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Data Quality Objectives Summary Report for Assessing Carbon Tetrachloride Concentrations in the Vadose Zone/Groundwater at the Plutonium Finishing Plant and Disposition of Waste Material

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Submitted by: Bechtel Hanford, Inc.

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Approval: G. B. Mitchem, Groundwater/Vadose Zone Integration Project Senior Task Lead

Signature _____ Date 8/13/01

L. R. Curry, Groundwater/Vadose Zone Integration Project Engineer

Signature _____ Date 8-13-01

C. J. Kemp, Groundwater/Vadose Zone Integration Project Environmental Lead

Signature _____ Date 8-11-01

V. J. Rohay, Groundwater/Vadose Zone Integration Project Task Lead

Signature _____ Date 8/10/01

The approval signatures on this page indicate that this document has been authorized for information release to the public through appropriate channels. No other forms or signatures are required to document this information release.

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Data Quality Objectives Summary Report for Assessing Carbon Tetrachloride Concentrations in the Vadose Zone/Groundwater at the Plutonium Finishing Plant and Disposition of Waste Material

Authors

M. E. Byrnes
Bechtel Hanford, Inc.

V. J. Rohay
CH2M HILL Hanford, Inc.

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ACRONYMS

AA	alternative action
AEA	alpha energy analysis
ANN	aluminum nitrate nonahydrate
bgs	below ground surface
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHI	CH2M Hill Hanford, Inc.
COC	contaminant of concern
COPC	contaminant of potential concern
CRDL	contract-required detection limit
CSM	conceptual site model
CWC	Central Waste Complex
&D	decontamination and decommissioning
DBBP	dibutyl butyl phosphonate
DBP	dibutyl phosphate
DNAPL	dense, non-aqueous phase liquid
dpm	disintegrations per minute
DQO	data quality objective
DR	decision rule
DS	decision statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FY	fiscal year
GEA	gamma energy analysis
GPC	gas proportional counting
GW	groundwater
HEIS	Hanford Environmental Information System
HPGe	high-purity germanium
HVAC	heating, ventilation, and air conditioning
ICP	inductively coupled plasma
K_d	distribution coefficient
LBGR	lower bound of gray region
LSC	liquid scintillation counting
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
NaI	sodium iodide
NTU	nephelometric turbidity unit
OU	operable unit
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PID	photoionization detector

PNNL	Pacific Northwest National Laboratory
PPE	personal protective equipment
ppmv	parts per million by volume
PQL	practical quantitation limit
PRF	Plutonium Reclamation Facility
PSQ	principal study question
PUREX	Plutonium-Uranium Extraction (Facility)
REDOX	Reduction-Oxidation (Facility)
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TBP	tributyl phosphate
TCLP	toxicity characteristic leaching procedure
TSD	treatment, storage, and disposal
UTS	universal treatment standards
VOA	volatile organic analyte
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 STEP 1 – STATE THE PROBLEM

The objective of data quality objective (DQO) Step 1 is to use the information gathered from the DQO scoping process, as well as other relevant information, to clearly and concisely state the problem to be resolved. This section defines the task objectives and assumptions, presents the task issues, summarizes the site background information, and provides a concise statement of the problem.

1.1 PROJECT OBJECTIVES

The objective of installing a well in the vicinity of the Plutonium Finishing Plant (PFP) is to support remediation of the carbon tetrachloride contamination in the subsurface. During drilling of the well, samples will be collected to assess the concentrations of carbon tetrachloride in the vadose zone and groundwater. The concentrations, distribution, and phases of the carbon tetrachloride will be used to evaluate if there is a continuing source of groundwater contamination at this location.

After collection of soil and groundwater samples, the well will be constructed as a groundwater extraction well that could be used for monitoring or groundwater remediation using the existing pump-and-treat system. However, if it is determined that a continuing source remains within the vadose zone at this location and that the source could be remediated using soil vapor extraction (SVE), the well will be constructed with a screened interval that could be used for vadose zone remediation. Alternative conceptual site models (CSMs) have been proposed to account for the high concentrations of carbon tetrachloride in groundwater in the vicinity of PFP.

The purpose of this DQO process is to identify the quality and quantity of data that need to be collected during installation of the well to support remedial decisions, to indicate which CSM of carbon tetrachloride release and migration is most likely, and to properly disposition waste generated by field operations.

1.2 PROJECT ASSUMPTIONS

The project assumptions for the well installation include the following:

- The well will be drilled and completed as a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) well within the 200-ZP-1 Operable Unit (OU).

- The U.S. Environmental Protection Agency (EPA) is the lead regulatory agency overseeing CERCLA groundwater monitoring activities for the 200-ZP-1 OU.

- The well will be installed within the protected area (i.e., within the security fence) of the PFP.

- The specific location of the well will be based on process knowledge and accessibility (above ground for the drilling rig and below ground for buried utilities). The proposed location is east of the PFP, near the buried effluent lines that carried carbon tetrachloride waste streams to the 216-Z-9 Trench for subsurface disposal.

- The proposed well location is not within a known waste site.

- The well will be drilled to approximately 87 m (285 ft) below ground surface (bgs), which is approximately 18 m (60 ft) below the water table.

- The well will be drilled using a design that allows it to be constructed as a groundwater extraction well in accordance with the *Washington Administrative Code* (WAC). The diameter of the extraction well will be 15 cm (6 in.) and the screen length will be 15 m (50 ft).

- If data collected during drilling indicate that the vadose zone contains a drainable, separate organic liquid phase of carbon tetrachloride, the well will be constructed as a vapor extraction well at that depth and the borehole will not be advanced further.

- If data collected during drilling indicate that the vadose zone contains a potential or continuing source of carbon tetrachloride contamination to groundwater (other than a drainable liquid phase), and that the source could be remediated using SVE, the well will be constructed with a screened interval in the vadose zone at the depth of the contamination.

- The well will be drilled using methods (e.g., downsizing) to ensure that a pathway is not created for downward movement of perched water or contamination to the groundwater. The most likely location to encounter perched water or drainable carbon tetrachloride is anticipated to be above the Plio-Pleistocene unit, which is a relatively low permeability layer at approximately 37 m (120 ft) bgs. The most likely location to encounter radiological contaminants is anticipated to be within the uppermost 15 m (50 ft).

- The radiological risk assessment for this well identified it as a medium risk well from 0 to 15 m (50 ft) bgs and a low risk well from 15 m (50 ft) to total depth.

- All soil cuttings and groundwater brought to the surface during well drilling will be containerized.

- From an environmental investigation standpoint, the primary contaminants of concern (COCs) are carbon tetrachloride and associated chemical and radiological co-contaminants that can be used to distinguish among competing CSMs of carbon tetrachloride release and migration. However, from a waste disposition standpoint, the COCs include all contaminants

(radiological and chemical) needed to determine if the wastes meet the waste acceptance criteria.

- The waste generated from well drilling and sampling operations shall be handled as CERCLA waste. Saturated soil cuttings or other waste that has come into contact with the groundwater shall assume the groundwater listed waste codes. The listed waste codes that apply to waste that has come into contact with groundwater in this immediate area include the following:

  - F001: 1,1,1-trichloroethane (TCA) and carbon tetrachloride
  - F002: methylene chloride
  - F003: acetone and methyl isobutyl ketone (MIBK)
  - F004: o-cresol, p-cresol, and cresylic acid
  - F005: methyl ethyl ketone (MEK).

- Waste that has come into contact with perched water shall assume the groundwater listed waste codes.

- Decontamination fluids and water resulting from well development do not require sampling because these wastes will be sent to the Purgewater Storage and Treatment Facility (also known as the ModuTanks™).

- Personal protective equipment (PPE) and small-volume miscellaneous wastes (e.g., gloves and wipes) should be designated based on the results from the soil samples collected from the unsaturated and saturated soil cuttings. All PPE that has come into contact with saturated soil cuttings (perched water and groundwater) shall assume all of the listed waste codes that apply to the groundwater.

- The types of waste material that are expected to result from drilling and sampling operations include soil cuttings, well development water, and PPE.

1.3 PROJECT ISSUES

1.3.1 Global Issues

No global issues resulted from decision-maker interviews.

1.3.2 Task-Specific Technical Issues and Resolutions

No task-specific technical issues were identified.

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1.4 EXISTING REFERENCES

Table 1-1 presents a list of all of the references that were reviewed as part of the scoping process, as well as a summary of the pertinent information contained within each reference. These references are the primary source for the background information presented in Section 1.5.

Table 1-1. Existing References. (4 Pages)

Reference	Summary
200-ZP-1 Groundwater Sampling and Analysis Plan/Quality Assurance Plan, BHI-00038, Rev. 1 (BHI 1995)	Presents the 1995 perimeter of the carbon tetrachloride plume in the vicinity of the 200-ZP-1 OU and identifies the wells that will be sampled for remedial action assessment and to track the plume periphery. Identifies the sampling frequency, analyses to be performed, and the list of wells from which groundwater level measurements will be collected.
200-ZP-1 IRM Phase II and III Remedial Design Report, DOE/RL-96-07, Rev. 0 (DOE-RL 1996)	Identifies the water-level monitoring network and groundwater sampling network used to monitor groundwater conditions in the vicinity of 200-ZP-1 OU. Some of the wells listed for monitoring differ from those identified in the *200-ZP-1 Groundwater Sampling and Analysis Plan/Quality Assurance Plan* (BHI 1995) because the shape of the carbon tetrachloride plume has changed over time, new wells were installed, etc. Provides computer simulation results.
Hanford Site Groundwater Monitoring for Fiscal Year 2000, PNNL-13404 (PNNL 2001)	Presents groundwater contours and perimeters of the carbon tetrachloride, chloroform, and trichloroethylene (TCE) plumes in the vicinity of 200-ZP-1 OU. Provides maps showing the location of sampled groundwater wells, and identifies the frequency at which wells are sampled, depth of well screens, etc.
Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations, DOE/RL-2000-71, Rev. 0 (DOE-RL 2001)	Summarizes the performance of the groundwater treatment system in FY 2000 and discusses the changes that have been observed in the plume shape and concentration during this reporting period. In summary, contaminants from the high concentration area have been contained; contaminant mass was removed from the high concentration portion of the aquifer; and increasing or high concentrations in the three northernmost extraction wells and in nearby monitoring wells indicate that additional dissolved mass is moving toward the pumping centers, away from the center of the plume.
Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium Plumes in the 200 West Area: 1994 through 1999 Update, BHI-01311, Rev. 0 (BHI 1999)	Discusses the updated hydrogeologic conceptual model for the carbon tetrachloride groundwater plume. Presents alternative hypotheses regarding the source of the contamination underlying PFP.
200 Areas Remedial Investigation/ Feasibility Study Implementation Plan – Environmental Restoration Program, DOE/RL-98-28, Rev. 0 (DOE-RL 1999)	Provides background geography, process, waste site, and COC knowledge, and strategy for the 200 Areas.
200 Areas Waste Sites Handbook, 3 vols., RHO-CD-673 (Maxfield 1979)	Includes waste site descriptions, releases, waste discharge information, and management reports.

Table 1-1. Existing References. (4 Pages)

Reference	Summary
Site Evaluation, in Expedited Response Action Proposal (EE/CA & EA) for 200 West Area Carbon Tetrachloride Plume, Appendix B, DOE/RL-91-32, Draft B (DOE-RL 1991)	Provides data summaries and analytical results from limited field investigations conducted at 216-Z-1A and 216-Z-9. Environmental setting information, COPC and COC information, and carbon tetrachloride information.
1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford, WHC-SD-EN-TI-248, Rev. 0 (Rohay et al. 1994)	Provides data summaries and analytical results from limited field investigations conducted at 216-Z-1A and 216-Z-9. Geological information, COPC and COC information, and carbon tetrachloride information.
Hanford Site Atlas, BHI-01119, Rev. 1 (BHI 1998b)	Provides maps of the Hanford Site.
WIDS reports for 200-PW-1 OU waste sites: 216-T-19 Crib, 216-Z-1&2 Cribs, 216-Z-1A Tile Field, 216-Z-3 Crib, 216-Z-9 Trench, 216-Z-12 Crib, 216-Z-18 Crib, 241-Z-361 settling tank, UPR-200-W-103, UPR-200-W-110	Summarizes site names, locations, types, status, site and process descriptions, associated structures, cleanup activities, environmental monitoring description, access requirements, references, regulatory information, and waste information (e.g., type, category, physical state, description, and stabilizing activities).
Performance Evaluation Report for Soil Vapor Extraction Operations at the Carbon Tetrachloride Site, February 1992-September 1999, BHI-00720, Rev. 4 (Rohay 2000)	Provides data summarizing and updating results of limited field investigations and vadose zone remediation for carbon tetrachloride and selected VOAs at 216-Z-9, 216-Z-1A, 216-Z-12, and 216-Z-18.
Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997, BHI-01105, Rev. 0 (Rohay 1997)	Provides data on the in situ soil vapor samples collected during drilling and on soil vapor concentrations at 216-Z-9, 216-Z-1A, and 216-Z-18.
FY 1993 Wellfield Enhancement Status Report and Data Package for the 200 West Area Carbon Tetrachloride Expedited Response Action, BHI-00105, Rev. 00, Appendix B (Rohay 1995)	Provides data on the in situ soil and soil vapor samples collected during drilling and on soil vapor concentrations at 216-Z-9, 216-Z-1A, and 216-Z-18.
FY93 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site, WHC-SD-EN-TI-202, Rev. 0, Appendix E (Rohay et al. 1993)	Provides data on the in situ soil and soil vapor samples collected during drilling and on soil vapor concentrations at 216-Z-9, 216-Z-1A, and 216-Z-18.
FY92 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site, WHC-SD-EN-TI-063, Rev. 0 (Rohay et. al 1992)	Provides data on the in situ soil and soil vapor samples collected during drilling and on soil vapor concentrations at 216-Z-9, 216-Z-1A, and 216-Z-18.

Table 1-1. Existing References. (4 Pages)

Reference	Summary
Submittal of Documentation in Fulfillment of Milestone M-15-37B, letter FH-000279, dated June 15, 2000 (FH 2000)	Contains information on COCs.
DNAPL Investigation Report, BHI-00431, Rev. 0 (Parker 1995)	Contains geological information.
241-Z-361 Sludge Characterization Data Quality Objectives, HNF-4225, Rev. 0 (LMHC 1999)	Contains historical waste site and COC disposal information for 241-Z-361 tank.
216-Z-12 Transuranic Crib Characterization: Operational History and Distribution of Plutonium and Americium, RHO-ST-44 (Kasper 1982)	Contains historical waste site, operational, geological, and COC disposal information.
Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report, RHO-ST-17 (Price et al. 1979)	Provides data summaries and analytical results from limited field investigations at 216-Z-1A. Contains geological, COPC, and COC information.
Report on Plutonium Mining Activities at 216-Z-9 Enclosed Trench, RHO-ST-21 (Ludowise 1978)	Provides data summaries and analytical results of plutonium inventories before and after removal at 216-Z-9. Provides logistical data of mining activities and current condition of the trench.
Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915 (Smith 1973)	Provides data summaries and analytical results of plutonium inventories at 216-Z-9 before removal.
Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites, BHI-01477 (Bauer and Yates 2001)	Provides information on COCs.
Well Deepening and Supplemental Vadose Zone Characterization at the Hanford 200 West Area 216-Z-9 Trench, BHI-01462, Rev. 0 (Miller 2001)	Provides information on COCs.
Z Plant Liquid Waste Disposal Through the 241-Z Vault, ARH-CD-323 (ARH 1976)	Contains historical waste site, operational, geological, and COC disposal information.
Hanford Sitewide Groundwater Remediation Strategy, DOE/RL-94-95, Rev. 1 (DOE-RL 1997a)	Contains groundwater and geological information.
History and Stabilization of the Plutonium Finishing Plant (PFP) Complex, Hanford Site, HNF-EP-0924 (Gerber 1997)	Contains historical account of process operations information for Z Plant and ancillary facilities, and feed process modifications at REDOX, PUREX, and T and B Plants. Discusses trouble encountered, solutions implemented, chemicals used, an overview of each processes' daily activities, building construction, functions, maintenance, and sampling, laboratory, and disposal activities.

Table 1-1. Existing References. (4 Pages)

Reference	Summary
200 Areas Disposal Sites for Radioactive Liquid Wastes, ARH-947 (Curren 1972)	Contains waste site and COC information.
Radionuclide Inventories of Liquid Waste Disposal Sites on the Hanford Site, HNF-1744 (FH 1999)	Contains waste site and COC information.
Waste Site Grouping for 200 Areas Soil Investigations, DOE/RL-96-81, Rev. 0 (DOE-RL 1997b)	Summarizes site name, location, type status, site and process descriptions, known and suspected contamination, preliminary contaminant distribution conceptual model, site conditions that may affect COC fate and transport, COC mobility in Hanford Site soils, COC distribution and transport to groundwater, and hazards associated with COCs. Contains soil porosity information for each waste site.
Z Plant Source Aggregate Area Management Study Report, DOE/RL-91-58, Rev. 0 (DOE-RL 1992)	Contains soil and geological information, COPC information, process history, and geophysical logging.
Final Report for the Remote CCTV Survey of Abandoned Process Effluent Drain Lines 840 and 840D in Support of the 200 West Area Carbon Tetrachloride ERA, WHC-SD-NR-ER-103, Rev. 0 (Pedersen 1993)	Contains information on camera inspection of buried effluent lines.
Plutonium Finishing Plant Wastewater Stream-Specific Report, WHC-EP-0342, Addendum 8 (Jensen 1990)	Summarizes process knowledge for PFP, sampling data for 1990 effluent stream to 216-Z-20, and COC information.
The 216-Z-8 French Drain Characterization Study, RHO-RE-EV-46 P (Marratt et al. 1984)	Contains historical waste site, operational, geological, and COC disposal information.
HEIS database	Contains well information and sampling data.
Listed Waste History at Hanford Facility TSD Units, WHC-MR-0517 (WHC 1996)	Document reviewed to assess the potential for encountering listed wastes.
Application of Listed Waste Codes to Secondary Solid Wastes Related to Well Construction, Maintenance, and Sampling, CCN 081034, interoffice memorandum to distribution, dated August 1, 2000 (Borghese 2000)	Document reviewed to assess the potential for encountering listed wastes.

COPC = contaminant of potential concern
FY = fiscal year
HEIS = Hanford Environmental Information System
PUREX = Plutonium-Uranium Extraction (Facility)
REDOX = Reduction-Oxidation (Facility)
VOA = volatile organic analyte
WIDS = Waste Information Data System

1.5 SITE BACKGROUND INFORMATION

1.5.1 Carbon Tetrachloride Source Term and Remediation Overview

The primary known sources of carbon tetrachloride contamination in the 200 West Area are the subsurface infiltration facilities used for soil column disposal of aqueous and organic liquid wastes associated with plutonium recovery operations within the PFP complex. Between 1955 and 1973, a total of 363,00 to 580,000 L (577,000 to 922,000 kg) of liquid carbon tetrachloride (in mixtures with other organic and aqueous actinide-bearing liquids) are estimated to have been discharged to the soil column at three subsurface disposal facilities near the PFP: the 216-Z-9 Trench, the 216-Z-1A Tile Field, and the 216-Z-18 Crib. The 216-Z-12 Crib is also estimated to have received a small volume of organics, which included carbon tetrachloride (Kasper 1982).

The organic solutions consisted of 50% to 85% by volume carbon tetrachloride mixed with tributyl phosphate (TBP), dibutyl butyl phosphonate (DBBP), or lard oil (DOE-RL 1991). The solvent that was discharged to the soil column also contained dibutyl phosphate (DBP), which is a degradation product of TBP. The organic solutions were periodically discharged to the predominantly water-wetted soil column in small (100- to 200-L) batches.

These organic solutions were approximately 4% to 8% of the total volume of liquid waste discharged to the disposal facilities. From 1955 to 1973, approximately 13.2 million L of aqueous wastewater were discharged to the three primary disposal sites. The aqueous stream consisted of acidic, high-salt (sodium nitrate) wastewater containing these organic solutions in saturated amounts (<1%). Thus, carbon tetrachloride was introduced to the vadose zone as an aqueous phase and as a dense, non-aqueous phase liquid (DNAPL) (Rohay 2000).

A CERCLA expedited response action was implemented in 1992 to remediate carbon tetrachloride in the vadose zone near these known sources (EPA and Ecology 1992). Soil vapor extraction was selected as the preferred remedial alternative. Between 1991 (when the pilot test was conducted) and September 1999, SVE operations removed 76,460 kg of carbon tetrachloride from the vadose zone.

The dissolved carbon tetrachloride groundwater plume, as defined by the 5-µg/L contour, extends over 11 km^2 (4.4 mi^2) and underlies most of the 200 West Area. In 1995, an interim action Record of Decision (ROD) was issued for the dissolved groundwater plume (EPA et al. 1995). The selected remedy was to use groundwater pump-and-treat technology to stabilize and reduce contaminant mass in the highest concentration portion of the carbon tetrachloride plume, as defined by the 2,000-µg/L contour. The PFP complex overlies the groundwater within the 2,000-µg/L and higher contours.

Pump-and-treat operations commenced in August 1996 in accordance with the 1995 interim action ROD. The 200-ZP-1 pump-and-treat system is currently composed of five extraction wells located to the north and east of the PFP and five injection wells located southwest of the PFP. Thus, the PFP overlies groundwater that is upgradient of the groundwater pump-and-treat

extraction wells. Co-contaminants in the groundwater include chloroform, trichloroethylene (TCE), nitrate, and possibly technetium-99 and tritium.

Between 1996 and 2000, carbon tetrachloride concentrations increased at the three northernmost extraction wells, indicating that the high concentrations were being pulled toward the pumping centers. Evaluation of data from nearby groundwater monitoring wells and analysis of hydraulic capture indicated that the high concentrations were being pulled from the area underlying the PFP complex. Between August 1994 (when the pilot test was conducted) and September 2000, the pump-and-treat system removed approximately 4,570 kg of carbon tetrachloride from the unconfined aquifer (DOE-RL 2001). The mass removed is 72% to 215% of the mass initially estimated to be contained within the 2,000-μg/L contour (DOE-RL 1991). The persistence of the carbon tetrachloride concentrations implies that the initial mass calculation was incorrect (e.g., because of greater depth distribution), and/or the reversible sorption to soils (the distribution coefficient [K_d]) is greater than assumed, and/or a continuing source of carbon tetrachloride is present in the vadose zone or groundwater (residual or DNAPL) (BHI 1999).

Determining if there are continuing sources of carbon tetrachloride groundwater contamination is needed as input to remedial decisions. Continuing sources in the vadose zone would need to be remediated prior to reaching final decisions on groundwater remediation. Continuing sources in the aquifer could affect selection of remedial alternatives for groundwater remediation.

Carbon tetrachloride concentration data are not available for the groundwater underlying the PFP complex because of the lack of groundwater wells in this area.

1.5.2 Sources of Potential Contamination in the Vicinity of the Proposed Well Location

The proposed well location is east of the PFP, near (but no closer than 3 m [10 ft] from) the below-grade PFP effluent discharge lines to the 216-Z-9 Trench. Lines 840 and 840D discharged process waste from the Recuplex plutonium recovery process (which operated in the 234-5Z Building of the PFP) into the 216-Z-9 Trench from 1955 until 1962. Waste generated by the Recuplex process included hydroiodic, hydrofluoric, sulfuric, and nitric acids; silver, plutonium, and other transuranic metals; and organic liquids (Bauer and Yates 2001).

The 216-Z-9 effluent lines run essentially parallel to one another through their entire length of approximately 213 m (700 ft). The lines are made up of 6-m (20-ft) lengths of 3.8-cm (1.5-in.)-diameter, Schedule-40 type, 304L stainless-steel piping. The construction drawings for the lines indicate that the required minimum depth of burial was 2 m (6 ft). Due to the surface contours in the vicinity, the depth of burial is likely to vary from 2 to 3 m (6 to 10 ft) along the piping route (Pedersen 1993). Based on the ground-penetrating radar survey conducted in May 2001 in preparation for drilling, the pipelines are approximately 2.2 m (7 ft) bgs.

A camera survey was conducted in 1993 to examine the pipelines for evidence of major leaks (Pedersen 1993). The camera survey was conducted from the basement of the 234-5Z Building, at the east end of tunnel #6. Prior to removing a section from each line to allow access, a small hole was drilled in each line and the atmosphere in the lines was sampled for residual carbon tetrachloride vapors and explosive gases. The test results were negative. The zero location for

the camera surveys was in the 234-5Z Building. The exterior of the building was approximately 69 cm (27 in.) from the zero location.

