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1.0 INTRODUCTION

1.1 PURPOSE

This work plan presents a detailed outline for FY 93 site characterization activities to be conducted at the carbon tetrachloride contamination site in 200 West Area of the Hanford Site in southeastern Washington. The carbon tetrachloride contamination is the primary focus of both the Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID) and 200 West Area Carbon Tetrachloride Expedited Response Action (ERA). The VOC-Arid ID is a technology development program to provide new technologies for cleanup of VOC, such as carbon tetrachloride, at arid sites. The ERA is an environmental restoration program to remove carbon tetrachloride from the unsaturated soils in the 200 West Area. The site characterization activities in support of the these two programs have been fully integrated throughout planning and implementation. This work plan provides the U.S. Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology) with the objectives and scope of the unified FY 93 site characterization plan.

1.2 BACKGROUND

The VOC-Arid ID is a U.S. Department of Energy (DOE) program funded by the Office of Technology Development that is targeted at the acquisition, development, demonstration, and deployment of technologies for evaluation and cleanup of VOC and associated contaminants in soils and ground waters of arid DOE sites. The DOE contractors, national laboratories, universities, and industry are participants in the program. New technologies will be demonstrated in the areas of site characterization; performance prediction, monitoring, and evaluation; contaminant extraction and ex situ treatment; in situ remediation; and site closure and monitoring. The performance of these technologies will be compared to baseline (i.e., conventional) technologies and documented to promote the transfer of the new technologies to industry for use at the Hanford Site and other DOE sites.

An ERA is a provision included in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) that allows accelerated cleanup activities to be undertaken at waste sites to abate imminent hazards or to prevent significantly increased degradation of the environment that might occur if action were delayed until completion of the remedial investigation/feasibility study and the record of decision. The ERA is implemented according to the requirements outlined in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), Part 3, Article XIII, Section 38), and in accordance with 40 CFR Part 300, Subpart E.

In December 1990, the EPA and Ecology requested the DOE, Richland Field Office (RL) to proceed with detailed planning, including nonintrusive field work required to implement the ERA for the carbon tetrachloride contamination in the 200 West Area. The request was made based on concerns that the carbon tetrachloride residing in the soils was continuing to spread to the ground water and, if left unchecked, would significantly increase the area of ground water contamination.

The initial demonstration site for the VOC-Arid ID is also the area of carbon tetrachloride contamination in the 200 West Area. The contamination is linked to past liquid waste disposal practices resulting from operation of the Plutonium Finishing Plant (PFP) in the 200 West Area near the center of the Hanford Site (Figure 1). Last et al. (1991) summarized the physical and chemical characteristics of this site for the principal investigators of candidate new technologies.

The first site evaluations were conducted at this site from January through April 1991 as part of the ERA to refine the preliminary conceptual model and to collect data in support of the selection and design of an initial remedial action (Hagood and Rohay 1991). The results of the Phase I ERA site evaluation were summarized in June 1991 (DOE-RL 1991, Appendix B). Based on this work and on the engineering evaluation and cost assessment, the preferred alternative for removal of the carbon tetrachloride from the unsaturated zone was identified as soil vapor extraction followed by aboveground collection on granular activated charcoal (DOE-RL 1991). In January 1992, EPA and Ecology authorized DOE to initiate soil vapor extraction for cleanup of the carbon tetrachloride in the unsaturated soils.

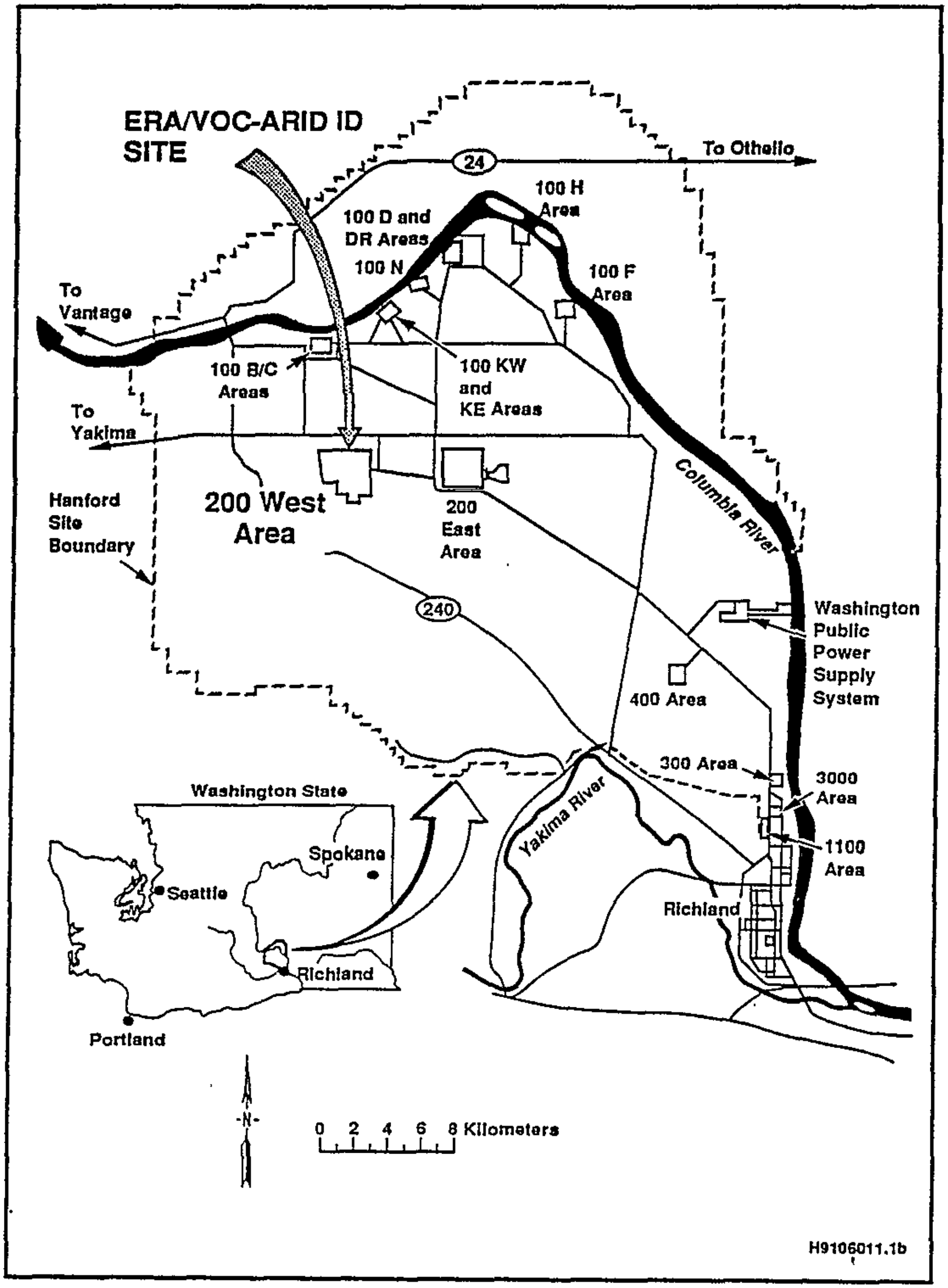
In March 1991, DOE approved the use of a categorical exclusion under Section D of DOE's National Environmental Policy Act (NEPA) Guidelines for the ERA site characterization activities. In April 1992, DOE approved the use of a categorical exclusion for the VOC-Arid ID site characterization activities. The activities discussed in this work plan, and the environmental impacts associated with these activities, are within the scope of activities and impacts discussed in the NEPA documentation supporting these two NEPA categorical exclusion approvals. It has, therefore, been determined that the activities described in this work plan are adequately addressed by this existing NEPA documentation and that no further NEPA documentation need be performed for these activities.

Detailed plans for conducting the Phase II (FY 92) of the ERA site evaluation and the initial (FY 92) VOC-Arid ID site characterization efforts were submitted in September 1991 (Rohay 1991) and November 1991 (Last and Rohay 1991), respectively. These site characterization and evaluation efforts were conducted jointly. The status and accomplishments of the combined FY 92 characterization program are described by Rohay et al. (1992). That report also includes or references all available raw data collected as part of the FY 92 characterization tasks. Interpretation and integration of the data, and the updated site conceptual model, will be reported in a separate document to be issued in January 1993.

1.3 APPROACH

The VOC-Arid ID and ERA site characterization programs have been merged to maximize efficient use of time and resources and to ensure that each activity and resulting product achieves the maximum usefulness to both programs. In addition, these activities will be coordinated with those of related programs in the 200 West Area, such as the 200 West Aggregate Area Management Study, the Resource Conservation and Recovery Act of 1976, the contemplated 200 West Area carbon tetrachloride ERA for ground water, if approved, and WAC 173-216 state waste discharge permitting.

Figure 1. Location of the VOC-Arid ID/ERA Site.



During FY 92, the carbon tetrachloride characterization effort focused on the unsaturated zone and on optimizing the effectiveness of the soil vapor extraction system in use for the ERA. Intrusive field activities were conducted near, but outside of, the carbon tetrachloride disposal sites. In FY 93, characterization will continue on the unsaturated zone, but intrusive field activities are planned to investigate directly beneath the disposal sites. In addition, characterization efforts will begin to address other remediation technologies such as in situ bioremediation and in situ heating.

2.0 SUMMARY OF SITE CHARACTERISTICS

This section provides a brief summary of site characteristics as background for this work plan. More detailed discussions of site characteristics are provided by Rohay and Johnson (1991), Last et al. (1991), and Rohay et al. (1992).

2.1 SITE OPERATIONS

This section describes the operational and disposal history of carbon tetrachloride at and near the PFP (Figure 2). No other plant in the 200 West Area is known to have used carbon tetrachloride.

The PFP was designed to process plutonium to a final product form using three process lines. Each of these process lines generated side streams that contained recoverable quantities of plutonium. The Recuplex facility and the Plutonium Reclamation Facility (PRF) (Figure 3) were established to recover plutonium from these streams and were the primary contributors of carbon tetrachloride to 200 West Area soils.

Carbon tetrachloride was used in mixtures with other organics to recover plutonium from aqueous streams. The aqueous waste stream, characterized as high-salt aqueous waste, was primarily a concentrated nitrate solution that had a pH of 1 (neutralized to a pH of 2.5 prior to discharge). The chemical processes used to recover plutonium resulted in the production of actinide-bearing aqueous and organic waste liquids. The primary radionuclide components of these liquids were plutonium-239/240 and americium-241.

Both aqueous and organic phase wastes were discharged to the same liquid waste disposal sites. The carbon tetrachloride was periodically discharged batch-wise as an organic phase mixture and was also a minor (<1%) component of the aqueous phase. The aqueous wastes were continuously discharged.

Figure 2. Site Map of the 200 West Area.

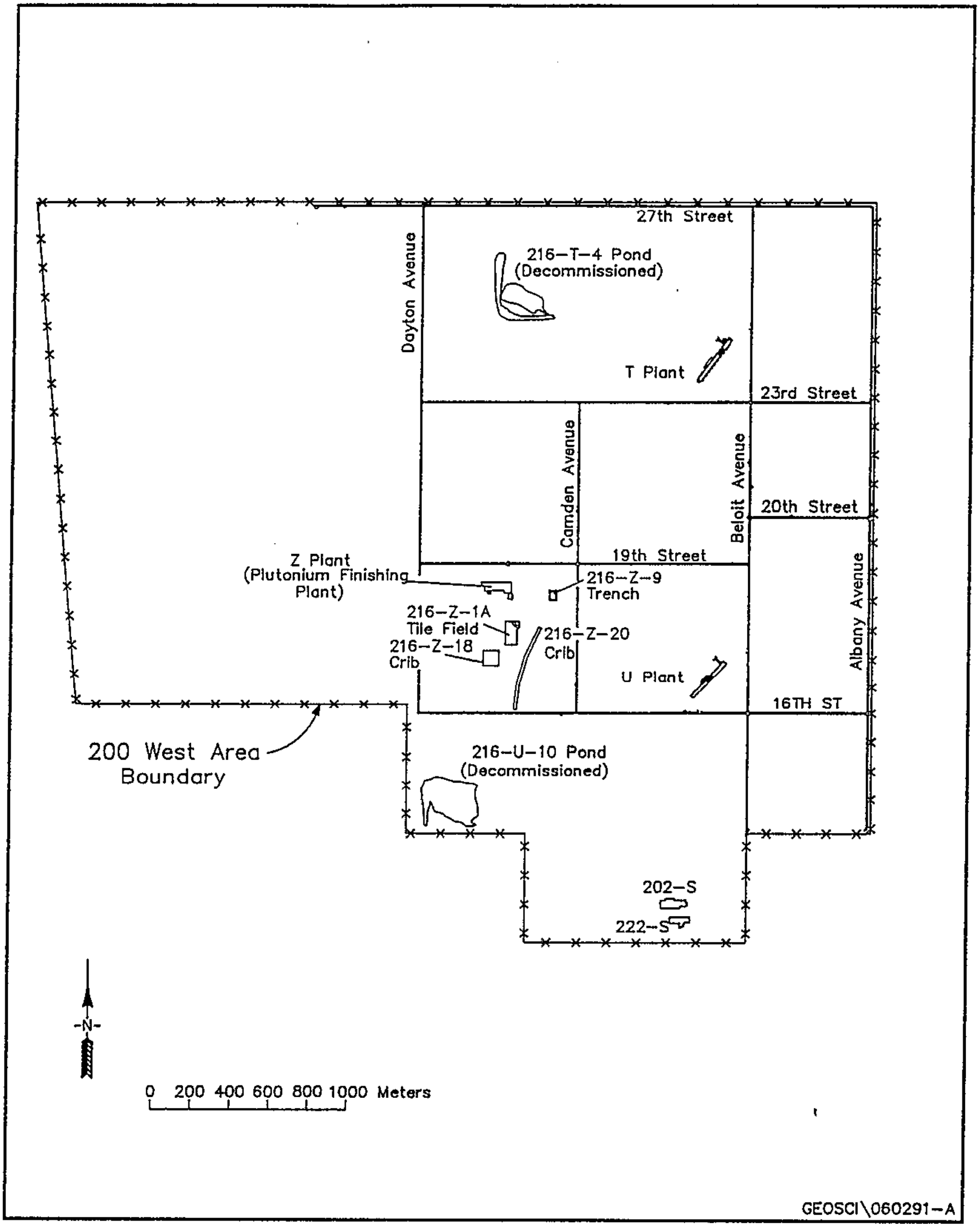


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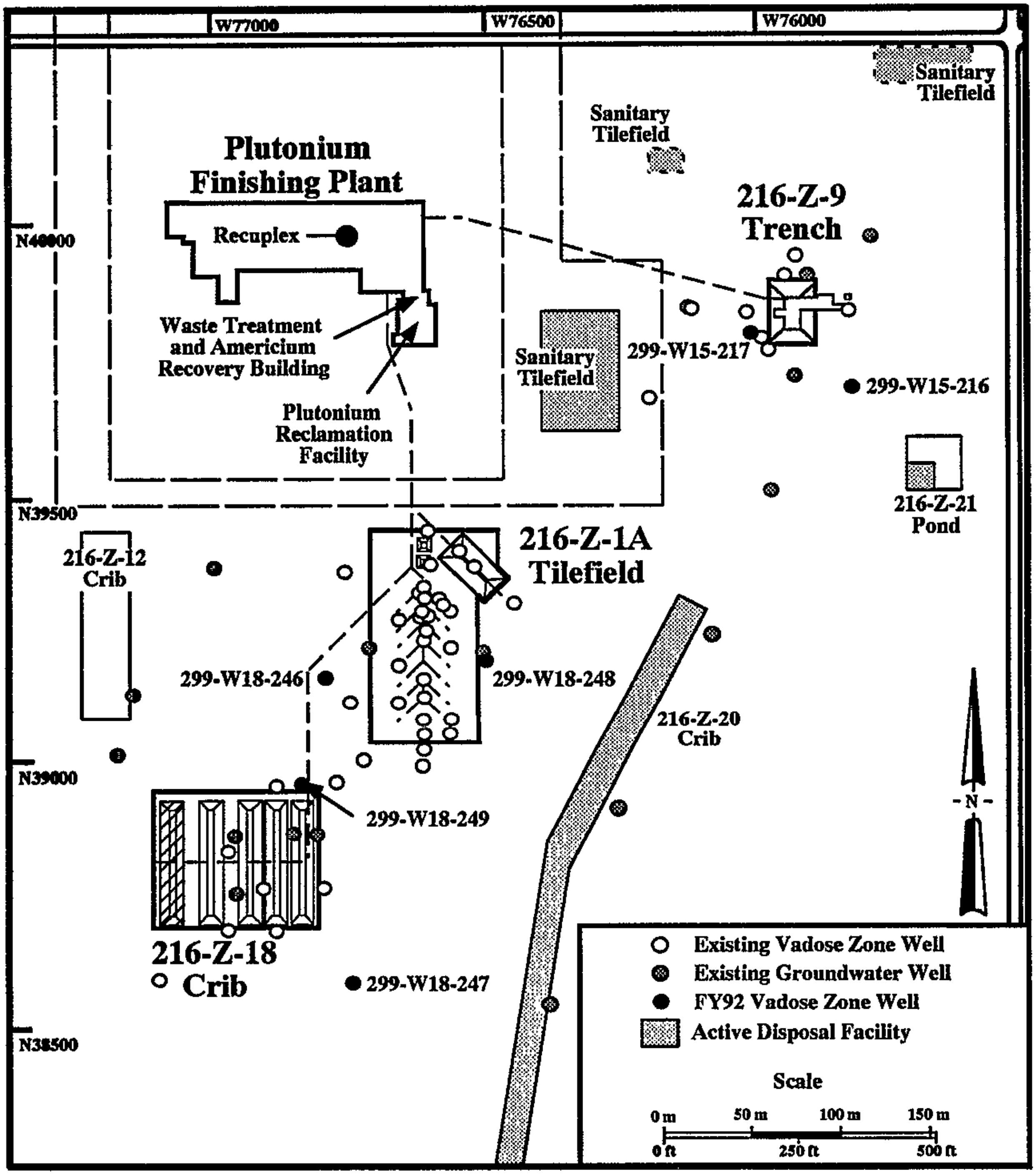
Figure 3. Existing Crib and Near-Field Wells at the Carbon Tetrachloride Site.



Organic liquids discharged to the disposal sites consisted of carbon tetrachloride in mixtures with tributyl phosphate, dibutyl butyl phosphonate, or lard oil. Degradation products of carbon tetrachloride include chloroform and methylene chloride. Breakdown products of tributyl phosphate include dibutyl phosphate and monobutyl phosphate. In addition to the plutonium and americium, other constituents of the waste streams discharged to the sites include aluminum, cadmium, calcium, chromium, fluoride, chloride, iron, iodine, magnesium, nickel, nitrate, rubidium, sodium, sulfate, sulfamate, cesium-137, cobalt-60, uranium, ruthenium-106, and strontium-90.

The carbon tetrachloride disposal sites, located near the PFP in the 200 West Area, are: the 216-Z-9 Trench; 216-Z-1A Tile Field; and 216-Z-18 Crib (Figure 3). The 216-Z-9 Trench was used from 1955 to 1962 to receive all organic and aqueous waste from the Recuplex facility. Organic and aqueous waste from the PRF was discharged to 216-Z-1A Tile Field from 1964 to 1969 and to 216-Z-18 Crib from 1969 to 1973. Discharge of carbon tetrachloride to the soil column was discontinued in 1973.

