control the activities, as appropriate. Examples of 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 and QC activities. The purpose of assessment is to ensure that 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 corrective actions/deficiencies in accordance with the contractor QA program, the corrective action management program, and associated procedures implementing 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 if 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 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; calculations of representative samples from the dataset). Validation will be performed to contractor Level C, which is a review for 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 duplicates, surrogate recoveries, duplicates, and analytical method blanks. 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, semivolatile 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 that physical property data and/or field screening results are useable.

2.4.2 Verification and Validation Methods

Validation activities will be based on EPA functional guidelines. Data validation may be performed by 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 that data are usable. Level C validation is 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 if 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 if 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

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

3.1 Site Background and Objectives

Site background information is contained in Addendum 2. 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 clearly 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 the 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 follow the same requirements as those for logbooks presented below and the data forms must be referenced in the logbooks. 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, matrix spikes, blanks)
- Location and types of samples
- Chain-of-custody details and variances relating to chain-of-custody
- Field measurements
- Field calibrations and surveys and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to any 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 that 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 location of boreholes, groundwater monitoring wells, and aquifer tubes described in this SAP. The actual locations will be determined based on a field walkdown 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 two planned boreholes and 13 planned groundwater monitoring wells to support characterization of the vadose zone and groundwater as outlined in Table 1-1. Two boreholes will be drilled into the groundwater in the 116-K-2 Trench. Each groundwater well will also have deep vadose zone samples collected for vadose zone characterization. The vadose zone will be characterized by performing intrusive investigations at the 116-K-2 Trench. Intrusive investigations consist mainly of collecting and analyzing samples from planned boreholes in areas of known or suspected contamination. 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 the activities will be used to verify the adequacy of interim remedial actions and refine the preliminary conceptual site model of the 100-K Decision Unit.

The scope of vadose zone characterization efforts includes field screening, collecting and analyzing soil samples from the vadose zone, collecting and analyzing aquifer sediment samples, 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 waste site and sample periodically to the water table. Vadose zone samples will be collected according to the sampling scheme shown in Table 3-1. The sampling scheme for each borehole also

includes collection of one sample of aquifer sediments and one filtered groundwater sample 1.5 m (5 ft) into the water table. The sampling scheme for deep vadose zone samples at groundwater wells includes collecting soil samples periodically above the water table and collecting samples of aquifer sediments in the water table. Additional samples may be collected 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 and surrounding the Hanford Ringold contact. 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 the 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 DOE/RL and EPA approval, in accordance with WAC 173-160, after geophysical logging and all sampling is completed.