The camera survey for line 840D extended for 106 m (347.9 ft) east of the access point in the 234-5Z Building basement, or approximately one-half of its length. The survey in line 840 only extended for 19 m (63 ft) east of the access point and, thus, did not reach the proposed location for the well. The survey of line 840 ended when the camera lens became obscured by sludge in the pipeline. The camera was withdrawn, and a radiation survey detected 2.5 million disintegrations per minute (dpm) alpha on the camera.

Based on the camera survey, no pipe breaks or major cracks were detected in line 840 or 840D; however, both lines exhibited areas of severe pitting and corrosion throughout the lengths examined. Line 840 appeared to be in the more deteriorated condition of the two pipes. Numerous pits were evident with apparent significant depth; however, it could not be determined if any of the pitting was through the wall (Pedersen 1993). For the purpose of this DQO process, it is assumed that leakage has occurred from these lines, resulting in the spread of contaminants into the soils surrounding and beneath the pipelines. Therefore, the waste designation portion of this DQO summary report addresses all of the potential COCs for the processes represented by those pipelines.

The two 3.8-cm (1.5-in.)-diameter stainless-steel effluent lines that carried waste from the 234-5Z Building to the 241-Z-8 settling tank run parallel to the 216-Z-9 effluent lines in the vicinity of the proposed well location (Marratt et al. 1984). The 241-Z-8 settling tank (silica storage tank) was used from 1955 to 1962 and is approximately 55 m (180.5 ft) east of the proposed well. The tank is 6 m (20 ft) west of the 216-Z-8 french drain used for discharge of the tank overflow to the ground. Contaminants in the waste conveyed by the 216-Z-8 effluent lines included calcium, iodine, magnesium, silica, nitrate/nitric acid, aluminum, fluoride, plutonium, americium, and fission products (Marratt et al. 1984, Waste Information Data System [WIDS], Maxfield 1979, DOE-RL 1992).

The 2607-Z septic tank and drain field, located at its nearest point approximately 50 m (164.1 ft) southeast of the proposed well location, operated from 1949 to approximately 1999. The unit received sanitary wastewater and septic waste from the 234-5Z and 2704-Z Buildings at a nominal rate of 23,000 L (6,000 gal) per day (DOE-RL 1992). It was estimated in 1991 to be receiving approximately 38,000 L (10,000 gal) of wastewater per day (25 gal/day/person times 400 PFP employees in 1991) (DOE-RL 1991). The septic tank is located approximately 33.6 m (110 ft) east of the 236-Z Building. The drain field is located 18.6 m (61 ft) east of the septic tank.

The 2607-Z septic tank is an 11-m by 3.4-m by 7-m (36-ft by 11-ft by 23-ft)-deep concrete box with a 95,000-L (25,000-gal)-capacity, two-chamber tank (DOE-RL 1992). The entire septic tank capacity would be released at one time when the dosing siphon was triggered. Using the above estimate, the tank would have been emptied every 3 to 4 days. The septic tank was designed to feed 36 rows of 15-cm (6-in.) drain tile, spaced at 2.4-m (8-ft) intervals, and running east-west in the drain field. The drain field lies in a gravel bed that extends a minimum of 46 cm (18 in.) below the drain pipe (DOE-RL 1992). However, the pipeline from the septic tank to the

drain field was reportedly corroded away when it was recently excavated. The septic tank and drain field were replaced in approximately 1999 by a sewer line. The new sewer line may be near the proposed well location. No radionuclides or hazardous chemicals have been associated with this unit (DOE-RL 1992).

Raw, sanitary, and fire water lines are buried in close proximity to the proposed well location. A manhole is located approximately 6 m (19.7 ft) east of the proposed well location.

The effluent line that conveyed wastewater from the 231-Z Building to the 216-Z-20 Trench is near the proposed well location. Since 1985, the routine effluents have been from cooling water and condensation from heating, ventilation, and air conditioning (HVAC) equipment and air compressors. Prior to 1985, the cells in 231-Z Building were used for processing radioactive materials (Jensen 1990).

In 1964, a rapid reaction occurred in a hood in Room 149 of the analytical laboratory when a package of unoxidized plutonium metal chips was added to a laboratory dissolver. Some of the contamination was released through gravity vents to the 234-5Z Building's roof and the surrounding ground area (Gerber 1997). The plutonium (estimated to be 0.01 g) was deposited over a 0.8- to 1.2-hectare (2- to 3-acre) area. The plutonium was subsequently flushed into the soil using water from fire hoses.

The chemical storage facility is located approximately 20 m (65.6 ft) southwest of the proposed well location. The facility includes large tanks that held nitric acid, aluminum nitrate nonahydrate (ANN), and sodium hydroxide. The tanks were reportedly filled by tanker truck. In approximately 1985, a spill occurred involving nitric acid at the transfer pump. Former PFP workers interviewed about this facility did not recall any catastrophic failures of the tanks. The sodium hydroxide tank is currently empty. The lines from this tank run underground to the south to the Plutonium Reclamation Facility (PRF). The lines to the nitric acid and ANN tanks are above ground and were back-drained before the tanks were emptied. The nitric acid tank has been emptied and flushed out. The ANN tank was drained 5 or 6 years ago; however, it is assumed that 2.5 cm (1 in.) of liquid or cake may remain in the bottom of this tank.

It is believed that the carbon tetrachloride was contained in drums and delivered to the 234-5Z Building by truck. The drums were stored on the loading dock and on the ground surface south of the chemical storage facility until the drums were transported into the plant's chemical makeup room. At the PRF, the drums were carried on an elevator to the chemical makeup room on the fourth floor. It is believed that one drum of carbon tetrachloride was spilled in the elevator or at some time during the process of transferring it into the elevator. It is not known if any drums of carbon tetrachloride leaked while being stored outside the building. It is also believed that the empty drums were recycled by being returned on trucks to the stores. Other chemicals may also have been stored in this location.

At the end of PRF operations in December 1987, all carbon tetrachloride was removed from the facility and disposed in accordance with regulations by being placed in polyethylene bottles, surrounded by absorbent, and over-packed in hazardous waste drums for shipment to the central

hazardous waste storage facility. Removal of carbon tetrachloride was completed in January 1988 (Jensen 1990).

In approximately 1989, a tank was added to the chemical storage facility to store carbon tetrachloride for use in a new campaign. Carbon tetrachloride was added to the tank (presumably from a tanker truck). The tank leaked several hundred gallons of carbon tetrachloride to a double-contained basin. The tank was drained thoroughly and taken out of service in approximately 1990. The carbon tetrachloride from the tank and from the basin was pumped into drums, which were shipped from the PFP complex in approximately 1991.

Since 1989, there has not been a single unusual occurrence report documenting personnel contamination on the ground or in a dig area for people working east of the 234-5ZA change room (i.e., in the proposed location for the well).

The proposed well location is approximately 6 m (20 ft) north of the northern edge of a concrete pad with two storage buildings. The northern building is the PFP temporary hazardous waste storage building and the southern building is the chemical storage building. Both buildings have sump containment so any spills will not enter the soil column.

Photographs of the PFP building taken during construction in 1948 suggest that construction materials may have been staged near the proposed well location (Gerber 1997). A review of PFP photographs indicates that no permanent structures have been located at the proposed well location, and only gravel and construction materials have been noted to be present (i.e., no drums are present). It is believed that nothing has been buried at this location.

A sterilant herbicide is applied annually to the gravel area at the proposed drilling location. The herbicide in use now is Krovar and the active ingredients are diuran and bromocil. The herbicide provides blanket coverage over the gravel. In the sandy near-surface materials at PFP, Krovar typically lasts 10 to 11 months, after which it is degraded by microbes. The last application was in the fall of 1999, and reapplication is not scheduled until October or November 2001. Weeds are treated by incidental spot treatment using a non-selective herbicide (active ingredient glyphosate), 2-4D, or dicamba. Pesticides are typically only used in close proximity to a building when a problem is noted. Pesticides would not be routinely applied around the storage buildings on the concrete pad by the proposed drilling location because employees do not inhabit those buildings.

An alternate location for the well was selected in the event that subsurface access at the preferred location was not feasible. The alternate well location is approximately 22.9 m (75 ft) south of the preferred location, which is on the southern side of the concrete pad with the two storage buildings.

1.5.3 Carbon Tetrachloride Vapor Concentrations

The proposed well location is approximately 180 m (591 ft) west-northwest of the 216-Z-9 Trench. Carbon tetrachloride vapor concentrations have been measured at 17 different positions in the vadose zone between the trench and the proposed well location since November

1996, when operation of the SVE system changed from continuous to noncontinuous. The vapor samples are collected from soil vapor probes that range in depth from 3 to 36 m (10 to 118 ft) bgs (above the low-permeability Plio-Pleistocene layer). The lateral distance from the trench to the 17 probes ranges from 35 to 220 m (11 to 722 ft). At locations that appear to lie beyond the radius of influence of the vapor extraction system, measured carbon tetrachloride concentrations range from 3 to 280 parts per million by volume (ppmv). Assuming that the source of this carbon tetrachloride vapor is the 216-Z-9 Trench, then concentrations within this range that are encountered during drilling above the Plio-Pleistocene layer may not be indicative of an additional vadose zone source.

1.6 DATA QUALITY OBJECTIVE TEAM MEMBERS AND KEY DECISION MAKERS

Individual members of the DQO team were carefully selected to participate in the seven-step DQO process based on their technical background to provide expertise in all of the technical areas needed to meet the task objectives. Although decision makers were not formally interviewed as part of this DQO, their concerns expressed during earlier 200-ZP-1 DQO interviews have been addressed.

Tables 1-2 and 1-3 identify each of the individual members of the DQO team and the key decision makers, respectively. These tables also identify the organization and technical area of expertise that each DQO team member or key decision maker represents.

Table 1-2. DQO Team Members. (2 Pages)

Name	Organization	Role and Responsibility
Mark Byrnes	BHI	DQO Facilitator
Russ Fabre	BHI	Field Implementation
Greg Gibbons	BHI	Radiation Control
Greg Hopkins	BHI	Waste Management
Chris Kemp	BHI	Environmental Lead
Chuck Miller	CHI	Soil Scientist
Virginia Rohay	CHI	Hydrogeologist
Cliff St. John	BHI	Industrial Hygiene
Dave St. John	CHI	Analytical Field Services
Craig Swanson	CHI	Hydrogeologist

Table 1-2. DQO Team Members. (2 Pages)

Name	Organization	Role and Responsibility
Wendy Thompson	BHI	Site Investigations
Richard Weiss	CHI	Radiochemical and Analytical, Data Management
Joan Woolard	BHI	Regulatory Support
Michelle Yates	CHI	Process History/COPCs/COCs

BHI = Bechtel Hanford, Inc.
CHI = CH2M Hill Hanford, Inc.

Table 1-3. DQO Key Decision Makers.

Name	Organization	Role and Responsibility
Arlene Tortoso	RL	Decision maker
Dennis Faulk	EPA	Decision maker

RL = U.S. Department of Energy, Richland Operations Office

1.7 PROJECT BUDGET AND CONTRACTUAL VEHICLES

Table 1-4 presents the budget for all of the task activities associated with the development and implementation of the sampling program, the performance of laboratory analyses, the performance of the data quality assessment, and the evaluation and reporting of investigation results. For the activities that need to be subcontracted, Table 1-4 presents the available contractual vehicles.

Table 1-4. Task Budget and Contractual Vehicles.

Task Activities	Budget	Contractual Vehicle
DQO workbook development	$15,000	N/A
Sampling and analysis plan development	$18,000	N/A
Field implementation	$407,000	N/A
Laboratory analyses	$40,000	N/A
Data quality assessment	$500	N/A
Documentation of investigation results	$3,000	N/A

N/A = not applicable

1.8 MILESTONE DATES

Table 1-5 presents the schedule for the completion of the task activities associated with the development and implementation of the sampling program, the performance of laboratory analyses, the performance of a data quality assessment, and the evaluation and reporting of investigation results.

Table 1-5. Milestone Dates.

Task Activities	Milestone Completion Date
DQO workbook development	August 17, 2001
Sampling and analysis plan development	August 17, 2001
Field implementation	October 31, 2001
Laboratory analyses	FY 2002
Data quality assessment	FY 2002
Documentation of investigation results	FY 2002

1.9 CONTAMINANTS OF CONCERN

A list of the COCs for the site under investigation was generated by initially listing all of the contaminants of potential concern (COPCs) based on historical process operations. Certain COPCs were then removed from the list if they have a short half-life, are not regulated, pose no risk, are non-toxic, or if process knowledge/analytical data confirm that insignificant releases have occurred.

1.9.1 Total List of Contaminants of Potential Concern

Table 1-6 identifies all of the COPCs for each type of media that will be encountered during installation of the well near the PFP. As discussed in Section 1.5.2, this DQO process assumes that leakage has occurred from the two pipelines near the new well to be drilled. Consequently, the waste designation portion of this DQO summary report addresses all of the potential COCs that were discharged through those pipelines.

1.9.2 Contaminant of Potential Concern Exclusions

The first step in the evaluation process involved extracting known toxic materials from the master COPC list for placement on the final COC list. Inorganic salts and acids represent a large group of constituents that may be present at the site. Because laboratory analyses are generally not acid- or compound-specific, the acids and inorganic salts were excluded from further consideration. Instead, the readily detected cations and anions (e.g., metals, fluorides, and nitrates) associated with the acids and inorganic salts serve as the target constituents for those compounds. This logic recognizes the small volumes of wastes released into large-volume aqueous discharges.

Table 1-6. Total List of COPCs for Each Media Type. (4 Pages)

Media	Known or Suspected Source of Contamination	Type of Contamination (General)	COPCs (Specific)
Groundwater	The primary sources of volatile organic contamination include 216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18. The effluent pipes leading from the PFP to these discharge cribs are suspected sources. An additional relatively minor source of chloroform is discharge of chlorinated potable water to ground.	Organics	Carbon tetrachloride, chloroform, methylene chloride, trichloroethylene (TCE), tetrachloroethylene (PCE), tributyl phosphate (TBP) Listed waste: F001: 1,1,1-trichloroethane (TCA) and carbon tetrachloride F002: methylene chloride F003: acetone, methyl isobutyl ketone (MIBK) F004: o-cresol, p-cresol, and cresylic acid F005: methyl ethyl ketone (MEK)
	The sources of nitrate include 216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18. The effluent pipes leading from the PFP to these discharge cribs are suspected sources. There is likely some small contribution from the agriculture discharges upgradient from the Hanford Site.	Inorganics	Carbonate, chloride, fluoride, nitrate, nitrite, phosphate, sulfate Cadmium, calcium, chromium, iron, magnesium, nickel, phosphorus, sodium, zinc
	One primary source of radionuclides may be the 216-Z-9 Trench. The effluent pipes leading from the PFP to this discharge crib are suspected sources. Tc-99 and tritium have been detected in groundwater extracted by 200-ZP-1 pump-and-treat operations.	Radionuclides	Tc-99, H-3 (tritium), gross alpha, gross beta, Co-60, Ru-106, Sb-125, Cs-137, uranium isotopes, Sr-90, Am-241, Np-237, plutonium isotopes
	N/A	Physical properties	pH, temperature, specific conductivity, alkalinity, turbidity, dissolved oxygen, total inorganic carbon, total organic carbon

Table 1-6. Total List of COPCs for Each Media Type. (4 Pages)

Media	Known or Suspected Source of Contamination	Type of Contamination (General)	COPCs (Specific)
Soil (drill cuttings)	The suspected sources of organic constituents include the effluent pipes carrying liquid wastes to the 216-Z-9 disposal facility. These effluent lines are in close proximity to the proposed well.	Organics	1,1-dichloroethane (DCA), 1,2-dichloroethane (DCA), 1,1,1-trichloroethane (TCA), acetone, benzene, carbon tetrachloride, cis-1,2-dichloroethylene (DCE), chlorobenzene, chloroform, cutting oils (lard oil), dibutyl butyl phosphonate (DBBP), dibutyl phosphate (DBP), ethylbenzene, hydraulic fluids (greases), hydroxylamine, hydroxylamine hydrochloride, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), methylene chloride, monobutyl phosphate, n-butyl benzene, normal paraffins, oxalic acid, phenol, toluene, tetrachloroethylene (PCE), trans-1,2-dichloroethylene (DCE), tributyl phosphate (TBP), trichloroethylene (TCE), xylene
	The suspected sources of inorganic constituents include the effluent pipes carrying liquid wastes to the 216-Z-9 disposal facility. These effluent lines are in close proximity to the proposed well.	Inorganics	Aluminum, aluminum fluoride, aluminum nitrate, aluminum nitrate (mono basic), aluminum sulfate, ammonia, ammonium hydroxide, ammonium lanthanum nitrate, ammonium oxalate, ammonium fluorosilicate, ammonium sulfate, arsenic nitrate, bismuth, cadmium nitrate, calcium, calcium carbonate (lime), calcium iodide, calcium fluoride, calcium nitrate, chloride, chromium, copper nitrate, ferric/ferrous sulfate, fluoride, gallium oxide, hydrochloric acid, hydrofluoric acid, hydroiodic acid, hydrogen, hydrogen peroxide, hydroxide, iron, lanthanum, lanthanum fluoride, lanthanum hydroxide, lanthanum nitrate, lithium chloride, magnesium, magnesium oxide, mercury, nickel, nitrate, nitric acid, peroxide, phosphate, phosphoric acid, plutonium, plutonium fluoride, plutonium dioxide, plutonium nitrate, plutonium peroxide, potassium permanganate, selenium, silver, sodium, sodium aluminate, sodium bicarbonate, sodium carbonate, sodium chloride, sodium fluoride, sodium hydroxide, sodium nitrate, sodium oxalate, sodium sulfate, sulfate, sulfuric acid, uranium, uranium dioxide, uranium trioxide, uranyl nitrate

Table 1-6. Total List of COPCs for Each Media Type. (4 Pages)

Media	Known or Suspected Source of Contamination	Type of Contamination (General)	COPCs (Specific)
	The suspected sources of radionuclides include the effluent pipes carrying liquid wastes to the 216-Z-9 disposal facility. These effluent lines are in close proximity to the proposed well.	Radionuclides	Am-241, Am-242, Am-243, Sb-123, Sb-125, Ce-141, Ce-144, Cs-134, Cs-135, Cs-137, Co-60, Cm-242, Cm-243, Cm-244, Cm-245, La-140, Pb-212, Pb-214, Np-237, Np-239, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Pa-233, Ra-224, Ra-226, Ra-228, Ru-103, Ru-106, Sr-89, Sr-90, Tc-99, Th-232, tritium, U-232, U-233, U-234, U-235, U-236, U-238
	The suspected sources of PCBs include the effluent pipes carrying liquid wastes to the 216-Z-9 disposal facility. These effluent lines are in close proximity to the proposed well.	PCBs	PCBs
	The suspected source of asbestos is the construction materials used to build the PFP.	Asbestos	Asbestos
	The suspected source of pesticides and herbicides is periodic application to the site for pest and weed control.	Pesticides/ herbicides	Pesticides: heptachlor epoxide, endosulfan sulfate, aldrin, alpha-BHC, beta-BHC, endosulfan II, 4,4'-DDT, alpha-chlordane, gamma-chlordane, dieldrin, endrin, methoxychlor, 4,4'-DDD, 4,4'-DDE, endrin aldehyde, heptachlor, toxaphene, endosulfan Herbicides: 2,4-D, 2,4,5-TP (silvex)
	Assessment of the drill cuttings for characteristic waste compounds is required to properly disposition the waste.	Characteristic waste (ignitability, corrosivity, reactivity, toxicity)	Toxicity characteristic metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver), organic compounds, pH, sulfide, cyanide, flash point
	N/A	Physical properties	Moisture content, particle size distribution, bulk density, total organic carbon, total inorganic carbon, pH, lithology

Table 1-6. Total List of COPCs for Each Media Type. (4 Pages)

Media	Known or Suspected Source of Contamination	Type of Contamination (General)	COPCs (Specific)
Soil vapor	The primary sources of volatile organic contamination include 216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18. The effluent pipes leading from the PFP to these discharge cribs are suspected sources. An additional relatively minor source of chloroform is the discharge of chlorinated potable water to the ground. The sanitary tile field may be a source of methane and carbon dioxide.	Volatile contaminants	Carbon tetrachloride, chloroform, methylene chloride, methyl ethyl ketone (MEK), methane
Aquifer	N/A	Hydraulic properties	Water production (flow rate) of well, water level (drawdown) changes, pumping performance capability

N/A = not applicable
PCB = polychlorinated biphenyl

The analytical approach employed for this project generally targets the significant risk drivers that are representative of the waste constituents present. The general suite-type analytical techniques yield results on many metals and organic compounds, providing a cost-effective approach for the known toxic materials that could be present.

The COPCs in the following categories were dropped from further consideration:

- Short-lived radionuclides with half-lives less than 2 years.
- Radionuclides that constitute less than 1% of the fission product inventory and for which historical sampling indicates nondetection.
- Naturally occurring isotopes that were not created as a result of Hanford Site operations.
- Constituents with atomic mass numbers greater than 242 that represent less than 1% of the actinide activities.
- Progeny radionuclides that build insignificant activities within 50 years and/or for which parent/progeny relationships exist that permit progeny estimation.
- Constituents that would be neutralized and/or decomposed by facility processes.

- Chemicals in a gaseous state that cannot accumulate in soil media. Although these COPCs were dropped from consideration for the purpose of waste designation of the soil/drill cuttings, they were retained for the purpose of environmental investigation of in situ soil vapor samples.

- Chemicals used in minor quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or high concentrations.

- Chemicals that are not persistent in the environment due to biological degradation or other natural mitigating features.

Table 1-7 provides the rationale for each of the COPCs that have been excluded from the final list of COCs.

Table 1-7. Rationale for COPC Exclusions. (3 Pages)

COPCs	Rationale for Exclusion
Soil (Drill Cuttings)	
Radionuclides	
Americium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Americium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Antimony-123	Not of concern because it is a stable (nonradioactive) fission product.
Cerium-141	Short-lived radionuclide (half-life <2 years).
Cerium-144	Short-lived radionuclide (half-life <2 years).
Cesium-135	Constituent generated at less than 5E-5 times the Cs-137 activity.
Curium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Curium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Curium-244	Constituent with atomic mass number greater than or equal to 242 that represents less than 1% of the actinide activity. May be reported via americium isotopic analysis.
Curium-245	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Lanthanum-140	Short-lived radionuclide (half-life <2 years).
Lead-212	Short-lived radionuclide (half-life <2 years) (10.6 hours).
Lead-214	Short-lived radionuclide (half-life <2 years) (27 minutes).
Neptunium-239	Short-lived radionuclide (half-life <2 years).

Table 1-7. Rationale for COPC Exclusions. (3 Pages)

COPCs	Rationale for Exclusion
Plutonium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGEN2 modeling of Hanford reactor production).
Protactinium-233	Although Pa-233 was detected during radionuclide system logging performed at boreholes in the representative sites referenced by Price et al. (1979), it is excluded from analysis because it is a daughter product and can be calculated from Np-237.
Radium-224	Excluded from analysis because concentration can be calculated from Th-232 if present.
Radium-226	Excluded from analysis because GEA (gamma spectroscopy) will report if detectable quantities are present.
Radium-228	Excluded from analysis because GEA (gamma spectroscopy) will report if detectable quantities are present.
Ruthenium-103	Short-lived radionuclide (half-life <2 years).
Strontium-89	Short-lived radionuclide (half-life <2 years).
Thorium-232	Excluded based on process knowledge indicating no known processing of thorium-enriched materials within the PFP complex; AEA (alpha spectroscopy) will report if detectable quantities are present.
Uranium-232	<2x 10E-03 times the U-238 activity.
Uranium-233	Measurement cannot resolve U-233 + U-234 isotopes, reported as U-234 or U-233/234.
Uranium-236	Measurement cannot resolve U-235 + U-236 isotopes, reported as U-235.
Inorganics	
Aluminum	This inorganic substance is unlikely to be present in toxic concentrations.
Bismuth	This inorganic substance is unlikely to be present in toxic concentrations.
Copper	This inorganic substance is unlikely to be present in toxic concentrations.
Gallium	This inorganic substance is unlikely to be present in toxic concentrations.
Hydrogen	Gas that cannot accumulate in soil media.
Hydroxide	Excluded form analysis because presence can be assessed via pH determination.
Iodine	This inorganic substance is unlikely to be present in toxic concentrations.
Lanthanum	This inorganic substance is unlikely to be present in toxic concentrations.
Lithium	This inorganic substance is unlikely to be present in toxic concentrations.
Manganese	This inorganic substance is unlikely to be present in toxic concentrations.
Peroxide	Not persistent in the environment due to biological degradation or other natural mitigating features.
Plutonium	Excluded from analysis as an inorganic because plutonium in these inorganic compounds is a radionuclide and will be evaluated by standard radiochemical analysis of plutonium isotopes.
Potassium	This inorganic substance is unlikely to be present in toxic concentrations.