Estimates of the volumes and quantities of various liquids and contaminants discharged to the three carbon tetrachloride disposal sites are summarized in Table 1. A total of 363,000 to 580,000 L of carbon tetrachloride is estimated to have been discharged to the soil column between 1955 and 1973.

Table 1. Contaminant Inventory in Carbon Tetrachloride Liquid Waste Disposal Sites.

Contaminant	216-Z-9	216-Z-1A[a]	216-Z-18
Carbon tetrachloride (L)	83,000-300,000	170,000	110,000
Plutonium (kg)	106[b]	57	23
Americium (kg)	2.5	1	-0.4
Total Liquid (L)	4.09×10^6	5.2×10^6	3.96×10^6
Period of Use	1955-1962	1964-1969	1969-1973

[a]From 1949 to 1959, the 216-Z-1A Tile Field received approximately 1×10^6 L of slightly basic, aqueous waste via overflow from associated 216-Z-1, -2, and -3 Cribs prior to disposal of PRF waste. From 1964 to 1969, PRF wastes were discharged directly to 216-Z-1A.

[b]58 kg were later removed.

Boreholes were drilled from 1949 to 1978 to characterize/monitor the three carbon tetrachloride disposal sites, primarily with regard to the radionuclide concentrations. Six boreholes were installed in FY 92 as part of the VOC-Arid ID/ERA characterization program. Fifty-two boreholes are potentially available in the vicinity of the carbon tetrachloride disposal sites for additional characterization, monitoring, and remediation (Figure 3). Construction details for these boreholes are summarized in the ERA proposal (DOE-RL 1991, Appendix C) and the FY 92 characterization status report (Rohay et al. 1992).

2.2 CONCEPTUAL MODELS

2.2.1 Hydrogeology

The geology of the 200 West Area consists primarily of fluvial and glaciofluvial sediments underlain by basalts. The principal geologic units are, from youngest to oldest (Figure 4):

- Hanford formation - unconsolidated glaciofluvial gravels, sands, and silts deposited by Pleistocene cataclysmic flood waters.
- Early "Palouse" soil - eolian silt and fine-grained sand.
- Plio-Pleistocene unit - basaltic ditritus and carbonate-rich paleosol, often referred to as the caliche layer.
- Ringold Formation - a series of consolidated alluvial sands and gravels, and overbank and lacustrine deposits, of late Miocene to Pliocene age.
- Saddle Mountains Basalt Formation - a series of miocene tholeiitic basalt flows.

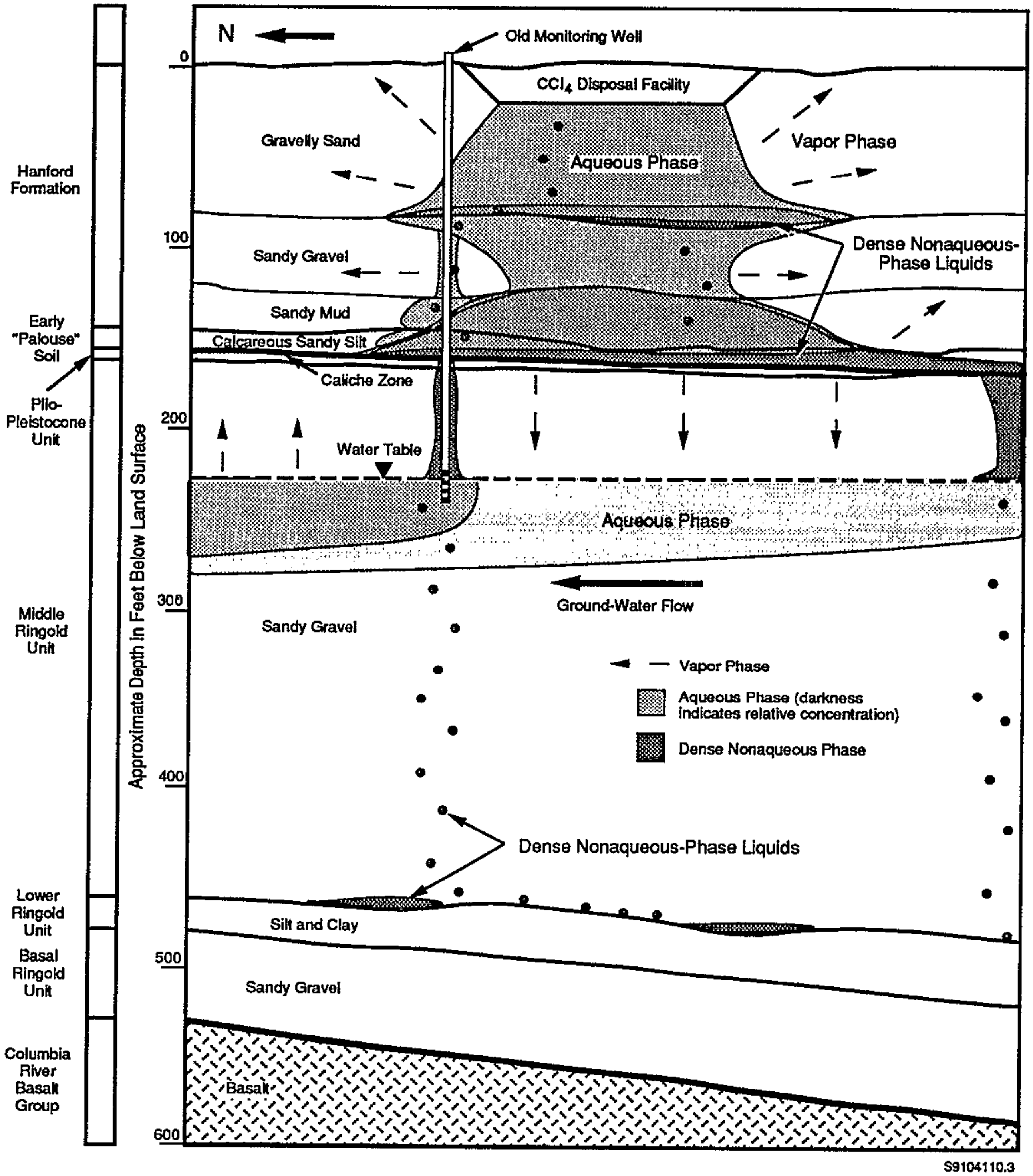
The unsaturated zone, which consists of sediments of the Ringold Formation, Plio-Pleistocene unit, early "Palouse" soil, and Hanford formation, ranges in thickness from 58 to 82 m across the 200 West Area and from 60 to 66 m beneath the carbon tetrachloride disposal sites. Because the Plio-Pleistocene unit is less permeable than the other units, it may temporarily divert or perch liquids and/or dense vapors. The top of this unit is approximately 40 m below ground surface. The topography of the Plio-Pleistocene surface suggests that it locally forms a ridge that extends south-southwest beneath the three carbon tetrachloride disposal sites and may divert fluids laterally to the west-northwest.

The uppermost aquifer in the 200 West Area is unconfined and located within the Ringold Formation. The saturated thickness of the uppermost aquifer ranges from 67 to 113 m. Ground water flow directions are generally radial outward from the southwest portion of the 200 West Area primarily because of the continuing influence of the residual ground water mound underlying the decommissioned 216-U-10 Pond (Figure 2). Recharge to the aquifer is primarily artificial recharge from waste disposal activities.

2.2.2 Carbon Tetrachloride Behavior

Carbon tetrachloride was discharged to the subsurface in the PFP area both in an aqueous solution and as a nonaqueous phase liquid. It is assumed that, initially, carbon tetrachloride was present and migrated in the unsaturated zone as an aqueous phase and as a separate, dense nonaqueous phase liquid (DNAPL). Subsequently, volatilization of the carbon tetrachloride has produced a vapor phase. Figure 4 illustrates the conceptual pathways and distribution of carbon tetrachloride released to the cribs. The conceptual behavior and distribution mechanisms are briefly described.

Figure 4. Conceptual Model of Carbon Tetrachloride Migration Pathways and Phase Distributions.



Aqueous phases containing dissolved carbon tetrachloride may have migrated directly to the ground water by exceeding the water retention capability of the soils beneath the crib. Pore volume estimates indicate that 216-Z-9 Trench is the most likely to have exceeded this capacity. Soil gas surveys also indicate the highest concentrations of carbon tetrachloride in the vicinity of the 216-Z-9 Trench. Volume estimates for the dissolved carbon tetrachloride plume in the upper 10 m of the unconfined aquifer account for <2% of the discharge inventory. This suggests that significant amounts of the carbon tetrachloride may still be present in the unsaturated zone, potentially providing a continuous source of contamination to the ground water. At a well 40 m northeast of the 216-Z-9 Trench, dissolved carbon tetrachloride is found in the aquifer 52 m below the water table; however, the borehole itself may have provided the pathway by which the carbon tetrachloride reached this depth.

Separate nonaqueous phase carbon tetrachloride may have settled deep in the aquifer via preferential pathways (such as unsealed wells) and remained undetected, providing a continuous source of contamination by dissolution. Residual DNAPL contamination may also remain trapped in the unsaturated zone pores. Separate, nonaqueous phase carbon tetrachloride has not been encountered in the either the aquifer or the unsaturated zone.

Liquid carbon tetrachloride has a moderately high vapor pressure and limited solubility, making it relatively volatile. Carbon tetrachloride vapors have been detected in gases extracted from soil pores in the unsaturated zone near the carbon tetrachloride disposal sites; measured concentrations have been highest at the 216-Z-9 Trench. In addition, carbon tetrachloride vapors have been detected at the wellhead during drilling throughout most of the 200 West Area since 1987. The density of carbon tetrachloride vapor is greater than uncontaminated vapors in the unsaturated zone. This contrast in vapor densities can result in density-driven advection, which can act to move carbon tetrachloride downward. Zones of relatively impermeable soils may laterally divert the carbon tetrachloride away from the disposal sites. In addition, carbon tetrachloride vapors in the unsaturated zone, which equilibrate with perched water and/or percolating waste water from other sources, may then be transported to the water table in dissolved form. Recent borehole drilling and sampling has indicated that the highest concentrations of carbon tetrachloride have been found in a silt and fine-grained sand (early "Palouse" soil) overlying a low permeability caliche horizon (Plio-Pleistocene unit).

Differences in crib sizes in quantities, frequencies, and concentrations of liquid wastes received and in heterogeneities of soil properties can impact mechanisms by which carbon tetrachloride is distributed in the soil.

3.0 FY 93 SITE EVALUATION PLAN

The FY 93 site characterization work covers the unsaturated and saturated zones, and includes drilling operations, aquifer testing, effluent pipeline evaluations, various nonintrusive sampling operations, and expanded data compilation. This section outlines the site characterization objectives and describes the specific tasks planned to accomplish them. The sampling and analysis plan, health and safety plan, and project management plan are included in the appendices.

3.1 OBJECTIVES

The FY 93 site evaluation tasks are focused on the unsaturated zone directly beneath the carbon tetrachloride disposal sites and on the ground water in the vicinity of the carbon tetrachlorid disposal sites. The primary purpose of the site characterization and evaluation activities outlined in this work plan is to refine the conceptual model of the site, both to aid development and testing of new technologies and to optimize removal of the carbon tetrachloride. Other objectives of the site characterization work include monitoring the performance of remedial actions (including remedial technology demonstrations); providing samples to support technology demonstrations; and demonstrating and using new characterization and monitoring technologies. Each of these objectives is discussed below.

3.1.1 Refine Conceptual Model of Site

Critical aspects of the model include descriptions of: (1) the nature and extent of the contamination; (2) the preferential transport pathways and rates (i.e., the hydrogeologic model); and (3) the behavioral characteristics of the wastes.

3.1.1.1 Nature and Extent of Contamination. Describing the nature and extent of contamination includes determining the identity, phase, concentration, and current distribution of the individual contaminants. This information is fundamental for identifying technology needs and for designing effective remedial actions.

3.1.1.2 Preferential Transport Pathways and Rates. Determination of the preferential transport pathways and rates is needed for both the unsaturated zone and unconfined aquifer, and requires defining the hydrogeologic model. Particular emphasis is on identifying the physical, chemical, and microbiological parameters of the subsurface environs that affect transport and on describing the spatial variability of these parameters. This information is needed to support predictive modeling (simulation) of the unsaturated zone in the vicinity of the carbon tetrachloride disposal facilities.

3.1.1.3 Behavioral Characteristics of the Wastes. Determining the behavior of the wastes includes defining the physical (i.e., phase partitioning, fluid properties, etc.) and chemical properties of the carbon tetrachloride, the co-contaminants and the mixtures discharged to the carbon tetrachloride disposal sites. Of principal interest are the physical, chemical, and microbiological characteristics of the wastes that affect their transport, sorption, and natural degradation. Descriptions of the behavioral characteristics of the wastes are needed to support predictive modeling and to identify technology needs.

3.1.2 Monitor Performance of Remedial Actions

Changes in the nature and extent of contamination can be used to assess the impact and performance of various remedial actions. Emphasis is on monitoring the ongoing vapor extraction operations for carbon tetrachloride in the unsaturated zone. Baseline data will also be collected for assessing future remedial technology demonstrations or actions in the unsaturated zone and ground water. Of particular importance is distinguishing the effects of natural stresses on the system from man-induced stresses.

3.1.3 Provide Data to Support Technology Demonstrations

Per request, data and samples are provided to principal investigators to support the design and demonstration of their individual technologies. In addition, baseline data are collected for performance evaluation of comparative technologies. Data are also collected to guide selection of appropriate new technologies for demonstration.

3.1.4 Demonstrate and Use New Characterization and Monitoring Technologies

Promising new site characterization and monitoring technologies are demonstrated as part of the site evaluation efforts. These technologies may be in addition to those sponsored by individual VOC-Arid ID principal investigators. The demonstrations are designed to collect site characterization data for the VOC-Arid ID/ERA in addition to testing the feasibility and value of the technology itself. Those technologies that constitute improvements to conventional methods will be used in site characterization activities.

3.2 DATA TECHNICAL NEEDS

The FY 93 site evaluation tasks designed to accomplish the four objectives described in Section 3.1 include field investigations, laboratory studies, data management and evaluation, and technology demonstration support. A discussion of each objective, the data needed to accomplish it, and the tasks designed to acquire these data is provided in this section. Table 2 outlines the data needs and data acquisition tasks designed to accomplish each objective.

Table 2. Data Technical Needs.

OBJECTIVE/DATA NEEDS \ TASKS	Source Term	Soil Gas	Geophysical Surveys	Existing Wells	New Wells	GW Sampling	Lab. Studies	Data Mgmt.	Numerical Modeling	Data Evaluation	Support Tech. Demos
REFINE CONCEPTUAL MODEL	X	X	X	X	X	X	X	X	X	X	X
NATURE OF CONTAMINATION										X	
Source Term	X										
Chemical Constituents/Mixtures Present		X		X	X	X		X			X
Phase(s) of Constituents/Mixtures		X			X	X					
Temporal Changes		X		X		X					
EXTENT OF CONTAMINATION										X	
Distribution of Contaminants in all media		X	X	X	X	X		X			X
Concentrations of Contaminants in all media		X		X	X	X		X			X
Inventory/Mass Balance Assessment		X			X	X			X		
Temporal Changes		X		X		X		X	X		
TRANSPORT PATHWAYS										X	
Vadose Zone/Groundwater											
Hydrogeologic Framework			X	X	X			X			X
Integrity of Old Wells				X							
Natural/Artifical Recharge	X			X							
Groundwater Potentials				X	X	X					
Pathways to Atmosphere											
Soil Gas Mechanisms		X									X
Well Head Mechanisms				X							
Biological Pathway											
Vegetation Concentrations	X										
TRANSPORT RATES										X	
Soil Vapor Movement					X		X		X		
Aqueous Waste Movement			X	X	X				X		
NAPL Movement							X		X		
Sorption/Desorption Parameters							X				
WASTE BEHAVIOR											
Physical Properties										X	
Phase Partitioning							X				
Movement in Porous Media							X				
Chemical Properties											
Degradation Chain							X				
Sorption							X				
Microbiological Degradation Chain											
SUPPORT TECH. DEMOS					X		X	X		X	X
DEMO. CHAR./ MON. TECHNOLOGIES	X	X	X	X	X					X	X

3.2.1 Refine Conceptual Model of the Site

The conceptual models presented in Section 2.2 were developed by integrating a general understanding of the behavior of carbon tetrachloride in the subsurface with the distribution of carbon tetrachloride observed during FY 91 and FY 92 site characterization. However, the nature of the carbon tetrachloride and co-contaminants and their lateral and vertical extent remain largely unknown. The location of principal pathways, transport rates, and waste behavior in the subsurface environs is also poorly defined. A better understanding of the contaminants, their distribution, and behavior is needed to assess the effectiveness of remedial actions, to improve the design of the remediation systems, to improve the selection and appropriate deployment of new promising technologies, and to support predictive modeling.

The data needed to meet this objective include: (1) better definition of the source terms (i.e., accurate contaminant inventories, the number and location of contaminant release points, and accurate release histories); (2) better definition of the wastes present in the environment (i.e., chemical constituents and mixtures, their physical phases), their distribution, and their concentrations in various media; (3) better definition of the hydrogeologic facies and their transport properties (e.g., porosity, pore size distribution, hydraulic conductivities, air permeabilities); (4) identification of probable manmade pathways (e.g., poorly sealed wells, intercomunication in wells, open/perforated wells); (5) definition of the driving forces (i.e., natural and artificial recharge, hydraulic potentials, barometric potentials, earth tides); (6) evaluation of the potential for vegetation uptake and release; and (7) determination of the waste mixture behavior (e.g., three-phase flow, chemical degradation cycles, microbiological degradation cycles, sorption/desorption).

Tasks identified to accomplish these objectives will test assumptions and predictions based on the hydrogeologic and contaminant behavior conceptual models and will take advantage of the opportunities to collect additional data. These tasks include: source term characterization; soil gas surveys; evaluation and sampling of existing wells; deepening/installing of crib wells; installation of a deep ground water well; ground water sampling; physical, chemical, and microbiological analyses; geochemical studies; waste transport studies; data management and evaluation; and numerical modeling.

3.2.2 Monitor Performance of Remedial Actions

Probes and sensors that can be resampled over a selected period of time probably provide the most useful data for monitoring and assessing performance of remedial action. Soil gas surveys, geophysical surveys, ground water sampling, and soil gas sampling at new and existing wells all provide opportunities to establish datasets on changes in contaminant and co-contaminant distributions and concentrations over time. Baseline monitoring for the ERA, which consists of periodic monitoring of soil gas at wellheads and probes, is designed in part to monitor the performance of the vapor extraction operations. Meteorological data collected at the Hanford Meteorological Station and at site-specific locations near the carbon tetrachloride disposal sites are needed to evaluate the effects of natural stresses on the systems.

3.2.3 Provide Data to Support Technology Demonstrations

The selection and success of new technologies are dependent on understanding the physical, chemical, and/or microbial constraints of the subsurface environment, and the nature, distribution, and concentration of the contaminants. For example, the high permeability of the unsaturated zone may be favorable to vapor extraction technologies; but the same coarse, unconsolidated, clast-supported gravels inhibit some advanced drilling technologies. Likewise, the nature and concentration of the contaminants may favor some sensor technologies over others, and/or may be more suitable to some in situ remediation technologies (e.g., bioremediation) than others. Virtually all data collected during site characterization will be useful in selecting and evaluating various new technologies. Site-specific data and samples requested by principal investigators of new the technologies are collected during soil gas surveys, drilling and sampling of crib boreholes, and drilling of a deep ground water well. Data from these tasks will also be used to support the ERA activities (e.g., vapor extraction system design and wellfield design).