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
116-K-2 Trench West One borehole to groundwater. Justification: Interim remedial action was successfully completed at this site in 2005 to mitigate impacts from this potential source. Results from this activity indicate the maximum concentration of hexavalent chromium within the trench exceeds the soil concentration for protection of the Columbia River.	25-27.5, 27.5-30, 30-32.5 (37.5-40 ^b aquifer sediment sample) by split spoon (4 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-2	During drilling 37.5-40 aquifer water sample ^b (1 filtered groundwater sample)	Metals and hexavalent chromium in accordance with Table 2-4
	Major formation and lithology changes by split spoon (2 samples)	Physical properties in accordance with Table 2-2		
116-K-2 Trench East One borehole to groundwater. Justification: Interim remedial action was successfully completed at this site in 2005 to mitigate impacts from this potential source. Results from this activity indicate the maximum concentration of hexavalent chromium exceeds the soil concentrations for protection of the Columbia River.	25-27.5, 27.5-30, 30-32.5, 32.5-35, 35-37.5, 37.5-40, (45-47.5 ^b aquifer sediment sample) by split spoon (7 samples)	Target analytes, field screening parameters and batch leach contacting test in accordance with Table 2-2	During drilling 45-47.5 aquifer water sample ^b (1 filtered groundwater sample)	Metals and hexavalent chromium in accordance with Table 2-4
	Major formation and lithology changes by split spoon (2 samples)	Physical properties in accordance with Table 2-2		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well #1</p> <p>To be drilled and installed in the unconfined aquifer in the 100-K Area</p> <p>Justification: To define the hexavalent chromium upgradient extent of the western extent of the 105-KW Reactor groundwater plume.</p>	<p>During drilling, samples to be grab collected every 5 ft or where lithology changes occur, in one pint jar and chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)</p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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 by split spoon (<u>7 samples</u>)</p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	<p>During drilling, 5 ft below water table^b (<u>1 filtered groundwater sample</u>)</p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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</u>)</p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #2 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the extent of hexavalent chromium, carbon-14, TCE, and strontium-90 in groundwater near the 116-KW-3 waste site, 107-KW condensate tanks, and downgradient of 105-KW Reactor area.	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #3 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the hexavalent chromium upgradient extent of the 105-KE Reactor plume	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well #4</p> <p>To be drilled and installed in the unconfined aquifer in the 100-K Area</p> <p>Justification: To define the extent of a identified "hot" spot of hexavalent chromium and strontium-90 in groundwater . Existing wells are available to define the extent of the hot spot to the east and north. No wells are currently available to define this anomalous hexavalent chromium concentration to the northwest and west.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)</p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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 by split spoon (<u>7 samples</u>)</p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	<p>During drilling, 5 ft below water table^b (<u>1 filtered groundwater sample</u>)</p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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</u>)</p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #5 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: A replacement for well 199-K-109A to further monitor and define the extent of strontium-90 hot spot	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #6 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the hexavalent chromium upgradient extent of the 116-K-2 Trench plume.	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #7 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the hexavalent chromium upgradient extent of the 116-K-2 Trench plume.	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #8 To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the hexavalent chromium upgradient extent of the 116-K-2 Trench plume	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (<u>1 filtered groundwater sample</u>)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Well #9 ^d To be drilled and installed in the unconfined aquifer in the 100-K Area Justification: To define the extent of hexavalent chromium in groundwater.	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^c	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (<u>12 samples</u>)	Constituents and field screening parameters in accordance with Table 2-4
	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 by split spoon (<u>7 samples</u>)	In accordance with Table 2-3: <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	During drilling, 5 ft below water table ^b (1 filtered groundwater sample)	Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4
	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</u>)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well R1</p> <p>Install borehole reaching a total depth approximately 50 ft within the RUM. Complete the borehole as a well in a water-producing zone within the RUM, if found, in the 100-K Area.</p> <p>Justification: To determine the extent of contamination that may reside in the RUM, physical and hydrologic properties of the RUM, and potential transport of contamination within the RUM.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>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 (14 samples)</p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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)</p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Batch leach contacting test • Radiological methods • EPA Methods 7196 and 6010 	<p>During drilling, 5 ft below water table^b (1 filtered groundwater sample)</p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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)</p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well R2</p> <p>Install borehole reaching a total depth approximately 50 ft within the RUM. Complete the borehole as a well in a water-producing zone within the RUM, if found, in the 100-K Area.</p> <p>Justification: To determine the extent of contamination that may reside in the RUM, physical and hydrologic properties of the RUM, and potential transport of contamination within the RUM.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>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 <u>(14 samples)</u></p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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 <u>(10 samples)</u></p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 	<p>During drilling, 5 ft below water table^b <u>(1 filtered groundwater sample)</u></p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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)</u></p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well R3</p> <p>Install borehole reaching a total depth approximately 50 ft within the RUM. Complete the borehole as a well in a water-producing zone within the RUM, if found, in the 100-K Area.</p> <p>Justification: To determine the extent of contamination that may reside in the RUM, physical and hydrologic properties of the RUM, and potential transport of contamination within the RUM.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>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 <u>(14 samples)</u></p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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 <u>(10 samples)</u></p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 • Mercury by EPA 7471 	<p>During drilling, 5 ft below water table^b <u>(1 filtered groundwater sample)</u></p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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)</u></p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
<p>Well R4</p> <p>Install borehole reaching a total depth approximately 50 ft within the RUM. Complete the borehole as a well in a water-producing zone within the RUM, if found, in the 100-K Area.</p> <p>Justification: To determine the extent of contamination that may reside in the RUM, physical and hydrologic properties of the RUM, and potential transport of contamination within the RUM.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^c</p>	<p>Geologic archive samples</p>	<p>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 (<u>14 samples</u>)</p>	<p>Constituents and field screening parameters in accordance with Table 2-4</p>
	<p>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 (<u>10 samples</u>)</p>	<p>In accordance with Table 2-3:</p> <ul style="list-style-type: none"> • Radiological methods • EPA Methods 7196 and 6010 • Mercury by EPA 7471 	<p>During drilling, 5 ft below water table^b (<u>1 filtered groundwater sample</u>)</p>	<p>Filtered groundwater sample for metals and hexavalent chromium in accordance with Table 2-4</p>
	<p>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</u>)</p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^a	Properties of Interest	Sample Interval Depth (ft bgs)/frequency	Analyte List
Sample 18 spatial/temporal uncertainty monitoring wells (Table 3-2) Multiple rounds	None	None	Collect one sample per well multiple sampling rounds to support remedial investigation. <u>(18 wells x approximately 3 rounds = 54 samples)</u>	Constituents and field screening parameters in accordance with Table 2-4