Table 1-7. Rationale for COPC Exclusions. (3 Pages)

COPCs	Rationale for Exclusion
Silicon	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Uranium	Excluded from analysis as an inorganic because uranium in these inorganic compounds is a radionuclide and will be evaluated by standard radiochemical analysis of uranium isotopes.
Organics	
Dibutyl butyl phosphonate (DBBP)	No direct standard analytical procedure available.
Dibutyl phosphate (DBP)	No direct standard analytical technique available.
Hydroxylamine	No direct standard analytical technique available.
Hydroxylamine hydrochloride	No direct standard analytical technique available.
Monobutyl phosphate	No direct standard analytical technique available.
Oxalate	No direct standard analytical technique available.
Other	
Ignitability	The characteristic of ignitability (flash point) is not applicable to soil
Ammonium	These COPCs do not influence the waste disposition decision-making process and, therefore, do not require analysis.
Oxide	This COPC has degraded to oxygen or is present as a salt. This COPC does not influence the waste disposition decision-making process and, therefore, does not require analysis.

AEA = alpha energy analysis
GEA = gamma energy analysis

1.9.3 Final List of Contaminants of Concern

Table 1-8 presents the final list of COCs for each media to be carried through the remainder of the DQO process.

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Soil (Drill Cuttings) and Groundwater	
Radionuclides	
Americium-241	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Antimony-125	Detected in groundwater at 216-Z-9, 216-Z-1A, and 216-Z-18 (Rohay et al. 1994).
Cesium-134	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Cesium-137	Known fission product (GE 1944 [Sections A, B, and C], GE 1951).
Cobalt-60	Known activation product (GE 1944 [Sections A, B, and C], GE 1951, WHC 1991).
Gross alpha	Standard radionuclide analysis for groundwater.
Gross beta	Standard radionuclide analysis for groundwater.
Hydrogen-3 (tritium)	Known fission product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Plutonium-238	Known production from fission reaction (GE 1944, Sections A, B, and C).
Plutonium-239	Known production from fission reaction (GE 1944, Sections A, B, and C).
Plutonium-240	Known production from fission reaction (GE 1944, Sections A, B, and C).
Plutonium-241	Known production from fission reaction (GE 1944, Sections A, B, and C).
Ruthenium-106	Detected in groundwater at 216-Z-9, 216-Z-1A, 216-Z-18 (Rohay et al. 1994).
Strontium-90	Known fission product (GE 1944 [Sections A, B, and C], GE 1951b). Analyzed as total radioactive strontium.
Technetium-99	Known fission product (GE 1944 [Sections A, B, and C], WHC 1991).
Uranium-234	Known feed from fission reaction (GE 1944, Sections A, B, and C).
Uranium-235	Known feed from fission reaction (GE 1944, Sections A, B, and C).
Uranium-238	Known feed from fission reaction (GE 1944, Sections A, B, and C).
Inorganics – Metals	
Arsenic	Metal is analyzed for waste designation purposes.
Barium	Metal is analyzed for waste designation purposes.
Cadmium	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Calcium	Although this COPC does not influence the waste disposition decision-making process, it is retained as a COC for environmental investigations. It was a target metal during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Chromium (total)	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Chromium (VI)	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Iron	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. It was a target metal during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Lead	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Magnesium	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. It was a target metal during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Mercury	Present in analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Nickel	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Phosphorus	Although this COPC does not influence the waste disposition process, it is retained as a COC for environmental investigations.
Selenium	Present in analytical results from sediment samples collected within the 241-Z-361 tank (FH 2000).
Silver	Present in analytical results from sediment samples collected at wells near 200-PW-1 sites (Rohay 1994).
Sodium	Although this COPC does not influence the waste disposition process, it is retained as a COC for environmental investigations.
Zinc	Although this COPC does not influence the waste disposition process, it is retained as a COC for environmental investigations.
General Inorganics	
Ammonia	Chemical historically used at PFP. Chemical is regulated by Washington State.
Carbonate	Although this COPC does not influence the waste disposition process, it is retained as a COC for environmental investigation of calcium carbonate content.
Chloride	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. It was a target anion during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Fluoride	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. It was a target anion during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Sulfate	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. It was a target anion during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Phosphate	Several compounds contained phosphate. The most widely used included TBP and its derivatives and DBBP, which was used Recuplex, PRF, and americium recovery operations (DOE-RL 1991). It was a target anion during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Nitrate/nitrite	Although this COPC do not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. Nitrate is a co-contaminant in groundwater. It was a target anion during environmental investigations at the 216-Z-9, 216-Z-1A, and 216-Z-18 source cribs (Rohay et al. 1994).
Organics – Volatile Organics	
1,1-dichloroethane (DCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
1,2-dichloroethane (DCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
1,1,1-trichloroethane (TCA)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994). Listed waste code "F001" for groundwater.
Acetone	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994). Listed waste code "F003" for groundwater.
Benzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Carbon tetrachloride	Carbon tetrachloride was widely used as a dilutant for TBP and DBBP in the Recuplex, PRF, and americium-241 recovery processes. Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone and has impacted groundwater (Rohay 1994). Carbon tetrachloride has been detected in groundwater in wells surrounding the PFP. Listed waste code "F001" for groundwater.
Cis-1,2-dichloroethylene (DCE)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Chlorobenzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Chloroform	Chloroform is a degradation product of carbon tetrachloride. Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose (Rohay 1994). Chloroform has been detected in groundwater in wells surrounding PFP.
Ethylbenzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Hydraulic fluids (greases)	Several types of hydraulic fluids were used during the milling and cutting of the plutonium buttons and/or rods.
Methyl ethyl ketone (MEK)	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994). Listed waste code "F005" for groundwater.
Methyl isobutyl ketone (MIBK)	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994). Listed waste code "F003" for groundwater.
Methylene chloride	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone (Rohay 1994). Listed waste code "F002" for groundwater.
n-butyl benzene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Toluene	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Tetrachloroethylene (PCE)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Trans-1,2-dichloroethylene (DCE)	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Trichloroethylene (TCE)	Analytical results and measurements have illustrated that this contaminant is prevalent throughout the vadose zone and has impacted groundwater (Rohay 1994).
Xylenes	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
Semi-Volatile Organics	
Normal paraffins (greases and cutting oils, lard oil)	Various types of normal paraffins were used as milling, cutting, and wash solutions during the production of plutonium buttons/rods.
Phenol	Analytical results and measurements have illustrated that this contaminant is found throughout the vadose zone (Rohay 1994).
o-cresol, p-cresol	Listed waste code "F004" for groundwater.
Cresylic acid[a]	Listed waste code "F004" for groundwater.
TBP and derivatives (mono, bi)	Extensive use in solvent extraction operation of Recuplex, PRF, and americium recovery operations (DOE-RL 1991).
Pesticides	
Heptachlor epoxide	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Endosulfan sulfate	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Aldrin	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Alpha-BHC	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Beta-BHC	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Endosulfan II	Personal communications with PFP staff suggests this pesticide may have been used at the site.
4,4'-DDT	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Alpha-chlordane	Personal communications with PFP staff suggests this pesticide may have been used at the site.

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Gamma-chlordane	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Dieldrin	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Endrin	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Methoxychlor	Personal communications with PFP staff suggests this pesticide may have been used at the site.
4,4'-DDD	Personal communications with PFP staff suggests this pesticide may have been used at the site.
4,4'-DDE	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Endrin aldehyde	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Heptachlor	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Toxaphene	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Endosulfan I	Personal communications with PFP staff suggests this pesticide may have been used at the site.
Herbicides	
2,4-D	Personal communications with PFP staff suggests this herbicide may have been used at the site.
2,4,5-TP (silvex)	Personal communications with PFP staff suggests this herbicide may have been used at the site.
Other	
pH[b]	Needed for determining if waste is a corrosive waste.
Reactivity (sulfide and cyanide)[b]	Sulfide and cyanide concentrations are needed to determine if the waste is reactive.
Toxic characteristics (metals and organics)[c]	Needed to determine if material is a characteristic waste.
PCBs	Various types of normal paraffins were used as milling, cutting, and wash solutions during the production of plutonium buttons/rods. These solutions almost always contained PCBs.
Asbestos	Construction photographs of the PFP suggest staging of potentially asbestos-containing building materials in 1948 in vicinity of proposed borehole.

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Physical Properties	
Total organic carbon	Organic carbon content affects sorption of carbon tetrachloride in subsurface and partitioning between solid and aqueous phases in aquifer.
Total inorganic carbon	Total inorganic carbon can be used to estimate the maximum potential calcium carbonate content.
Specific conductivity	Specific conductivity of groundwater helps differentiate between ambient groundwater and river water input (e.g., cooling water discharges).
Groundwater temperature	Groundwater temperature affects the equilibrium partitioning of carbon tetrachloride between the aqueous and vapor phases.
Alkalinity	Alkalinity of groundwater is a standard characterization parameter.
Groundwater turbidity	Turbidity is measured during well development to evaluate the clarity of the water.
Groundwater dissolved oxygen	Dissolved oxygen levels indicate whether the groundwater is in an oxidized or reduced state.
Moisture content	Moisture content of vadose zone soils affects permeability for vapor phase flow.
Particle size distribution	Particle size distribution relates to relative porosity and hydraulic conductivity of soil matrix.
Bulk density	Bulk density is a standard characterization parameter.
Lithology	Lithology and variations in lithology affect subsurface migration of contaminants and fluids.
Soil Vapor	
Volatile Organics	
Carbon tetrachloride	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. Carbon tetrachloride is found in soil vapor near known carbon tetrachloride discharge sites (Rohay 2000).
Chloroform	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. Chloroform is a degradation product of carbon tetrachloride. Chloroform is found in soil vapor near known carbon tetrachloride discharge sites (Rohay 2000).
Methylene chloride	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. Methylene chloride is a degradation product of carbon tetrachloride. Methylene chloride is found in soil vapor near known carbon tetrachloride discharge sites (Rohay 2000).
Methyl ethyl ketone (MEK)	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. Methyl ethyl ketone is found in soil vapor near known carbon tetrachloride discharge sites (Rohay 2000).

Table 1-8. Final COC List. (8 Pages)

Final COCs	Rationale for Inclusion
Other	
Methane	Although this COPC does not influence the waste disposition decision making process, it is retained as a COC for environmental investigations. The sanitary landfill south of the drilling location may be a source of methane.
Hydraulic Properties	
Aquifer	
Water production (flow rate) of well	The relative water production (flow rate) of the well is a consideration in evaluating the effectiveness of groundwater extraction for aquifer remediation.
Water-level (drawdown) changes	The water level changes that occur during pumping of the well are a consideration in evaluating the effectiveness of groundwater extraction for aquifer remediation.
Pumping performance capability	The pumping performance capability of the well is a consideration in evaluating the effectiveness of groundwater extraction for aquifer remediation.

[a] Cresylic acid is a synonym for cresol.
[b] Not a COC but is required for dispositioning waste material.
[c] As opposed to running the toxicity characteristic leaching procedure, samples shall be analyzed for volatile organic compounds, semi-volatile organic compounds, and metals, and the 20 times rule shall be implemented.

1.9.4 Distribution of Contaminants of Concern

Table 1-9 identifies the best understanding of how the carbon tetrachloride arrived at the site and the fate and transport mechanisms (e.g., wind or water) that may have impacted its distribution (e.g., layering or lateral homogeneity). The COCs include carbon tetrachloride and its co-contaminants; however, carbon tetrachloride is the focus of this discussion because understanding its distribution is driving the environmental investigation.

Table 1-9. Distribution of COCs. (2 Pages)

Media	COCs	How COC Arrived at Site[a]	Expected Distribution (Heterogeneous/ Homogeneous)
Ground-water	See Table 1-8	How carbon tetrachloride reached groundwater at the location of the proposed well is uncertain. Five likely scenarios include the following: 1. Downward migration of carbon tetrachloride (aqueous or non-aqueous) through cribs and underlying soil column to groundwater with lateral migration to the PFP. 2. Downward migration of carbon tetrachloride (aqueous or non-aqueous) through cribs and underlying soil column to Plio-Pleistocene unit with lateral migration along top of Plio-Pleistocene unit toward the PFP and then to groundwater. Carbon tetrachloride also migrates vertically through the Plio-Pleistocene unit to the groundwater with lateral migration to the PFP. 3. Downward migration of carbon tetrachloride (aqueous or non-aqueous) to groundwater from an unknown source within the PFP complex. 4. Downward migration of carbon tetrachloride vapor from known source cribs to groundwater in vicinity of crib, with lateral migration to the PFP, or downward and lateral migration of vapor to groundwater underlying the PFP complex. 5. A combination of the above processes contributing to groundwater contamination at the proposed well location.	Semi-homogeneous (when dissolved in groundwater)[b] Heterogeneous (when separate organic phase liquid present, but not dissolved, in groundwater)

Table 1-9. Distribution of COCs. (2 Pages)

Media	COCs	How COC Arrived at Site[a]	Expected Distribution (Heterogeneous/ Homogeneous)
Soil (drill cuttings)	See Table 1-8	It is unknown whether carbon tetrachloride is present within the soil at the proposed well location. Its distribution in soil is expected to help differentiate among the scenarios proposed to explain its presence in the underlying groundwater. Possible sources for carbon tetrachloride in soil at the well location include: nearby discharges from unknown sources; nearby liquid spills (e.g., leaking drums) and/or leaking pipes; moving contaminated soil around during construction and maintenance activities; migration to well location from discharges to known source sites; dissolution of vapor phase by infiltrating recharge water with subsequent downward migration; residual above present groundwater from lowering of historic water table.	Heterogeneous
Soil vapor	See Table 1-8	It is unknown whether carbon tetrachloride is present within the soil vapor at the proposed well location. Its distribution in soil vapor is expected to help differentiate among the scenarios proposed for its presence in the underlying groundwater. Possible sources for carbon tetrachloride in soil vapor at the well location include volatilization from nearby aqueous or non-aqueous carbon tetrachloride in vadose zone. Volatilization from known sources of aqueous or non-aqueous carbon tetrachloride within vadose zone with lateral migration to well location; volatilization from aqueous or non-aqueous carbon tetrachloride in groundwater with vertical migration to well location.	Homogeneous[a]

[a] COCs include carbon tetrachloride and potential co-contaminants. However, carbon tetrachloride is the focus of this discussion because understanding its distribution is driving the environmental investigation. The identity and distribution of co-contaminants will help differentiate among the alternative scenarios.

[b] Note that contamination is defined as relatively homogeneous in that the concentration is more or less the same in the near vicinity (few meters) of the sampling point.

1.10 CURRENT AND POTENTIAL FUTURE LAND USE

The current and potential future uses for the land in the immediate vicinity of the site under investigation are summarized in Table 1-10. This information is needed later in the DQO process to support the evaluation of decision error consequences.

Table 1-10. Current and Potential Future Land Use.

Current Land Use	Potential Future Land Use
Industrial	Residential

1.11 PRELIMINARY ACTION LEVELS

The preliminary action levels that apply to each of the COCs are presented in Tables 1-11a and 1-11b with the basis for each action level. The action level is defined as the threshold value that provides the criterion for choosing between alternative actions (AAs). The action levels presented in Table 1-11a for drilling and well construction activities are based on carbon tetrachloride concentrations that would further degrade groundwater. The action levels presented in Table 1-11b are based on waste acceptance criteria for the waste disposal site, regulatory thresholds, and/or risk. The final numerical action level will be set in DQO Step 5. The alternative actions are presented in Table 2-1.

Table 1-11a. List of Preliminary Action Levels for Drilling and Well Construction. (2 Pages)

Media	COCs	Preliminary Action Level	Basis
Drilling			
Soil	Carbon tetrachloride	Drainable, separate organic liquid phase based on field observations during drilling.	Protection of groundwater resource; potential for well to create migration pathway to groundwater.
Soil vapor	Carbon tetrachloride	20,000 to 120,000 ppmv based on field screening of in situ soil vapor samples collected during drilling.	Protection of groundwater resource; potential for well to create migration pathway to groundwater. Upper level is saturated vapor concentration (120,000 ppmv) as indicator of nearby separate organic liquid phase. Lower level is highest vapor concentration observed during previous characterization drilling in vicinity of source cribs (21,000 ppmv) (Rohay 1997).

Table 1-11a. List of Preliminary Action Levels for Drilling and Well Construction. (2 Pages)

Media	COCs	Preliminary Action Level	Basis
Well Construction			
Soil vapor	Carbon tetrachloride	600 to 20,000 ppmv based on field screening of in situ soil vapor samples collected during drilling.	Protection of groundwater resource: potential for vadose zone contamination to degrade quality of groundwater. Upper level is highest vapor concentration observed during previous characterization drilling in vicinity of source cribs (21,000 ppmv) (Rohay 1997). Lower level is vapor concentration that could further degrade groundwater containing dissolved carbon tetrachloride concentrations of approximately 4,000 ppb or less (assuming equilibrium described by Henry's Law).

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
Groundwater	Carbon tetrachloride	0.005 mg/L	N/A	N/A	N/A
	1,1,1-trichloroethane (TCA)	0.2 mg/L	N/A	N/A	N/A
	Methylene chloride	N/A	N/A	N/A	N/A
	Acetone	N/A	N/A	N/A	N/A
	Methyl isobutyl ketone (MIBK)	N/A	N/A	N/A	N/A
	o-cresol, p-cresol	N/A	N/A	N/A	N/A
	Cresylic acid	N/A	N/A	N/A	N/A
	Methyl ethyl ketone (MEK)	N/A	N/A	N/A	N/A

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
Soil (drill cuttings)	***Radionuclides***				
	Americium-241	N/A	3.13E+04 pCi/g	N/A	N/A
	Antimony-125	N/A	N/A	N/A	N/A
	Cesium-134	N/A	N/A	N/A	N/A
	Cesium-137	N/A	2.00E+07 pCi/g	N/A	N/A
	Cobalt-60	N/A	N/A	N/A	N/A
	Hydrogen-3 (tritium)	N/A	N/A	N/A	N/A
	Neptunium-237	N/A	9.38E+02 pCi/g	N/A	N/A
	Plutonium-238	N/A	9.38E+05 pCi/g	N/A	N/A
	Plutonium-239	N/A	1.81E+04 pCi/g	N/A	N/A
	Plutonium-240	N/A	1.81E+04 pCi/g	N/A	N/A
	Plutonium-241	N/A	3.88E+06 pCi/g	N/A	N/A
	Strontium-90	N/A	4.38E+09 pCi/g	N/A	N/A
	Technetium-99	N/A	8.13E+05 pCi/g	N/A	N/A
	Uranium-234	N/A	4.63E+04 pCi/g	N/A	N/A
	Uranium-235	N/A	1.69E+03 pCi/g	N/A	N/A
	Uranium-238	N/A	7.50E+03 pCi/g	N/A	N/A
	Inorganics – Metals				
	Arsenic	N/A	3.0E+03 mg/kg	5.0 mg/L	5.0 mg/L TCLP
	Barium	N/A	9.4E+05 mg/kg	100.0 mg/L	21 mg/L TCLP
	Cadmium	N/A	3.9E+04 mg/kg	1.0 mg/L	0.11 mg/L TCLP
	Chromium (total)	N/A	5.9E+04 mg/kg	5.0 mg/L	0.60 mg/L TCLP
	Chromium (VI)	N/A	5.9E+04 mg/kg	N/A	N/A

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
	Lead	N/A	N/A	5.0 mg/L	0.75 mg/L TCLP
	Mercury	N/A	N/A	0.2 mg/L	0.025 mg/L TCLP
	Nickel	N/A	N/A	N/A	11 mg/L TCLP
	Selenium	N/A	4.0E+05 mg/kg	1.0 mg/L	5.7 mg/L TCLP
	Silver	N/A	3.5E+05 mg/kg	5.0 mg/L	0.14 mg/L TCLP
	General Inorganics				
	Ammonia	N/A	N/A	N/A	N/A
	Chloride	N/A	N/A	N/A	N/A
	Fluoride	N/A	N/A	N/A	N/A
	Nitrate/nitrite	N/A	N/A	N/A	N/A
	Phosphate	N/A	N/A	N/A	N/A
	Sulfate	N/A	N/A	N/A	N/A
	Organics – Volatile Organics				
	1,1-dichloroethane (DCA)	N/A	N/A	N/A	6.0 mg/kg
	1,2-dichloroethane (DCA)	N/A	6.0 mg/kg	0.5 mg/L	6.0 mg/kg
	1,1,1-trichloroethane (TCA)	N/A	6.0 mg/kg	N/A	6.0 mg/kg
	Acetone	N/A	160 mg/kg	N/A	160 mg/kg
	Benzene	N/A	10 mg/kg	0.5 mg/L	10 mg/kg
	Carbon tetrachloride	N/A	6.0 mg/kg	0.5 mg/L	6.0 mg/kg
	Cis-1,2-dichloroethylene (DCE)	N/A	N/A	N/A	N/A
	Chlorobenzene	N/A	6.0 mg/kg	100.0 mg/L	6.0 mg/kg
	Chloroform	N/A	6.0 mg/kg	6.0 mg/L	6.0 mg/kg

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
	Ethylbenzene	N/A	10 mg/kg	N/A	10 mg/kg
	Hydraulic fluids (greases)	N/A	N/A	N/A	N/A
	Methyl ethyl ketone (MEK)	N/A	36 mg/kg	200.0 mg/L	36 mg/kg
	Methyl isobutyl ketone (MIBK)	N/A	33 mg/kg	N/A	33 mg/kg
	Methylene chloride	N/A	30 mg/kg	N/A	30 mg/kg
	n-butyl benzene	N/A	N/A	N/A	N/A
	Toluene	N/A	10 mg/kg	N/A	10 mg/kg
	Tetrachloroethylene (PCE)	N/A	6.0 mg/kg	0.7 mg/L	6.0 mg/kg
	Trans-1,2-dichloroethylene (DCE)	N/A	N/A	N/A	30 mg/kg
	Trichloroethylene (TCE)	N/A	6.0 mg/kg	0.5 mg/L	6.0 mg/kg
	Xylene	N/A	30 mg/kg	N/A	30 mg/kg
	Organics – Semi-Volatile Organics				
	Normal paraffins (greases and cutting oils)	N/A	N/A	N/A	N/A
	Cutting oils (lard oil)	N/A	N/A	N/A	N/A
	Phenol	N/A	N/A	N/A	6.2 mg/kg
	TBP and derivatives (mono, bi)	N/A	N/A	N/A	N/A
Soil (drill cuttings)	***Pesticides***				
	Heptachlor epoxide	N/A	N/A	N/A	0.066 mg/kg
	Endosulfan sulfate	N/A	N/A	N/A	0.13 mg/kg
	Aldrin	N/A	N/A	N/A	0.066 mg/kg

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
	Alpha-BHC	N/A	N/A	N/A	0.066 mg/kg
	Beta-BHC	N/A	N/A	N/A	0.066 mg/kg
	Endosulfan II	N/A	N/A	N/A	0.13 mg/kg
	4,4'-DDT	N/A	N/A	N/A	0.087 mg/kg
	Alpha-chlordane	N/A	N/A	N/A	0.26 mg/kg
	Gamma-chlordane	N/A	N/A	N/A	0.26 mg/kg
	Dieldrin	N/A	N/A	N/A	0.13 mg/kg
	Endrin	N/A	N/A	0.02 mg/L	0.13 mg/kg
	Methoxychlor	N/A	N/A	10.0 mg/L	0.18 mg/kg
	4,4'-DDD	N/A	760,000 mg/kg	N/A	0.087 mg/kg
	4,4'-DDE	N/A	540,000 mg/kg	N/A	0.087 mg/kg
	Endrin aldehyde	N/A	N/A	N/A	0.13 mg/kg
	Heptachlor	N/A	N/A	0.008 mg/L	0.066 mg/kg
	Toxaphene	N/A	N/A	0.5 mg/L	2.6 mg/kg
	Endosulfan I	N/A	N/A	N/A	0.13 mg/kg
	Herbicides				
	2,4-D	N/A	N/A	10.0 mg/L	10 mg/kg
	2,4,5-TP (silvex)	N/A	N/A	1.0 mg/L	7.9 mg/kg
	Other				
	pH[b]	N/A	N/A	≤2 or ≥12.5[c]	N/A
	Sulfide	N/A	N/A	N/A	N/A
	Cyanide	N/A	N/A	N/A	N/A

Table 1-11b. List of Preliminary Action Levels for Waste Designation. (6 Pages)

Media	COCs	MCL	ERDF Waste Acceptance Criteria[a]	TCLP Limit (or Other)	UTS
	PCBs	N/A	500 mg/kg	N/A	N/A
	Asbestos	N/A	N/A	N/A	N/A

[a] Source: *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 3 (BHI 1998a).
[b] Not a COC but is required for dispositioning waste material.
[c] Source: 40 *Code of Federal Regulations* (CFR) 261.22.
ERDF = Environmental Restoration Disposal Facility
MCL = maximum contaminant level
N/A = not applicable
TCLP = toxicity characteristic leaching procedure
UTS = universal treatment standards

1.12 CONCEPTUAL SITE MODEL

At this time five preliminary CSMs have been proposed to account for the high concentration of carbon tetrachloride in groundwater in the vicinity of the PFP. Each CSM for groundwater contamination could result in a different distribution of carbon tetrachloride and co-contaminants in the site soils, soil vapor, and groundwater. The goal of this DQO process is to develop a sampling design for the well installation that will indicate which CSM is more likely. Identification of the more likely CSM will focus future source investigations and support remedial decisions. The CSM will then continue to be refined as additional data become available.