The technology support needs identified to date include: collection of soil samples to support the in situ bioremediation and supercritical fluid extraction/field transportable detection technology demonstrations; access to a number of isolated screened intervals to support sensor technology demonstrations; and analytical data on the concentration of co-contaminants (principally the phosphonates and phosphates) that may affect sensor performance. Other technology support needs are expected to arise as the technology demonstrations mature.

3.2.4 Demonstrate and Use New Characterization and Monitoring Technologies

Before new technologies can be adopted for environmental restoration work, including site characterization, they must compare favorably to the conventional technologies in terms of safety, speed, reliability, accuracy, economy, and/or feasibility. Data collected during site characterization activities using conventional technologies is thus needed as the baseline for evaluation of the new technologies. The specific data needed will depend on the technology being demonstrated. In addtion, new technologies are tested as part of site characterization to evaluate their utility.

3.3 DATA QUALITY NEEDS

The EPA has devised a classification of analytical levels for contaminant data (EPA 1987):

- Level I consists of field screening methods
- Level II entails more advanced on site analytical techniques
- Level III pertains to standard laboratory program procedures
- Level IV consists of EPA Contract Laboratory Program (CLP) procedures
- Level V pertains to specially developed procedures where standard methods are not available or where a high degree of analytical sensitivity is required.

As the analytical level increases, costs and turnaround times also increase substantially.

The data quality needs are defined by the analytical levels required to meet the VOC-Arid ID and ERA objectives. In general, the VOC-Arid ID/ERA site characterization analytical data should be reproducible and reliable, and realtime, but do not need to be validated in accordance with CLP procedures. The data quality needs are identified in Table 3, which lists the analytical levels to be applied to each type of analysis. Data quality needs in this context apply only to laboratory or field analyses.

Table 3. Data Quality Needs.

Subsurface Material	Type of Analysis	EPA Analytical Level
Soil	Soil gas volatile organic analysis	I, II
	Geotechnical testing of cores	I, II, III
	Chemical analyses of soil samples	I, II, III
	Radiological analyses of soil samples	I, II, III, V
	Volatile organic analysis of soil samples	I, II, III
	Microbial analyses	I, II, III
Ground water	Chemical analyses	I, II, III, IV

3.4 SITE EVALUATION APPROACH AND TASKS

The FY 93 site evaluation tasks are designed to be consistent with the following investigation approach:

- Maximize use of field screening methods as appropriate
- Maximize use of existing data and wells
- Focus data collection on specific contaminants of concern
- Use "off-the-shelf" technology as appropriate, in conjunction with the demonstration of new technologies.

The FY 93 site evaluation tasks include intrusive field activities such as drilling new wells. However, these tasks are designed to minimize the generation of hazardous, radioactive, and/or mixed waste and to prevent downward migration of contaminants.

The FY 93 site evaluation tasks are summarized in this section. Descriptions of each task are presented in the following sections.

3.4.1 Field Investigation Tasks

Field investigation tasks are composed of the following:

- Source Term Characterization
  - Evaluate effluent pipeline integrity
  - Investigate source of secondary ground water maximum
  - Assess artificial recharge
- Conduct Soil Gas Surveys
  - Map lateral distribution of VOC
  - Estimate VOC vapor flux from soils
  - Map vertical distribution of VOC
- Conduct Geophysical Surveys
- Existing Well Investigations
  - Borehole geophysical logging
  - Evaluate integrity of old wells
  - Sample selected wells
- New Well Investigations
  - Crib wells
  - Deep ground water monitoring well
  - Chemical analyses
  - Physical analyses
  - Microbiological analyses
  - Technology demonstration boreholes
- Sample Ground Water.

3.4.2 Laboratory Studies

Laboratory studies include the following:

- Geochemical
- Soil Physics/Waste Characteristic.

3.4.3 Data Management and Evaluation Tasks

Data management and evaluation tasks include the following:

- Data Management, Integration, Presentation
- Numerical Modeling
- Data Evaluation
  - Refine conceptual model
  - Evaluate efficiency of remedial actions
  - Assess risk.

3.4.4 Technology Demonstrations Support

Technology demonstrations support includes the following:

- Miscellaneous Support to Technology Demonstrations
- Support Characterization Technology Demonstrations.

3.5 FIELD INVESTIGATION TASKS

A description of each field investigation task is provided below. This description includes the task objectives and scope (including sample locations, and analyses, where appropriate). Additional detailed information, including procedures, is provided in the sampling and analysis plan (Appendix A).

3.5.1 Source Term Characterization

The objective of this task is to identify all sources of carbon tetrachloride contamination observed in the subsurface. This information will be used to guide remediation and monitoring efforts.

The scope of this task includes identifying locations and timing of carbon tetrachloride discharges to the soil column and assessing the impact of other aqueous discharges on the distribution of the carbon tetrachloride.

3.5.1.1 Evaluate Effluent Pipeline Integrity. The objective of this subtask is to estimate the location and quantity of any leaks from the carbon tetrachloride effluent pipelines to estimate how much organic and aqueous effluent discharged from PFP actually went to the three carbon tetrachloride disposal cribs as intended. The effluent pipelines to be examined include those used to convey organic and aqueous effluent from 1955 to 1973 from the Recuplex facility to the 216-Z-9 Trench and from the PRF to the 216-Z-1A Tile Field and the 216-Z-18 Crib. The 216-Z-9 pipelines will be examined first using a forward-looking color camera. Other methods, such as surface and vegetation sampling, soil gas sampling, cone penetrometer vapor sampling, and/or soil sampling via borings, may be used for confirmation and plume definition/leak volume estimates. If feasible, pipelines used after 1973 for liquid transfer will also be evaluated. (NOTE: This task was approved as part of the FY 92 ERA Phase II plan (Rohay 1991) and thus can be initiated immediately. It was postponed to FY 93 for budgetary reasons.)

3.5.1.2 Investigate Source of Secondary Ground Water Maximum. The objective of this subtask is to determine the source of the secondary concentration maximum in the dissolved ground water plume. Methods of investigation include examining historical waste management practices for possible sources in this area; comparing the ground water chemistry at points along the principal flow path of the carbon tetrachloride ground water plume for indications of multiple sources; and evaluating carbon tetrachloride degradation rates and ground water travel times. Additional/confirmatory data might be collected, if needed, via vegetation sampling, soil gas surveys, sampling of existing wells (soil gas and ground water), cone penetrometer vapor sampling, and/or installation of new wells.

3.5.1.3 Assess Artificial Recharge. Data on the discharge volumes/rates, and locations of all effluents (including sanitary tile fields) within 1 km of the primary carbon tetrachloride disposal sites will be compiled and evaluated for possible impacts on the unsaturated zone and ground water hydrogeology and/or redistribution of carbon tetrachloride wastes. These data will be acquired from existing documents and/or personnel interviews.

3.5.2 Conduct Soil Gas Surveys

The objective of this activity is to map the lateral and vertical distribution of carbon tetrachloride and other selected VOC in the vicinity of and away from the three disposal sites. This information will support determination of the nature and distribution of the contaminants and will provide baseline data for comparison of soil gas and sensor technologies. The general distribution of the soil gas concentrations will be compared to the locations of the disposal facilities and the ground water concentrations.

The scope of this task includes the lateral and vertical distribution of VOC in the unsaturated zone and VOC flux at the soil-air interface.

3.5.2.1 Map Lateral Distribution of VOC. New soil gas surveys will be conducted to complement previous soil gas surveys. A total of 150 to 530 soil gas sampling points have been planned (Last and Rohay 1992). Twenty-two points were installed in FY 91 and 60 points were installed in FY 92. In FY 93, approximately 40 points will be installed (some through asphalt) to define the maximum extent of detectable VOC (>0.02 ppm carbon tetrachloride). Figure 5 illustrates the location of the soil gas points.

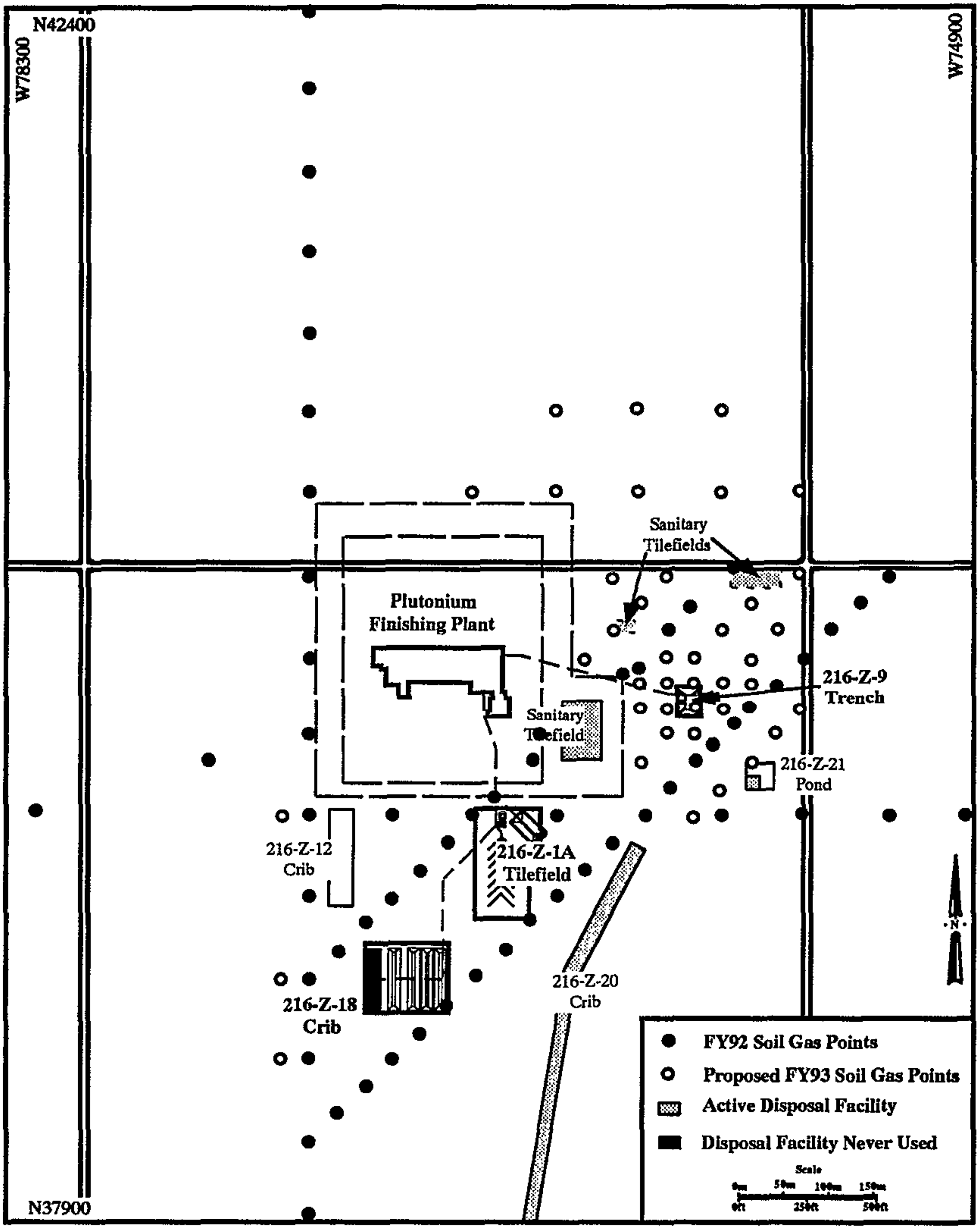
The sampling points consist of expendable (left-in-place) tips installed to a depth of approximately 1.2 m. New points will be completed in such a fashion as to prevent intercommunication with the atmosphere (i.e., a surface seal of bentonite or other suitable material will be installed). The concentrations of VOC will be measured at least once at all new and existing soil gas points using a gas chromatograph (GC) and field screening instruments (e.g., photoionization detector [PID], organic vapor monitor, Odyssey). Empirical correlations will be established between the GC and field screening results. Alternative analytical methods (e.g., ion-trap) may be demonstrated. Oxygen and carbon dioxide levels will be measured using field instrumentation as possible indicators of biological activity.

If possible, continuous monitoring of selected ports will be conducted to establish the time variant behavior of VOC concentrations to assist selection of the periodicity of routine monitoring.

3.5.2.2 Estimate VOC Vapor Flux From Ambient Soil Surface. Passive soil gas technologies will be used to estimate the vapor flux from the soil-air surface. These technologies will also continue to be evaluated for use as prospecting and/or monitoring tools.

3.5.2.3 Map Vertical Distribution of VOC. Existing wells of various depths will be sampled for VOC vapor concentrations. Existing perforated intervals and some new perforated intervals will be packed off and sampled. If available, a cone penetrometer will be used to conduct vertical profile sampling, and/or install deep soil gas ports for monitoring purposes. The VOC vapor concentrations will be measured using both GC and field screening instrumentation.

Figure 5. Proposed Soil Gas Sampling Locations.



9 3 1 2 9 1 1 1 6 4

3.5.3 Conduct Geophysical Surveys

The objective of this task is to define the three-dimensional configuration of mappable hydrofacies and/or contaminant plumes in the vicinity of the three principal carbon tetrachloride disposal sites.

The scope of this task includes surface geophysical techniques. Most of the geophysical surveys for FY 93 will be conducted as part of site characterization technology demonstrations. For example, Colman Research Corporation (Coleman Research) plans to conduct direct current resistivity, time-domain electromagnetics (TDEM), frequency-domain electromagnetics (FDEM), ground-penetrating radar (GPR), spectral-induced polarization (SIP), and seismic reflection and refraction surveys in the 200 West Area. This work will also support Coleman Research's data fusion task. A separate test plan will provide details of these activities.

3.5.4 Existing Well Investigations

The objective of this task is to continue assessments of the old wells as contaminant transport pathways; remove any known pathways; and evaluate the lithology and/or contamination penetrated by the boreholes.

The scope of this task includes borehole geophysical logging, past well maintenance practices, water level measurements, and archived borehole samples.

3.5.4.1 Borehole Geophysical Logging. Borehole geophysical logging will be conducted at selected wells within a 100-m radius around the three carbon tetrachloride disposal sites. The geophysical tools to be used include gross gamma and/or spectral gamma (for delineation of radiological contamination, and marker lithologic units). Other tools such as neutron-epithermal neutron (for detection of perched water) and/or neutron thermal lifetime (for detection of chlorine) may also be tested. Downhole camera surveys, caliper logs, magnetic logs and/or other tools may be run in those wells where potential contaminant pathways exist, and/or extensive remediation is planned.

3.5.4.2 Wellhead Vapor Emissions. Personnel interviews will be conducted to investigate the historical use of various well cap designs. Wellhead concentrations and fluxes of VOC vapor will also be measured at selected wells.

3.5.4.3 Well Remediation. Ten ground water wells and two unsaturated zone wells were evaluated as part of FY 92 well evaluation activities (Rohay et al. 1992). Remediation or modification of the ground water wells in proximity to the 216-Z-9 Trench (299-W15-5, 299-W15-6, 299-W15-8, and 299-W15-9) should receive priority because the contaminant concentrations appear to be highest at that site and because these wells still intersect the water table. Consideration will be given to use of the wells for vapor extraction and/or monitoring and ground water investigations.

Other old wells within a 100-m radius of each site will be reviewed for remediation needs (surface seals, paint, well numbers, new well caps, annular seals, packers, abandonment) and a plan developed for the completion of these modifications. If possible, all wells not surveyed, or surveyed prior to 1992 will be resurveyed using both Lambert metric and Hanford plant coordinates.

3.5.4.4 Water Level Measurements. Water level measurements will be taken once per quarter in all available ground water wells within a 1-km radius around the three primary disposal sites. Ground water potential maps and flow nets will be constructed from these data and corrected for open interval length and position within the aquifer.

3.5.4.5 Evaluation of Archived Borehole Samples. Archived sediment samples from critically located wells (i.e., deep wells, and those along selected cross section lines) will be relogged by a geologist. Geological samples collected during FY 92 will be sieved and analyzed for clay content.

3.5.5 New Well Investigations

The objective of this task is to obtain data on the nature, distribution, transport pathways, and behavior of contaminants (e.g., phase partitioning, sorption parameters) immediately below each disposal facility and fully penetrating the uppermost aquifer.

The scope of this task includes:

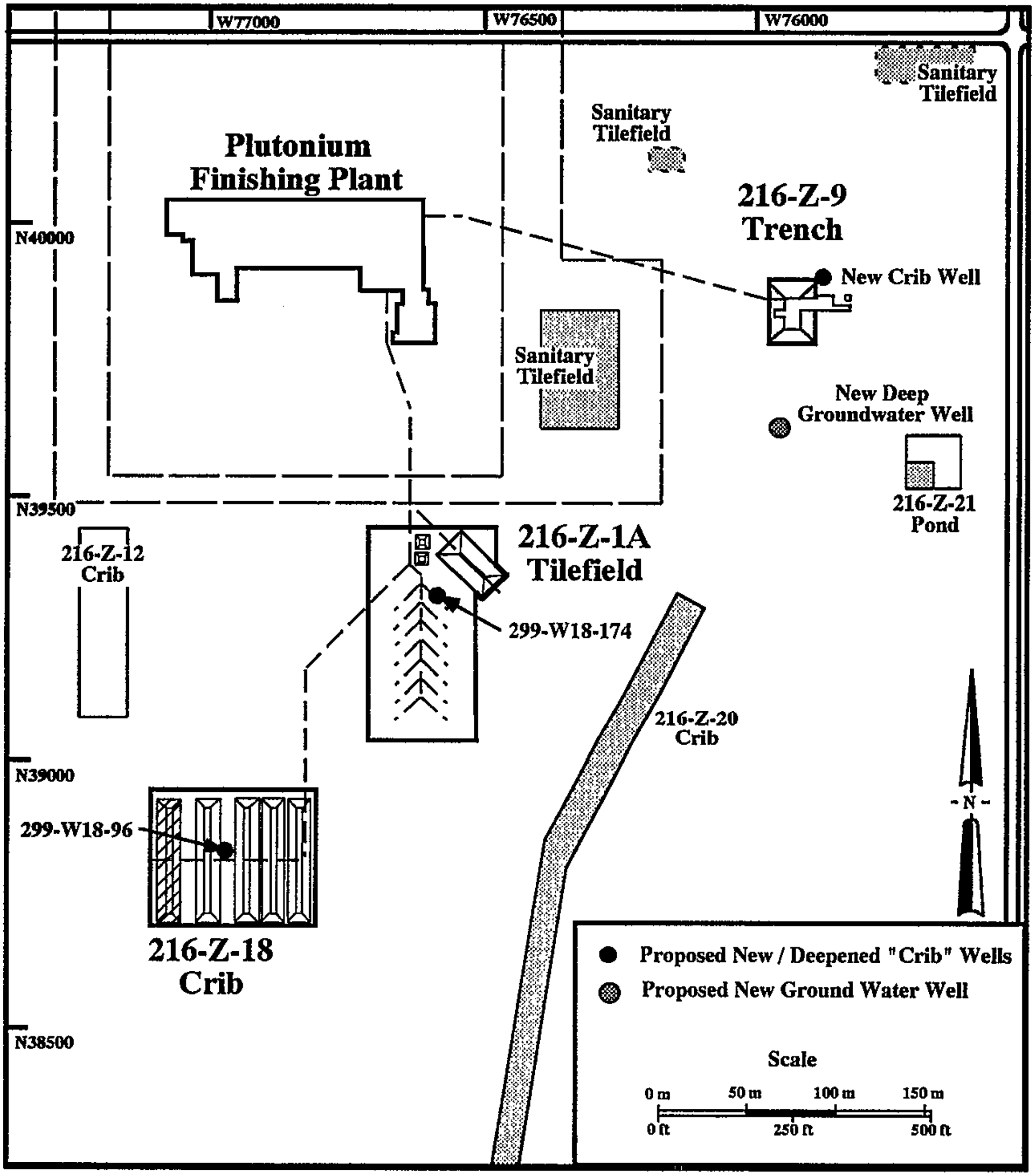
- Deepening existing boreholes that have already penetrated the radiological contamination within the cribs.
- Installing an angle borehole underneath a crib.
- Drilling and sampling one deep groundwater well.
- Drilling and sampling one bioremediation well.
- Drilling one in situ heating well if requested.
- Collecting geochemical, lithologic, hydrologic, and microbiologic samples.