Summary

Number of samples:	<u>Soil/Aquifer sediment chemical</u> : 103 <u>Physical property</u> : 78 <u>Geologic archive samples</u> : variable	<u>Water samples collected during drilling</u> : 166 <u>Spatial/temporal uncertainty samples</u> : 54 (3 rounds total)
Minimum number of field quality control samples:	<u>Soil/Aquifer sediment chemical</u> : 19 (6 equipment blank, 6 field blank, 6 duplicate, 1 split) <u>Physical property</u> : 0 <u>Geologic archive samples</u> : 0	<u>Water samples collected during drilling</u> : 28 (9 equipment blank, 9 field blank, 9 duplicate, 1 split) <u>Spatial/temporal uncertainty samples</u> : 10 (3 equipment blank, 3 field blank, 3 duplicate, 1 split)
Total number of samples:	<u>Soil/aquifer sediment chemical</u> : 122 <u>Physical property</u> : 78 <u>Geologic archive samples</u> : variable	<u>Water samples collected during drilling</u> : 194 <u>Spatial/temporal uncertainty samples</u> : 64

- 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.
- This sample is intended to be collected from 5 ft into the unconfined aquifer.
- Archive samples may be omitted at the discretion of the field geologist due to radiological field data.
- Well #9 is pending approval per Section 106 of the National Historic Preservation Act.

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
RUM = Ringold upper mud

TCE = trichloroethene

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 wells screened in the Ringold upper mud unit, slug testing and pump testing will be performed to characterize hydraulic conductivity.

Well Depth and Screen Placement

For the nine new groundwater wells in the unconfined aquifer in the 100-K Area, a 6.1 m (20 ft) or longer screen will be installed.

For the four new groundwater wells reaching a total depth approximately 15 m (50 ft) within the Ringold upper mud unit, complete the boreholes as wells in a water-producing zone within the Ringold upper mud unit, if found. Up to a 6.1 m (20-ft) screen will be installed based on ability to produce water in the water-bearing Ringold 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 25.4 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 15.2 cm (6-in.) wells with Schedule 10, Type 304 or 316, stainless steel, V-slot continuous wire wrap screen, atop a 1.5 m (5 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 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 upon field conditions. If the completion differs from the WAC 173-160 requirements, then variances will be obtained from Ecology.

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 RI in the existing groundwater wells for each contaminant identified in Table 1-3.

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

199-K-11	199-K-31	199-K-37	199-K-142	199-K-157
199-K-18	199-K32A	199-K-106A	199-K-151	699-72-73
199-K-20	199-K-34	199-K-108A	199-K-152	699-73-61
199-K-22	199-K-36	199-K-117A		

To determine 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. It is required the groundwater be sampled throughout a decision unit 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 following discussion explains the method used to develop both the number and location of sampling points along with the sampling frequency for the decision units associated with the River Corridor RI/FS investigations. 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).