Table 1-12 presents a tabular depiction of the five alternative CSMs, identifying the sources, release mechanisms, migration pathways, and potential receptors for carbon tetrachloride. The COCs include carbon tetrachloride and its co-contaminants; however, carbon tetrachloride is the focus of this discussion because understanding its distribution is driving the environmental investigation. Table 1-12 also summarizes the potential exposure scenarios.

Table 1-12. Tabular Depiction of the Conceptual Site Model. (3 Pages)

Media	COCs[a]	Source	Release Mechanism	Migration Pathways	Potential Receptors
CSM #1: Downward migration of carbon tetrachloride (aqueous or non-aqueous) through cribs and underlying soil column to groundwater with lateral migration of groundwater to the PFP.					
Ground-water	Carbon tetrachloride	216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18 Cribs	Downward migration of aqueous or non-aqueous carbon tetrachloride to groundwater from known source cribs, with lateral migration of groundwater to the PFP.	Infiltrating recharge water (migration downward through cribs and contaminated vadose zone), vadose zone flow, soil vapor, groundwater, surface water (river).	Human and ecological receptors (fish and birds of prey)
Exposure Scenario: Humans may be exposed to contamination in a future residential scenario by drinking contaminated groundwater. Fish may be exposed to contamination over time if the groundwater contaminant plume migrates to the Columbia River. If fish are contaminated, humans and birds of prey that consume the fish may also be exposed to contamination.					
CSM #2: Downward migration of carbon tetrachloride (aqueous or non-aqueous) through cribs and underlying soil column to the Plio-Pleistocene unit with lateral migration along top of the Plio-Pleistocene unit toward the PFP and then to groundwater. Carbon tetrachloride also migrates vertically through the Plio-Pleistocene unit to the groundwater, with lateral migration of groundwater to the PFP.					
Ground-water	Carbon tetrachloride	216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18 Cribs	Downward migration of aqueous or non-aqueous carbon tetrachloride to Plio-Pleistocene unit from known cribs with lateral migration along top of the Plio-Pleistocene unit toward the PFP. Carbon tetrachloride also migrates vertically through the Plio-Pleistocene unit to groundwater, with lateral migration of groundwater to the PFP.	Infiltrating recharge water (migration downward through cribs and contaminated vadose zone and along top of the Plio-Pleistocene unit), vadose zone flow, soil vapor, groundwater, surface water (river).	Human and ecological receptors (fish and birds of prey)
Exposure Scenario: Humans may be exposed to contamination in a future residential scenario by drinking contaminated groundwater. Fish may be exposed to contamination over time if the groundwater contaminant plume migrates to the Columbia River. If fish are contaminated, humans and birds of prey that consume the fish may also be exposed to contamination.					

Table 1-12. Tabular Depiction of the Conceptual Site Model. (3 Pages)

Media	COCs[a]	Source	Release Mechanism	Migration Pathways	Potential Receptors
CSM #3: Downward migration of carbon tetrachloride (aqueous or non-aqueous) to groundwater from an unknown source within the PFP complex.					
Ground-water	Carbon tetrachloride	Unknown source within PFP vicinity	Downward migration of carbon tetrachloride (aqueous or non-aqueous) to groundwater from an unknown source within the PFP complex.	Air[b], infiltrating recharge water (migration downward through contaminated vadose zone), vadose zone flow, soil vapor, groundwater, surface water (river).	Human and ecological receptors (fish, rodents, and birds)
Exposure Scenario: Human receptors may be exposed to contamination by ingesting contaminated surface soil, surface water, and/or groundwater. Ecological receptors (e.g., rodents and birds) may be exposed by ingesting contaminated surface soil and surface water. Fish may be exposed to contamination over time if the groundwater contaminant plume migrates to the Columbia River. If fish are contaminated, humans and birds of prey that consume the fish may also be exposed to contamination.					
CSM #4: Downward migration of carbon tetrachloride vapor from known source cribs to groundwater in vicinity of crib, with lateral migration to the PFP or downward and lateral migration of vapor to groundwater underlying the PFP complex.					
Ground-water	Carbon tetrachloride	216-Z-1A, 216-Z-9, 216-Z-12, and 216-Z-18 Cribs	Downward migration of carbon tetrachloride vapor from known source cribs to groundwater in vicinity of crib, with lateral migration to the PFP, or downward and lateral migration of vapor to groundwater underlying the PFP complex.	Infiltrating recharge water (downward migration through cribs and contaminated vadose zone), soil vapor, groundwater, surface water (river).	Human and ecological receptors (fish and birds of prey)
Exposure Scenario: Humans may be exposed to contamination in a future residential scenario by drinking contaminated groundwater. Fish may be exposed to contamination over time if the groundwater contaminant plume migrates to the Columbia River. If fish are contaminated, humans and birds of prey that consume the fish may also be exposed to contamination.					

Table 1-12. Tabular Depiction of the Conceptual Site Model. (3 Pages)

Media	COCs[a]	Source	Release Mechanism	Migration Pathways	Potential Receptors
CSM #5: A combination of the above processes contributing to groundwater contamination at the proposed well location.					
Ground-water	Carbon tetrachloride	216-Z-1A, 216-Z-9, 216-Z-12, 216-Z-18 Cribs and unknown source within PFP vicinity	Downward migration of aqueous, non-aqueous, and/or vapor-phase carbon tetrachloride to groundwater.	Air[b], infiltrating recharge water (downward migration through cribs and contaminated vadose zone), soil vapor, groundwater, surface water (river).	Human and ecological receptors (fish, rodents, and birds)
Exposure Scenario: Human receptors may be exposed to contamination by ingesting contaminated surface soil, surface water, and/or groundwater. Ecological receptors (e.g., rodents and birds) may be exposed by ingesting contaminated surface soil and surface water. Fish may be exposed to contamination over time if the groundwater contaminant plume migrates to the Columbia River. If fish are contaminated, humans and birds of prey that consume the fish may also be exposed to contamination.					

[a] COCs include carbon tetrachloride and potential co-contaminants. However, carbon tetrachloride is the focus of this discussion because the conceptual models were developed to propose the processes responsible for its distribution at the drilling site. The identity and distribution of co-contaminants will help differentiate among the alternative conceptual models.

[b] CSM contamination may be present in both surface and deep soil. Because contamination is present in surface soil, air (wind) would be one migration pathway. Run-off and surface water vertical migration to groundwater would be a second pathway, and groundwater would be a third pathway. Human workers and the surrounding ecological populations are potential receptors because contaminants are found in surface soils that could be ingested.

1.13 STATEMENT OF THE PROBLEM

The statements defining the problems addressed by this DQO process are as follows:

- Problem #1: Groundwater data collected at the 200-ZP-1 pump-and-treat extraction and monitoring wells indicate that there is a persistent, high concentration plume of dissolved carbon tetrachloride in the groundwater under the PFP complex. The apparent persistence of the plume suggests that there may be continuing sources of groundwater contamination in the vadose zone and/or groundwater. It is uncertain whether the sources of this groundwater contamination originated from the known discharge sites south and east of PFP and/or possible unknown discharge sites within the PFP complex. This uncertainty is reflected in the five preliminary CSMs that have been proposed to account for the high concentration of carbon tetrachloride in groundwater near the PFP. The decision has been made to drill a well within the PFP complex to evaluate whether there is an additional and/or continuing source of carbon tetrachloride groundwater contamination at this location. This DQO process needs to identify the environmental measurements (e.g., concentrations, distributions, and phases of carbon tetrachloride and co-contaminants, as well as physical properties) that need to be collected during drilling of this well to determine if additional and/or continuing sources of

carbon tetrachloride are present (in the vadose and/or saturated zone) at the well location, to support remedial decisions, and to indicate which CSM is most likely.

- Problem #2: The well will be constructed as a groundwater extraction well that could be used for groundwater remediation using the existing pump-and-treat system. This DQO process needs to identify the environmental measurements (e.g., concentrations, distributions, and phases of carbon tetrachloride and co-contaminants, as well as physical properties) that need to be collected during drilling of the well to support the design of the well and the decision regarding future use of the well for groundwater remediation.

- Problem #3: If it is determined that a source of carbon tetrachloride contamination remains within the vadose zone at the borehole location and that the source could be remediated using SVE, the well could be completed with a screened interval at that depth for SVE. This DQO process needs to identify the environmental measurements (e.g., concentrations, distributions, and phases of carbon tetrachloride and co-contaminants, as well as physical properties) that need to be collected during drilling of the well to support the design of the well and the decision regarding future use of the well for vadose zone remediation.

- Problem #4: Waste material resulting from drilling and sampling operations (e.g., soil, groundwater, decontamination fluids, and PPE) needs to be properly dispositioned.

2.0 STEP 2 – IDENTIFY THE DECISION

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problems identified in DQO Step 1 and the AAs that would result from the resolution of the PSQs. The PSQs and AAs are then combined into decision statements (DSs) that express a choice among AAs. Table 2-1 presents the task-specific PSQs, AAs, and resulting DSs. This table also provides a qualitative assessment of the severity of the consequences of taking an AA if it is incorrect. This assessment takes into consideration human health and the environment (flora/fauna) and political, economic, and legal ramifications. The severity of the consequences is expressed as low, moderate, or severe. The preliminary action levels presented in Tables 1-11a and 1-11b and refined in DQO Step 5 provide the criteria for choosing between alternative actions.

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
Problems #1, #2, and #3			
PSQ #1 – Is there a continuing source of carbon tetrachloride groundwater contamination in the vadose zone and/or groundwater at the well location?			
1-1	Conclude that there is a continuing source and evaluate alternatives to remediate the source.	The groundwater or vadose zone may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low
1-2	Conclude that there is not a continuing source and do not evaluate alternatives to remediate the source.	Groundwater contamination may persist, increasing the risks of potential exposure to workers and the environment.	Severe
DS #1 – Determine if there is a continuing source of carbon tetrachloride groundwater contamination in the vadose zone and/or groundwater at the well location justifying the need to evaluate alternatives to remediate the source; otherwise do not evaluate alternatives to remediate the source.			
PSQ #2 – Is operation of a groundwater extraction well at this location appropriate?			
2-1	Conclude that operation is appropriate and use the well for groundwater remediation.	The groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low
2-2	Conclude that operation is inappropriate and use the well for groundwater monitoring only.	The opportunity will be missed for increasing COC extraction recovery rate and reducing time needed to remediate groundwater.	Moderate
DS #2 – Determine if operation of a groundwater extraction well at this location is appropriate and justifies the use of the well for groundwater remediation; otherwise use the well for groundwater monitoring only.			

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
PSQ #3 – Is operation of a SVE well at this location appropriate?			
3-1	Conclude that operation is appropriate, that further advancement of the borehole is inappropriate, and construct the well for vadose zone remediation only.	The vadose zone may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources. Vadose zone data deeper than the extraction interval and groundwater data will not be collected at this location. The opportunity will be missed to remediate deeper vadose zone, where contamination may pose an even greater risk to groundwater.	Severe
3-2	Conclude that operation is appropriate, that further advancement of the borehole is appropriate, and construct the well for both vadose zone remediation and groundwater remediation.	The vadose zone may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low
3-3	Conclude that operation is inappropriate and construct a groundwater well only.	Groundwater contamination may persist, increasing the risks of potential exposure to workers and the environment.	Severe
DS #3 – Determine if operation of a SVE well at this location is appropriate and justifies the use of the well for vadose zone remediation only, or for both vadose zone and groundwater remediation; otherwise construct as a groundwater well only.			
PSQ #4 – Which CSM (see Table 1-12) is more likely?			
4-1	Conclude that groundwater contamination at well location originated from a known source crib with lateral migration of groundwater to the PFP (CSM #1), and focus future remediation efforts at known source cribs.	The groundwater contamination may persist, increasing the risks of potential exposure to workers and the environment. The vadose zone or groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low to severe
4-2	Conclude that groundwater contamination at well location originated from a known source crib with lateral migration of carbon tetrachloride liquid to the PFP in the vadose zone (CSM #2), and focus future remediation efforts between known source cribs and the PFP complex.	Groundwater contamination may persist, increasing the risk of potential exposure to workers and the environment. The vadose zone or groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low to severe

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
4-3	Conclude that groundwater contamination at well location originated from an unknown source within the PFP complex (CSM #3), and focus future remediation efforts in vicinity of the PFP complex.	Groundwater contamination may persist, increasing the risk of potential exposure to workers and the environment. The vadose zone or groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low to severe
4-4	Conclude that groundwater contamination at well location originated from a known source crib with downward migration of carbon tetrachloride vapor to groundwater and lateral migration of groundwater to the PFP, or lateral and downward migration of vapor to groundwater at the PFP (CSM #4), and focus future remediation efforts at known source cribs and between known source cribs and the PFP complex.	Groundwater contamination may persist, increasing the risk of potential exposure to workers and the environment. The vadose zone or groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low to severe
4-5	Conclude that groundwater contamination at well location originated from a combination of the above processes (CSM #5), and focus future remediation efforts at a combination of source cribs, the PFP complex, and intermediate locations.	Groundwater contamination may persist, increasing the risk of potential exposure to workers and the environment. The vadose zone or groundwater may be inappropriately remediated, resulting in unnecessary expenditure of funds and inefficient use of resources.	Low to severe
DS #4 – Determine which CSM is more likely and focus future remediation activities at more likely origin of groundwater contamination; otherwise, retain all CSMs for future remediation planning.			
Problem #4			
PSQ #1 – Is the material radiologically contaminated?			
1-1	Determine that the material <u>is</u> radiologically contaminated and evaluate material for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
1-2	Determine that the material <u>is not</u> radiologically contaminated and evaluate material for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to radiological contamination.	Severe

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
DS #1 – Determine if the material is radiologically contaminated and will be evaluated for treatment or disposal at the ERDF or CWC OR if it is not radiologically contaminated and will be evaluated for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2a.			
PSQ #2a – Is the material a listed hazardous waste?			
2a-1	Determine that the material is a listed hazardous waste and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2a-2	Decide the material is not a listed hazardous waste and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to listed hazardous waste.	Severe
DS #2a – Determine if the material is a listed hazardous waste and will be evaluated for treatment or disposal at the ERDF or CWC OR if the material is not a listed hazardous waste and will be evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2b.			
PSQ #2b – Is the material a characteristic hazardous waste (e.g., ignitable, corrosive, reactive, or toxic)?			
2b-1	Determine that the material is a characteristic hazardous waste and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2b-2	Determine that the material is not a characteristic hazardous waste and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to characteristic hazardous waste.	Severe
DS #2b – Determine if the material is a characteristic hazardous waste and will be evaluated for treatment or disposal at the ERDF or CWC OR whether the material is not a characteristic hazardous waste and will be evaluated for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2c.			
PSQ #2c – Is the material a toxic dangerous waste as defined by Washington State criteria?			
2c-1	Determine that the material is a toxic dangerous waste and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2c-2	Determine that the material is not a toxic dangerous waste and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to toxic dangerous waste.	Severe

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
DS #2c – Determine if the material is a toxic dangerous waste and will be evaluated for treatment or disposal at ERDF or CWC OR if the material is not a toxic dangerous waste and will be evaluated for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2d.			
PSQ #2d – Is the material a persistent waste as defined by Washington State criteria?			
2d-1	Determine that the material is a persistent dangerous waste and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2d-2	Determine that the material is not a persistent dangerous waste and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to persistent waste.	Severe
DS #2d – Determine if the material is a persistent waste and will be evaluated for treatment or disposal at the ERDF or CWC OR if the material is not a persistent waste and will be evaluated for being returned to the ground or disposal at a solid waste landfill, ERDF, or offsite TSD unit. Proceed to DS #2e.			
PSQ #2e – Does the material exceed MTCA Method B Risk levels?			
2e-1	Determine that the material is above MTCA Method B levels and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of disposing of clean wastes as if it were contaminated above MTCA Method B levels.	Low
2e-2	Determine that the material is not above MTCA Method B levels and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to wastes contaminated above MTCA Method B levels.	Severe
DS #2e – Determine if the material is above MTCA Method B levels and will be evaluated for treatment or disposal at the ERDF or CWC OR if the material is not above the MTCA Method B levels and will be evaluated for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2f.			
PSQ #2f – Is the material a PCB waste?			
2f-1	Determine that the material is a PCB waste and evaluate for treatment or disposal at the ERDF or CWC.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2f-2	Determine that the material is not a PCB waste and evaluate for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.	Public may be exposed to PCB waste.	Severe

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
DS #2f – Determine if the material is a PCB waste and will be evaluated for treatment or disposal at the ERDF or CWC OR if the material is not a PCB waste and will be evaluated for return to the ground or for disposal at a solid waste landfill, the ERDF, or an offsite TSD unit. Proceed to DS #2g.			
PSQ #2g – Is the material an asbestos waste?			
2g-1	Determine that the material is an asbestos waste and is regulated as an asbestos waste.	Unnecessary cost of treating clean material as if it were contaminated.	Low to moderate
2g-2	Determine that the material is not an asbestos waste and is not regulated as such.	Public may be exposed to an asbestos waste.	Severe
DS #2g – Determine if the material is an asbestos waste and will be regulated as an asbestos waste OR if the material is not an asbestos waste and will not be regulated as such. Proceed to DS #3.			
PSQ #3 – Does the material's radiological activity exceed the disposal facility's waste acceptance criteria limits?			
3-1	Determine that the radiological activity of the material does exceed the disposal facility's waste acceptance criteria limits. Evaluate the waste for chemical waste designation and negotiate disposition with the regulators.	Unnecessary cost of treating clean material as if it exceeded the waste acceptance criteria.	Low to moderate
3-2	Determine that the radiological activity of the material does not exceed the disposal facility's waste acceptance criteria limits. Evaluate the waste for chemical waste designation and dispose of material in an approved facility.	Public may be exposed to radiological contamination.	Severe
DS #3 – Determine if the material does exceed the disposal facility's waste acceptance criteria and will be evaluated for chemical composition followed by negotiating disposition options with the regulators OR if the material does not exceed the disposal facility's waste acceptance criteria and waste will be will be evaluated for chemical composition followed by disposal at an approved facility. Proceed to DS #4.			
PSQ #4 – Is the material land disposal restricted?			
4-1	Determine that the material is land disposal restricted and treat material prior to disposal.	Unnecessary cost of treating clean material as if it were land disposal restricted.	Low to moderate

Table 2-1. Summary of DQO Step 2 Information. (7 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
4-2	Determine that the material is not land disposal restricted and do not treat the material prior to disposal. Dispose the material in an onsite facility without treatment.	Public may be exposed to land disposal restricted waste.	Severe
DS #4 – Determine if the material is land disposal restricted and requires treatment prior to disposal OR if the material is not land disposal restricted and may be disposed in an onsite facility without treatment.			

CWC = Central Waste Complex
MTCA = *Model Toxics Control Act* (WAC 173-340)
TSD = treatment, storage, and disposal

3.0 STEP 3 – IDENTIFY INPUTS TO THE DECISION

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the DSs identified in DQO Step 2. The data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL] requirements, precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.1 INFORMATION REQUIRED TO RESOLVE DECISION STATEMENTS

Table 3-1 specifies the information (data) required to resolve each of the DSs identified in Table 2-1 and identifies whether the data already exist. For the existing data, the source references for the data have been provided with a qualitative assessment as to whether the data are of sufficient quality to resolve the corresponding DS. The qualitative assessment of the existing data was based on the evaluation of the corresponding quality control data (e.g., spikes, duplicates, and blanks), detection limits, data collection methods, etc.

Table 3-1. Required Information and Reference Sources. (4 Pages)

DS #	Remediation Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
Problems #1, #2, and #3						
1, 2, 3, and 4	Soil contaminant concentration data at well location	Concentrations, distribution, and phases of carbon tetrachloride and chemical and radiological co-contaminants in vadose zone and aquifer soils at well location Depth data	N	N/A	N/A	Y
	Soil physical property data at well location	Moisture content, total organic carbon, total inorganic carbon, particle size distribution, bulk density, pH, and lithology at borehole location Depth data	N	N/A	N/A	Y
1, 2, and 4	Groundwater contaminant concentration data at well location	Concentrations, distribution, and phases of carbon tetrachloride and chemical and radiological co-contaminants in groundwater at well location Depth data	N	N/A	N/A	Y

Table 3-1. Required Information and Reference Sources. (4 Pages)

DS #	Remediation Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
	Groundwater physical property data at well location	Total organic carbon, total inorganic carbon, pH, specific conductivity, alkalinity, temperature, turbidity, and dissolved oxygen at borehole location Depth data	N	N/A	N/A	Y
1, 3, and 4	Soil vapor contaminant concentration data at well location	Concentrations and distribution of carbon tetrachloride and volatile co-contaminants in soil vapor at well location Depth data	N	N/A	N/A	Y
2	Aquifer hydraulic properties at well location	Water level changes, flow rate, and pumping performance associated with groundwater pumping at well	N	N/A	N/A	Y
4	Soil contaminant concentration data at known source cribs	Concentrations, distribution, and phases of carbon tetrachloride and chemical and radiological co-contaminants in vadose zone and aquifer soils at 216-Z-9, 216-Z-1A, and 216-Z-18 Depth and location data	Y	Rohay 2000 Rohay et al. 1994 Price et al. 1979	Y	N
	Soil contaminant concentration data between known source cribs and well location	Concentrations, distribution, and phases of carbon tetrachloride and co-contaminants in vadose zone and aquifer soils between 216-Z-9, 216-Z-1A, and well location Depth and location data	N	N/A	N/A	N[a]
	Soil vapor contaminant concentration data at known source cribs	Concentrations and distribution of carbon tetrachloride and volatile co-contaminants in soil vapor at 216-Z-9, 216-Z-1A, and 216-Z-18 Depth and location data	Y	Rohay 1995, 1997, 2000 Rohay et al. 1993	Y	N

Table 3-1. Required Information and Reference Sources. (4 Pages)

DS #	Remediation Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
	Soil vapor contaminant concentration data between known source cribs and well location	Concentrations and distribution of carbon tetrachloride and co-contaminants in soil vapor between 216-Z-9, 216-Z-1A, and well location Depth and location data	Y	Rohay 1997, 2000	Y	N[a]
	Groundwater contaminant concentration data at known source cribs	Concentrations of carbon tetrachloride and co-contaminants in groundwater at 216-Z-9, 216-Z-1A, and 216-Z-18 Depth and location data	Y	DOE-RL 1991, 2001 Parker 1995 Rohay et al. 1994	Y	N[a]
	Groundwater contaminant concentration data between known source cribs and well location	Concentrations of carbon tetrachloride and co-contaminants in groundwater between 216-Z-9, 216-Z-1A, and well location Depth and location data	N	N/A	N/A	N[a]
1, 2, and 4	Groundwater contaminant concentration data at 200-ZP-1 pump-and-treat wells	Concentrations of carbon tetrachloride and co-contaminants at 299-W15-32, 299-W15-33, 299-W15-34, 299-W15-35, 299-W15-36, and associated monitoring wells Depth and location data	Y	DOE-RL 2001	Y	N
4	Geologic data	Configuration of Plio-Pleistocene layer between 216-Z-9, 216-Z-1A, and well location	Y	Rohay et al. 1994 BHI 1999	Y	N[a]
	Hydrologic data	Configuration of water table in 200 West Area since 1955	Y	PNNL historic water level database	Y	N
Problem #4						
1	Information on radiological composition of waste	Requirements specified in BHI-EE-10, *Part II – Implementing Procedures*, Procedure 8.0	N	N/A	N/A	Y

Table 3-1. Required Information and Reference Sources. (4 Pages)

DS #	Remediation Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
2a	Information on listed hazardous waste codes that apply to the waste	Listed hazardous waste code status	Y	N/A	N/A	Y (vadose zone)
2b	Information on characteristic hazardous waste codes that apply to the waste	Characteristic hazardous waste code status	N	N/A	N/A	Y
2c	Information on toxic waste codes that apply to the waste	Toxic waste code status	N	N/A	N/A	Y
2d	Information on persistent waste codes that apply to the waste	Persistent waste code status	N	N/A	N/A	Y
2e	Information on chemical composition of waste for comparison against MTCA Method B risk levels	Information specified in MTCA Method B	N	N/A	N/A	Y
2f	PCB concentrations	Concentrations of PCBs in soil	N	N/A	N/A	Y
2g	Asbestos concentrations	Concentrations of asbestos in soil	N	N/A	N/A	Y
3	Information on radiological composition of waste	Requirements specified in the ERDF waste acceptance criteria (BHI 1998a)	N	N/A	N/A	Y
4	Information regarding land disposal restricted materials	Requirements specified in 40 CFR 268.40	N	N/A	N/A	Y

[a] The scope of this DQO summary report is the single well in the vicinity of the PFP. Verification/refinement of the CSM(s) might require acquisition of additional data at the source cribs or between the source cribs and the well location; however, the data will not be collected as part of this field activity.