In addition, five vapor extraction and/or monitoring wells will be drilled in the carbon tetrachloride disposal area. These wells are part of wellfield enhancement for the active vapor extraction operations and are described in a separate work plan. (NOTE: The deepening of existing wells was approved as part of the FY 92 VOC-Arid ID work plan (Last and Rohay 1991). The work was postponed until FY 93 to allow time for preparation, which was actively pursued during FY 92. Drilling of the deep ground water well was approved as part of the FY 92 ERA work plan (Rohay 1991). It was postponed to FY 93 for budgetary reasons.)

3.5.5.1 Crib Boreholes. This subtask involves deepening two existing boreholes within the 216-Z-1A Tile Field and the 216-Z-18 Crib confines and drilling one new well that angles beneath the 216-Z-9 Trench.

Existing wells selected for deepening are 299-W18-174 (216-Z-1A Tile Field) and 299-W18-96 (216-Z-18 Crib). The locations of these wells are shown in Figure 6. Wells 299-W18-174 and 299-W18-96 were originally completed just below field detectable radionuclide contamination. Each borehole will be deepened a minimum of 3 to 6 m (10 to 20 ft) below the bottom of the innermost well casing or, at a maximum, to the top of the Plio-Pleistocene unit at 43 m depth.

Figure 6. Location of Proposed Crib and Near-Field Boreholes/Monitoring Wells.



The angle borehole will be drilled at the northeast corner of the 216-Z-9 Trench and will proceed at a 45-degree angle toward the southwest corner. because this facility consists of an excavation with a concrete cover, access to beneath the crib will be approached from outside the crib boundaries. The target depth is 35 m at the top of the Plio-Pleistocene Unit. It is anticipated that the sonic drilling technology will be used and will be provided through the VOC-Arid ID.

Each borehole will be periodically sampled for VOC vapors, sampled using a split-spoon for physical and chemical analyses, and geophysically logged. These boreholes will be drilled using techniques to prevent the downward propagation of contaminants. The final depths will be selected based on results of well cutting screening analyses and discrete soil gas samples collected during drilling operations. The boreholes will be constructed as unsaturated zone monitoring/vapor extraction wells for the ERA and to accommodate technology demonstrations (Appendix A).

If possible, in situ soil gas samples will be collected from each borehole at selected horizons (every 6 m, approximately) using a SEAMIST (tradename of Science & Engineering Associates, Inc., Santa Fe, New Mexico) system (Rohay and McLellan 1992), conventional packer assemblies, and/or the Bore Sampler (WHC 1992). Tests of other in situ soil gas sampling devices, if available, may be conducted at selected horizons. Radiological conditions/ safety concerns may prohibit this sampling in places. Geophysical logging (e.g., gross gamma, spectral gamma, and/or other tools) may be conducted after the installation of each length of temporary casing. If possible, air permeability testing will be conducted at selected horizons (every 6 m, approximately) using a SEAMIST system (Rohay and McLellan 1992) and/or other technologies. Additional geotechnical testing may be conducted at selected horizons, with a maximum of three tests conducted in any one borehole.

Soil samples will be collected continuously or at a minimum of every 1.5 m and at significant lithologic, moisture, or contaminant changes. These samples will be obtained using split-spoon sampling techniques and/or other approved sampling methods (e.g., drive-barrel). Split-spoon samples will be collected a minimum of every 6 m. LEXAN (tradename of the General Electric Company) liners will be used in conjunction with the split-spoon sampler.

An onsite geologist will examine and qualitatively describe all core and borehole cuttings for grain size, $CaCO_3$, lithology, and moisture. All borehole cuttings and samples will be screened for alpha and beta-gamma contamination using portable survey equipment, and for VOC using a PID or similar instrument.

If the data obtained by deepening these two wells are not sufficient (e.g., if no co-contaminants are encountered), new wells may be installed to investigate the contaminant characteristics at the crib bottoms and in other radiologically contaminated areas. The new wells may be drilled within the existing crib boundaries. If needed, these wells will be described in the work plan for FY 94 site characterization activities.

3.5.5.2 Install Deep Ground Water Well. The objective of this subtask is to obtain data on the nature and distribution of contaminants in the aquifer in the vicinity of the disposal facilities, and to obtain data on the lithology, geochemistry, hydrology, and microbiology of the aquifer materials.

This subtask involves the drilling of a deep well to the top of basalt (160 m). This well will be located within the vicinity of the 216-Z-9 Trench, but outside of its radiological unsaturated zone plume, to characterize the distribution of carbon tetrachloride within the unconfined aquifer as related to wells 299-W15-6 and 299-W15-8 as possible conduits for carbon tetrachloride migration. Figure 6 illustrates the proposed location of this deep well. Other existing wells may be deepened or at least cleaned out to their original depth to provide data on contamination at depth within the unconfined aquifer. Lithologic samples, soil gas samples, and depth-discrete water samples will be collected. Geophysical logging using gross gamma, spectral gamma, and/or other tools will be performed. Aquifer tests will be conducted so as to not produce large volumes of purge water (e.g., slug interference testing).

The well will be drilled by telescoping the temporary casing to seal off any perched water and to prevent the downward propagation of contaminants to deeper levels. Completion details for the deep well are dependent on the results of the depth-discrete ground water samples.

An onsite geologist will examine and qualitatively describe all core and borehole cuttings according to a regimented protocol for grain size, $CaCO_3$, lithology, and moisture. All borehole cuttings and samples will be screened for alpha and beta-gamma contamination using portable survey equipment, and for VOC using a PID or similar instrument.

Soil samples (via drive barrel where possible) will be collected every 1.5 m and at lithologic, moisture, and/or contaminant changes. Split-spoon samples will be collected approximately every 6 m for determination of carbon tetrachloride concentrations. Other split-spoon samples may be collected where screening analyses of the well cuttings and/or soil samples indicate the presence of VOC. In addition, split-spoon samples (representing the range of unsaturated zone hydrogeologic units) will be collected to support the testing of a centrifuge for unsaturated zone transport measurements and to support the testing of supercritical fluid extraction technology. Special split-spoon samples will be collected to support the characterization of subsurface microbial populations pursuant to testing of biological treatment technologies.

The unsaturated zone will be sampled in situ for soil gas vapors and tested for air permeability using a SEAMIST system (Rohay and McLellan 1992) or other technologies (e.g., Bore Sampler). The in situ soil gas samples will be analyzed for VOC, including carbon tetrachloride and chloroform, using a GC. Soil gas samples may be collected with time during air withdrawal tests.

Depth-discrete ground water samples will be collected at 6-m intervals and at significant lithologic and/or contaminant changes (noted via screening techniques) throughout the unconfined aquifer.

3.5.5.3 Conduct Physical Sample Analyses. All uncontaminated (i.e., below field detection) soil samples will be analyzed in the laboratory for particle size (including hydrometer analyses), $CaCO_3$, moisture content, and lithology (binocular microscope). Selected core samples will be analyzed for their water-retention characteristic curves, saturated hydraulic conductivity, bulk density, porosity, air permeability, and mineralogy (including clays). In addition, some thin sections will be made for detailed lithological, mineralogical, and pore size distribution analyses. Other cores may be analyzed for thermal conductivity and electrical resistivity as functions of water content.

3.5.5.4 Conduct Chemical Analyses. Discrete soil gas samples will be analyzed for oxygen, carbon dioxide, and VOC (using a mobile laboratory and GC or other fast-turnaround technology).

Soil samples will be analyzed for pH, total organic compounds (TOC), total organic halogens (TOX), specific conductance, VOC, semivolatile and other organic compounds, metals, cations, anions, and radionuclides. The list of target constituents is presented in Table 4. The intervals to be analyzed will be selected based on the depth-discrete soil gas sampling and other screening results. VOC samples will be collected at a minimum of every 1.5 m.

Selected cores will also be analyzed for geochemical constituents. Geochemical analyses may include cation exchange capacity, total carbon, surface area, pore water chemistry, sorption studies, and isotope (e.g., ^{36}Cl) analyses.

Table 4. Target Compounds.

Volatile Organic Compounds	
Carbon tetrachloride	Chloroform
Methylene chloride	Tetrachloroethylene
Trichloroethylene	Methyl ethyl ketone
Semivolatile and Other Organic Compounds	
Tributyl phosphate	Dibutyl phosphate
Dibutyl butyl phosphonate	Monobutyl phosphate
Triglycerides (lard oil)	
Metals	
Aluminum	Magnesium
Iron	Chromium
Cadmium	Nickel
Anions/Cations	
Chloride	Nitrate
Fluoride	Sulfate
Calcium	Phosphate
Radionuclides	
Plutonium	Americium
Strontium-90	Gamma emitters
	Uranium

(NOTE: Compounds may be added to or deleted from this list as the investigation progresses, based on feasibility of analytical techniques and the identification of additional co-contaminants, by the project scientist or task manager.)

Ground water samples will be analyzed for pH, TOC, TOX, specific conductance, VOC, semivolatiles and other organic compounds, metals, anions, cations, and radionuclides. Target constituents are presented in Table 4.

3.5.5.5 Conduct Microbiological Analyses. Aseptic split-barrel samples will be collected for microbiological analyses based on recommendations from the in situ bioremediation technology team.

3.5.5.6 Drill Technology Demonstration Boreholes. Two boreholes will be drilled as part of technology demonstrtions for in situ treatment tasks of the VOC-Arid ID. One will be in support of the In Situ Biological Treatment of Hanford Groundwater task, and one will be in support of the In Situ Heating/ Corona Destruction task.

The in situ bioremediation task is directed toward demonstrating in situ degradation of carbon tetrachloride in groundwater. The purpose of the site characterization work is to determine the physical, hydrologic, transport, and chemical parameters of the aquifer and to install a well system that can be used for implementing and monitoring the remediation demonstration. Characterization activities in FY 93 will focus on determination of the lateral and vertical distribution of hydrogeologic properties for the unconfined aquifer.

During FY 93, a bioremediation well will be drilled at the demonstration site in the 200 West Area between 241-T Tank Farm and 221-T Plant, where two bioremediation boreholes, 299-W11-29 and 299-W11-30, have already been installed. The new well will be a multiple-screen well to be used both for characterization and for the in situ remediation demonstration system. The selection of three to four screened intervals will be based on results obtained from existing site characterization data and hydrologic tests to be conducted early in the year before final construction. It is anticipated that this well be centered between the two existing wells (FIgure 7). Additional dual-screened wells are planned, but will not be drilled this fiscal year.

A brief description of the sampling and testing planned for this well is provided below. Details will be included in a separate sampling and analysis plan as part of the in situ bioremediation task work plan.

During drilling, geologic samples will be collected by core barrell or split-spoon samplers every 1.5 m and/or after a major lithologic change in encountered. From those samples, a suite of samples will be selected from specific depths within the saturated zone and the 6 m immediately above it for laboratory analysis to define the geologic properties of the subsurface. In addition, samples collected every 1.5 m will be submitted for geotechnical analyses including sediment grain-size distribution, lithologic description, calcium-carbonate content, moisture content, saturated hydraulic conductivity, bulk density, particle density, water suction potential, and porosity. Not all analyses will be conducted on every sample submitted.

When the final depth has been reached, a suite of borehole geophysical logs will be run to provide data on the subsurface distribution of lithologic units. Borehole geophysical log surveys may include: natural gamma, neutron-epithermal neutron, density, and fluid temperature.

After the well has been completed, aquifer testing will be conducted to determine hydraulic properties. Test methods will include standard hydrologic techniques such as slug (single-well) and constant rate pumping tests, as well as state-of-the-art slug or pulse interference methods. The single-well tests are planned for each of the two existing wells, 299-W11-29 and 299-W-11-30. The multiple-well interference tests will include all three wells.

Plan View of Well Site

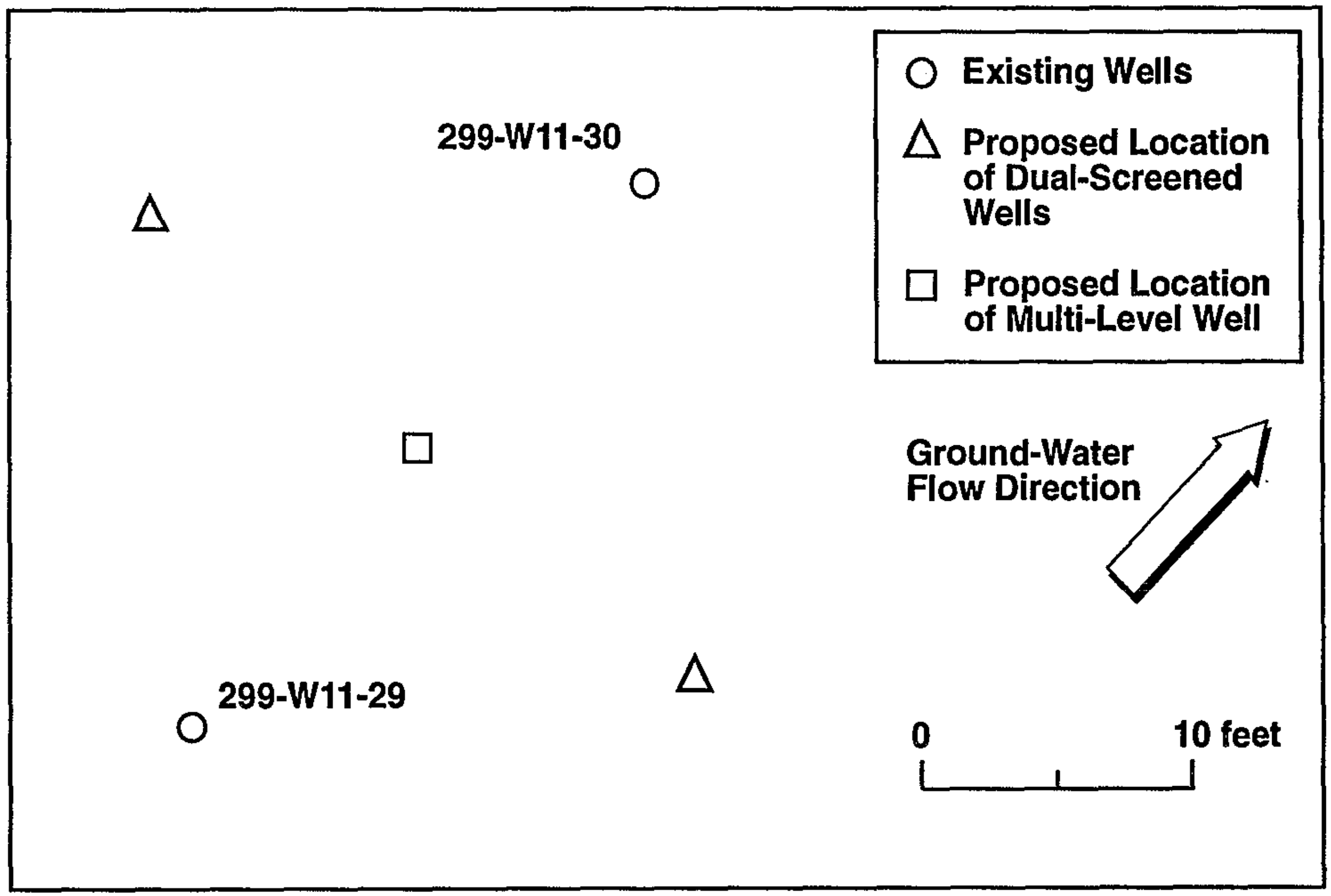


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Figure 7. Location of Proposed Bioremediation Wells.

Groundwater samples will be collected from each screened interval in the new well using submersible pumps or bailers. Unstable hydrochemical parameters, such as pH, Eh, oxygen content, and alkalinity will be determined in the field at the time of sample collection.

Tracer testing will be conducted in selected wells and monitoring intervals to further refine the understanding of the hydrologic and transport properties of the unconfined aquifer. Initial testing will consist of the standard borehole-dilution tracer techniques; dynamic cross-hole tracer tests will also be considered.

Installation of a new well is planned to support field testing of an in situ heating technology. Tentative plans are to conduct the field test at a site of volatile organic contamination near the fire station in the 300 Area. The proposed well would be approximately 15 m deep. Details on the construction and sampling will be provided in the test plan for this activity.

3.5.6 Ground Water Sampling

The objective of this task is to monitor concentrations of VOC in ground water from wells in and around the three disposal sites and at the perimeter of the ground water plume. In addition, the vertical distribution of such compounds within the aquifer will be further investigated wherever feasible.

The scope of this task includes obtaining ground water samples from existing wells and from any new wells drilled during FY 93. If necessary, sampling pumps and/or packers will be installed and wells will be rehabilitated. The data will be integrated with the results from the ongoing Hanford Site ground water monitoring programs.

Ground water samples will be collected from approximately 26 wells. The initial list of wells to be sampled (Table 5) was chosen based on sampling conducted during FY 91 and FY 92 and in coordination with other ground water monitoring programs. At the discretion of the project scientist or field team leader, wells may be added or subtracted from this list based on results of current sampling. Sampling during FY 93 will occur twice, once in November and once in May.

Ongoing Hanford Site ground water monitoring programs that include 200 West Area wells are: (1) the Operational Ground Water Monitoring Network, (2) the RCRA program, (3) the 200 West Aggregate Area Management Study under CERCLA, (4) any ground water monitoring required by liquid waste discharge permits, and (5) Pacific Northwest Laboratory site-wide monitoring. The various sampling efforts are coordinated by the Operational Ground Water Program. Table 5 indicates which wells are already being sampled under an existing program. Duplication of sampling efforts will be avoided whenever possible.

Ground water sampling from discrete zones at varying depths will be conducted in existing wells that have a suitable screened interval within the aquifer. Based on the FY 92 well evaluation (Rohay et al. 1992), it is recommended the sampling be conducted from the bottom of the screened interval in well 299-W15-6 to assess the extent of the carbon tetrachloride contamination encountered there. Well 299-W15-5 is scheduled for sampling in October 1992. Other wells that may be suitable for further investigation of the vertical distribution of organic compounds in the aquifer include 299-W18-1 and 299-W18-3. This work will be coordinated with the vertical profiling of ground water contaminants being conducted by the 200 West Aggregate Area Management Study during FY 93.