Sample Number and Location

Sampling well locations within a groundwater decision unit must be identified to spatially represent all of the areas within a decision unit, regardless of facility or known contaminant plume locations. These sampling networks should represent locations where human or ecological receptors could potentially encounter groundwater. The primary pathway for human exposure is through direct contact with groundwater obtained from a residential or community water well. Identification of sampling locations to assess the direct exposure pathways is to assume development of the land for future human habitation. With this scenario as a guide to assessing a viable sampling grid of plausible groundwater pathways, land use regulations were used to develop a reasonable network of supply wells for each decision unit, based on state regulations and site-specific hydrologic properties. This approach resulted in a sampling grid and corresponding network of monitoring wells tailored for each decision unit. As part of this semi-quantitative approach, the locations of community water delivery systems were developed to meet not only the negotiated Tri-Party land use needs but also State of Washington requirements.

Rules and regulations of the Washington State Department of Health (DOH) regarding public water supplies, WAC 246-290, “Group A Public Water Supplies,” are explained in the associated guidance document, DOH 331-123, *Water System Design Manual*. This manual is maintained by the DOH and provides the necessary information on specifications to develop groundwater resources for human use. By applying these specifications to the possible locations of water supply wells that might act as complete exposure pathways, the number and spacing of sampling locations is determined with credibility for each decision unit, providing justified and defensible monitoring networks.

Based on remedial action goals for DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, the assumption for future habitation is families will live on the land, grow a garden, and raise livestock to provide approximately 25 percent of the family’s food requirements. This land usage places specific state and daily water requirements for each residence. Because the remedial action goals are based on groundwater restored to highest beneficial use (i.e. drinking water), the *Washington Growth*

Management Act requires each residence occupy at least one acre of land. It is also assumed that at least a 5-acre plot per unit is necessary to raise livestock. Thus, each residence in the following scheme assumes a family plot size of 5 acres.

Therefore, residential water usage must be sufficient to supply not only in-house needs but also to irrigate a large garden and to water livestock. For a water well that supplies one residence, Ecology requires a minimum of 1,514.2 liters per day (L/day) (400 gallons per day [gal./day]). Thus, an extreme lower limit is established for in-house use. However, for a communal system, which the DOH regulates, guidance on the daily water use is found in DOH 331-123. One of the key parameters for estimating potential water use is the lot size of the individual residence.

Another important consideration is location of the well within the state because of climate differences east and west of the Cascade Mountains. Based on utility records in eastern Washington, which has a dominantly arid climate, a residence's maximum day demand is 5,675 L/day (1,500 gal./day) for lot sizes in excess of 2.5 acres. Although values as high as 30,283.3 L/day (8,000 gal./day) have been recorded, the historical sizing guideline of 5,675 L/day (1,500 gal./day) has generally been adequate. With the information on requirements for residential water supplies, the number of possible supply wells and thus the number of sampling points is calculated based on how much water the local aquifer is expected to produce.

To provide the number of sampling points for the well network, the average groundwater yields, calculated from pump tests conducted at each decision unit, are used to determine the number of residences supported on one supply well. Thus the grid size specific to each decision unit is determined. Use of a random grid generator provides approximate locations for sampling points based on the final number of sampling points and the total area of each decision unit. To the degree possible, one well within each grid was chosen to represent the potential exposure pathway; thereby providing a network of sampling points to provide a spatially representative sampling network of groundwater wells.

In addition to determining the maximum number and location of potential exposure pathways, additional wells were added to networks to define potential exposures associated with known contaminant plumes. Current monitoring wells were chosen to provide data on maximum contaminant levels and to define plume extents. For decision units with active remedial activities, extraction/injection and chemical treatment wells were not included in any of the well networks. The pump and treat wells are not configured for routine sampling and the chemical treatment wells are not representative of ambient groundwater conditions.

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 decision units 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/groundwater 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 at each of decision units located along the river corridor. 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 decision unit along the river, capture the maximum effects of changing river elevations on aquifer conditions as well as the transitional time between the maximum and minimum changing conditions.