N/A = not applicable

PNNL = Pacific Northwest National Laboratory

Because DS #2g (Problem #4) requires no additional information, it has not been carried through the remainder of the DQO process.

3.2 BASIS FOR SETTING THE ACTION LEVEL

The action level is the threshold value that provides the criterion for choosing between AAs. Table 3-2 identifies the basis (i.e., regulatory threshold or risk-based) for establishing the action level for each of the COCs. The numerical value for the action level is defined in DQO Step 5.

Table 3-2. Basis for Setting Action Level. (5 Pages)

DS #	Remediation Variable	COCs	Basis for Setting Action Level
Problems 1, 2, 3			
1	Soil contaminant concentration data at well location Groundwater contaminant concentration data at well location Soil vapor contaminant concentration data at well location Soil physical property data at well Groundwater physical property data at well	Carbon tetrachloride in soil, soil vapor, and groundwater Moisture content of vadose zone soils Lithology of soils Groundwater temperature	Distribution and mobility of carbon tetrachloride non-dissolved phase (e.g., separate organic phase or reversibly sorbed phase) in vadose zone and aquifer soils at well location. Distribution of carbon tetrachloride soil concentrations at well location. Distribution of carbon tetrachloride soil vapor concentrations at well location. Distribution of carbon tetrachloride dissolved groundwater concentrations at well location. Soil moisture profile at well location. Lithologic profile of vadose zone and aquifer at well location.

Table 3-2. Basis for Setting Action Level. (5 Pages)

DS #	Remediation Variable	COCs	Basis for Setting Action Level
2	Groundwater contaminant concentration data at well location and 200-ZP-1 extraction and monitoring wells Aquifer soils physical property data at well Aquifer hydraulic property data at well	Carbon tetrachloride in groundwater Co-contaminants in groundwater Lithology Water production (flow rate) of well Water level (drawdown) changes Pumping performance capability	Interim ROD remedial action objectives (EPA et al. 1995). Distribution and mobility of carbon tetrachloride non-dissolved phase (e.g., separate organic phase or reversibly sorbed phase) in aquifer at well location. Distribution of carbon tetrachloride dissolved groundwater concentrations at well location. Comparison of groundwater concentrations at well location to those at 200-ZP-1 extraction and monitoring wells. Lithologic profile of aquifer at well location. Absence of co-contaminants that would be incompatible with above-ground treatment system. Numerical prediction that impact of new groundwater extraction well is beneficial to achievement of interim ROD remedial action objectives.

Table 3-2. Basis for Setting Action Level. (5 Pages)

DS #	Remediation Variable	COCs	Basis for Setting Action Level
3	Soil contaminant concentration data at well Soil vapor contaminant concentration data at well Soil physical property data at well	Carbon tetrachloride in soil and soil vapor Other volatile compounds in soil vapor Moisture content of vadose zone soils Lithology	Engineering evaluation/cost analysis, Table 2 (DOE-RL 1991): Moisture content is low; organic carbon content is low; permeability is high (2E-08 to 5.6E-08 cm^2); hydraulic conductivity is >1E-08 cm/s. Distribution and mobility of carbon tetrachloride non-dissolved phase (i.e., separate organic phase) in vadose zone soils at well location based on field observations. Concentration of carbon tetrachloride in soil vapor based on field measurements. Soil moisture profile at well location based on field observations. Lithologic profile of vadose zone at well location based on field observations. Absence of volatile co-contaminant that would be incompatible with above-ground treatment system based on field screening. Evaluation that new SVE well is beneficial to achievement of expedited response action remedial objectives (EPA and Ecology 1992).

Table 3-2. Basis for Setting Action Level. (5 Pages)

DS #	Remediation Variable	COCs	Basis for Setting Action Level
4	Soil contaminant concentration data at well location and from well to source cribs Groundwater contaminant concentration data at well location and from well to source cribs Soil vapor contaminant concentration data at well location and from well to source cribs Soil physical property data at well Groundwater physical property data at well Geologic data Hydrologic data	Carbon tetrachloride in soil, soil vapor, and groundwater Co-contaminants in soil, soil vapor, and groundwater Moisture content of vadose zone soils Lithology of soils	Distribution and mobility of carbon tetrachloride non-dissolved phase (e.g., separate organic phase or reversibly sorbed phase) in vadose zone and aquifer soils at well location. Distribution of carbon tetrachloride soil concentrations at well location. Distribution of carbon tetrachloride soil vapor concentrations at well location. Distribution of carbon tetrachloride dissolved groundwater concentrations at well location. Soil moisture profile at well location. Lithologic profile of vadose zone and aquifer at well location. Identity and distribution of chemical and radiological co-contaminants at well location relative to identity and distribution at source cribs. Distribution of soil vapor concentrations at well location relative to distribution at source cribs. Comparison of groundwater concentrations at well location to those at source cribs and at 200-ZP-1 extraction and monitoring wells. Numerical predictions of whether historic groundwater underlying known source cribs could have reached well location. Relative slope of Plio-Pleistocene layer between known source cribs and well location.

Table 3-2. Basis for Setting Action Level. (5 Pages)

DS #	Remediation Variable	COCs	Basis for Setting Action Level
Problem 4			
1	Radiological composition	Am-241, Sb-125, Cs-134, Cs-137, Co-60, H-3 (tritium), Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Sr-90, Tc-99, U-234, U-235, U-238	BHI-EE-10, *Part II – Implementing Procedures*, Procedure 8.0
2a	Listed hazardous waste codes	F001: 1,1,1-trichloroethane (TCA) and carbon tetrachloride F002: methylene chloride F003: acetone and methyl isobutyl ketone (MIBK) F004: o-cresol, p-cresol, and cresylic acid F005: methyl ethyl ketone (MEK)	40 CFR 261
2b	Characteristic hazardous waste codes	pH, sulfide, cyanide, VOCs, SVOCs, metals, pesticides, herbicides	40 CFR 261
2c	Toxic dangerous waste codes	All nonradiological COCs	WAC 173-303-100(5)
2d	Persistent waste codes	Halogenated organic compounds, polycyclic aromatic compounds, PCBs	WAC 173-303-100 (6)
2e	MTCA Method B list of COCs	Organic compounds, PCBs, metals, and other inorganics	MTCA Method B table
2f	PCBs	PCBs	MTCA Method B table
3	Radiological composition	Am-241, Sb-125, Cs-134, Cs-137, Co-60, H-3 (tritium), Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Sr-90, Tc-99, U-234, U-235, U-238	BHI 1998a (ERDF waste acceptance criteria)
4	Chemical composition	See table in 40 CFR 268.40	40 CFR 268.40

3.3 COMPUTATIONAL AND SURVEY/ANALYTICAL METHODS

Table 3-3 identifies the DSs where existing data do not exist or are of insufficient quality to resolve the DSs. For these DSs, Table 3-3 presents computational and/or surveying/sampling methods that could be used to obtain the required data.

Table 3-3. Information Required to Resolve the Decision Statements. (5 Pages)

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
Problems #1, #2, and #3				
1, 2, 3, and 4	Soil contaminant concentration data at well location	Concentration, distribution, and phase of following COCs:	N/A	Soil sampling during drilling of well and analysis by following methods:
		• Volatile organics in soil		• SW-846, Method 8260
		• Semi-volatile organics in soil		• SW-846, Method 8270 • Method 413.2
		• General inorganics in soil		• Method 353.2 • Method 300.0[a]
		• Metals in soil		• SW-846, Method 6010 • SW-846, Method 7196
		• Radionuclides in soils		• Alpha spectroscopy • GPC • Gamma spectroscopy • LSC • Chemical separation/beta proportional count • Chemical separation/alpha proportional count
		• Depth data		• Geologist record
	Soil physical property data at well location	Distribution of following physical property data:	N/A	Soil sampling during drilling of well and analysis by following methods:
		• Moisture content		• D2216
		• Total organic carbon		• Method 415.1
		• Total inorganic carbon		• Method 415.1M
		• Particle size distribution		• D422 • BHI-EE-05, Procedure 1.21
		• Bulk density		• D2937
		• pH		• Method 9045
		• Lithology		• BHI-EE-01, Procedure 7.0
		• Depth data		• Geologist record

Table 3-3. Information Required to Resolve the Decision Statements. (5 Pages)

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
1 and 2	Groundwater contaminant concentration data at well location	Concentration, distribution, and phase of following COCs:	N/A	Soil sampling during drilling of well and analysis by following methods:
		• Volatile organics in groundwater		• SW-846, Method 8260
		• Semi-volatile organics in groundwater		• SW-846, Method 8270 • Method 413.2
		• General inorganics in groundwater		• Method 353.2 • Method 300.0[a]
		• Metals in groundwater		• SW-846, Method 6010 • SW-846, Method 7196
		• Radionuclides in groundwater		• Alpha spectroscopy • Alpha scintillation • GPC • Gamma spectroscopy • LSC • Chemical separation/beta proportional count
		• Depth data		• Geologist record
	Groundwater physical properties at well location	Distribution of following physical property data:	N/A	Groundwater sampling during drilling of well and analysis by following methods:
		• Total organic carbon		• Method 415.1
		• Total inorganic carbon		• Method 415.1M
		• pH		• Method 9045
		• Specific conductivity		• Field screening
		• Groundwater temperature		• Field screening
		• Alkalinity		• Method 310.1
		• Dissolved oxygen		• Field screening
		• Turbidity		• Field screening
		• Depth		• Geologist record

Table 3-3. Information Required to Resolve the Decision Statements. (5 Pages)

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
1, 3, and 4	Soil vapor contaminant concentrations at well location	Concentrations and distribution of following COCs: • Volatile contaminants in soil vapor • Other volatile compounds in soil vapor	N/A	Soil vapor sampling during drilling of well and analysis by following methods: • Photoacoustic infrared or gas chromatograph analysis of soil vapor collected in Tedlar bags • PID headspace analysis of soil cuttings • Downhole passive carbon sorption technology • Landfill gas analysis of soil vapor collected in Tedlar bags
2	Hydraulic properties of aquifer	Water production (flow rate) of well Water level (drawdown) changes Pumping performance capability	N/A	Well development data
4	Soil contaminant concentration data between known source cribs and well location	Concentrations, distribution, and phase of carbon tetrachloride and co-contaminants in soil between 216-Z-9, 216-Z-1A, and well location Depth and location data	Graphical methods	N/A
	Soil vapor contaminant concentration data between known source cribs and well location	Concentrations and distribution of carbon tetrachloride and co-contaminants in soil vapor between 216-Z-9, 216-Z-1A, and well location Depth and location data	Graphical methods	N/A
	Groundwater contaminant concentration data between known source cribs and well location	Concentrations of carbon tetrachloride and co-contaminants in groundwater between 216-Z-9, 216-Z-1A, and well location Depth and location data	Graphical methods	N/A
	Hydrologic data	Configuration of water table in 200 West Area since 1955	Graphical methods	N/A

Table 3-3. Information Required to Resolve the Decision Statements. (5 Pages)

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
2	Capture zone modeling	Well development data	Numerical groundwater modeling	N/A
Problem #4				
1	Radiological composition	Am-241, Sb-125, Cs-134, Cs-137, Co-60, H-3 (tritium), Np-237, Pu-238, Pu-239, Pu-240, Pu-241[b], Sr-90, Tc-99, U-234, U-235, U-238	N/A	Gamma spectroscopy Alpha spectroscopy LSC
2a	Listed hazardous waste codes	F001: 1,1,1-trichloroethane (TCA) and carbon tetrachloride F002: methylene chloride F003: acetone and methyl isobutyl ketone (MIBK) F004: o-cresol, p-cresol, and cresylic acid F005: methyl ethyl ketone (MEK)	N/A	SW-846, Method 8260 SW-846, Method 8270
2b	Characteristic hazardous waste codes	pH (corrosivity) sulfide, cyanide (reactivity) VOCs, SVOCs, pesticides, herbicides, and metals from TCLP list (toxicity)	N/A	SW-846, Method 9045C SW-846, Sections 7.3.4.2 and 7.3.3.2 SW-846, Method 6010 SW-846, Method 7471 SW-846, Method 8260 SW-846, Method 8270 SW-846, Method 8081B SW-846, Method 8151A
2c	Toxic dangerous waste codes	VOCs, SVOCs, and metals	N/A	SW-846, Methods 6010 SW-846, Method 7471 SW-846, Method 8260 SW-846, Method 8270 (or TCLP method)
2d	Persistent waste code status	Halogenated organic compounds Polycyclic aromatic compounds PCBs	N/A	SW-846, Method 8260 SW-846, Method 8270 SW-846, Method 8082

Table 3-3. Information Required to Resolve the Decision Statements. (5 Pages)

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
2e	MTCA Method B list of COCs	Organic compounds (including pesticides and herbicides), PCBs, metals, and other inorganics	N/A	SW-846, Methods 8260 SW-846, Method 8270 SW-846, Method 8081B SW-846, Method 8151A SW-846, Method 6010 SW-846, Method 7471
2f	PCBs	PCBs	N/A	SW-846, Method 8082
3	Radiological composition	Am-241, Sb-125, Cs-134, Cs-137, Co-60, H-3 (tritium), Np-237, Pu-238, Pu-239, Pu-240, Pu-241[b], Sr-90, Tc-99, U-234, U-235, U-238	N/A	Gamma spectroscopy Alpha spectroscopy LSC
4	Chemical composition	See table in 40 CFR 268.40	NA	Covered by analyses specified above to address DS #1, DS #2, and DS #3

[a] Carbonate will be evaluated by inorganic carbon content results.
[b] Pu-241 concentrations to be calculated based on concentration of other isotopes of plutonium and americium.
GPC = gas proportional counting
LSC = liquid scintillation counting
N/A = not applicable
PID = photoionization detector
SVOC = semi-volatile organic compound
VOC = volatile organic compound

Because groundwater or soil sampling data are not available from within the PFP complex, there are no data to support vadose zone or groundwater modeling. However, numerical groundwater modeling may be conducted using data collected from the well (see Table 3-4). Numerical evaluation of historical water levels, gradients, and discharges may be conducted.

Table 3-4. Details on Identified Computational Methods.

DS #	Computational Method	Source/Author	Application to Study
Problems #1, #2, and #3			
4	Numerical evaluation	N/A	Evaluate whether CSM #1 is feasible based on available PNNL data describing configuration of water table since 1955 (i.e., could carbon tetrachloride have reached the vicinity of PFP from known source cribs).
2	Numerical groundwater model	N/A	Evaluate impact on the interim ROD (EPA et al. 1995) remedial action objectives of using new groundwater well for extraction.

N/A = not applicable

Table 3-5 identifies each of the survey and/or analytical methods that may be used to provide the required information needed to resolve each of the DSs. The possible limitations associated with each of these methods and the estimated cost are also provided.

Table 3-5. Potentially Appropriate Survey/Analytical Methods. (2 Pages)

DS #	Remediation Variable	Potentially Appropriate Survey/Analytical Method	Possible Limitations	Cost
Problems #1, #2, and #3				
1, 2, 3, and 4	Concentrations and distribution of volatile organics, semi-volatile organics, general inorganics, metals, and radionuclides in vadose zone and aquifer soils and groundwater	Soil and groundwater samples collected at multiple depths during borehole drilling followed by sampling and analysis using the methods listed in Table 3-3	Obtaining a representative sample	Moderate
	Phase of volatile organics in soil and groundwater	Visual observations	Obtaining a representative sample Observing minute or subtle changes	Low
	Distribution of soil and groundwater physical property data	Soil and groundwater samples collected at multiple depths during drilling followed by sampling and analysis using the methods listed in Table 3-3	Obtaining a representative sample	Moderate

Table 3-5. Potentially Appropriate Survey/Analytical Methods. (2 Pages)

DS #	Remediation Variable	Potentially Appropriate Survey/Analytical Method	Possible Limitations	Cost
1, 3, and 4	Concentrations and distribution of volatile organics and other volatile compounds in soil vapor	Soil vapor samples collected at multiple depths during borehole drilling followed by analysis using methods listed in Table 3-3	Obtaining a representative sample	Low
2	Hydraulic properties of aquifer	Water production (flow rate) of well Water level (drawdown) changes Pumping performance capability	Receiving and storing (i.e., purgewater truck) volume of water required for well development	Moderate
Problem #4				
1	Radiological composition	Gamma spectroscopy Alpha spectroscopy LSC	Obtaining representative sample	Moderate (soil sample)
2a	Listed hazardous waste codes	SW-846, Method 8260 SW-846, Method 8270	Obtaining representative sample	Moderate (soil sample)
2b	Characteristic waste codes	SW-846, Method 9045C; SW-846, Sections 7.3.4.2 and 7.3.3.2; SW-846, Methods 6010, 7471, 8260, and 8270	Obtaining representative sample	Moderate (soil sample)
2c	Toxic dangerous waste codes	SW-846, Methods 6010, 7471, 8260, and 8270	Obtaining representative sample	Moderate (soil sample)
2d	Persistent waste code status	SW-846, Methods 8260, 8270, and 8082	Obtaining representative sample	Moderate (soil sample)
2e	MTCA Method B list of COCs	SW-846, Methods 8260, 8270, 6010, and 7471	Obtaining representative sample	Moderate (soil sample)
2f	PCBs	SW-846, Method 8082	Obtaining representative sample	Moderate (soil sample)
3	Radiological composition	Gamma spectroscopy, alpha spectroscopy, LSC	Obtaining representative sample	Moderate (soil sample)
4	Chemical and radiological composition	Covered by analyses specified above to address DS #1, DS #2, and DS #3	Obtaining representative sample	Moderate (soil sample)

[a] WAC 173-303-100(6) requires halogenated organic compounds (volatile organics compounds) and polycyclic aromatic compounds (semi-volatile organic compounds) to be analyzed to determine if waste is persistent.

3.4 ANALYTICAL PERFORMANCE REQUIREMENTS

Tables 3-6a and 3-6b define the analytical performance requirements for the data needed to be collected to resolve each of the DSs. These performance requirements include the PQL and the precision and accuracy requirements for each of the COCs.

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
Problems #1, #2, and #3						
Soil: VOCs						
1, 2, 3, and 4	Trans-1,2-dichloroethene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	1,1-dichloroethane	SW-846, Method 8260	N/A	10 µg/kg	[b]	[a]
	Cis-1,2-dichloroethene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	Chloroform	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	1,2-dichloroethane	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Benzene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Ethylbenzene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	n-butyl benzene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	Chlorobenzene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Carbon tetrachloride	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Tetrachloroethene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Trichloroethene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	m-xylene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	o-xylene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	p-xylene	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	Toluene	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	1,1,1-trichloroethane (TCA)	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Methylene chloride	SW-846, Method 8260	N/A	5 µg/kg	[b]	[b]
	Acetone	SW-846, Method 8260	N/A	20 µg/kg	[b]	[b]

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
	Methyl ethyl ketone (MEK)	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
	Methyl isobutyl ketone (MIBK)	SW-846, Method 8260	N/A	10 µg/kg	[b]	[b]
Soils: SVOCs						
1, 2, 3, and 4	Tributyl phosphate (TBP)	SW-846, Method 8270	N/A	330 µg/kg	[b]	[b]
	Phenol	SW-846, Method 8270	N/A	330 µg/kg	[b]	[b]
Soils: Miscellaneous						
1, 2, 3, and 4	Oil and grease (lard oil)	Method 413.2 (oil and grease, hexane extraction with gravimetric determination)	N/A	20,000 µg/kg	±25%	±35%
Soils: Metals						
1, 2, 3, and 4	Cadmium	SW-846, Method 6010	N/A	500 µg/kg	±25%	±35%
	Calcium	SW-846, Method 6010	N/A	500,000 µg/kg	±25%	±35%
	Chromium (total)	SW-846, Method 6010	N/A	1,000 µg/kg	±25%	±35%
	Chromium (VI)	SW-846, Method 7196	N/A	500 µg/kg	±25%	±35%
	Iron	SW-846, Method 6010	N/A	10,000 µg/kg	±25%	±35%
	Magnesium	SW-846, Method 6010	N/A	500,000 µg/kg	±25%	±35%
	Nickel	SW-846, Method 6010	N/A	4,000 µg/kg	±25%	±35%
	Phosphorus	SW-846, Method 6010	N/A	5,000 µg/kg	±25%	±35%
	Sodium	SW-846, Method 6010	N/A	500,000 µg/kg	±25%	±35%

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
Soils: Radionuclides						
1, 2, 3, and 4	Gross alpha	GPC	N/A	10 pCi/g	±30%	±35%
	Gross beta	GPC	N/A	15 pCi/g	±30%	±35%
	Am-241	Alpha spectroscopy	N/A	2 pCi/g	±30%	±35%
	Co-60	Gamma spectroscopy	N/A	2 pCi/g	±30%	±35%
	Cs-137	Gamma spectroscopy	N/A	2 pCi/g	±30%	±35%
	Pu-238	Alpha spectroscopy	N/A	2 pCi/g	±30%	±35%
	Pu-239/240	Alpha spectroscopy	N/A	2 pCi/g	±30%	±35%
	Pu-241	[d]	[d]	[d]	[d]	[d]
	Ru-106	LSC	N/A	2 pCi/g	±30%	±35%
	Sr-90	Chemical separation/beta proportional count	N/A	5 pCi/g	±30%	±35%
	Np-237	Chemical separation/alpha count	N/A	2 pCi/g	±30%	±35%
	Sb-125	Gamma spectroscopy	N/A	2 pCi/g	±30%	±35%
Soils: Inorganics						
1, 2, 3, and 4	Chloride	Method 300.0	N/A	2,000 µg/kg	±25%	±35%
	Fluoride	Method 300.0	N/A	5,000 µg/kg	±25%	±35%
	Nitrate	Method 300.0	N/A	750 µg/kg	±25%	±35%
	Nitrite	Method 300.0	N/A	2,500 µg/kg	±25%	±35%
	Nitrate/nitrite	Method 353.2	N/A	750 µg/kg	±25%	±35%

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
	Carbonate (total inorganic carbon)	Method 415.1M	N/A	12,500 µg/kg	±25%	±35%
	Phosphate	Method 300.0	N/A	5,000 µg/kg	±25%	±35%
	Sulfate	Method 300.0	N/A	5,000 µg/kg	±25%	±35%
Groundwater: VOCs						
1, 2, and 4	Carbon tetrachloride	SW-846, Method 8260	N/A	5 µg/L	[b]	[b]
	Chloroform	SW-846, Method 8260	N/A	5 µg/L	[b]	[b]
	Methylene chloride	SW-846, Method 8260	N/A	5 µg/L	[b]	[b]
	Trichloroethylene (TCE)	SW-846, Method 8260	N/A	5 µg/L	[b]	[b]
	Tetrachloroethylene (PCE)	SW-846, Method 8260	N/A	5 µg/L	[b]	[b]
Groundwater: Semi-Volatiles						
1, 2, and 4	Tributyl phosphate (TBP)	SW-846, Method 8270	N/A	10 µg/L	[b]	[b]
Groundwater: Inorganics						
1, 2, and 4	Carbonate (total inorganic carbon)	Method 415.1M	N/A	500 µg/L	±25%	±35%
	Chloride	Method 300.0	N/A	200 µg/L	±25%	±35%
	Fluoride	Method 300.0	N/A	500 µg/L	±25%	±35%
	Nitrate	Method 9056	N/A	75 µg/L	±25%	±35%
	Nitrite	Method 300.0	N/A	250 µg/L	±25%	±35%
	Nitrate/nitrite	Method 353.2	N/A	75 µg/L	±25%	±35%