Table 5. Ground Water Wells to be Sampled.

Well	Responsible Program
299-W7-4	RCRA
299-W7-5	RCRA
299-W10-4	N/A
299-W10-15[a]	RCRA
299-W10-17[a]	RCRA
299-W10-18[a]	RCRA
299-W11-28[a]	RCRA
299-W14-12[a]	RCRA
299-W15-6	200 West Aggregate Area Management Study
299-W15-8	Operational Ground Water Monitoring Network
299-W15-12	N/A
299-W15-16[a]	RCRA
299-W15-22[a]	RCRA
299-W18-2	N/A
299-W18-9[a,b]	N/A
299-W18-17	Operational Ground Water Monitoring Network
299-W18-20	Operational Ground Water Monitoring Network
299-W18-25[a]	RCRA
299-W18-29	RCRA/Operational Ground Water Monitoring Network
299-W18-30[a]	RCRA
299-W19-32[a]	RCRA
299-W23-13[a]	RCRA
699-38-70	N/A
699-39-79	N/A
699-43-88	N/A
699-49-79	N/A

[a]VOA samples added for November and May sampling.
[b]Bailed sample.

Ground water samples will be analyzed for VOC using a gas chromatograph/ mass spectrometer (GC/MX) in the laboratory and/or with portable field screening equipment, if feasible. Samples from wells that have carbon tetrachloride concentrations at or below 5 ppb (e.g., 699-43-88 and 699-49-79) will be analyzed using a more sensitive GC method. In-well sampling will be conducted, if feasible, using a permeation sampler.

3.6 LABORATORY STUDIES

Soil physics and geochemical laboratory studies will be conducted to define some of the basic behavioral properties of the carbon tetrachloride waste in the site soils. This information will contribute to the refinement of the conceptual model; to predictive modeling of contaminant transport; and to the design of effective remediation strategies. Conduct of these studies is dependent on the FY 93 funding levels.

3.6.1 Soil Physics/Waste Characteristic Studies

The objective of these studies is to characterize the distribution, transport, and behavior of fluids and vapors in the unsaturated zone.

The scope of this work includes both laboratory experiments and computer simulations, using liquid organic waste mixtures, particularly those containing carbon tetrachloride, carbon tetrachloride vapor, and subsurface conditions similar to those encountered in the 200 West Area.

3.6.1.1 Retention of Organics. The objective of this subtask is to measure the retention of liquid organic waste mixtures in porous media as a function of water content. A unique air-organic-water retention cell will be constructed that will be able to measure the retention of fluids by capillary forces. The cell, which will be connected to vacuum-pressure regulators and burets, will be packed with sediments similar to those of the 200 West Area and saturated with varying amounts of water and liquid organic mixtures. The liquid organics will then be extracted from the cell at a constant rate through chemically treated ceramics until the organic liquid phase appears to be immobile. The organic liquid content remaining in the porous media will be determined via mass balance. The data can be used to determine how much organic liquid will drain from the Hanford sediments toward the water table.

3.6.1.2 Transport of Vapors. The objective of this subtask is to evaluate the potential of carbon tetrachloride vapors to move throughout the subsurface. The advective movement of fluid is a result of a pressure difference in the fluid phase and the influence of gravity. When the fluid is a gas, the gravity component is typically neglected. However, when liquid organic wastes contain dense VOC, such as carbon tetrachloride, the gaseous phase adjacent to where volatilization is occurring may be denser than ambient gaseous-phase densities. This density difference may enhance the downward movement of contaminant molecules, which can significantly affect the rate and extent by which ground water becomes contaminated. The other major mechanism by which contaminant molecules can move through the subsurface, other than advective flow, is chemical diffusion, where chemical diffusion is the spreading of contaminant molecules because of a spatial concentration difference. Under this subtask, the movement of carbon tetrachloride vapor molecules because of diffusive and advective processes will be evaluated. This will involve both laboratory and computer investigations. In the laboratory, the diffusion of carbon tetrachloride will be measured in Hanford sediments. The effects of organic liquids co-disposed with carbon tetrachloride on carbon tetrachloride volatilization will also be measured. Computer investigations will focus on forecasting the subsurface behavior of carbon tetrachloride vapors. A predictive computer tool will be adapted to model advective and diffusive gaseous movement.

3.6.2 Geochemical Studies

The objectives of the geochemical studies will be to evaluate the waste-sediment interactions influencing the sorption/desorption of carbon tetrachloride and its decomposition products, chloroform and methylene chloride, on mineral surfaces.

This task will evaluate the interactions of the primary contaminants with Hanford sediments, clay minerals isolated from those sediments, and model clay minerals under saturated aqueous conditions and also under unsaturated conditions that mimic the conditions found in the unsaturated zone. The effects of the various co-contaminants (i.e., alkyl phosphates and lard oil) on retention of the primary contaminants by these sediments will also be evaluated. The emphasis will be on determining retardation factors and other parameters important for estimating transport of the primary contaminants in the saturated and unsaturated zones of the Hanford sediments.

As a consequence of having no dipole moment, no hydrogen bonding capacity, and no charge, carbon tetrachloride interacts only weakly with solid surfaces. Highly polar molecules like water, on the other hand, interact very strongly with charged solid surfaces and may exclude nonpolar molecules like carbon tetrachloride from any interaction with the surface. With uncharged, nonpolarizable surfaces, however, the interactions of polar molecules are similar to those of carbon tetrachloride. Not surprisingly, then, retention of carbon tetrachloride by soil mineral surfaces in contact with aqueous solutions is essentially nil, whereas retention by soil humic surfaces is more favorable (water is not as strongly attracted to uncharged portions of the humic solids). Although humic retention of carbon tetrachloride would be expected to be of limited importance in water-saturated Hanford sediments because of their low native organic matter contents, the co-disposal of large amounts of alkyl phosphates and lard oil with carbon tetrachloride at Hanford may have created hydrophobic surfaces or reservoirs in the sediments that could serve to retain carbon tetrachloride and other organic solvents. In the unsaturated zone, drier conditions reduce the competition from water and thus may allow more interaction of carbon tetrachloride vapors with soil mineral surfaces than that observed for dissolved carbon tetrachloride in the saturated sediments. Because their dipole moments fall between those for water and carbon tetrachloride, the behavior of chloroform and methylene chloride with respect to sediment surfaces would also be expected to fall between that for water and carbon tetrachloride.

3.6.2.1 Unsaturated Conditions. Vapor-phase adsorption isotherms for all primary contaminants will be performed at several temperatures, using thin films of sediment or sediment plus co-contaminant mounted on windows in an infrared gas cell. The amounts adsorbed at equilibrium, as well as the rates of adsorption and removal by air stripping, will be quantified by infrared spectroscopy. Use of infrared spectroscopy will also provide direct evidence for reaction mechanisms and modes of interaction. Vapor-flow column studies will be performed at several temperatures and relative humidities using infrared and/or GC detection systems. The impact of nutrient additions on primary contaminant mobility will be investigated in future years.

3.6.2.2 Saturated Conditions. Adsorption isotherms using radiolabeled compounds will be performed at several temperatures to allow estimation of the heat of sorption. The emphasis in the first year will be on chloroform and methylene chloride retention because of previous work showing essentially no interaction between carbon tetrachloride and sediments under saturated conditions. The impact of co-contaminants and bi-phasic systems on retention will also be investigated in batch equilibrium and flow-through column studies. In future years, the introduction of nutrients into sediments and its impact on fate and transport of radionuclides (e.g., americium, plutonium) and VOC will be studied. In addition, chemical and radiological degradation rates of key VOC will be studied in laboratory experiments if significant concentrations of degradation products are identified in near-crib unsaturated zone sediments during the FY 93 characterization activities.

3.7 DATA MANAGEMENT, INTEGRATION, AND PRESENTATION

Characterization data collected from these site evaluation efforts will be managed and integrated with those data collected in support of other Hanford Site programs (e.g., RCRA, CERCLA).

The objective of this task is to establish an interactive database/graphics retrieval and display capability.

The Hanford Environmental Information System (HEIS) and Geographical Information System (GIS) will be used as the backbone for all data entry, storage, and graphics retrieval/display capability.

3.7.1 Data Entry

The objective of data entry is to enter all VOC-Arid ID and ERA site data into the HEIS database, as appropriate. This subtask includes the entry of existing data (e.g., drillers logs, geophysical logs, chemical analysis data, etc.), the acquisition/modification of field computers and macros for direct data entry, and HEIS support for preparation of new data fields and loader programs.

3.7.2 Data Manipulation and Display

The HEIS/GIS will form the heart of the data manipulation and display tools. This system will be used to generate concentration contour maps, geologic cross sections, isopach maps, and structural contour maps. Some software modifications are anticipated to develop new HEIS/GIS capabilities (e.g., full well displays, addition of data qualifiers, definition of formation tops, etc.). Other programs/protocols will be developed to assist the use of off-the-shelf graphics and modeling software. The subtask will also produce report tables, maps, graphs, etc. as needed.

3.7.3 Support Data Fusion Efforts

Data fusion support is aimed at providing Coleman Research with the environmental and site-specific expertise necessary to make the development of an environmental data fusion work station successful. Coleman Research has been funded by the Characterization, Monitoring, and Sensor Technology Integrated Program to apply U.S. Department of Defense data fusion capabilities to the DOE's Environmental Restoration Program. The VOC-Arid ID site was selected as the initial demonstration site for this technology. Support to Coleman Research will consist of technical guidance regarding environmental assessments, providing historical and recently collected data on the VOC-Arid

Id site, providing interpreted data sets for use in their data fusion work station, providing field and laboratory support for their geophysical data collection efforts, and testing of the prototype work station.

3.7.4 Issue U Pond Characterization Report

The U Pond characterization report covers revision and documentation of a U Pond characterization report drafted in 1981. This report contains valuable information on disposal facilities in the vicinity of the carbon tetrachloride disposal facilities.

3.8 NUMERICAL MODELING

The work planned for numerical modeling of the distribution of carbon tetrachloride in the subsurface environment at Hanford will build on the work accomplished in FY 92. This work includes two modeling efforts: numerical modeling of multiphase flow in the unsaturated zone using the Single-Phase And Multiphase Flow and Transport in 2 Dimensions (SAMFT2D) model; and development of the Enginering Simulator.

3.8.1 Multiphase Flow in the Unsaturated Zone

The objective of this task is to simulate the behavior of the multiphase system -- carbon tetrachloride/water/vapor -- in the unsaturated zone to aid the design and monitoring of remedial activities.

The scope of the work for FY 93 is to use SAMFT2D to investigate two important aspects of the two-phase flow analysis completed in FY 92 and to perform a three-phase flow analysis of the disposal of carbon tetrachloride at the 216-Z-9 Trench.

The initial objective for FY 93 is to evaluate the effect of sequential batching of the water and carbon tetrachloride in the source term and the slope of the Plio-Pleistocene (caliche) layer in the unsaturated zone. In FY 92, runs made with SAMFT2D assumed that the water and carbon tetrachloride were both released from the processing facility simultaneously, although the fluids were assumed to be immiscible. This was done as an expediency since the timing for the release of the two liquids was not known. The first task in FY 93 will be to assume that the liquid disposal operation involved disposal of carbon tetrachloride first with the water being discharged at a later time in a given interval. While the exact manner of disposal of the liquids is not known, several combinations will be tried to evaluate what the effect, if any, that this sequential mixing would have on the distribution of carbon tetrachloride in the subsurface.

The conceptual model applied in the FY 92 modeling process also assumed that the Plio-Pleistocene layer was horizontal. This assumption reduced the size of the simulation grid in that the model could be made symmetrical about the centerline of the crib and, therefore, was more economical for getting the model operational. However, the slope of the Plio-Pleistocene unit could have a significant effect on the distribution of the carbon tetrachloride by permitting it to move down dip on this unit of lower hydraulic conductivity.

The quantity of carbon tetrachloride percolating into the Plio-Pleistocene may also be reduced.

Work accomplished in FY 92 treated three-phase flow in the subsurface, i.e., the flow of liquid water, liquid carbon tetrachloride, and gas (air). SAMFT2D has the capability of dealing with carbon tetrachloride vapor as well, i.e., three-phase flow plus carbon tetrachloride vapor. In FY 93, SAMFT2D will be employed in a three-phase mode to simulate the movement and distribution of water, air, and carbon tetrachloride vapor and liquid. This will result in a more realistic simulation since carbon tetrachloride has a high vapor pressure and can be expected to readily move in the gaseous state. Three-phase simulation will provide information as to the extent that carbon tetrachloride may have moved in its liquid and gaseous forms. This simulation will provide input for air flow models being used for wellfield design and can be expected to complement the analyses that those models can perform.

As with any modeling effort, the simulations are dependent on information obtained during the field investigations. In this regard, close contact will be maintained with those performing field activities to maximize the information obtained.

3.8.2 Engineering Simulator

This work is being conducted in support of treatment technology demonstrations and is covered under a sseparate scope of work within the VOC-Arid ID, but is included here for. The Engineering Simulator is a predictive modeling tool to aid both in remediation selection and design and in process control, optimization, and performance evaluation during remedial operations. The activities to be conducted include: (1) application of the predictive modeling tools to support the field design, operations, and data evaluations of VOC-Arid ID technology demonstrations; (2) assess the impact of subsurface spatial heterogeneity on proposed remediation technologies; (3) evaluate the technical and regulatory effectiveness of remedial technologies being demonstrated; and (4) develop and test the Engineering Simulator within the end-user community.

3.9 DATA EVALUATION

The purpose of site data evaluation is threefold: to further refine the conceptual model of the site and carbon tetrachloride behavior; to evaluate the risks associated with contamination present at this site; and, to evaluate the effectiveness of remedial actions.

Site data will be integrated and evaluated to refine the current hydrogeologic conceptual model and the conceptual understanding of carbon tetrachloride behavior. The nature and distribution of contaminants will be refined and compared from pre- and postremedial actions. Hydrostratigraphic units will be delineated, along with unsaturated zone and ground water flow paths and rates. The conceptual understanding of multiphase flow will be evaluated, along with sorption and other contaminant transport parameters and microbial species and populations.

This task is designed to produce the reports describved in Chapter 4 of this work plan.

3.10 SUPPORT TECHNOLOGY DEMONSTRATIONS

The objective of this task is to provide the principal investigators of new technologies with specific site data, samples, and/or other needs to support the development and/or demonstration of their technology.

3.10.1 Miscellaneous Support to Technology Demonstrations

Miscellaneous support to technology demonstrations includes the dissemination of existing site data on an as-needed basis, the collection of specific site data and/or samples, and acquisition or access to specialized equipment needed to support the technology demonstrations. The support needs identified to date include: collecting soil samples to support the bioremediation and supercritical fluid extraction/optical detection (SFE/OD) technology demonstrations; providing access to a number of isolated screened intervals to support sensor technology demonstrations; and collecting analytical data on the concentration of co-contaminants (principally the phosphonates and phosphates) which may affect sensor performance. Other support needs are expected to arise as the technology demonstrations mature.

The sample needs identified to date include: three aseptic soil cores of the aquifer material and three of the early "Palouse" soil horizon to support bioremediation technology demonstrations; small (50-g) samples of all nonradiologically contaminated horizons and up to three bulk (5-gal) samples to support the SFE/OD technology demonstrations. The tasks that will directly address these needs include the drilling and sampling of new wells (and installation of multiple-screens in the unsaturated zone wells) and the chemical analysis of soil gas samples from these wells.

3.10.2 Support to Characterization and Monitoring Technology Demonstrations

Data collected from the field investigation tasks will be used for comparison to data collected during the demonstration of new site characterization and monitoring technologies. Efforts will be made to provide opportunities for demonstration of new technologies during the characterization activities to allow evaluation of the new technologies relative to speed, reliability, accuracy, and economy. In addition, the data will provide a useful means of evaluating changes in the contaminant distributions induced by the ERA, remedial technology demonstrations, and other natural and/or human-induced stresses to the subsurface environment.

This task also includes support of the site characterization technical support group, identification of site characterization and monitoring technology needs, and review of the principal investigator technology test plans and evaluation reports. Included in this subtask is travel and preparation of presentations essential for attracting innovative technologies and external peer review of the technology demonstrations.

4.0 REPORTING/DELIVERABLES

The results from the FY 92 site evaluations will be compiled and integrated with existing data and with data collected in support other Hanford Site programs. These data and the resulting interpretations will be displayed in cross sections, maps, and tables that illustrate the nature and distribution of contaminants, the site characteristics (geology, hydrology, geochemistry), and the behavior of carbon tetrachloride and other contaminants in the system. A final report on the results of the FY 92 site evaluation will be submitted at the end of January 1993. A technical journal article will be prepared on the FY 92 results and submitted for external peer review by April 1993.

A similar report will be prepared for the work completed during FY 93. A draft report, presenting the status of the FY 93 activities and the resulting data, will be submitted at the end of September 1993. The final report, including data evaluations, will be submitted at the end of January 1994.

5.0 SCHEDULE

The tentative schedule for completing the FY 93 site evaluation activities is presented in Figure 8.

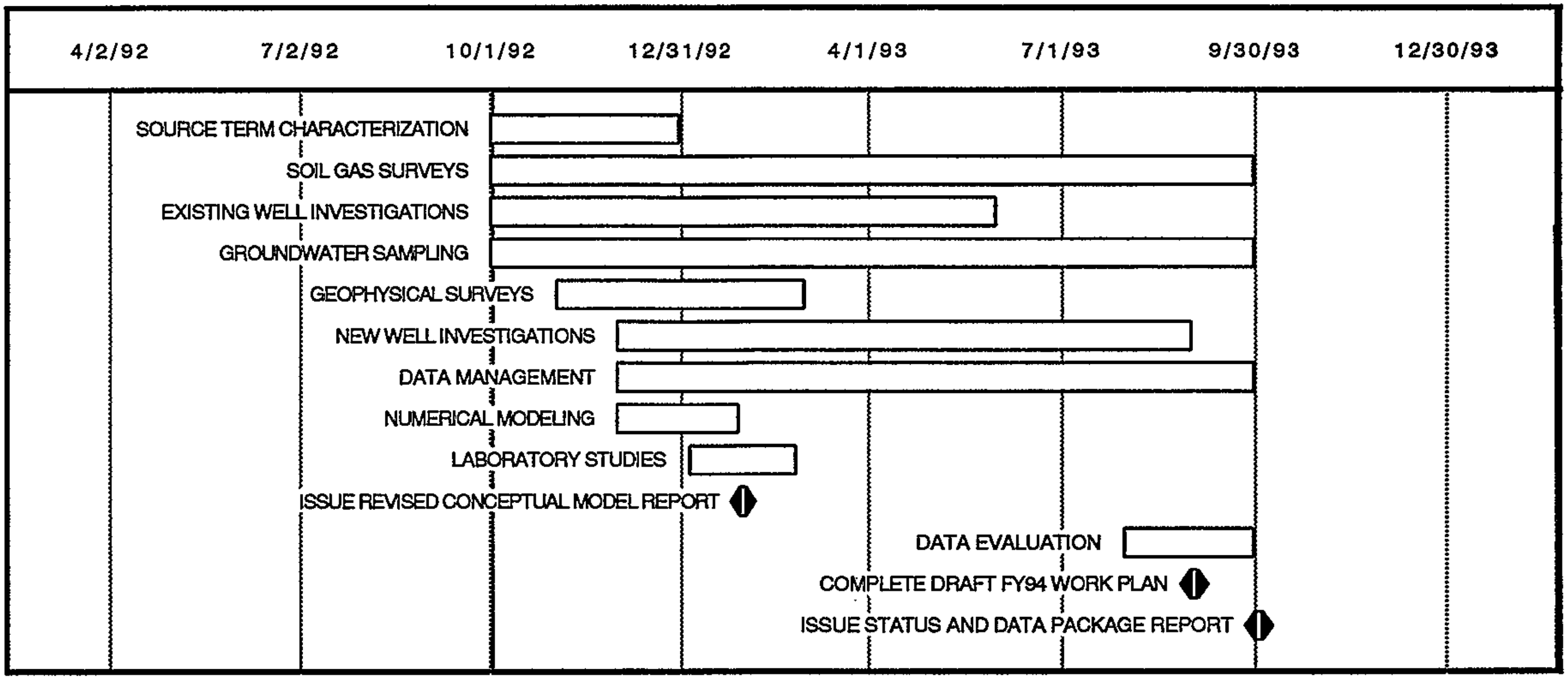

Figure 8. Tentative Schedule for FY 92 Site Characterization.