3.5.2.3 Aquifer Tubes

Table 3-3 summarizes aquifer tube activities. If possible, aquifer tubes should be advanced using direct-push methods. A set of three new aquifer tubes will be installed to multiple depths at one location in the 100-K Area. The depth of each aquifer tube screen should be based on previously collected aquifer tube and well data. Direct-push methods can be used to drive a casing with a screened lower end to provide for in situ probes and data loggers. Ideal positioning is near the seasonally low-river-stage shoreline, for example, the river-stage shoreline when the lowest anticipated mean river discharge occurs. Historically, the lowest anticipated river discharge is September through November.

Aquifer tube water samples will be collected for analysis in three sampling rounds to support the RI when the river stage is low enough to obtain samples. Samples will be analyzed for carbon-14, hexavalent chromium, tritium, and trichloroethene (TCE).

Table 3-3. Aquifer Tube Sample/Measurement Locations and Depth

Sampling Location	Action	Water Chemistry	
		Frequency	Analyte List
Three new aquifer tubes at one location (Location #1) in the 100-K Area	Drive three new aquifer tubes to support RI	Collect one sample per aquifer tube for three rounds	C-14, hexavalent chromium, tritium, and TCE (in accordance with Table 2-4) Field screening parameters (in accordance with Table 2-4)
Total number of real samples:		9	
Minimum number of field quality control samples:		4 (1 equipment blank, 1 field blank, 1 duplicate, 1 split)	
Total number of samples:		13	

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 four 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, and then containerized in accordance with the sampling procedure. If sample volume requirements cannot be met, samples will be collected according to the following priority, as applicable: hexavalent chromium, metals (including mercury), batch leach contacting test, tritium, nitrate, strontium-90, technetium-99, other radionuclides, VOCs, physical properties and other anions.

Groundwater samples collected during drilling, before development, will be pumped from selected intervals. The pump will be operated for a period of time sufficient to provide stabilized field readings, but not necessarily three casing volumes.

For the RA groundwater monitoring well network, before sample capture, the pump will be operated for a sufficient time to provide stabilized field readings, and at least three casing volumes. Aquifer tube samples will be grab sampled with a pump, with no purge before sample collection.

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.

More significant changes in sample locations not affecting the data needs will require notification and approval of the project lead. Changes to sample locations resulting in impacts to meeting data needs will require concurrence from 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 shall 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 bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events. Field decontamination (e.g., field washing and reuse) is not appropriate for sampling equipment.

The drill rig derrick, all down-hole 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 in 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, to 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 application/operation of the instrument. The hand-held probe is an alpha detection instrument commonly used on the Hanford Site to obtain 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 3-4 and 3-5.

Table 3-4. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size ^a
Gamma energy analysis	None	6 months	G/P	750 g
Liquid scintillation counter	None	6 months	G	33 g
Isotopic - plutonium	None	6 months	G/P	5 g
Strontium-90	None	6 months	G/P	5 g
Gas flow proportional counting	None	6 months	G/P	5 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
EPA 8260 ^b	Cool ~4 °C	14 days	G	50 g
EPA 300.0	Cool ~4 °C	28 days/ 48 hours	G/P	50 g
ASTM D2216	None	None	Moisture-proof container	200 g
ASTM D2434-68	None	None	P	1,000 g
ASTM D2937	None	None	G/P	1,000 g

Table 3-4. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size ^a
ASTM D5084	None	None	P	1,000 g
Batch Leaching Contacting Test	Cool ~4 °C	28 days from field to extraction	G	100 g/120 mL

a. Based on minimum QC requirements.

b. Field preservation EPA 5035A may also be used.

For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.

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

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*.

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*.