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
	Phosphate	Method 300.0	N/A	500 µg/L	±25%	±35%
	Sulfate	Method 300.0	N/A	500 µg/L	±25%	±35%
Groundwater: Metals						
1, 2, and 4	Cadmium	SW-846, Method 6010	N/A	5 µg/L	±25%	±35%
	Calcium	SW-846, Method 6010	N/A	5,000 µg/L	±25%	±35%
	Chromium (total)	SW-846, Method 6010	N/A	10 µg/L	±25%	±35%
	Chromium (VI)	SW-846, Method 7196	N/A	10 µg/L	±25%	±35%
	Iron	SW-846, Method 6010	N/A	100 µg/L	±25%	±35%
	Magnesium	SW-846, Method 6010	N/A	5,000 µg/L	±25%	±35%
	Nickel	SW-846, Method 6010	N/A	40 µg/L	±25%	±35%
	Phosphorus	SW-846, Method 6010	N/A	50 µg/L	±25%	±35%
	Sodium	SW-846, Method 6010	N/A	5,000 µg/L	±25%	±35%
	Zinc	SW-846, Method 6010	N/A	20 µg/L	±25%	±35%
Groundwater: Radionuclides						
1, 2, and 4	Tc-99	LSC	N/A	30 pCi/L	±30%	±35%
	H-3 (tritium)	LSC	20,000 pCi/L[c]	400 pCi/L	±30%	±35%
	Gross alpha	GPC	N/A	3 pCi/L	±30%	±35%
	Gross beta	GPC	N/A	4 pCi/L	±30%	±35%
	Co-60	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%
	Ru-106	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
	Np-237	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%
	Sr-90	LSC	N/A	2 pCi/L	±30%	±35%
	Uranium isotopes	Alpha spectroscopy	N/A	2 pCi/L	±30%	±35%
	Sb-125	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%
	Cs-137	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%
	Plutonium isotopes	Alpha spectroscopy	N/A	2 pCi/L	±30%	±35%
	Am-241	Gamma spectroscopy	N/A	50 pCi/L	±30%	±35%
Soil Vapor: VOCs						
1, 3, and 4	Carbon tetrachloride	Field screening using photoacoustic infrared detector	20,000 ppmv 600 ppmv	1 ppmv	N/A	N/A
	Chloroform	Field screening using photoacoustic infrared detector	N/A	1 ppmv	N/A	N/A
	Methylene chloride	Field screening using photoacoustic infrared detector	N/A	1 ppmv	N/A	N/A
	MEK	Field screening using photoacoustic infrared detector	N/A	1 ppmv	N/A	N/A
Soil Vapor: Other						
1, 3, and 4	Methane	Landfill gas analyzer	N/A	0.1%	N/A	N/A

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
Soil: Physical Properties						
1, 2, 3, and 4	Moisture content	D2216	N/A	N/A	N/A	N/A
	Particle size distribution	D422	N/A	N/A	N/A	N/A
	Bulk density	D2937	N/A	N/A	N/A	N/A
	Lithology	BHI-EE-01, Procedure 7.0	N/A	N/A	N/A	N/A
	Total organic carbon	Method 415.1	N/A	25,000 µg/kg	±25%	±35%
	pH	SW-846, Method 9045	N/A	0.1 pH unit	N/A	N/A
Groundwater Physical Properties						
1, 2, and 4	Groundwater temperature	Field screening	N/A	N/A	N/A	N/A
	Total organic carbon	Method 415.1	N/A	1,000 µg/L	±25%	±35%
	Specific conductivity	Field screening	N/A	N/A	N/A	N/A
	Alkalinity	Method 310.1	N/A	N/A	N/A	N/A
	Dissolved oxygen	Field screening	N/A	N/A	N/A	N/A
	Turbidity	Field screening	<5 NTU	N/A	N/A	N/A
	pH	SW-846, Method 9045	N/A	0.1 pH unit	N/A	N/A

Table 3-6a. Analytical Performance Requirements for Environmental Investigation Sampling. (8 Pages)

DS #	COCs	Survey/ Analytical Method	Action Levels	CRDL[a]	Precision Req't	Accuracy Req't
Aquifer Hydraulic Properties						
2	Water production (flow rate)	Well development	N/A	N/A	N/A	N/A
	Water level changes (drawdown)	Well development	N/A	N/A	N/A	N/A
	Groundwater pumping performance	Well development	N/A	N/A	N/A	N/A

[a] Laboratory contract quantification limit values.
[b] As required by corresponding method.
[c] Source: 40 CFR 141.16.
[d] Pu-241 concentration to be calculated based on concentration of other plutonium and americium isotopes.
CRDL = contract-required detection limit
N/A = not applicable
NTU = nephelometric turbidity unit

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
Problem #4									
1, 2, 3, and 4	***Radionuclides***								
	Americium-241	Gamma spectroscopy	3.13E+04 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Antimony-125	Gamma spectroscopy	N/A	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Cesium-134	Gamma spectroscopy	N/A	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Cesium-137	Gamma spectroscopy	2.00E+07 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Cobalt-60	Gamma spectroscopy	N/A	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Hydrogen-3 (tritium)	LSC	N/A	N/A	N/A	N/A	400 pCi/g	±30%	±35%
	Neptunium-237	Gamma spectroscopy	9.38E+02 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Plutonium-238	Alpha spectroscopy	9.38E+05 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Plutonium-239	Alpha spectroscopy	1.81E+04 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Plutonium-240	Alpha spectroscopy	1.81E+04 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Plutonium-241	[d]	3.88E+6 pCi/g	N/A	N/A	N/A	[d]	[d]	[d]
	Strontium-90	GPC	4.38E+09 pCi/g	N/A	N/A	N/A	5 pCi/g	±30%	±35%
	Technetium-99	LSC	8.13E+05 pCi/g	N/A	N/A	N/A	30 pCi/g	±30%	±35%
	Uranium-234	Gamma spectroscopy	4.63E+04 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Uranium-235	Gamma spectroscopy	1.69E+03 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Uranium-238	Gamma spectroscopy	7.50E+03 pCi/g	N/A	N/A	N/A	2 pCi/g	±30%	±35%
	Inorganics – Metals								
	Arsenic	SW-846, Method 6010B	3.0E+03 mg/kg	5.0 mg/L	5.0 mg/L TCLP	N/A	10,000 µg/kg	±25%	±35%
	Barium	SW-846, Method 6010B	9.4E+05 mg/kg	100.0 mg/L	21 mg/L TCLP	N/A	20,000 µg/kg	±25%	±35%
	Cadmium	SW-846, Method 6010B	3.9E+04 mg/kg	1.0 mg/L	0.11 mg/L TCLP	N/A	500 µg/kg	±25%	±35%
	Chromium (total)	SW-846, Method 6010B	5.9E+04 mg/kg	5.0 mg/L	0.60 mg/L TCLP	N/A	1,000 µg/kg	±25%	±35%
	Chromium (VI)	SW-846, Method 7196	5.9E+04 mg/kg	N/A	N/A	N/A	500 µg/kg	±25%	±35%

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Lead	SW-846, Method 6010B	N/A	5.0 mg/L	0.75 mg/L TCLP	N/A	10,000 µg/kg	±25%	±35%
	Mercury	SW-846, Method 7471	N/A	0.2 mg/L	0.025 mg/L TCLP	N/A	500 µg/kg	±25%	±35%
	Nickel	SW-846, Method 6010B	N/A	N/A	11 mg/L TCLP	N/A	4,000 µg/kg	±25%	±35%
	Selenium	SW-846, Method 6010B	4.0E+05 mg/kg	1.0 mg/L	5.7 mg/L TCLP	N/A	10,000 µg/kg	±25%	±35%
	Silver	SW-846, Method 6010B	3.5E+05 mg/kg	5.0 mg/L	0.14 mg/L TCLP	N/A	2,000 µg/kg	±25%	±35%
	General Inorganics								
	Ammonia	SW-846, Method 350.1	N/A	N/A	N/A	N/A	500 µg/kg	±25%	±35%
	Chloride	SW-846, Method 300.0	N/A	N/A	N/A	N/A	2,000 µg/kg	±25%	±35%
	Fluoride	SW-846, Method 300.0	N/A	N/A	N/A	N/A	5,000 µg/kg	±25%	±35%
	Nitrate	SW-846, Method 300.0	N/A	N/A	N/A	N/A	750 µg/kg	±25%	±35%
	Nitrite	SW-846, Method 300.0	N/A	N/A	N/A	N/A	2,500 µg/kg	±25%	±35%

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Phosphate	SW-846, Method 9056	N/A	N/A	N/A	N/A	5,000 µg/kg	±25%	±35%
	Sulfate	SW-846, Method 9056	N/A	N/A	N/A	N/A	5,000 µg/kg	±25%	±35%
	Organics – Volatile Organics								
	1,1-dichloroethane (DCA)	SW-846, Method 8260	N/A	N/A	6.0 mg/kg	N/A	10 µg/kg	c	c
	1,2-dichloroethane (DCA)	SW-846, Method 8260	6.0 mg/kg	0.5 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c
	1,1,1-trichloroethane (TCA)	SW-846, Method 8260	6.0 mg/kg	N/A	6.0 mg/kg	N/A	5 µg/kg	c	c
	Acetone	SW-846, Method 8260	160 mg/kg	N/A	160 mg/kg	N/A	20 µg/kg	c	c
	Benzene	SW-846, Method 8260	10 mg/kg	0.5 mg/L	10 mg/kg	N/A	5 µg/kg	c	c
	Carbon tetrachloride	SW-846, Method 8260	6.0 mg/kg	0.5 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c
	Cis-1,2-dichloroethene	SW-846, Method 8260	N/A	N/A	N/A	N/A	10 µg/kg	c	c
	Chlorobenzene	SW-846, Method 8260	6.0 mg/kg	100.0 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Chloroform	SW-846, Method 8260	6.0 mg/kg	6.0 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c
	Ethylbenzene	SW-846, Method 8260	10 mg/kg	N/A	10 mg/kg	N/A	5 µg/kg	c	c
	Hydraulic fluids (greases)	SW-846, Method 413.2	N/A	N/A	N/A	N/A	20,000 µg/kg	±25%	±35%
	Methyl ethyl ketone (MEK)	SW-846, Method 8260	36 mg/kg	200.0 mg/L	36 mg/kg	N/A	10 µg/kg	c	c
	Methyl isobutyl ketone (MIBK)	SW-846, Method 8260	33 mg/kg	N/A	33 mg/kg	N/A	10 µg/kg	c	c
	Methylene chloride	SW-846, Method 8260	30 mg/kg	N/A	30 mg/kg	N/A	5 µg/kg	c	c
	n-butyl benzene	SW-846, Method 8260	N/A	N/A	N/A	N/A	10 µg/kg	c	c
	Toluene	SW-846, Method 8260	10 mg/kg	N/A	10 mg/kg	N/A	5 µg/kg	c	c
	Tetrachloro-ethylene (PCE)	SW-846, Method 8260	6.0 mg/kg	0.7 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c
	Trans-1,2-dichloroethene	SW-846, Method 8260	N/A	N/A	30 mg/kg	N/A	10 µg/kg	c	c
	Trichloroethene (TCE)	SW-846, Method 8260	6.0 mg/kg	0.5 mg/L	6.0 mg/kg	N/A	5 µg/kg	c	c
	Xylenes	SW-846, Method 8260	30 mg/kg	N/A	30 mg/kg	N/A	10 µg/kg	c	c

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Organics – Semi-Volatile Organics								
	Phenol	TBD	N/A	N/A	6.2 mg/kg	N/A	330 µg/kg	c	c
	TBP and derivatives (mono, bi)	SW-846, Method 8270	N/A	N/A	N/A	1% WAC 173-303-9903, 9905	330 µg/kg	c	c
	Pesticides								
	Heptachlor epoxide	SW-846, Method 8081B	N/A	N/A	0.066 mg/kg	N/A	1.65 µg/kg	c	c
	Endosulfan sulfate	SW-846, Method 8081B	N/A	N/A	0.13 mg/kg	N/A	3.3 µg/kg	c	c
	Aldrin	SW-846, Method 8081B	N/A	N/A	0.066 mg/kg	N/A	1.65 µg/kg	c	c
	Alpha-BHC	SW-846, Method 8081B	N/A	N/A	0.066 mg/kg	N/A	1.65 µg/kg	c	c
	Beta-BHC	SW-846, Method 8081B	N/A	N/A	0.066 mg/kg	N/A	1.65 µg/kg	c	c
	Endosulfan II	SW-846, Method 8081B	N/A	N/A	0.13 mg/kg	N/A	3.3 µg/kg	c	c
	4,4'-DDT	SW-846, Method 8081B	N/A	N/A	0.087 mg/kg	N/A	3.3 µg/kg	c	c
	Alpha-chlordane	SW-846, Method 8081B	N/A	N/A	0.26 mg/kg	N/A	16.5 µg/kg	c	c

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Gamma-chlordane	SW-846, Method 8081B	N/A	N/A	0.26 mg/kg	N/A	16.5 µg/kg	c	c
	Dieldrin	SW-846, Method 8081B	N/A	N/A	0.13 mg/kg	N/A	3.3 µg/kg	c	c
	Endrin	SW-846, Method 8081B	N/A	0.02 mg/L	0.13 mg/kg	N/A	3.3 µg/kg	c	c
	Methoxychlor	SW-846, Method 8081B	N/A	10.0 mg/L	0.18 mg/kg	N/A	16.5 µg/kg	c	c
	4,4'-DDD	SW-846, Method 8081B	760,000 mg/kg	N/A	0.087 mg/kg	N/A	3.3 µg/kg	c	c
	4,4'-DDE	SW-846, Method 8081B	540,000 mg/kg	N/A	0.087 mg/kg	N/A	3.3 µg/kg	c	c
	Endrin aldehyde	SW-846, Method 8081B	N/A	N/A	0.13 mg/kg	N/A	3.3 µg/kg	c	c
	Heptachlor	SW-846, Method 8081B	N/A	0.008 mg/L	0.066 mg/kg	N/A	1.65 µg/kg	c	c
	Toxaphene	SW-846, Method 8081B	N/A	0.5 mg/L	2.6 mg/kg	N/A	1.65 µg/kg	c	c
	Endosulfan I	SW-846, Method 8081B	N/A	N/A	0.13 mg/kg	N/A	1.65 µg/kg	c	c

Table 3-6b. Analytical Performance Requirements for Waste Sampling. (8 Pages)

DS #	COCs	Survey/Analytical Method	ERDF Waste Acceptance Criteria[a]	TCLP Limit	UTS	Other	CRDL[b]	Precision Req't	Accuracy Req't
	Herbicides								
	2,4-D	SW-846, Method 8151A	N/A	10.0 mg/L	10 mg/kg	N/A	400 µg/kg	c	c
	2,4,5-TP (silvex)	SW-846, Method 8151A	N/A	1.0 mg/L	7.9 mg/kg	N/A	20 µg/kg	c	c
	Other								
	pH	SW-846, Method 9045C	N/A	N/A	N/A	<2, ≥12.5	0.1 pH unit	N/A	N/A
	PCBs	SW-846, Method 8082	500 mg/kg	N/A	N/A	N/A	16.5 µg/kg	c	c
	Asbestos	40 CFR 61, Subpart M	N/A	N/A	N/A	40 CFR 61, Subpart M	N/A	N/A	N/A
	Cyanide	SW-846, Method 9010	590 mg/kg (total)	N/A	N/A	590 mg/kg (total) 30 mg/kg (amenable) 40 CFR 268.40	500 µg/kg	±25%	±35%
	Sulfides	SW-846, Method 9030	N/A	N/A	N/A	40 CFR 261.23(a)(5)	5,000 µg/kg	±25%	±35%

[a] *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (BHI 1998a).
[b] Values are laboratory contract quantification limits.
[c] As required by corresponding analytical method.
[d] Pu-241 concentrations to be calculated based on concentrations of americium/plutonium isotopes.
N/A = not applicable
TBD = to be determined

4.0 STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (hindrances or obstacles) that must be taken into consideration in the sampling design. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

4.1 POPULATION OF INTEREST

Prior to defining the spatial and temporal boundaries of the site under investigation, it is first necessary to clearly define the populations of interest that apply for each DS (Table 4-1). The intent of Table 4-1 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 4-1. Characteristics that Define the Population of Interest. (2 Pages)

DS #	Population of Interest	Unit Measurement Size	Total Number of Potential Measurement Units Within the Population
Problems #1, #2, and #3			
1, 2, 3, and 4	Soil samples collected during drilling of new well	0.8 m long Split-spoon sampler	114
1, 2, and 4	Groundwater samples collected during installation of new well	1 L	7 (assume 1 sample every 10 ft in aquifer)
1, 3, and 4	Soil vapor samples collected during drilling of new well	1 L	22 (assume 1 sample every 10 ft in vadose zone)
Problem #4			
1	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)	1 kg	4,000
2a	Chemical concentrations in soil (drill cuttings) (see Table 3-2 for potential "listed" chemicals of concern)		
2b	Chemical concentrations in soil (drill cuttings) (pH, sulfide, cyanide, and TCLP list – 40 CFR 261.24)		

Table 4-1. Characteristics that Define the Population of Interest. (2 Pages)

DS #	Population of Interest	Unit Measurement Size	Total Number of Potential Measurement Units Within the Population
2c	Chemical concentrations in soil (drill cuttings) (toxicity characteristics list – WAC 173-303-090)		
2d	Chemical concentrations in soil (drill cuttings) (persistent list – WAC 173-303-090[6]))		
2e	Chemical concentrations in soil (drill cuttings) (MTCA Method B list – WAC 173-340)	1 kg	4,000
2f	PCB concentrations in soil (drill cuttings)		
3	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)		
4	Chemical concentrations in soil (drill cuttings) (40 CFR 268.40, Subpart D list)		

N/A = not applicable

4.2 GEOGRAPHIC BOUNDARIES

Table 4-2 identifies the geographic boundaries that apply to each DS. Limiting the geographic boundaries of the study area ensures that the investigation does not expand beyond the original scope of the task.

Table 4-2. Geographic Boundaries of the Investigation.

DS #	Geographic Boundaries of the Investigation
Problems #1, #2, and #3	
1, 2, 3, and 4	Location of proposed well.
Problem #4	
1, 2a through 2f, 3, and 4	Does not apply to soil (drill cuttings) that is containerized.

4.3 ZONES WITH HOMOGENEOUS CHARACTERISTICS

Table 4-3 defines the zones within the site under investigation that have relatively homogeneous characteristics. These zones were identified by using existing information to segregate the elements of the population into subsets that exhibit relatively homogeneous characteristics (e.g., concentrations and types of contaminants). Dividing the site into separate zones reduces the overall complexity of the problem because the site is then in more manageable "pieces."

Table 4-3. Zones with Homogeneous Characteristics.

DS #	Population of Interest	Zone	Homogeneous Characteristic Logic
Problems #1, #2, and #3			
1, 2, 3, and 4	Soil samples collected during drilling of new well	Vadose zone and unconfined aquifer	Heterogeneous
1, 2, and 4	Groundwater samples collected during installation of new well	Upper 20 m (60 ft) of unconfined aquifer	Semi-homogeneous when dissolved in groundwater. Heterogeneous when separate organic phase liquid is present, but not dissolved, in groundwater.
1, 3, and 4	Soil vapor samples collected during drilling of new well	Vadose zone	Homogeneous
Problem #4			
1	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)	Containerized soil cuttings	Heterogeneous
2a	Chemical concentrations in soil (drill cuttings) (see Table 3-2 for potential "listed" chemicals of concern)		
2b	Chemical concentrations in soil (drill cuttings) (pH, sulfide, cyanide, and TCLP list – 40 CFR 261.24)		
2c	Chemical concentrations in soil (drill cuttings) (WAC 173-303-100[5])		
2d	Chemical concentrations in soil (drill cuttings) (persistent list – WAC 173-303-090[6])		
2e	Chemical concentrations in soil (drill cuttings) (MTCA Method B list – WAC 173-340)		
2f	PCB concentrations in soil (drill cuttings)		
3	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)		
4	Chemical concentrations in soil (drill cuttings) (40 CFR 268.40, Subpart D list)		

4.4 TEMPORAL BOUNDARIES

Table 4-4 identifies temporal boundaries that may apply to each DS. The temporal boundary refers to both the timeframe over which each DS applies (e.g., number of years) and when (e.g., season, time of day, and weather conditions) the data should optimally be collected.

Table 4-4. Temporal Boundaries of the Investigation.

DS #	Timeframe	When to Collect Data
Problems #1, #2, and #3		
1 and 4	N/A	If possible, avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.
2	N/A	If possible, avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.
3	N/A	If possible, avoid high barometric pressure because this may drive atmospheric air into soil through borehole and reduce concentration of VOCs in soil vapor near borehole.
Problem #4		
1	6 months (time required to disposition waste)	Avoid wet weather sampling conditions.
2a	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.
2b		
2c		
2d		
2e		
2f	6 months (time required to disposition waste)	No specific requirements.
3	6 months (time required to disposition waste)	Avoid wet weather sampling conditions.
4	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.

N/A = not applicable

4.5 SCALE OF DECISION MAKING

In Table 4-5, the scale of decision making has been defined for each DS. The scale of decision making is defined by joining the population of interest and the geographic and temporal boundaries of the area under investigation.

Table 4-5. Scale of Decision Making. (3 Pages)

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
Problems #1, #2, #3					
1, 2, 3 and 4	Soil samples collected during drilling of new well	Location of new well	N/A	If possible, avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Concentrations, distribution, phases of carbon tetrachloride and co-contaminants, physical properties of soil samples at location of new well.
1, 2, and 4	Groundwater samples collected during installation of new well	Location of new well	N/A	If possible, avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Concentrations, distribution and phases of carbon tetrachloride and co-contaminants in groundwater samples at location of new well.
1, 3, and 4	Soil vapor samples collected during drilling of new well	Location of new well	N/A	If possible, avoid high barometric pressure because this may drive atmospheric air into soil through borehole and reduce concentration of VOCs in soil vapor near borehole.	Concentrations and distribution of carbon tetrachloride and co-contaminants in soil vapor samples at location of new well.
Problem #4					
1	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid wet weather sampling conditions.	Maximum concentration of radionuclides (see Table 1-8 for isotopes of concern) in soil (drill cuttings) over 6 months following the commencement of drilling.
2a	Chemical concentrations in soil (drill cuttings) (see Table 3-2 for potential "listed" chemicals of concern)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals ("listed") in soil (drill cuttings) over 6 months following the commencement of drilling.

Table 4-5. Scale of Decision Making. (3 Pages)

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
2b	Chemical concentrations in soil (drill cuttings) (pH, sulfide, cyanide, and TCLP list – 40 CFR 261.24)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals (pH, sulfide, cyanide, and TCLP list – 40 CFR 261.24) in soil (drill cuttings) over 6 months following the commencement of drilling.
2c	Chemical concentrations in soil (drill cuttings) (WAC 173-303-100[5])	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals (toxicity characteristics list – WAC 173-303-090) in soil (drill cuttings) over 6 months following the commencement of drilling.
2d	Chemical concentrations in soil (drill cuttings) (persistent list – WAC 173-303-090 [6])	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals (persistent list – WAC 173-303-090[6]) in soil (drill cuttings) over 6 months following the commencement of drilling.
2e	Chemical concentrations in soil (drill cuttings) (MTCA Method B list – WAC 173-340)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals (MTCA Method B list – WAC 173-340) in soil (drill cuttings) over 6 months following the commencement of drilling.

Table 4-5. Scale of Decision Making. (3 Pages)

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
2f	PCB concentrations in soil (drill cuttings)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	No specific requirements.	Maximum concentration of PCBs in soil (drill cuttings) over 6 months following the commencement of drilling.
3	Radionuclides in soil (drill cuttings) (see Table 1-8 for isotopes of concern)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid wet weather sampling conditions.	Maximum concentration of radionuclides (see Table 1-8 for isotopes of concern) in soil (drill cuttings) over 6 months following the commencement of drilling.
4	Chemical concentrations in soil (drill cuttings) (40 CFR 268.40, Subpart D list)	N/A; does not apply to soil cuttings that are containerized	6 months (time required to disposition waste)	Avoid high temperature extremes because VOCs may be lost to atmosphere during sampling.	Maximum concentration of chemicals (40 CFR 268.40, Subpart D list) in soil (drill cuttings) over 6 months following the commencement of drilling.