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APPENDIX A

VOLATILE ORGANIC COMPOUNDS-ARID INTEGRATED DEMONSTRATION (VOC-ARID ID) AND 200 WEST AREA CARBON TETRACHLORIDE EXPEDITED RESPONSE ACTION (ERA) SAMPLING AND ANALYSIS PLAN

PART 1 - QUALITY ASSURANCE PROJECT PLAN

PART 2 - FIELD SAMPLING PLAN

The purpose of this sampling and analysis plan (SAP) is to detail the quality assurance (QA) and quality control (QC) procedures used to ensure that technical data generated during the Volatile Organic Compounds-Arid Integrated Demonstration and 200 West Area Carbon Tetrachloride Expedited Response Action are accurate, precise, complete, and representative of actual field conditions. This SAP is organized to detail the analytical laboratory procedures in the QA project plan and to detail the sampling, field measurement, and sample handling procedures in the field sampling plan.

QA is defined as an integrated program designed for assuring reliability of monitoring and measurement data. QC is defined as the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process. All environmental monitoring and laboratory analyses conducted for this project must be performed in accordance with this plan.

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PART 1

QUALITY ASSURANCE PROJECT PLAN

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1.0 PROJECT DESCRIPTION

1.1 OBJECTIVE

The primary objective of the Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID) is to demonstrate new technologies for the characterization, remediation, and monitoring of the 200 West Area carbon tetrachloride contamination. The primary objective of the 200 West Area expedited response action (ERA) is to remove carbon tetrachloride from the unsaturated soils in the 200 West Area. The VOC-Arid ID and ERA site characterization programs have been merged to maximize efficient use of time and resources and to ensure that each activity and the resulting products achieve the maximum usefulness to both programs. The focus of the FY 93 VOC-Arid ID/ERA site characterization effort will be on further refining the conceptual model and on providing baseline data to support the technology demonstrations. Specific project objectives for the field investigation tasks of the FY 93 site evaluation are outlined in Section 3.1 of this work plan.

1.2 BACKGROUND

The VOC-Arid ID/ERA site is located in the south-central part the Hanford Site's 200 West Area (Figures 1, 2, and 3 of this work plan). The descriptions of the location and physical characteristics of the demonstration site, nature and extent of contamination, and detailed background information regarding the history of this site is in Section 2.0 of this work plan.

1.3 APPLICABILITY

This QA project plan applies specifically to the FY 93 site characterization field activities and laboratory analyses performed as part of environmental investigations for the VOC-Arid-ID/ERA. It is an element of the SAP prepared specifically for this phase of investigation. All plans and procedures referenced herein are available for review on request at the direction of the project manager.

QA and QC procedures are used to ensure that technical data generated during the VOC-Arid ID and ERA are accurate, precise, complete, and representative of actual field conditions. All field monitoring, screening, and sampling is defined by data quality objectives (DQO) (Section 3.3) as being Level I, II, or III. Laboratory analyses may be Level I, II, III, or IV. QA/QC for these activities will consist of technically sound procedures with associated instrument calibration and maintenance, and field and laboratory documentation.

1.4 SPECIFIC OJBECTIVES

Specific objectives for field investigation tasks are given in Table 1-1.

Table 1-1. Field Investigation Task Objectives.

Field Task	Objective
Source Term Characterization	Identify all sources of carbon tetrachloride observed in the subsurface.
Conduct Soil Gas Surveys vicinity of and	Map the lateral and vertical distribution of carbon tetrachloride vapor and other selected VOC in the away from the three disposal sites.
Conduct Geophysical Surveys	Define the three-dimensional configuration of major mappable hydrofacies and/or contaminant plumes in the vicinity of the three principal carbon tetrachloride disposal sites.
Existing Well Investigations	Continue assessments of the old wells as contaminant transport pathways; remove any known pathways; and evaluate the lithology and/or contamination penetrated by the boreholes.
New Well Investigations	Obtain data on the nature, distribution, transport pathways, and behavior of contaminants (e.g., phase partitioning, sorption parameters): (1) below each disposal facility, down to the Plio-Pleistocene unit; and (2) adjacent to the disposal facility and fully penetrating the unconfined aquifer.

A field sampling matrix relating these field investigation tasks with subtasks, investigation methods, and estimated numbers of samples is shown in Table 3-2.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Overall responsibility of site characterization activities for the VOC-Arid ID/ERA will be maintained by the Westinghouse Hanford Company (WHC) project manager. The WHC field team leader will be responsible for coordinating onsite drilling activities with Kaiser Engineers-Hanford (KEH) drilling personnel. WHC personnel will be responsible for site geologist support. Pacific Northwest Laboratory (PNL) personnel will be responsible for performing and coordinating environmental sampling, volatile organics analyses, and special sampling for principal investigators; coordinating the chemical and radiological analyses by DataChem Laboratories and IT Analytical Services; and the reporting of analytical results.

Table 3-1. Field Investigation Tasks and Analytical Levels (Sheet 1 of 5).

Controlling Task	Subtasks	Primary Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level	Potential Additional/Confirmatory Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level
Source Term Characterization *Identify all sources of CCl4 contamination observed in the subsurface*	Evaluation of Effluent Pipelines	Forward-looking color camera	Visual analysis of recorded image	5	I	Surface/Vegetation		5	I, II
						Soil gas sampling	GC, Field Screening	20	I, II
						Cone penetrometer	GC, Field Screening	5	I, II
						Soil sampling (borings)	GC, Field Screening	1	I, II
	Investigate Source of Secondary Ground Water Maximum	Survey of existing documents	Paper search	N/A	I	Vegetation sampling		5	I, II
		Comparison of ground water chemistry along principal flow path of CCl4 plume	Ground water monitoring	N/A	I	Soil gas surveys	GC, Field Screening	20	I, II
						Sample existing wells - soil gas and ground water	GC, Field Screening	10	I, II
		Evaluate CCl4 degradation rates and ground water travel times	Ground water monitoring	N/A	I	Cone penetrometer	GC, Field Screening	5	I, II
						Install new wells		1	N/A
	Assessment of Artificial Recharge	Compile/evaluate data on discharge volumes/rates, and locations of effluents within 1 km of primary CCl4 disposal sites	Compilation/evaluation of existing documents	N/A	I				
			Personal interviews	N/A	I				
Conduct Soil Gas Surveys *Map lateral and vertical distribution of CCl4 and other VOC in the vicinity and away from the three disposal sites*	Map Lateral Distribution of VOC	Soil gas survey of new and existing soil gas points	GC, OVM, Odyssey	366	I, II	Ion-trap			I, II
		Survey of oxygen and carbon dioxide levels	Field instrumentation	122	I, II	Continuous monitoring of selected ports	Odyssey	5	I, II
	Estimate VOC Vapor Flux From Ambient Soil Surface	Passive soil gas survey technologies	EMFLUX, PETREX	50	I, II				
	Map Vertical Distribution of VOC	Soil gas survey of existing wells - existing and new perforated intervals	GC, OVM	30	I, II	Cone penetrometer vertical profile sampling	GC, OVM	20	I, II

Table 3-1. Field Investigation Tasks and Analytical Levels (Sheet 2 of 5).

Controlling Task	Subtasks	Primary Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level	Potential Additional/Confirmatory Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level
Geophysical Surveys		Surface geophysical techniques	Seismic Reflection/ Refraction	4	I, II				
Define the 3-D configuration of major mappable hydrofacies and/or contaminant plumes in the vicinity of the three principal CCl4 disposal sites			Electromagnetic Induction (FDEM, TDEM)	2	I, II				
			Resistivity (DC, SIP)	2	I, II				
			Ground Penetrating Radar	1	I, II				
Existing Well Investigations	Borehole Geophysical Logging	Borehole geophysical logging of selected wells within a 100-m radius around the three CCl4 disposal sites	Gross Gamma/ Spectral Gamma	19	I, II	Neutron/Epithermal Neutron	Detection of perched water	6	I, II
Continue assessments of old wells as contaminant pathways; remove any known pathways; evaluate the lithology and/or contamination penetrated by the boreholes						Neutron Thermal Lifetime	Detection of chlorine	5	I, II
						Downhole camera surveys	Visual	15	I, II
						Caliper, Corrosion logs	Visual	15	I, II
						Magnetic Tool	Visual	15	I, II
	Wellhead Vapor Emissions	Personal interviews - historical use of various well cap designs	Compilation/Evaluation	N/A	I				
		Measurement of well head concentrations and fluxes of VOC vapor at selected wells	Field screening PID, GC	120	I				
	Well Remediation	Remediation or modification of ground water wells in proximity to the 216-Z-9 Trench		N/A	N/A	Vapor extraction	Compilation/Evaluation	N/A	I
						Ground water monitoring		N/A	I
		Survey of wells using both Lambert metric and Hanford plant coordinates		30	I	Physical/Document Review	Compilation/Evaluation	N/A	I

Table 3-1. Field Investigation Tasks and Analytical Levels (Sheet 3 of 5).

Controlling Task	Subtasks	Primary Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level	Potential Additional/Confirmatory Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level
Existing Well Investigations (continued)	Water Level Measurements	Water level measurements taken once per quarter in all available ground water wells within a 1-km radius around the three primary disposal sites	Steel Tape, Transducer	80	I	Groundwater potential maps, flow nets constructed		N/A	I
	Evaluation of Archived Borehole Samples	Relog samples from critically located wells using a regimented protocol	Visual	800	I				
		FY92 samples to be sieved and analyzed for clay content	ASTM Procedure	200	I, II, III				
New Well Investigations *Obtain data on the nature, distribution, transport pathways, and behavior of contaminants immediately below each disposal facility and fully penetrating the uppermost aquifer*	New Crib Wells *Deepen 2 Existing Wells: 299-W18-174 (216-Z-1A Tile Field) and 299-W18-96 (216-Z-18 Crib)* *Drill 1 new inclined well under the 216--Z-9 Trench*	Wellhead vapor monitoring	GC, colorimetric tube, radionuclide detectors	54	I, II	Soil gas sampling	Tests of other soil gas sampling devices	23	I
		Soil gas sampling	GC, colorimetric tube, SEAMIST, Borehole Sampler	23	I, II	Air Permeability	SEAMIST	23	I, II
		Geophysical logging	Gross Gamma/ Spectral Gamma	9	I, II	Other logging tools			
		Core and borehole cuttings	Grain Size, $CaCO_3$, pH, moisture, lithology, radioactivity, VOCs, particle size (hydrometer)	54	I, II, III				
		Split-barrel soil sampling	water retention, unsat. hydraulic conduct., bulk density, porosity, air permeability, mineralogy - and -	23	I, II, III				
			Thin sections: lithology, mineralogy, pore size distribution - and -	3	I, II				
			Cation exchange cap., total organic carbon, surface area, Pore water chemistry, sorption studies, isotope analysis	3	I, II, III				

Table 3-1. Field Investigation Tasks and Analytical Levels (Sheet 4 of 5).

Controlling Task	Subtasks	Primary Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level	Potential Additional/Confirmatory Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level
New Well Investigations (continued)	New Crib Wells (continued)	Split-barrel sampling (cont.)	VOAs, SVOCs, metals, ions, radionuclides	54	I, II, III V				
		Aseptic split-barrel sampling	Microbiology analysis	2	I, II, III				
	Install Deep Ground Water Well	Wellhead vapor monitoring	GC, colorimetric tube, radionuclide detectors	105	I, II	Deepen or clean out existing wells	Ground water monitoring	17	I, II
	Obtain data on the nature and distribution of contaminants in the aquifer in the vicinity of the disposal facilities, and obtain data on the lithology, geochemistry, hydrology, and microbiology of the aquifer materials	Soil gas sampling	MS, GC, colorimetric tube, SEAMIST, Borehole Sampler	17	I, II				
			Oxygen, carbon dioxide	17	I, II				
		Geophysical logging	Gross / Spectral Gamma	3	I, II	Other logging tools			
		Core and borehole cuttings	Grain Size, CaCO3, pH, moisture, lithology, radioactivity, VOCs, particle size (hydrometer)	105	I, II, III				
		Split-barrel soil samples	moisture content, water retention, unsat. hydraulic conduct., bulk density, porosity, air permeability, mineralogy	40	I, II, III				
			- and - Thin sections: lithology, mineralogy, pore size distribution	3	I, II				
			- and - Cation exchange cap., total carbon, surface area, Pore water chemistry, sorption studies, isotope analysis	6	I, II, III				
			VOCs, SVOCs, metals, ions, radionuclides	33	I, II, III V				
			sat. hydr. con., pore water chem, mineralogy	18	I, II, III				
		Aseptic split-barrel sampling	Microbiology analysis	4	I, II, III				

Table 3-1. Field Investigation Tasks and Analytical Levels (Sheet 5 of 5).

Contolling Task	Subtasks	Primary Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level	Potential Additional/Confirmatory Method(s) of Investigation	Sample Method(s) and/or Analyses	Est. No. of Samples	Analytical Level
New Well Investigations (continued)	Install Deep Ground Water Well (continued)	Groundwater sampling	pH, TOC, TOX, specific conductance, VOGC, SVOCs, metals, anions, ions, radionuclides	18	I, II, III				
Ground Water Sampling *Monitor concentrations of VOCs in ground water from wells in and around the three disposal sites and at the perimeter of the ground water plume* *Investigate the vertical distribution of VOCs within the aquifer*		Ground water sampling of 17 wells in November 1992 and in May 1993	GC, portable field screening equipment, MS	17	I, II	Groundwater Sampling	Permeation sampler		I, II

VOC - volatile organic compound
VOGC - volatile organic gas chromatograph
SVOC - semi-volatile organic compound
TOX - total organic halogens
TOC - total organic carbon
PID - photoionization detector
GC - gas chromatograph
OVM - organic vapor monitor

3.0 QA OBJECTIVES FOR MEASUREMENT

Samples must be collected and analyzed in a manner that will allow valid conclusions to be drawn from the resulting data. The overall VOC-Arid ID/ERA site characterization QA objectives are to develop and implement procedures for obtaining and evaluating data in an accurate, precise, and complete manner so that measurement data, sampling procedures, and field measurements provide information that is comparable and representative of actual field conditions.

The precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are indicators of data quality. Explanations of PARCC parameters are as follows (from EPA 1987):

<u>Precision</u>

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value. Precision is usually stated in terms of standard deviation, but other estimates such as the coefficient of variation (relative standard deviation), range (maximum value minus minimum value), and relative range are common.

The overall precision of measurement data is a mixture of sampling and analytical factors. Analytical precision is much easier to control and quantify than sampling precision. There are more historical data related to individual method performance and the "universe" is limited to the samples received in the laboratory. In contrast, sampling precision is unique to each site.

<u>Accuracy</u>

Accuracy measures the bias in a measurement system; it is difficult to measure for the entire data collection activity. Sources of error are:

- sampling process
- field contamination
- preservation
- handling
- sample matrix
- sample preparation
- analysis techniques.

Sampling accuracy may be assessed by evaluating the results of field/trip blanks. Analytical accuracy may be assessed through the use of known and unknown QC samples and matrix spikes.

<u>Representativeness</u>

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is most concerned with the proper design of the sampling program. The representativeness criterion is best satisfied by making certain that sampling locations are selected properly and a sufficient number of samples are collected.

Representativeness is addressed by describing sampling techniques and the rationale used to select sampling locations. Sampling locations can be biased (based on existing data, instrument surveys, observations, etc.) or unbiased (completely random or stratified-random approaches). Either way, the rationale used to determine sampling locations must be explicitly explained. If a sampling grid is being used, it should be shown on a map of the site. Type of sample, such as a grab or composite sample, as well as the relevant standard operating procedure for the sample collection, should be specified.

<u>Completeness</u> Completeness is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is essentially the same for all data uses: that a sufficient amount of valid data be generated. It is important that critical samples are identified and plans made to achieve valid data for them.

<u>Comparability</u> Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units. Comparability is limited to the other PARCC parameters because only when precision and accuracy are known can data sets be compared with confidence.

WHC and PNL project managers will be responsible for ensuring PARCC requirements are met. This will be accomplished by reviewing the records of field sampling, monitoring, and laboratory activities.

The data quality needs, which are the data quality levels required to meet the VOC-Arid ID/ERA objectives, are based on criteria provided in <u>Data Quality Objectives for Remedial Response Activities: Volume 1, Development Process</u> (EPA 1987). These data quality needs are explained in Section 3.3 and listed in Table 3 of this work plan. Table 3-1 is a list of analytical levels and expanded definitions (adapted from EPA 1987).

Table 3-1. EPA Analytical Levels.

Level I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but results are available in real time. It is the least costly of the analytical options.

Level II — Field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a mobile laboratory onsite. There is a wide range in the quality of data that can be generated. Quality depends on the use of suitable calibration standards, reference materials, and sample preparation equipment; and the training of the operator. Results are available in real time or several hours.

Level III — All analyses performed in an offsite analytical laboratory. Level III analyses usually use EPA (1986) analytical methods, but may also elect to use Contract Laboratory Program (CLP) procedures. Level III analyses do not usually utilize the validation or documentation procedures required of CLP Level IV analysis. The laboratory may or may not be a CLP laboratory.

Level IV — CLP Routine Analytical Services (RAS). All analyses are performed in an offsite CLP-qualified analytical laboratory following CLP protocols. Level IV analyses are characterized by rigorous QA/QC protocols and prescribed documentation.

Level V — Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory which may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP Special Analytical Services (SAS) are Level V.

Field screening of most sediment and soil gas samples will be analyzed at EPA Level II (EPA 1987) using a portable gas chromatograph or other field screening equipment to determine if more precise sampling and analysis is necessary. Field screening with a calibrated instrument is adequate for determining concentrations of 1 ppm or more, and the results may be obtained in real time. Accuracy, precision, and detection limits of the instrument will be determined during field calibration and documented. Laboratory screening will be technically correct using a calibrated instrument and documented. Table 3-2 is a matrix of field investigations with associated analytical levels.

4.0 SAMPLING PROCEDURES

The procedures that will be used to support the field sampling plan have been selected from the *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan* (WHC 1990) and *Procedures for Ground-Water Investigations* (PNL 1989). Selected procedures include environmental investigation instructions (EII) from the *Environmental Investigations and Site Characterization Manual* (WHC 1988a), and quality requirements (QR) and quality instructions (QI) from *Quality Assurance Manual* (WHC 1988b).