28 days/48 hours = 48 hours for nitrate, nitrite, phosphate, others 28 days. P = plastic

G = glass

Table 3-5. Sample Preservation, Container, and Holding Time for Water Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
Carbon-14	None	6 months	G/P	60 mL
Strontium 89/90 - Sr-90	HNO ₃ to pH <2	6 months	G/P	2000 mL
Tritium (H-3)	None	6 months	G	60 mL
EPA 6010	HNO ₃ to pH <2	6 months	G/P	300 mL
EPA 6020 or 200.8	HNO ₃ to pH <2	6 months	G/P	300 mL
EPA 7196	Cool ~4 °C	24 hours	aG	500 mL
EPA 7470 or 200.8	HNO ₃ to pH <2	28 days	G	500 mL
EPA 8260	Cool ~4 °C, HCl or H ₂ SO ₄ to pH <2	14 days	aGs	40 mL
EPA 300.0	Cool ~4 °C	28 days/48 hours	P	125 mL
Total uranium (chemical)	HNO ₃ to pH <2	6 months	G/P	500 mL

* Based on minimum QC requirements

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

For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.

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

28 days/48 hours = 48 hours for nitrate, nitrite, phosphate, others 28 days

aG = amber glass

G = glass

aGs = amber glass septum (no head space)

P = plastic

3.7.2 Container Labeling

The sample location, depth, and corresponding HEIS number 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 information:

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

Except for volatile organic analysis 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 volatile organic analysis 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 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-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*. Pursuant to 40 CFR 300.440, "Procedures for Planning and Implementing Off-Site Response Actions," approval from the CERCLA lead agency Remedial Project Manager is required before returning unused samples or waste from offsite laboratories.

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 further 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

- 10 CFR 830, Subpart A, "Nuclear Safety Management, Quality Assurance Requirements," *Code of Federal Regulations*. Available at:
http://edocket.access.gpo.gov/cfr_2008/janqtr/pdf/10cfr830.7.pdf
- 10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at:
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Appendix A
Laboratory Standard Compound List

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Laboratory Standard Compound List

Tables A-1 through A-5 provide the laboratory standard compound list.

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

CAS #	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%
NO ₃ -N	Nitrogen in nitrate*	75	750	±20%/±30%	80-120%/70-130%
NO ₂ -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%

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

For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

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

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
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%
7439-98-7	Molybdenum	20	2,000	±20%/±30%	80-120%/70-130%
7440-28-0	Thallium	50	5,000	±20%/±30%	80-120%/70-130%
7440-38-2	Arsenic	100	10,000	±20%/±30%	80-120%/70-130%
7440-41-7	Beryllium	2	500	±20%/±30%	80-120%/70-130%
7440-42-8	Boron	20	2,000	±20%/±30%	80-120%/70-130%
7782-49-2	Selenium	100	10,000	±20%/±30%	80-120%/70-130%
7440-09-7	Potassium	4,000	400,000	±20%/±30%	80-120%/70-130%
7429-90-5	Aluminum	50	5,000	±20%/±30%	80-120%/70-130%
7439-89-6	Iron	50	5,000	±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%
7440-02-0	Nickel	40	4,000	±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%
7440-36-0	Antimony	60	6,000	±20%/±30%	80-120%/70-130%
7440-39-3	Barium	20	2,000	±20%/±30%	80-120%/70-130%
7440-43-9	Cadmium	2	500	±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%
7440-62-2	Vanadium	25	2,500	±20%/±30%	80-120%/70-130%
7440-66-6	Zinc	10	1,000	±20%/±30%	80-120%/70-130%
7440-70-2	Calcium	1,000	100,000	±20%/±30%	80-120%/70-130%
7440-31-5	Tin	100	10,000	±20%/±30%	80-120%/70-130%
7440-69-9	Bismuth	100	10,000	±20%/±30%	80-120%/70-130%
7723-14-0	Phosphorus	100	50,000	±20%/±30%	80-120%/70-130%
7440-21-3	Silicon	20	2,000	±20%/±30%	80-120%/70-130%
7440-24-6	Strontium (elemental)	10	1,000	±20%/±30%	80-120%/70-130%

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 #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
7439-92-1	Lead	2	500	±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%
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%
7782-49-2	Selenium	4	1,000	±20%/±30%	80-120%/70-130%