N/A = not applicable

4.6 PRACTICAL CONSTRAINTS

Table 4-6 identifies all of the practical constraints that may impact the data collection effort. These constraints include physical barriers, difficult sample matrices, high radiation areas, or any other condition that will need to be taken into consideration in the design and scheduling of the sampling program.

Table 4-6. Practical Constraints on Data Collection.

The following are practical constraints that could be encountered during the drilling program:

- Borehole soil samplers may not obtain sufficient volumes of sample media if the sampled zone is 0.6 m (2 ft) thick or less. Advancement of borehole casing may smear contamination down hole.
- Drilling operations may volatilize VOAs (including carbon tetrachloride) that are present. Thus, an unrepresentative measurement may be obtained.
- The soils in the vadose zone may include cemented zones that could pose sampling challenges.
- Health and safety constraints may be imposed during characterization sampling to ensure that as low as reasonable achievable issues are properly addressed when sampling radiologically contaminated soils.
- Laboratory constraints are expected when analyzing soil samples with high contaminant concentrations. Soil samples in this category would be analyzed in an onsite laboratory. Impacts are expected in cost, degradation of detection limits, and possible reduction in the analyte lists. If analytical turnaround times are extended, the short holding times for certain nonradiological constituents may be exceeded. In addition, soil physical property testing may not be possible in onsite laboratories.
- Extreme weather conditions could limit or shut down field screening operations.

5.0 STEP 5 – DEVELOP A DECISION RULE

The purpose of DQO Step 5 is initially to define the statistical parameter of interest (i.e., maximum or mean) that will be used for comparison against the action level. The statistical parameter of interest specifies the characteristic or attribute that the decision maker would like to know about the population. The final action level for each of the COCs is also identified in DQO Step 5. When this is established, a decision rule (DR) is developed for each DS in the form of an "IF…THEN…" statement that incorporates the parameter of interest, the scale of decision making, the action level, and the AAs that would result from resolution of the decision. Note that the scale of decision making and AAs were identified earlier in DQO Steps 4 and 2, respectively.

5.1 INPUTS NEEDED TO DEVELOP DECISION RULES

Tables 5-1 and 5-2 present all of the information needed to formulate the DRs identified in Section 5.2. This information includes the DSs and AAs identified earlier in DQO Step 2, the scale of decision making identified in DQO Step 4, the statistical parameter of interest, and the final action levels for each of the COCs.

Table 5-1. Decision Statements. (2 Pages)

DS #	Decision Statement
Problems #1, #2, and #3	
1	Determine if there is a continuing source of carbon tetrachloride groundwater contamination in the vadose zone and/or groundwater at the well location justifying the need to evaluate alternatives to remediate the source; otherwise, do not evaluate alternatives to remediate the source.
2	Determine if operation of a groundwater extraction well at this location is appropriate and justifies the use of the well for groundwater remediation; otherwise, use the well for groundwater monitoring only.
3	Determine if operation of a SVE well at this location is appropriate and justifies the use of the well for vadose zone remediation only, or for both vadose zone and groundwater remediation; otherwise, construct as a groundwater well only.
4	Determine which CSM is more likely and focus future remediation activities at more likely origin of groundwater contamination; otherwise, retain all CSMs for future remediation planning.
Problem #4	
1	Determine if the material <u>is</u> radiologically contaminated and will be evaluated for onsite disposal <u>OR</u> if it <u>is not</u> radiologically contaminated and will be evaluated for offsite disposal.
2a	Determine if the material <u>is</u> a listed hazardous waste and will be assigned a listed hazardous waste code <u>OR</u> if the material <u>is not</u> a listed hazardous waste and will not be regulated as such.
2b	Determine if the material <u>is</u> a characteristic hazardous waste and will be assigned a characteristic waste code <u>OR</u> if the material <u>is not</u> a characteristic hazardous waste and will not be regulated as such.

Table 5-1. Decision Statements. (2 Pages)

DS #	Decision Statement
2c	Determine if the material is a toxic dangerous waste and will be assigned a toxic dangerous waste code OR if the material is not a toxic dangerous waste and will not be regulated as such.
2d	Determine if the material is a persistent waste and will be assigned a persistent waste code OR if the material is not a persistent waste and will not be regulated as such.
2e	Determine if the material is above MTCA Method B levels and must be disposed of as a MTCA waste, OR if the material is not above the MTCA Method B levels and should not be disposed of as a MTCA waste.
2f	Determine if the material is a PCB waste and will be regulated as a PCB waste OR if the material is not a PCB waste and will be regulated as such.
3	Determine if the material does exceed the disposal facility's waste acceptance criteria and disposal will be negotiated with the regulators OR if the material does not exceed the disposal facility's waste acceptance criteria and waste will be disposed in an approved facility.
4	Determine if the material is land disposal restricted and requires treatment before disposal OR if the material is not land disposal restricted and may be disposed in an onsite facility without treatment.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
Problems #1, #2, and #3							
1	Carbon tetrachloride in soil, soil vapor, and groundwater Moisture content of vadose zone soils Lithology of soils Groundwater temperature	Maximum concentration, relative distribution, mobility of phase Range of physical properties	Concentrations, distribution, and phases of carbon tetrachloride in soil, soil vapor, and groundwater samples at location of new well. Physical properties of the soil, soil vapor, and groundwater samples at location of new well.	N/A	N/A	N/A	1. Conclude that there is a continuing source and evaluate alternatives to remediate the source. 2. Conclude that there is not a continuing source and do not evaluate alternatives to remediate the source.
2	Carbon tetrachloride in groundwater Co-contaminants in groundwater Lithology Water production (flow rate) of well Water level (drawdown) changes Pumping performance capability	Maximum concentration, relative distribution, mobility of phase Range of physical properties	Concentrations, distribution, and phases of carbon tetrachloride and co-contaminants in groundwater samples at location of new well.	N/A	N/A	Evaluation that new groundwater extraction well is beneficial to achievement of interim ROD remedial action objectives (EPA et al. 1995)	1. Conclude that operation is appropriate and use the well for groundwater remediation. 2. Conclude that operation is inappropriate and use the well for groundwater monitoring only.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
3	Carbon tetrachloride in soil and soil vapor Other volatile compounds in soil vapor Moisture content of vadose zone soils Lithology	Maximum concentration, relative distribution, mobility of phase Range of physical properties	Concentrations and distribution of carbon tetrachloride and co-contaminants in soil vapor samples and of carbon tetrachloride in soil samples. Physical properties of the soil vapor samples and of carbon tetrachloride in soil samples at location of new well.	N/A	N/A	Drainable, separate organic phase carbon tetrachloride liquid based on field observation 20,000 ppmv carbon tetrachloride in the in situ soil vapor based on field screening 600 ppmv carbon tetrachloride in in situ soil vapor based on field screening Evaluation that new SVE well is beneficial to achievement of expedited response action remedial objectives (EPA and Ecology 1992)	1. Conclude that operation is appropriate, that further advancement of the borehole is inappropriate, and construct the well for vadose zone remediation only. 2. Conclude that operation is appropriate, that further advancement of the borehole is appropriate, and construct the well for both vadose zone and groundwater remediation. 3. Conclude that operation is inappropriate and construct a groundwater well only.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
4	Carbon tetrachloride in soil, soil vapor, and groundwater Co-contaminants in soil, soil vapor, and groundwater Moisture content of vadose zone soils Lithology of soils	Maximum concentration, relative distribution, mobility of phase Range of physical properties	Concentrations, distribution, and phase of carbon tetrachloride and co-contaminants in soil, soil vapor, and groundwater samples at location of new well Physical properties of soil, soil vapor, and groundwater samples at location of new well.	N/A	N/A	N/A	1. Conclude that one of the alternative CSMs is more likely, and focus future remediation activities at more likely origin of groundwater contamination. 2. Conclude that one of the alternative CSMs is not more likely, and focus future remediation activities among all proposed origins of groundwater contamination.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
Problem #4							
1	See Table 3-6b	Maximum	Maximum concentration of radionuclides (see Table 1-8 for isotopes of concern) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is radiologically contaminated and evaluate material for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not radiologically contaminated and evaluate material for being returned to the ground, or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2a	See Table 3-6b	Maximum	Maximum concentration of chemicals ("listed") in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is a listed hazardous waste and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not a listed hazardous waste and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2b	See Table 3-6b	Maximum	Maximum concentration of chemicals (pH, sulfide, cyanide, and TCLP list – 40 CFR 261.24) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is a characteristic hazardous waste and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not a characteristic hazardous waste and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2c	See Table 3-6b	Maximum	Maximum concentration of chemicals (WAC 173-303-100[5]) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is a toxic dangerous waste and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not a toxic dangerous waste and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2d	See Table 3-6b	Maximum	Maximum concentration of chemicals (persistent list – WAC 173-303-090[6]) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is a persistent dangerous waste and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not a persistent dangerous waste and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2e	See Table 3-6b	Maximum	Maximum concentration of chemicals (MTCA Method B list – WAC 173-340) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is above MTCA Method B levels and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not above MTCA Method B levels and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
2f	See Table 3-6b	Maximum	Maximum concentration of PCBs in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is a PCB waste and evaluate for treatment or disposal at the ERDF or CWC. Not radiologically contaminated: Determine that the material is not a PCB waste and evaluate for being returned to the ground or disposal at a solid waste landfill, the ERDF, or an offsite TSD unit.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
3	See Table 3-6b	Maximum	Maximum concentration of radionuclides (see Table 1-8 for isotopes of concern) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the radiological activity of the material does exceed the disposal facility's waste acceptance criteria limits. Evaluate the waste for chemical waste designation and negotiate disposition with the regulators. Not radiologically contaminated: Determine that the radiological activity of the material does not exceed the disposal facility's waste acceptance criteria limits. Evaluate the waste for chemical waste designation and dispose of material in an approved facility.

Table 5-2. Inputs Needed to Develop Decision Rules. (12 Pages)

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	BHI-EE-10, Procedure 8.0 (pCi/g)	MTCA Method B (100 X GW) (mg/kg)	Other Action Levels	Alternative Actions
4	See Table 3-6b	Maximum	Maximum concentration of chemicals (40 CFR 268.40, Subpart D list) in soil (drill cuttings) over 6 months following the commencement of drilling.	See Table 3-6b	See Table 3-6b	See Table 3-6b	Radiologically contaminated: Determine that the material is land disposal restricted and treat material prior to disposal. Not radiologically contaminated: Determine that the material is not land disposal restricted and do not treat the material prior to disposal. Dispose the material in an onsite facility without treatment.

GW = groundwater
N/A = not applicable

5.2 DECISION RULES

Table 5-3 presents DRs that correspond to each of the DSs identified in Table 5-1.

Table 5-3. Decision Rules. (5 Pages)

DS #	DR #	Decision Rule
Problems #1, #2, and # 3		
1	1	If the maximum concentration, relative distribution, and mobility of carbon tetrachloride, and range of physical properties, within the vadose zone soils, soil vapor, and groundwater indicate that there is a continuing source of carbon tetrachloride groundwater contamination in the vadose zone and/or groundwater at the well location, then evaluate alternatives to remediate the source; otherwise, do not evaluate alternatives to remediate the source.
2	2	If the maximum concentration, relative distribution, and mobility of carbon tetrachloride and co-contaminants, and range of physical properties, in groundwater; the hydraulic properties of the aquifer; and the evaluation of the interim ROD remedial action objectives (EPA et al. 1995) indicate that operation of a groundwater extraction well at the well location would be appropriate, then recommend using well for groundwater extraction; otherwise use the groundwater well for monitoring only.
3	3	If the maximum concentration, relative distribution, mobility of carbon tetrachloride and co-contaminants, and range of physical properties, in soil and soil vapor; and the evaluation of the expedited response action remedial objectives (EPA and Ecology 1992) indicate that operation of a SVE well at the well location is appropriate, then construct the well with a screened interval for SVE; otherwise, construct as groundwater well only. If drainable, separate organic phase and/or soil vapor concentrations exceeding 20,000 ppmv are observed in the vadose zone, then construct as a vapor extraction well at that depth and do not advance the borehole further. If soil vapor concentrations between 600 and 20,000 ppmv are observed in the vadose zone, advance the borehole to total depth and construct as both a groundwater and vadose zone remediation well.
4	4	If the maximum concentration, relative distribution, mobility of carbon tetrachloride and co-contaminants, and range of physical properties, within the vadose zone soils, soil vapor, and groundwater indicate that one CSM is more likely, focus future remediation activities at more likely origin of groundwater contamination; otherwise, retain all CSMs for future remediation planning.
Problem #4		
1	1	Radiologically contaminated: 1. If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) does exceed the criteria for being released as "nonradioactive" in accordance with BHI-EE-10, *Part II – Implementing Procedures*, Procedure 8.0 and is not a dangerous, PCB or asbestos waste, then treat the material as radiologically contaminated and evaluate material for disposal at the ERDF. Proceed to DS #2a. 2. If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) does exceed the criteria for being released as "nonradioactive" in accordance with BHI-EE-10, Procedure 8.0 and is a dangerous, PCB or asbestos waste, then treat the material as radiologically and chemically contaminated and evaluate material for disposal at the ERDF or CWC. Proceed to DS #2a.

Table 5-3. Decision Rules. (5 Pages)

DS #	DR #	Decision Rule
		Not radiologically contaminated: 1. If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) does not exceed the criteria for being released as "nonradioactive" in accordance with BHI-EE-10, Procedure 8.0 and is not a dangerous, PCB, or asbestos waste, then evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2a. 2. If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) does not exceed the criteria for being released as "nonradioactive" in accordance with BHI-EE-10, Procedure 8.0 and is a dangerous, PCB, or asbestos waste, then evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2a.
2a	2a	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings are radiologically contaminated and are a listed hazardous waste, then evaluate for treatment or disposal at the ERDF or CWC. Proceed to DS #2b. 2. If the maximum concentration shows drill cuttings are radiologically contaminated and are not a listed hazardous waste, then evaluate for treatment or disposal at the ERDF. Proceed to DS #2b. Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings are not radiologically contaminated and are a listed hazardous waste, then evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2b. 2. If the maximum concentration shows drill cuttings are not radiologically contaminated and are not a listed hazardous waste, then evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2b.
2b	2b	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a characteristic hazardous waste, then treat the material as a radiologically contaminated characteristic hazardous waste and evaluate for disposal at the ERDF or CWC. Proceed to DS #2c. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a characteristic hazardous waste, then do not treat the material as a characteristic hazardous waste and evaluate for disposal at the ERDF. Proceed to DS #2c.

Table 5-3. Decision Rules. (5 Pages)

DS #	DR #	Decision Rule
		Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a characteristic hazardous waste, then treat the material as a characteristic hazardous waste and evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2c. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a characteristic hazardous waste, then do not treat the material as a radiologically or chemically contaminated waste and evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2c.
2c	2c	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a toxic dangerous waste, then treat the material as a radiologically contaminated toxic dangerous waste and evaluate for disposal at the ERDF or CWC. Proceed to DS #2d. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a toxic dangerous waste, then do not treat the material as a toxic dangerous waste and evaluate for disposal at the ERDF. Proceed to DS #2d. Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a toxic dangerous waste, then treat the material as a toxic dangerous waste and evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2d. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a toxic dangerous waste, then do not treat the material as a radiologically or chemically contaminated waste and evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2d.
2d	2d	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a persistent dangerous waste, then treat the material as a radiologically contaminated persistent dangerous waste and evaluate for disposal at the ERDF or CWC. Proceed to DS #2e. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a persistent dangerous waste, then do not treat the material as a persistent dangerous waste and evaluate for disposal at the ERDF. Proceed to DS #2e.

Table 5-3. Decision Rules. (5 Pages)

DS #	DR #	Decision Rule
		Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a persistent dangerous waste, then treat the material as a persistent dangerous waste and evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2e. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a persistent dangerous waste, then do not treat the material as a radiologically or chemically contaminated waste and evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2e.
2e	2e	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do exceed MTCA Method B levels, then evaluate for disposal at the ERDF or CWC. Proceed to DS #2f. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do not exceed MTCA Method B levels, then evaluate for disposal at the ERDF. Proceed to DS #2f. Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do exceed MTCA Method B levels, then evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #2f. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do not exceed MTCA Method B levels, then evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #2f.
2f	2f	Radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a PCB waste, then treat the material as a radiologically contaminated PCB waste and evaluate for disposal at the ERDF or CWC. Proceed to DS #3. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a PCB waste, then do not treat the material as a PCB waste and evaluate for disposal at the ERDF. Proceed to DS #3.

Table 5-3. Decision Rules. (5 Pages)

DS #	DR #	Decision Rule
		Not radiologically contaminated: 1. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do exceed the criteria for being a PCB waste, then treat the material as a PCB waste and evaluate for disposal at the ERDF or an offsite TSD unit. Proceed to DS #3. 2. If the maximum concentration shows drill cuttings (over 6 months following the commencement of drilling) are not radiologically contaminated and chemical concentrations in drill cuttings do not exceed the criteria for being a PCB waste, then do not treat the material as a radiologically or chemically contaminated waste and evaluate for return to the ground or for disposal at a solid waste landfill. Proceed to DS #3.
3	3	Radiologically contaminated: If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) do exceed the disposal facility waste acceptance criteria, evaluate the waste for chemical waste designation and negotiate disposition with the regulators. Proceed to DS #4. Not radiologically contaminated: If the maximum concentration of radionuclides in drill cuttings (over 6 months following the commencement of drilling) do not exceed the disposal facility waste acceptance criteria, evaluate the waste for chemical waste designation and dispose material in an approved facility. Proceed to DS #4.
4	4	Radiologically contaminated: If process knowledge or analytical results do dictate land disposal restriction imposed treatment, then the material shall be treated and disposed at the ERDF or CWC. Not radiologically contaminated: If process knowledge or analytical results do not dictate land disposal restriction-imposed treatment, then the material shall be disposed at the ERDF.

6.0 STEP 6 – SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Because analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which DSs (if any) require a statistically based sample design. For those DSs requiring a statistically based sample design, DQO Step 6 defines tolerable limits on the probability of making a decision error.

6.1 STATISTICAL VERSUS NON-STATISTICAL SAMPLING DESIGN

Table 6-1 provides a summary of the information used to support the selection between a statistical versus a non-statistical sampling design for each DS. The factors that were taken into consideration in making this selection included the timeframe over which each of the DSs applies, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required. Note that a non-statistical design was selected for each of the DSs because one objective of this study is to identify the "maximum" concentration of COCs in soil vapor, soil, and groundwater.

Table 6-1. Statistical Versus Non-Statistical Sampling Design. (2 Pages)

DS #	Timeframe (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/Moderate/Severe)	Resampling Access After Remediation (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/ Non-Statistical)
Problems #1, #2, and #3				
1	N/A	Severe	Inaccessible	Non-statistical
2	N/A	Moderate	Accessible	
3	N/A	Severe	Accessible	
4	N/A	Moderate	Inaccessible	
Problem #4				
1	6 months	Moderate	Inaccessible	Non-statistical
2a				
2b				
2c				
2d				
2e				

Table 6-1. Statistical Versus Non-Statistical Sampling Design. (2 Pages)

DS #	Timeframe (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/Moderate/Severe)	Resampling Access After Remediation (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/ Non-Statistical)
2f	6 months	Moderate	Inaccessible	Non-statistical
3				
4				

N/A = not applicable

6.2 NON-STATISTICAL DESIGNS

For those DSs to be resolved using a non-statistical design, there is no need to define the "gray region" or the tolerable limits on decision error because these only apply to statistical designs. Refer to Section 7.1 for details on the selected non-statistical sampling designs.

6.3 STATISTICAL DESIGNS

Because no statistical designs are proposed for this sampling effort, Table 6-2 does not apply.

Table 6-2. Statistical Parameter of Interest Concentration Ranges.

DS #	Media	COCs	Statistical Parameter of Interest	Range	
				Lower Limit	Upper Limit
Not applicable					

6.4 DECISION ERRORS

Because no statistical designs are proposed for this sampling effort, this section does not apply.

6.5 NULL HYPOTHESIS

Because no statistical designs are proposed for this sampling effort, Table 6-3 does not apply.

Table 6-3. Defining the Null Hypothesis.

Null Hypothesis Statement	Indicate Selection
Site media are assumed to be contaminated until it is shown to be clean.	N/A
Site media are assumed to be clean until it is shown to be contaminated.	

N/A = not applicable

6.6 TOLERABLE LIMITS FOR DECISION ERROR

Because no statistical designs are proposed for this sampling effort, Tables 6-4 and 6-5 do not apply.

Table 6-4. Statistical Designs.

DS #	Media	Selected Statistical Design	Boundaries of the Gray Region	Tolerable Limits for Incorrect Decision	
				At LBGR	At Action Level
Not applicable					

LBGR = lower bound of gray region

Table 6-5. Tolerable Decision Errors.

DS #	Media	COCs	Statistical Parameter of Interest	Statistical Parameter of Interest Range	Final Action Level	Gray Region	Tolerable Decision Error	
							At LBGR (%)	At Action Level (%)
Not applicable								

7.0 STEP 7 – OPTIMIZE THE DESIGN

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective data collection design that satisfies all of the data quality requirements.

7.1 NON-STATISTICAL DESIGN

Tables 7-1 through 7-3 have been completed for those DSs to be resolved using a non-statistical approach.

7.1.1 Non-Statistical Screening Method Alternatives

Table 7-1 identifies all of the screening technologies that were considered to resolve each DS and the optional methods of implementing each technology. The table also summarizes the limitations associated with each screening technology and/or method of implementation and provides the estimated cost for implementation.

Table 7-1. Potential Non-Statistical Screening Alternatives. (2 Pages)

DS #	Media	Screening Technology	Potential Implementation Designs	Limitations	Cost
Problems #1, #2, and #3					
1, 3, and 4	Soil vapor	Soil vapor sampling	1. Systematic soil vapor sampling with borehole depth at 6.1-m (20-ft)-depth intervals from ground surface to water table (total of 11 samples). Samples analyzed in the field for VOCs using photoionization detector and Bruel &Kjaer gas monitor. 2. Performing soil vapor screening (using photoionization detector) on soil drill cuttings as they are removed from the borehole (every 0.8 m [2.5 ft]). 3. Perform both options (1) and (2) above.	1. Obtaining representative sample. 2. Because volatile organics may be lost to the atmosphere during drilling process, the soil vapor screening results may not be representative of the formation. 3. Same as (1) and (2) above.	1. $50/sample (total $550). 2. No cost. 3. $50/sample (total $550).

Table 7-1. Potential Non-Statistical Screening Alternatives. (2 Pages)

DS #	Media	Screening Technology	Potential Implementation Designs	Limitations	Cost
Problem #4					
1	Soil	Radiological scanning surveys	1. Scanning soil cuttings with hand-held screening instruments as they are removed from the borehole. 2. Performing downhole logging using NaI detector. 3. Performing downhole logging using HPGe detector.	1. Not able to provide isotope specific data or reach detection limits requirements specified in BHI-EE-10, Procedure 8.0 for returning soil to the ground. 2. Not able to provide data for alpha or beta emitting isotopes. 3. Not able to provide data for alpha or beta emitting isotopes.	1. No additional cost because the RadCon group will be onsite scanning continuously due to medium risk. 2. $3,000. 3. $3,000.
2a	Soil	N/A; requires process knowledge and/or sampling data	N/A	N/A	N/A
2b	Soil				
2c	Soil				
2d	Soil				
2e	Soil				
2f	Soil				
3	Soil				
4	Soil				

HPGe = high-purity germanium
N/A = not applicable
NaI = sodium iodide

7.1.2 Non-Statistical Sampling Method Alternatives

Table 7-2 identifies the various types of media that need to be sampled to resolve each DS and alternative methods for collecting these samples. This table presents alternative implementation designs for each sampling method and identifies any limitations that may be associated with each sampling method and/or design. An estimated cost for the implementation of each sampling design has also been provided for comparison purposes.