The tasks of the FY 93 site evaluation are discussed in Section 3.6 of this work plan,. EII will govern these tasks as applicable. Tasks performed by subcontractors or participant contractors will comply with applicable portions of the EII (WHC 1988a) and/or with WHC-approved subcontractor or participant contractor procedures.

Procedural approval, revision, and distribution control requirements applicable to EII are addressed in EII 1.2, Preparation and Revision of Environmental Investigations Instructions. Deviations from established EII required in response to unforeseen field situations may be authorized in compliance with EII 1.4, Deviation from Environmental Investigations Instructions. Unplanned deviations from procedures may be documented in, for example, field logbooks.

Sampling locations, frequencies, and analyses for new well investigations are described in the field sampling plan (FSP).

Borehole sampling for lithologic, physical, geochemical, microbial, volatile organics, chemical, radionuclide, and soil gas analyses will be performed as defined in the FSP. Sample numbers, types, locations, and other site-specific considerations will also be defined in the FSP.

5.0 SAMPLE CUSTODY

Sample custody will be maintained using chain-of-custody forms if sample analysis does not immediately follow sample collection. Results of analyses will be traceable to original samples through the unique code or identifier assigned to the sample in the field and recorded on the chain-of-custody form and/or sampling form.

6.0 CALIBRATION PROCEDURES

Calibration of measuring equipment will be done according to manufacturer's manuals governing its use. Calibration of WHC, participant contractor, or subcontractor analytical equipment shall be as defined by applicable standard analytical methods.

7.0 ANALYTICAL PROCEDURES

Methods of investigation are identified in Table 3-2. Analytical procedures for these methods will be selected or developed prior to use, and will be in compliance with WHC or PNL procedures and/or procurement control requirements where applicable. EPA Level III and V analyses will be performed by qualified WHC and PNL employees or CLP laboratories.

All analytical procedures approved for use in VOC-Arid ID/ERA investigations will require the use of standard reporting techniques and units consistent with EPA reference methods to facilitate the comparability of data sets in terms of precision and accuracy. Analytical procedures and reporting units for different sample types are given in Table 7-1.

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Table 7-1. Sampling, Analysis, and Reporting Summary.

SOIL Sample Type	Sampling Procedure	Container	Quantity	Preservation	Holding time	Analytical Level	Prep Method/ Analytical Procedure	Detection Level	Reporting Units
VOA	FSP Sec. 5.4	40 ml amber glass w/ teflon septum	5-10 gm	Methanol Refrigeration	14 days	III	PNL: VOA-3	PID: 10 ppb ELCD: 40 ppb	ppb
ICP Metals	FSP Sec. 5.4	250 ml glass jar	5 gm	Refrigeration	6 months	III	3010/ 6010 (1)	300-30000 (2)	µg/kg
Pb	FSP Sec. 5.4	250 ml glass jar	5 gm	Refrigeration	6 months	III	7421 (1)	500 µg/kg	µg/kg
Hg	FSP Sec. 5.4	250 ml glass jar	5 gm	Refrigeration	28 days	III	7471 (1)	400 µg/kg	µg/kg
Anions	FSP Sec. 5.4	250 ml glass jar	5 gm	Refrigeration	ASAP after collection	III	300.0, EPA-600/ 4-84-017	200-1000 (2)	µg/kg
Gross Alpha, Gross Beta	FSP Sec. 5.4	40 ml amber	(full jar)	none	15 business days	III	135/ 136	N/A	pci/g
Gamma Scan	FSP Sec. 5.4	250 ml glass jar	(full jar)	none	20 business days	III	140	N/A	pci/g
Sr-90	FSP Sec. 5.4	100 ml platic jar	50 gm	none	30 business days	III	140	N/A	pci/g
Pu, Am	FSP Sec. 5.4	100 ml platic jar	100 gm	none	25 business days	III	140	N/A	pci/g
TOC	FSP Sec. 5.4	40 ml amber	20 gm	Refrigeration	28 days	III	9060 (1)	N/A	µg/kg
Cyanide	FSP Sec. 5.4	250 ml glass jar	30 gm	Refrigeration	14 days	III	9010 (1)	1000 µg/kg	µg/kg
SVOA (ABN)	FSP Sec. 5.4	250 ml glass jar	120 gm	Refrigeration	7 days	III	3540 or 3550/ 8270 (1)	660-66000 (2)	µg/kg
CaCO3 content	FSP Sec. 5.2	moisture tin		none	1 year	III	N/A	N/A	per cent
Moisture content	FSP Sec. 5.2	moisture tin		none	3 days	III	N/A	N/A	per cent
Particle Size Distribution	FSP Sec. 5.2	500 ml glass "mason" jar	1 kg (approximate)	none	1 year	III	N/A	N/A	per cent
Geochemical	FSP Sec. 5.6	5 gallon bucket	5 gallons	none	14 days	III	N/A	N/A	N/A
Physical Properties (unsat K, Pore water, moisture)	FSP Sec. 5.3	(2) 0.5' length sediment core	1' core	none	28 days	III	N/A	N/A	N/A
Microbiologic	FSP Sec. 5.7	2' (4"dia) sediment core	core	Argon atmosphere Refrigeration	ASAP after sampling	III	N/A	N/A	N/A
Soil Gas	FSP Sec. 5.9	750 ml glass bulb	750 ml	(Al foil wrap)	24 hours	III	N/A	N/A	ppb
GROUND WATER Sample Type	**Sampling Procedure**	**Container**	**Quantity**	**Preservation**	**Holding time**	**Analytical Level**	**Prep Method/ Analytical Procedure**	**Detection Level**	**Reporting Units**
ICP Metals	FSP Sec. 5.8	1000 ml poly	(full jar)	Nitric Acid with pH<2	6 months	III	3010/ 6010	3-300 (2)	µg/L
Ions	FSP Sec. 5.8	125 ml poly	(full jar)	none	Per procedure	III	300.0, EPA-600/4-84-017	100-500 (2)	µg/L
SVOA (ABN)	FSP Sec. 5.8	2000 ml glass amber	(full jar)	none	7 days	III	3510 or 3520/ 625 (1)	10-1000 (2)	µg/L
Gross Alpha, Gross Beta	FSP Sec. 5.8	1000 ml poly	(full jar)	Nitric Acid with pH<2	15 business days	III	135/ 136	N/A	pci/g
Gamma Scan	FSP Sec. 5.8	1000 ml poly	(full jar)	Nitric Acid with pH<2	20 buisiness days	III	140	N/A	pci/g
VOGC	FSP Sec. 5.8	40 ml amber glass w/ teflon septum	40 ml	Methanol Refrigeration	14 days	III	PNL: VOA-3	PID: 10 ppb ELCD: 40 ppb	ppb

(1) SW 846, EPA, 1987. (2) Depends on constituent.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

The task coordinator will be responsible for preparing a detailed data package that includes all information used to perform data validation. As a minimum, data packages for Level III and V analyses will include:

- Sample documentation, including identification of the organization and individuals performing the extraction and/or analysis; documentation of any sample custody; and the date/time of sample receipt, extraction, and analysis.
- Instrument calibration documentation, including equipment type and model, for the time period in which the sample analysis was performed.
- QC data for the methods used.
- Analytical results or data deliverables, including reduced data, reduction formulae or algorithms, and identification of data outliers or deficiencies.

The project managers/principal investigators will be responsible for preparing a report summarizing and interpreting the results of analyses.

9.0 INTERNAL QC

Internal QC methods will be used, and include:

- field duplicate samples
- field blanks
- equipment blanks
- trip blanks.

As feasible, duplicate samples will be analyzed by field- and laboratory-screening equipment.

10.0 PERFORMANCE AND SYSTEMS AUDITS

Audits in environmental investigations are considered to be systematic checks that verify the quality of operation of one or more elements of the total measurement system. Performance audit requirements will be met by the use of internal QC methods. Systems audits will be scheduled if requested by the project manager or the U.S. Department of Energy, Richland Field Office.

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field that directly affects the quality of the analytical data will be subject to preventive maintenance measurements that ensure minimization of measurement system downtime. Field equipment maintenance instructions will be as defined by the procedures governing their use.

12.0 DATA ASSESSMENT PROCEDURES

Measurement data will be assessed and documented for qualities such as precision and accuracy by the task coordinator responsible for that measurement. Any data evaluation will be documented in field and laboratory notebooks in which information related to the sampling activities is recorded.

13.0 CORRECTIVE ACTIONS

Corrective actions are procedures that might be implemented on samples that do not meet QA specifications. A corrective action request might be generated, for example, by an audit. Corrective actions may include resampling or reanalyzing samples, if feasible. The primary responsibility for corrective action resolution is assigned to the PNL project manager.

14.0 REFERENCES

EPA, 1986, *Test Methods for Evaluating Solid Waste - Physical/Chemical Methods*, 3rd Ed., SW-846, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA, 1987, *Data Quality Objectives for Remedial Response Activities: Volume 1, Development Process*, EPA/540/G-97-003, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

PNL, 1989, *Procedures for Ground-Water Investigations*, PNL-MA-567, Pacific Northwest Laboratory, Richland, Washington.

WHC, 1988a, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988b, *Quality Assurance Manual*, WHC-CM-4-2, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990, *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan*, WHC-EP-0383, Westinghouse Hanford Company, Richland, Washington.

PART 2

FIELD SAMPLING PLAN

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CONTENTS

FIGURES:

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1.0 SITE BACKGROUND

This field sampling plan addresses the new well investigations borehole drilling and sampling activities to be done as part of the Phase III Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID)/200 West Area Carbon Tetrachloride Expedited Response Action (ERA) site characterization. Background information on the site can be found in Section 2 of the work plan. Field sampling activities for other tasks outlined in Table QAPP 3-2 will be documented in the associated test plans, letters of instruction, etc., for those specific tasks.

2.0 SAMPLING OBJECTIVES

Field investigation tasks were described in Section 3.6 of the work plan. Details regarding the sample locations, frequencies, and analyses for each task are included in Section 3.6 or will be included in individual test plans, statements of work, letters of instruction, work orders, or internal memoranda.

Three unsaturated zone boreholes and one unconfined aquifer characterization borehole are planned to be drilled in FY 93. Two existing boreholes will be deepened, and one new angled crib well drilled to investigate contamination directly beneath the carbon tetrachloride disposal sites. One deep ground water well will be installed to investigate the vertical distribution of carbon tetrachloride in the unconfined aquifer in the vicinity of these carbon tetrachloride disposal facilities. These investigations are summarized in Table FSP 2-1.

Table FSP 2-1. New Well Investigations Summary.

<u>299-W18-96 (Deepen)</u>

<u>Location</u>	216-Z-18 Crib
<u>Depth</u>	41 m (to top of Plio-Pleistocene unit).
<u>Completion</u>	Crib unsaturated zone monitoring/vapor extraction well (Figure FSP 2-1).
<u>Potential Contamination</u>	<u>Unsaturated Zone</u>: Carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, dibutylbutyl phosphonate, plutonium, americium.
<u>Rationale</u>	Collect data on nature and distribution of carbon tetrachloride waste discharged to 216-Z-18 Crib. Collect site-specific hydrogeologic data (e.g., pore size distribution).

Sampling/ Testing

- Wellhead monitoring and drive-barrel sampling every (5 ft).
- Split-spoon sampling every 6 m and each 1.5 m from bottom of the Hanford formation through the early "Palouse" soil to top of the Plio-Pleistocene unit.
- Lithologic, moisture, calcium carbonate ($CaCO_3$), VOC, and semivolatile compound (SVOC) analyses every 1.5 m from drive-barrel and/or split-spoon samples.
- Physical properties, chemical, and radiological analyses from all split-spoon sample intervals and at significant lithologic and/or contaminant concentration changes (i.e., lithologic contacts, changes of one order of magnitude in concentration).
- Microbiological sampling from early "Palouse" soil.
- Associated geophysical logging, soil-gas sampling, geochemical, and geotechnical testing as required.

299-W18-174 (Deepen)

Location: 216-Z-1A Tile Field

Depth: 41 m (to top of Plio-Pleistocene unit).

Completion: Crib unsaturated zone monitoring/vapor extraction well (Figure FSP 2-1).

Potential Contamination: Unsaturated Zone:

Carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, dibutylbutyl phosphonate, plutonium, americium.

Rationale: Collect data on nature and distribution of carbon tetrachloride directly beneath the 216-Z-1A Tile Field. Collect site-specific hydrogeologic data (e.g., pore size distribution). Provide data on the geometry of the Plio-Pleistocene unit.

Sampling/ Testing

- Wellhead monitoring and drive-barrel sampling every 1.5 m.
- Split-barrel sampling every 6 m and each 1.5 m from bottom of the Hanford formation through the early "Palouse" soil to top of the Plio-Pleistocene unit.
- Lithologic, moisture, $CaCO_3$, VOC, and SVOC analyses every 1.5 m from drive-barrel and/or split-spoon samples.
- Physical properties, chemical, and radiological analyses from all split-spoon sample intervals and at significant lithologic and/or contaminant concentration changes (i.e., lithologic contacts, changes of one order of magnitude in concentration).
- Microbiological sampling from early "Palouse" soil.
- Associated geophysical logging, soil-gas sampling, geochemical, and geotechnical testing as required.

New Angled Crib Well at 216-Z-9 Trench

Location	216-Z-9 Trench; new borehole located near NE corner proceeding at 45-deg angle toward the SW corner.
Depth	35 m (to top of Plio-Pleistocene unit), total length equals 50 m.
Completion	Angled monitoring/vapor extraction well (Figure FSP 2-2).
Potential Contamination	Carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, dibutylbutyl phosphonate, plutonium, americium.
Rationale	Collect data on nature and distribution of carbon tetrachloride and co-contaminants discharged to 216-Z-9 Trench. Collect site-specific hydrogeologic data.
Sampling/ Testing	• Wellhead monitoring and drive-barrel sampling every 1.5 m. • Split-spoon sampling every 6 m and each 1.5 m from bottom of the Hanford formation through the early "Palouse" soil to top of the Plio-Pleistocene unit. • Lithologic, moisture, $CaCO_3$, VOC, and SVOC analyses every 1.5 m from drive-barrel and/or split-spoon samples. • Physical properties, chemical, and radiological analyses from all split-spoon sample intervals and at significant lithologic and/or contaminant concentration changes (i.e., lithologic contacts, changes of one order of magnitude in concentration). • Microbiological sampling from early "Palouse" soil. • Associated geophysical logging, soil-gas sampling, geochemical, and geotechnical testing as required.

New Deep Ground Water Well

Location	South of 216-Z-9 Trench, midway between wells 299-W15-8 and 299-W15-5
Depth	160 m (top of basalt).
Completion	Deep ground water monitoring well (Figure FSP 2-3).
Potential Contamination	Unsaturated Zone: Carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, plutonium, americium, cadmium. Perched Water (encountered in 299-W15-216): Same as unsaturated zone.

Saturated Zone:

Carbon tetrachloride, chloroform, cyanide, iodine-129, uranium, tetrachloroethylene, trichloroethylene.

Rationale

Characterize distribution of carbon tetrachloride within unsaturated zone and unconfined and semiconfined aquifers; investigate preferential pathway (formerly unsealed boreholes 299-W15-5, 299-W15-6, 299-W15-8).

Sampling/Testing

Unsaturated Zone:

- Wellhead monitoring and drive-barrel sampling every 1.5 m.
- Split-spoon sampling every 6 m and each 1.5 m from bottom of the Hanford formation through the early "Palouse" soil and Plio-Pleistocene unit to top of the Ringold Formation.
- Lithologic, moisture, $CaCO_3$, VOC, and SVOC analyses every 1.5 m from drive-barrel and/or split-spoon samples.
- Physical properties, chemical, and radiological analyses from all split-spoon sample intervals and at significant lithologic and/or contaminant concentration changes (i.e., lithologic contacts, changes of one order of magnitude in concentration).
- Microbiological sampling from early "Palouse" soil.
- Associated geophysical logging, soil-gas sampling, geochemical, and geotechnical testing as required.

Saturated Zone:

- Wellhead monitoring and drive-barrel sampling every 1.5 m.
- Ground water sampling every 6 m and at significant lithologic and/or contaminant concentration changes (i.e., lithologic contacts, changes of one order of magnitude in concentration).
- Split-spoon sampling every 15 m.
- Lithologic, moisture, and $CaCO_3$ analyses every 1.5 m from drive-barrel and/or split-spoon samples.
- VOC and SVOC analyses from ground water and split-spoon samples.
- Physical properties and chemical analyses from all split-spoon sample intervals.
- Associated geophysical logging, soil-gas sampling, geochemical, geotechnical, and aquifer testing as required.

A summary of the sampling plan (Table QAPP 3-2) has been compiled from the five field investigation tasks outlined in the work plan, Section 3.6. The plan is subject to field modification and revision during the course of the FY 93 investigations.

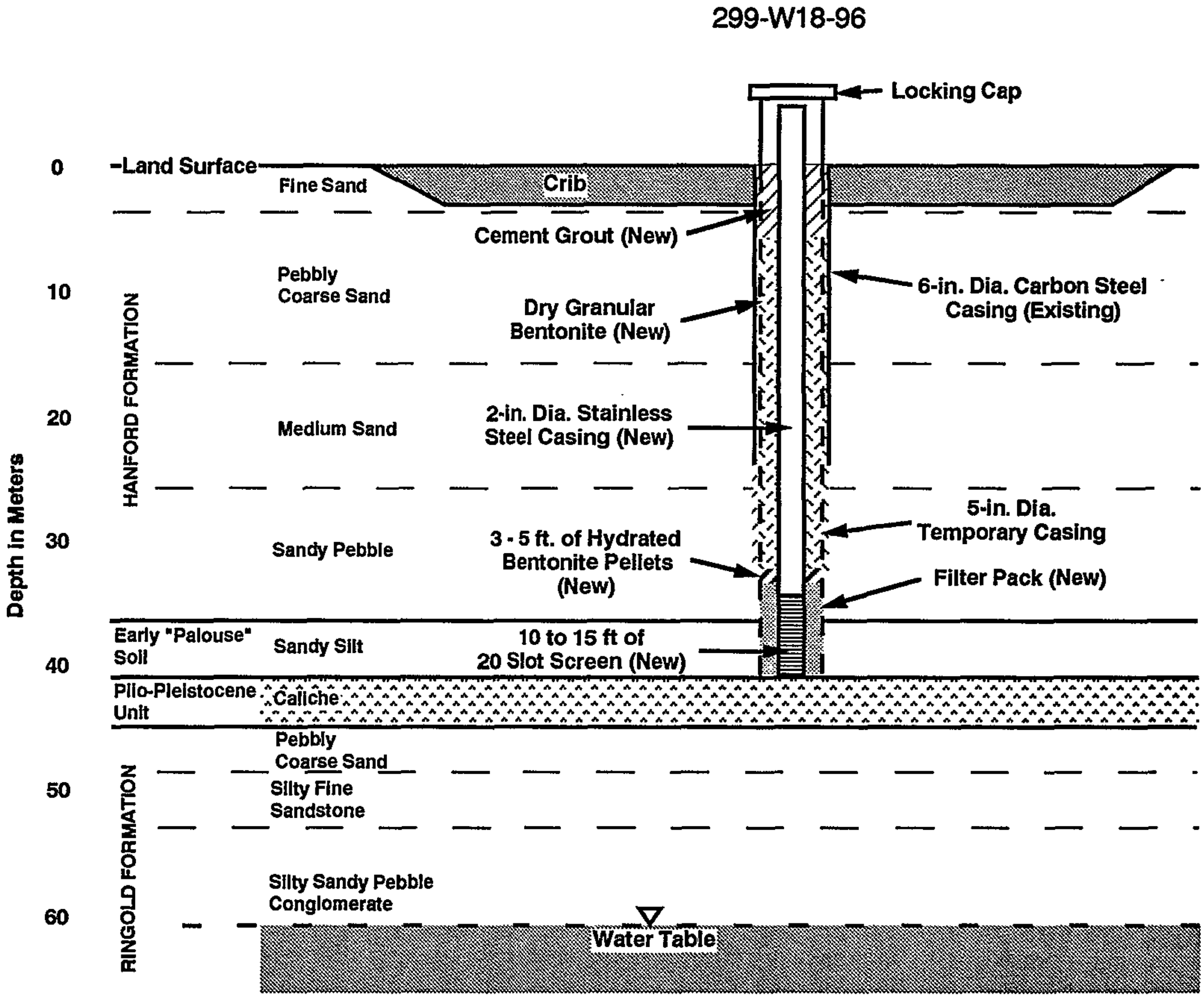


Figure FSP 2-1. Crib Unsaturated Zone Monitoring/Vapor Extraction Well Completion Diagram.