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

For EPA Method 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 #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
100-41-4	Ethylbenzene	5	5	±20%/±30%	80-120%/70-130%
100-42-5	Styrene	5	5	±20%/±30%	80-120%/70-130%
10061-01-5	cis-1,3-dichloropropene	5	5	±20%/±30%	80-120%/70-130%
10061-02-6	trans-1,3-dichloropropene	5	5	±20%/±30%	80-120%/70-130%
107-06-2	1,2-dichloroethane	5	5	±20%/±30%	80-120%/70-130%
108-10-1	4-methyl-2-pentanone	10	10	±20%/±30%	80-120%/70-130%
108-88-3	Toluene	5	5	±20%/±30%	80-120%/70-130%
108-90-7	Chlorobenzene	5	5	±20%/±30%	80-120%/70-130%
124-48-1	Dibromochloromethane	5	5	±20%/±30%	80-120%/70-130%
127-18-4	Tetrachloroethene	5	5	±20%/±30%	80-120%/70-130%
1330-20-7	Xylenes (total)	10	10	±20%/±30%	80-120%/70-130%

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

CAS #	Constituent	Water EQL ($\mu\text{g/L}$)	Soil EQL ($\mu\text{g/kg}$)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
540-59-0	1,2-dichloroethene(total)	10	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
591-78-6	2-hexanone	20	20	$\pm 20\%/\pm 30\%$	80-120%/70-130%
67-64-1	Acetone	20	20	$\pm 20\%/\pm 30\%$	80-120%/70-130%
71-43-2	Benzene	1.5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
71-55-6	1,1,1-trichloroethane	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
74-83-9	Bromomethane	10	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
74-87-3	Chloromethane	10	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-00-3	Chloroethane	10	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-01-4	Vinyl chloride	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-09-2	Methylene chloride	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-15-0	Carbon disulfide	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-25-2	Bromoform	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-27-4	Bromodichloromethane	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-34-3	1,1-dichloroethane	2	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
75-35-4	1,1-dichloroethene	10	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
78-87-5	1,2-dichloropropane	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
78-93-3	2-butanone	10	10	$\pm 20\%/\pm 30\%$	80-120%/70-130%
79-00-5	1,1,2-trichloroethane	2	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
79-34-5	1,1,2,2-tetrachloroethane	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
56-23-5	Carbon tetrachloride	1	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
79-01-6	Trichloroethene	1	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
67-66-3	Chloroform	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
106-46-7	1,4-Dichlorobenzene	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%
156-59-2	cis-1,2-Dichloroethylene	5	5	$\pm 20\%/\pm 30\%$	80-120%/70-130%

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. Gamma Spectroscopy, Germanium High-Energy Detectors (Gamma Energy Analysis)

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi/g)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
14331-83-0	Actinium-228	—	—	±30%	70-130%
14596-10-2	Americium-241	50	1	±30%	70-130%
13981-41-4	Barium-133	—	0.2	±30%	70-130%
13966-02-4	Beryllium-7	50	0.3	±30%	70-130%
14913-49-6	Bismuth-212	—	—	±30%	70-130%
14733-03-0	Bismuth-214	—	—	±30%	70-130%
CE/PR-144	Cerium/Praseodymium-144	—	—	±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%
15092-94-1	Lead-212	—	—	±30%	70-130%
15067-28-4	Lead-214	—	—	±30%	70-130%
14681-63-1	Niobium-94	—	—	±30%	70-130%
13966-00-2	Potassium-40	—	—	±30%	70-130%
13982-63-3	Radium-226	—	0.1	±30%	70-130%
15262-20-1	Radium-228	—	0.2	±30%	70-130%
14274-82-9	Thorium-228	—	—	±30%	70-130%
TH-232	Thorium-232	—	—	±30%	70-130%
15065-10-8	Thorium-234	—	—	±30%	70-130%
15832-50-5	Tin-126	—	—	±30%	70-130%
15117-96-1	Uranium-235	50	0.5	±30%	70-130%
U-238	Uranium-238	500	10	±30%	70-130%
14391-65-2	Silver-108m	—	0.2	±30%	70-130%

Where EQL is not specified, current EQLs of laboratories contracted to the Hanford Site are applicable.

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

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