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
Problems #1, #2, and #3					
1, 2, 3, and 4	Soil	Split-spoon sampler	1. Collect soil samples systematically (6.1-m [20-ft]-depth intervals) from ground surface to bottom of well within aquifer for laboratory analysis (total of 14 samples). 2. Judgmentally select soil sampling intervals for laboratory analysis (total of 9 samples) using stratigraphic knowledge from surrounding boreholes. 3. Judgmentally select soil sampling intervals for laboratory analysis (total of 9 samples) using results from soil vapor screening. 4. Collect soil samples (9 total) judgmentally at likely zones of contamination using site knowledge and systematically throughout rest of borehole depth; use soil vapor screening to identify additional contaminated zones that should be sampled.	1. Does not use site knowledge gained at known source crib characterization and remediation to focus sampling on likely zones of contamination. 2. May miss significant zones of contamination if CSM based on source cribs is incorrect at well location. 3. Because volatile organics may be lost to the atmosphere during drilling process, the soil vapor screening results may not be representative of the formation and might not identify contaminated zones for sampling. 4. More expensive if additional samples (more than 9 samples) are collected based on soil vapor screening.	1. $3,700 2. $2,400 3. $2,400 4. $2,400
1 and 2	Ground-water	Ground-water sampling pump	Sample one groundwater monitoring well screening the upper portion of the unconfined aquifer following well development; systematically sample groundwater every 3 m (10 ft) within the aquifer during drilling.	Grab samples collected during drilling may not be representative.	$300

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
Problem #4					
1	Soil	Grab sample	**Vadose Zone:** 0 to 0.6 m (2 ft) below surface gravel layer. Collect one soil sample using grab sample methods 0 to 0.6 m (2 ft) below the surface gravel layer for analysis of suspected near-surface contaminants (i.e., asbestos, PCBs, pesticides, and herbicides).	None	$800
		Split-spoon sampler	**Vadose Zone:** 0 to 15.3 m (50 ft): The soil cuttings from the top 15.3 m (50 ft) of this well (medium-risk interval) shall be scanned using both hand-held radiological (e.g., Eberline E-600 with SHP 380 AB probe) and chemical (e.g., organic vapor analyzer) field screening instruments prior to being transferred into containers (see Figure 7-1). Collect one grab soil sample from 0 to 0.6 m (2 ft) below surface gravel layer for analysis of suspected near-surface contaminants (asbestos, PCBs, pesticides, and herbicides). Collect one soil sample using a split-spoon sampler from 8.5 to 9.3 m (28 to 30.5 ft) bgs for radiological analysis using methods defined in Table 3-6b. This sampling interval is approximately 5.5 m (18 ft) below the bottom of the 216-Z-9 waste transfer pipeline, which is approximately 3.1 m (10 ft) deep and passes within 6.4 m (21 ft) of the well location.	None	$1,770 (GEA, AEA, LSC)

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
			Assuming that contamination migrates laterally at a maximum angle of 45 degrees (below horizontal) from the pipeline, contamination would be encountered by the borehole no deeper than 9.5 m (31 ft) bgs. The selected sampling interval is slightly above this projected depth. The analytical results from this sample shall be used for waste designation purposes. **NOTE:** If field screening measurements (or visual observations) indicate that contamination is present in higher concentrations at another depth interval (within the top 15.3 m [50 ft] of drilling), then the sample for analytical testing will preferentially be collected from the interval showing the highest contamination levels. In this situation, the pre-selected sampling interval would be discarded. This approach will ensure the worst-case sample is sent for analytical testing. <u>15.3 m (50 ft) to water table</u>: The soil cuttings from 15.3 m (50 ft) bgs to the highest recorded water table at 58 m (191 ft) bgs (low-risk interval) shall be scanned using both hand-held radiological (e.g., Eberline E-600 with SHP 380 AB probe) and chemical (e.g., organic vapor analyzer) field screening instruments prior to being transferred into containers (see Figure 7-1).		

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
			These cuttings are expected to be free from radiological contamination. If elevated readings are detected, a sample shall be collected (second vadose zone sample) from the interval showing the highest contamination levels. If no elevated readings are detected, soil cuttings should be dispositioned based on the results from the sample collected from the 0 to 15.3-m (50-ft) interval. **Saturated Zone**: All soil cuttings from below the highest recorded water table at 58 m (191 ft) bgs shall be containerized (see Figure 7-1). Collect one soil sample using a split-spoon sampler from 1.5 to 2.3 m (5 to 7.5 ft) below the current water table for radiological analysis using methods defined in Table 3-6b.		
2a	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if listed waste codes apply to vadose zone soils in addition to saturated soils.	None	$1,182 (VOCs and SVOCs)
2b	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if waste is a characteristic hazardous waste.	None	$750[a]
2c	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if waste is a toxic dangerous waste.	None	N/A Data collected to resolve DS #2b shall also be used to resolve DS #2c.

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

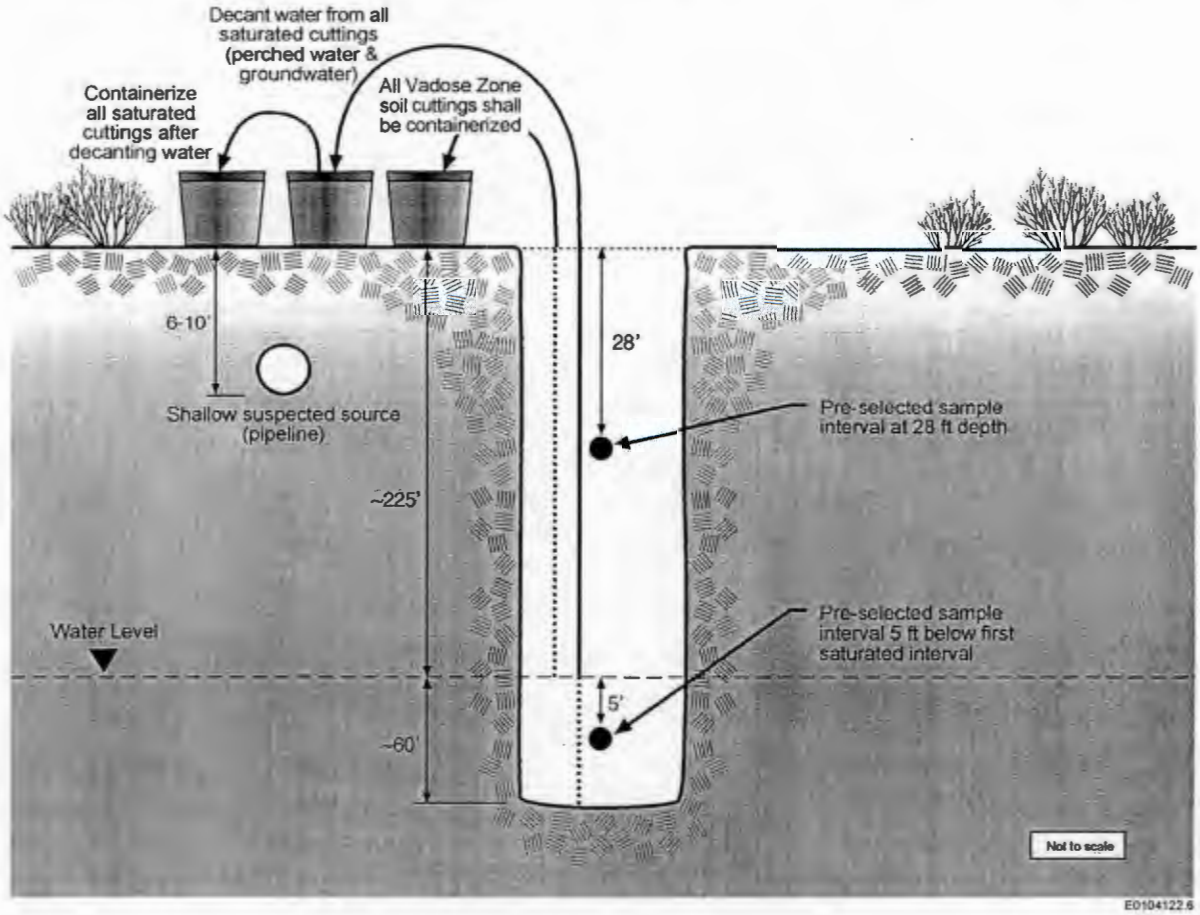
DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
2d	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if waste is a persistent dangerous waste.	None	$302[b]
2e	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if MTCA Method B limits have been exceeded.	None	N/A Data collected to resolve DS #2a through 2d shall also be used to resolve DS #2e.
2f	Soil	Split-spoon sampler	The same two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for PCB composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if waste contains PCBs.	None	N/A Data collected to resolve DS #2d and 2e shall also be used to resolve DS #2f.
3	Soil	Split-spoon sampler	The analytical results from the two split-spoon samples collected for radiological composition above (Problem #4, DS #1) shall be used to determine if disposal facility waste acceptance criteria limits have been exceeded.	None	N/A Data collected to resolve DS #1 shall also be used to resolve DS #3.

Table 7-2. Potential Non-Statistical Sampling Method Alternatives. (6 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
4	Soil	Split-spoon sampler	The same two samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for chemical composition using methods defined in Table 3-6b. The results from these analyses shall be used to determine if waste is land disposal restricted.	None	N/A Data collected to resolve DS #1 through 3 shall also be used to resolve DS #4.

[a] Reflects cost to run analyses for metals, pH, sulfide and cyanide. Cost for VOC/SVOC analysis previously addressed in cost reported for DS #2a.
[b] Reflects cost to run analyses for PCBs only. Cost for VOC/SVOC analysis previously addressed in cost reported for DS #2a.
N/A = not applicable

Figure 7-1. Proposed Handling and Sampling Intervals for Waste Designation.



7.1.3 Non-Statistical Implementation Design

Table 7-3 presents the selected screening technologies and sampling methods for resolving each DS and a summary of the proposed implementation design. The table also provides the basis for the selected implementation design.

Table 7-3. Selected Implementation Design. (4 Pages)

DS #	Media	Selected Screening Technologies	Selected Sampling Methods	Potential Implementation Designs
Problems #1,# 2, and # 3				
1	Soil and soil vapor	Soil vapor sampling with depth in borehole	Soil and soil vapor sampling with depth in borehole	Systematic sampling
				Judgmental sampling
				Random sampling

Selected Implementation Design: A combination of systematic and judgmental sampling will be used for soil sampling and soil vapor sampling. Soil samples will be collected from the ground surface to the bottom of the well, within the aquifer, at judgmental locations based on stratigraphic and contaminant knowledge from the known source cribs (Figure 7-2). In between the judgmental locations, soil samples will be collected systematically at approximately 12.2-m (40-ft) intervals. Soil vapor samples shall be collected at the same locations as the soil samples from the ground surface to the water table. In between the judgmental locations, soil vapor samples will be collected systematically at approximately 6.1-m (20-ft) intervals. Samples shall be analyzed using the methods specified in Table 3-6a.

Basis for Selection: Judgmental sampling was selected to maximize use of site knowledge gained during characterization and remediation at known source cribs to focus sampling on likely zones of contamination. Systematic sampling was selected to provide coverage of the intervals between the judgmental samples so unanticipated zones of contamination are not missed. The systematic soil vapor sampling and field screening of soil cuttings, which is more frequent than the systematic soil sampling, will be used to identify additional contaminated zones where soil samples should be collected. Field screening (e.g., screening of drill cuttings) alone was not relied upon to choose soil sampling locations because volatile organics in drill cuttings may be lost to the atmosphere, providing unrepresentative indicators of the contamination in the formation.

The rationale for the selected environmental investigation soil samples is as follows:

- 8.5 m (28 ft): Characterize the vadose zone at the depth anticipated to intercept contamination leaks from the 216-Z-9 effluent pipeline that is approximately 3 m (10 ft) deep and passes within 6.4 m (21 ft) of the well location.
- 18.3 m (60 ft): Characterize the vadose zone between 9.1-m (30-ft) depth and Plio-Pleistocene unit; evaluate vertical distribution of contaminants.
- 36.6 m (120 ft): Characterize top of Plio-Pleistocene unit, a zone of potential perching.
- 41.1 m (135 ft): Characterize center of Plio-Pleistocene unit, a zone of potential sorption.
- 45.7 m (150 ft): Characterize bottom of Plio-Pleistocene unit, evaluate gradient through Plio-Pleistocene.
- 54.9 m (180 ft): Characterize vadose zone between Plio-Pleistocene unit and water table; evaluate vertical distribution of contaminants.

Table 7-3. Selected Implementation Design. (4 Pages)

DS #	Media	Selected Screening Technologies	Selected Sampling Methods	Potential Implementation Designs
• 67.1 m (220 ft): Characterize capillary fringe, a zone of potential accumulation. • 69.2 m (227 ft): Characterize shallow portion of unconfined aquifer. • 86 m (282 ft): Characterize deeper portion of unconfined aquifer. The systematic soil vapor sampling and field screening of soil cuttings, which is more frequent than the systematic soil sampling, will be used to identify additional contaminated zones where collection of additional soil samples should be considered. A soil vapor concentration exceeding 1,250 ppmv would indicate a zone where additional soil samples might be collected. Field screening (e.g., screening of drill cuttings) alone was not relied upon to choose soil sampling locations because volatile organics in drill cuttings may be lost to the atmosphere, providing unrepresentative indicators of the contamination in the formation.				
2	Groundwater	N/A	Groundwater sampling with depth in the aquifer during drilling. Groundwater well installation and sampling using a groundwater pump	Only one well will be drilled at a pre-selected location.
Selected Implementation Design: Groundwater grab samples will be collected at approximately 3-m (10-ft) intervals from the top of the aquifer (68.3 m [224 ft]) to total depth (86.9 m [285 ft]) during drilling. Following well development, a groundwater sample will be collected using a sample pump. Three groundwater samples (i.e., grab samples at 70.1 m and 86.9 m and the pumped sample) shall be analyzed using the methods specified in Table 3-6a. Other samples will be analyzed for VOCs only, using the method specified in Table 3-6a.				
Basis for Selection: The systematic groundwater sampling will be used to provide a vertical profile of carbon tetrachloride and other volatile organics in the aquifer.				
Problem #4				
1	Soil (drill cuttings)	Radiological scanning surveys	Collecting two waste disposition soil samples from the vadose zone and one from the saturated zone for radiological analysis	Systematic sampling Judgmental sampling Random sampling
Selected Implementation Design: Judgmental. Samples shall be analyzed using the methods specified in Table 3-6b. The proposed sampling approach is as follows: Vadose Zone: • 0 to 15.3 m (50 ft): The soil cuttings from the top 15.3 m (50 ft) of this well (medium-risk interval) shall be scanned using both hand-held radiological (e.g., Eberline E-600 with SHP 380 AB probe) and chemical (e.g., organic vapor analyzer) field screening instruments prior to being transferred into containers (Figure 7-1). Collect one grab soil sample from 0 to 0.6 m (2 ft) below surface gravel layer for analysis of suspected near-surface contaminants (i.e., asbestos, PCBs, pesticides, and herbicides) due to past practices and construction activities. Collect one soil sample using a split-spoon sampler from 8.5 to 9.3 m (28 to 30.5 ft) bgs for radiological analysis using methods defined in Table 3-6b. This sampling interval is approximately 5.5 m (18 ft) below the bottom of the 216-Z-9 waste transfer pipeline that is approximately 3.1 m (10 ft) deep and passes within 6.4 m (21 ft) of the well location. Assuming that contamination migrates laterally at a maximum angle of 45 degrees (below horizontal) from the pipeline, contamination would be encountered by the borehole no deeper than 9.5 m (31 ft) bgs. The selected sampling interval is slightly above this projected depth.				

Table 7-3. Selected Implementation Design. (4 Pages)

DS #	Media	Selected Screening Technologies	Selected Sampling Methods	Potential Implementation Designs
NOTE: If field screening measurements (or visual observations) indicate that contamination is present in higher concentrations at another depth interval (within the top 15.3 m [50 ft] of drilling), then the sample for analytical testing will preferentially be collected from the interval showing the highest contamination levels. In this situation, the pre-selected sampling interval would be discarded. This approach will ensure that the worst-case sample is sent for analytical testing. • 15.3 m (50) ft to water table: The soil cuttings from 15.3 m (50 ft) bgs to the highest recorded water table at 58 m (191 ft) bgs (low-risk interval) shall be scanned using both hand-held radiological (e.g., Eberline E-600 with SHP 380 AB probe) and chemical (e.g., organic vapor analyzer) field screening instruments prior to being transferred into containers (see Figure 7-1). These cuttings are expected to be free from radiological contamination. If elevated readings are detected, a sample shall be collected (third vadose zone sample) from the interval showing the highest contamination levels. If no elevated readings are detected, soil cuttings should be dispositioned based on the results from the sample collected from the 0- to 15.3-m (50-ft) interval. Saturated zone: All soil cuttings from below the highest recorded water table shall be containerized (see Figure 7-1). Collect one soil sample using a split-spoon sampler from 1.5 to 2.3 m (5 to 7.5 ft) below the current water table for chemical and radiological analysis using methods defined in Table 3-6b.				
Basis for Selection: Soil sampling for waste disposition shall be performed using a judgmental approach because a worst-case sample is desirable.				
2a to 2f	Soil (drill cuttings)	N/A	The same two waste disposition split-spoon soil samples collected for radiological composition above (Problem #4, DS #1) shall also be tested for applicable chemical characteristics	Systematic sampling
				Judgmental sampling
				Random sampling
Selected Implementation Design: Judgmental, using the same approach outlined for Problem #4, DS #1 above. Samples shall be analyzed using the methods specified in Table 3-6b.				
Basis for Selection: Soil sampling for waste disposition shall be performed using a judgmental approach because a worst-case sample is desirable.				
3	Soil (drill cuttings)	N/A	The same two waste disposition split-spoon soil samples collected for Problem #4, DS #1 above shall also be tested to see if radiological composition meets disposal facility waste acceptance criteria	Systematic sampling
				Judgmental sampling
				Random sampling
Selected Implementation Design: Judgmental, using the same approach outlined for Problem #4, DS #1 above. Samples shall be analyzed using the methods specified in Table 3-6b.				
Basis for Selection: Soil sampling for waste disposition shall be performed using a judgmental approach because a worst-case sample is desirable.				

Table 7-3. Selected Implementation Design. (4 Pages)

DS #	Media	Selected Screening Technologies	Selected Sampling Methods	Potential Implementation Designs
4	Soil (drill cuttings)	N/A	The same two waste disposition split-spoon soil samples collected for radiological composition above (Problem #4, DS #1) shall also be tested to determine if material is land disposal restricted	Systematic sampling
				Judgmental sampling
				Random sampling
Selected Implementation Design: Judgmental, using the same approach outlined for Problem #4, DS #1 above. Samples shall be analyzed using the methods specified in Table 3-6b.				
Basis for Selection: Soil sampling for waste disposition shall be performed using a judgmental approach because a worst-case sample is desirable.				

N/A = not applicable

7.2 STATISTICAL DESIGN

Because no statistical designs are proposed for this sampling effort, this section does not apply.

7.2.1 Data Collection Design Alternatives

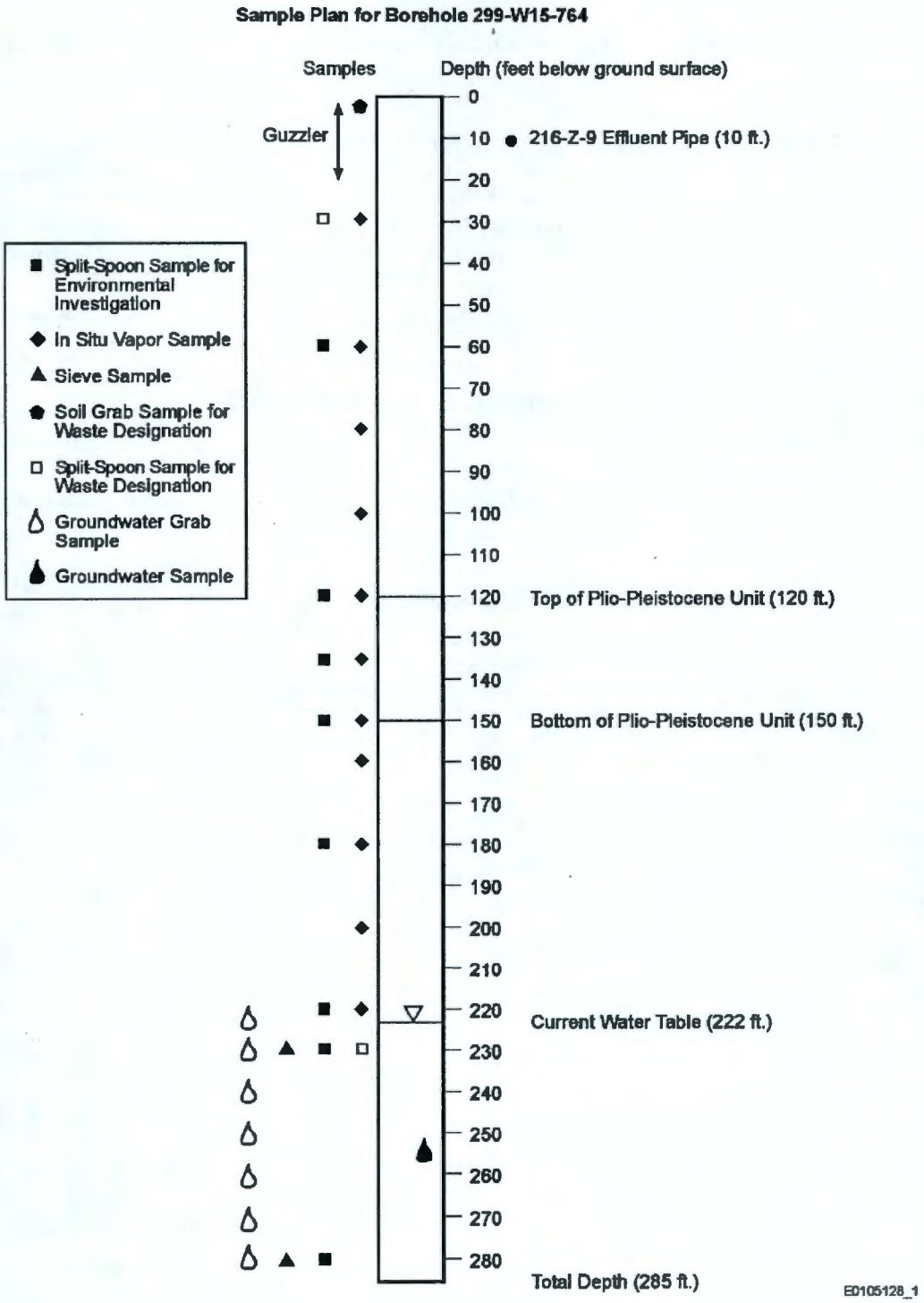
Because no statistical designs are proposed for this sampling effort, Table 7-4 does not apply.

Table 7-4. Selected Statistical Design.

DS #	Media	Statistical Design Alternatives
1	N/A	
Selected Statistical Design: N/A		
Basis for Selection: N/A		

N/A = not applicable

Figure 7-2. Proposed Sampling Intervals for Environmental Investigation.



7.2.2 Mathematical Expressions for Solving Design Problems

Because no statistical designs are proposed for this sampling effort, Table 7-5 does not apply.

Table 7-5. Statistical Methods for Testing the Null Hypothesis.

DS #	Media	Statistical Method Alternatives	Selected Statistical Method for Testing Null Hypothesis	Assumptions Made in Selecting Statistical Method	Formula for Calculating Number of Samples/ Measurements
Not applicable					

7.2.3 Select the Optimal Sample/Measurement Size that Satisfies the Data Quality Objectives

Because no statistical designs are proposed for this sampling effort, Table 7-6 does not apply.

Table 7-6. Sample/Measurement Size Based on Varying Error Tolerances and LBGR.

		Mistakenly Concluding < Action Level		
		α =	α =	α =
DS #1				
LBGR = N/A				
Mistakenly Concluding > Action Level	β=	N/A	N/A	N/A
	β=			
	β=			

N/A = not applicable

7.2.4 Sampling/Measurement Cost

Because no statistical designs are proposed for this sampling effort, Table 7-7 does not apply.

Table 7-7. Sampling Cost Based on Varying Error Tolerances and LBGR.

		Mistakenly Concluding < Action Level		
		α =	α =	α =
DS #1				
LBGR = N/A				
Mistakenly Concluding > Action Level	β=	N/A	N/A	N/A
	β=			
	β=			

N/A = not applicable

7.2.5 Selecting the Most Resource-Effective Data Collection Design

Because no statistical designs are proposed for this sampling effort, Table 7-8 does not apply.

Table 7-8. Most Resource-Effective Data Collection Design.

Not applicable

7.2.6 Final Statistical Sampling Design

Because no statistical designs are proposed for this sampling effort, Table 7-9 does not apply.

Table 7-9. Final Statistical Sampling/Measurement Design.

DS #	Statistical Sampling/Measurement Design	Number of Samples/ Measurements	Total Number of Samples/Measurements Within Population (Table 4-1)
Not applicable			

8.0 REFERENCES

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