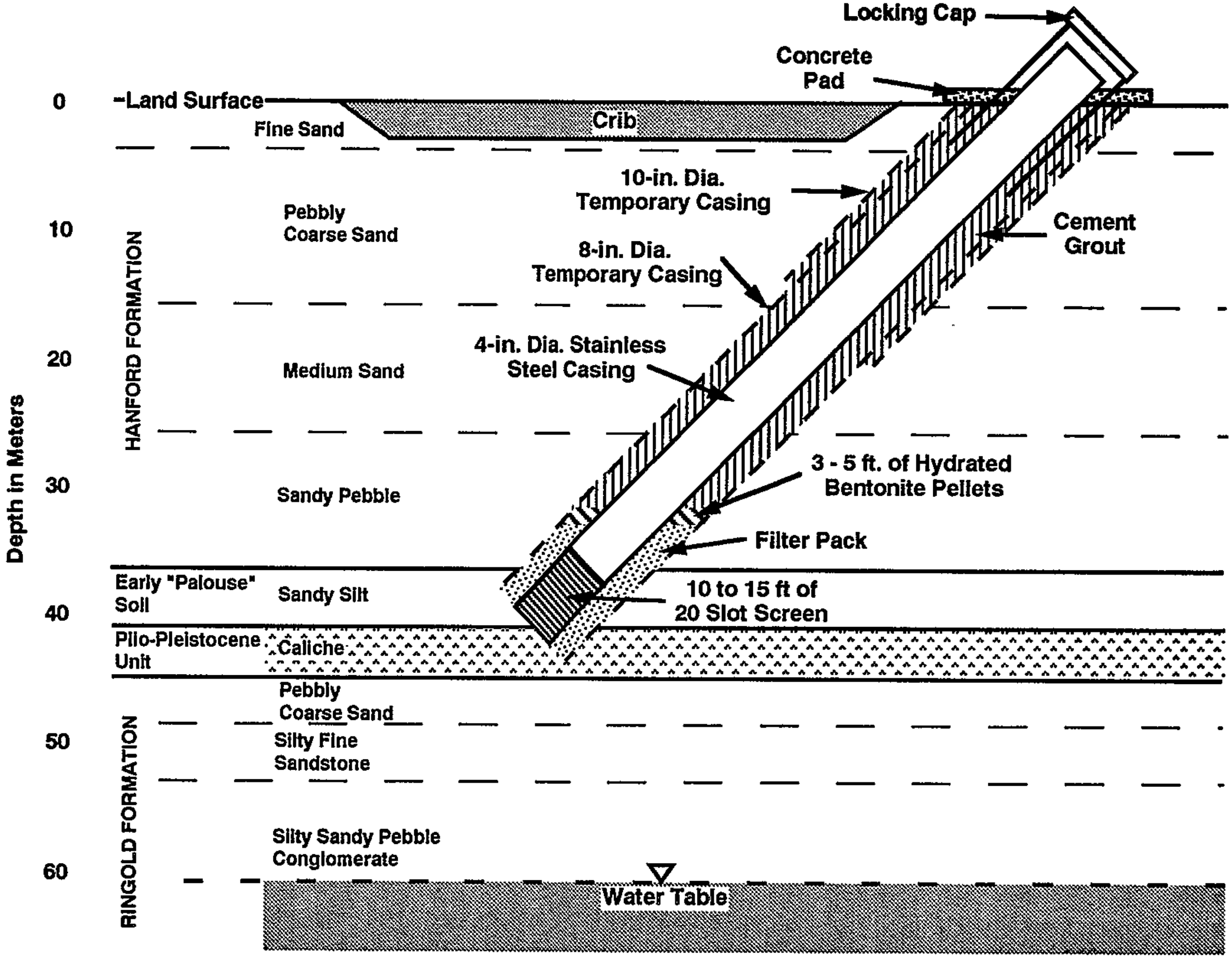
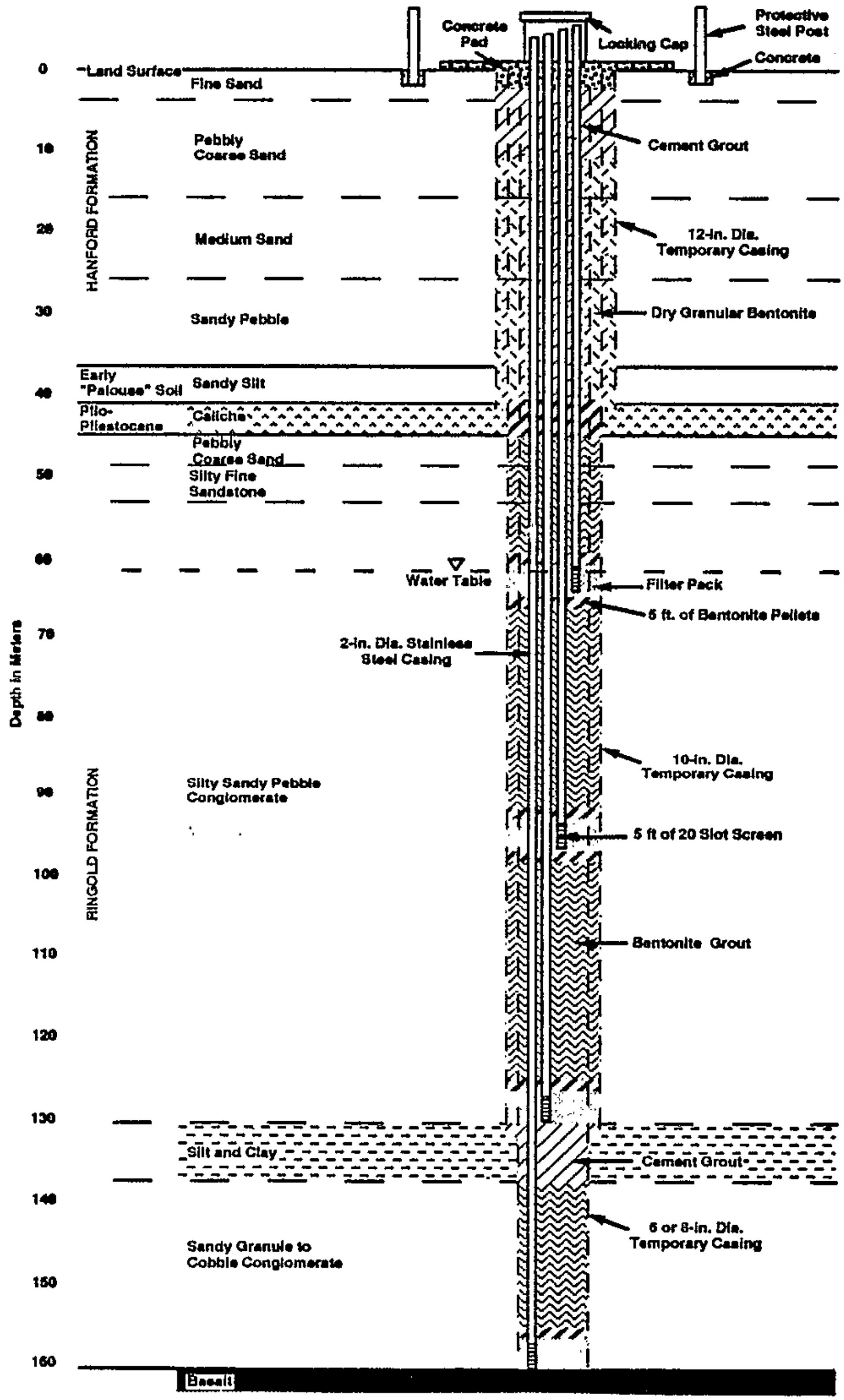


Figure FSP-2-2. Angled Monitoring/Vapor Extraction Well Completion Diagram.

Figure FSP 2-3. Deep Ground Water Monitoring Well Completion Diagram.



3.0 SAMPLE LOCATION AND FREQUENCY

Tables FSP 3-1, 3-2, 3-3, and 3-4 show borehole sampling depths and frequencies for the four boreholes.

4.0 SAMPLE DESIGNATION

Each sample will be assigned a unique Hanford Environmental Information System (HEIS) sample number by the site geologist. Subsamples to be analyzed for chemicals and radionuclides will keep the sample number of the original sample. All ground water samples from the same sampling location will have the same HEIS number. The HEIS numbers will be used on all documentation of the samples.

5.0 SAMPLING PROCEDURES

Sediment samples will be taken for analyses to characterize the host material and contaminants. Analyses may include:

- determination of chemical constituent concentrations in the sediment matrix and sorbed to the sediment
- physical property analysis for properties governing hydrologic movement in sediment
- mineralogic analysis and lithologic description
- microbiologic analysis
- pore water analysis.

Ground water samples will be taken from the single deep ground water monitoring borehole. Ground water samples will be analyzed for ground water chemistry and radioactive, volatile, and semivolatile constituents.

Soil-gas sampling will be done at the ground surface and from the boreholes drilled. Sampling from the boreholes will be done by two different methods: using the SEAMIST (tradename of Science & Engineering Associates, Inc., Santa Fe, New Mexico) sampler and the borehole sampler.

Samples will be taken and handled according to the requirements defined for each specific sample. The general procedure governing sample handling, from extraction through analysis is similar in scope for all samples. Once samples are collected (according to the defined procedure), they will be screened for any radioactivity before further handling can proceed. While the radioactivity screening is being done, samples will be stored onsite according to the appropriate preservation technique. Once released by Radiation Safety, samples will be divided into specific containers for laboratory distribution and transported (under the appropriate preservation method) to either the Pacific Northwest Laboratory (PNL) sampling group for offsite distribution, or to the specific laboratory personnel responsible for analysis. Remaining sampled material will be disposed of at the collection site, or by the laboratory personnel according to laboratory procedures. Sample processing steps are shown in Figure FSP 5-1. All sample handling will be documented on chain-of-custody forms.

Table FSP 3-1. 299-W18-96 Sample Matrix.

		Analysis	Screening		Physical						Supercritical Fluid Extr.		Microbial	VOA				Chemical			Radionuclides						Soil Gas	
		Laboratory	WHC		WHC					WSU / PNL	PNL		PNL	PNL				Data Chem			ITAS						WHC	PNL
		Contact	V. Rohay		V. Rohay					Conca/Serne	J. Amonette		M. Truex	K. Olsen				J. Julya			J. Julya						V. Rohay	S. Luttrell
		Sample Type	Field		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field		Field		F	Lab		Field	Lab	Lab	Lab	Lab	Lab	Field	Field
		Analyses	Wellhead/ Cuttings	Rad Survey	Archive Lithologic	Moisture CaCO3	Part. Size Dist.	Porosity Bulk Density	Air Perm.	Unsat. K Sat. K Pore Water Chem	Mineralogy Cation Ex. Cap.		Micro-biology	VOA Drive Barrel		VOA Split Barrel		DB	SVOA (ABN) SB	Ions, ICP Pb, Hg Cyn, TOC	(a)	Gross Alpha Gross Beta	Gamma Scan	Sr 90	PUIS	Amer	SEAMIST	Bore Sampler
		Sample Method	A	B	C	C	C	D	D	D	C	C	B	F	G	F	G	F	D	D	D	D	D	D	D	D	H	I
Depth		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	9	9	9	9	10	10	11	6	12	13	14	14	14	1	1
Ft	M	Horizon																										
5	1.5	Existing Well																										
10	3.0	Existing Well																										
15	4.6	Existing Well																										
20	6.1	Existing Well																										
25	7.6	Existing Well																										
30	9.1	Existing Well																										
35	10.7	Existing Well																										
40	12.2	Existing Well																										
45	13.7	Existing Well																										
50	15.2	Existing Well																										
55	16.8	Existing Well																										
60	18.3	Existing Well																										
65	19.8	Existing Well																										
70	21.3	Existing Well																										
75	22.9	Existing Well																										
80	24.4	Hanford	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
85	25.9	Hanford	1	1	2	1	1								1			1			2	(2)	(2)	(2)	(2)	(2)		
90	27.4	Hanford	1	1	2	1	1							1	1			1			1	(1)	(1)	(1)	(1)	(1)		
95	29.0	Hanford	1	1	2	1	1								1			1										
100	30.5	Hanford	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
105	32.0	Hanford	1	1	2	1	1								1			1										
110	33.5	Hanford	1	1	2	1	1							1	1			1										
115	35.1	Hanford	1	1	2	1	1								1			1										
120	36.6	Hanford	1	1	2	1	1	1	1	1	1	1		1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
125	38.1	Early Palouse	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
130	39.6	Early Palouse	1	1	2	1	1							1	1	1	2	1	(2)	(2)	1	(1)	(1)	(1)	(1)	(1)	1	1
135	41.1	Plio-Pleis.	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
		Total Samples	12	12	24	12	12	5	5	5	2	2	1	8	12	6	7	12	(7)	(7)	9	(9)	(9)	(9)	(9)	(9)	6	6

Container Key

[1] No Container - value entry in borehole log
[2] Headspace container
[3] Plastic Bag
[4] Glass mason jar - clear
[5] Metal moisture tin
[6] Split-barrel core - 6 in. length, lexan liner
[7] 5 gallon plastic bucket
[8] Aseptically sampled split-barrel core - 2 ft. length, lexan liner
[9] 40 ml glass jar, amber w/septum, methanol preservative
[10] 125 ml glass jar - amber
[11] 250 ml (8 oz.) glass jar - clear
[12] 40 ml glass jar - amber
[13] 250 ml polypropolene jar - white
[14] 125 ml polypropolene jar - white

NOTE:
Bold numbers represent FIELD samples
Sample numbers in "()" represent LAB samples split up from field samples

Laboratory Key

Data Chem — Data Chem Laboratories - Richland, WA
ITAS — IT Analytical Services - Richland, WA
PNL — Pacific Northwest Laboratory - Richland, WA
WHC — Westinghouse Hanford Co. - Richland, WA
WSU — Washington State University - Richland, WA

No Trip Blanks for this well
Rad Duplicates @ 85 ft
VOA Duplicates @ 130 ft
Chem Duplicates @ 130 ft

Sample Method Key

A Photoionization Detector, Colorimetric Tube
B Alpha, Beta, Gamma Scanners
C Drive Barrel
D Split Barrel
E Aseptic Split Barrel
F Grab sample
G Core-Borer
H SEAMIST - Soil Gas Sampler
I Bore Sampler - Soil Gas Sampler

(a) Field sample is split into containers for lab analyses.

9 [illegible] 7

Table FSP 3-2. 299-W18-174 Sample Matrix.

Depth Ft	Depth M	Horizon	Screening		Physical						Superoritical Fluid Extr.		Microbial	VOA				Chemical			Radionuclides						Soil Gas	
		Laboratory	WHC		WHC					WSU / PNL	PNL		PNL	PNL				Data Chem			ITAS						WHC	PNL
		Contact	V. Rohay		V. Rohay					Conca/Serne	J. Amonette		M. Truex	K. Olsen				J. Julya			J. Julya						V. Rohay	S. Luttrell
		Sample Type	Field		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field		Field		F	Lab		Field	Lab	Lab	Lab	Lab	Lab	Field	Field
		Analyses	Wellhead/ Cuttings	Rad Survey	Archive Lithologic	Moisture CaCO3	Part. Size Dist.	Porosity Bulk Density	Air Perm.	Unsat. K Sat. K Pore Water Chem	Mineralogy Cation Ex. Cap.		Micro-biology	VOA Drive Barrel		VOA Split Barrel		SVOA (ABN) DB	SVOA (ABN) SB	Ions, ICP Pb, Hg Cyn, TOC	(a)	Gross Alpha Gross Beta	Gamma Scan	Sr 90	PUIS	Amer	SEAMIST	Bore Sampler
		Sample Method	A	B	C	C	C	D	D	D	C	C	E	F	G	F	G	F	D	D	D	D	D	D	D	D	H	I
		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	9	9	9	9	10	10	11	6	12	13	14	14	14	1	1
5	1.5	Existing Well																										
10	3.0	Existing Well																										
15	4.6	Existing Well																										
20	6.1	Existing Well																										
25	7.6	Existing Well																										
30	9.1	Existing Well																										
35	10.7	Existing Well																										
40	12.2	Existing Well																										
45	13.7	Existing Well																										
50	15.2	Hanford	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
55	16.8	Hanford	1	1	2	1	1								1			1			2	(2)	(2)	(2)	(2)	(2)		
60	18.3	Hanford	1	1	2	1	1							1	1			1			1	(1)	(1)	(1)	(1)	(1)		
65	19.8	Hanford	1	1	2	1	1								1			1										
70	21.3	Hanford	1	1	2	1	1	1	1	1				1	2	1	1	2	(1)	(2)	2	(2)	(2)	(2)	(2)	(2)	1	1
75	22.9	Hanford	1	1	2	1	1								1			1										
80	24.4	Hanford	1	1	2	1	1							1	1			1										
85	25.9	Hanford	1	1	2	1	1								1			1										
90	27.4	Hanford	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
95	29.0	Hanford	1	1	2	1	1								1			1										
100	30.5	Hanford	1	1	2	1	1							1	1			1										
105	32.0	Hanford	1	1	2	1	1								1			1										
110	33.5	Hanford	1	1	2	1	1	1	1	1	1	1		1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
115	35.1	Hanford	1	1	2	1	1								1			1										
120	36.6	Hanford	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
125	38.1	Early Palouse	1	1	2	1	1	1	1	1			1	1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
130	39.6	Early Palouse	1	1	2	1	1				1	1		1	1	1	2	1	(2)	(2)	1	(1)	(1)	(1)	(1)	(1)	1	1
135	41.1	Plio-Pleis.	1	1	2	1	1	1	1	1				1	1	1	1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
		Total Samples	18	18	36	18	18	7	7	7	2	2	1	11	19	8	9	19	(9)	(10)	12	(12)	(12)	(12)	(12)	(12)	8	8

Container Key

[1] No Container - value entry in borehole log
[2] Headspace container
[3] Plastic Bag
[4] Glass mason jar - clear
[5] Metal moisture tin
[6] Split-barrel core - 6 in. length, lexan liner
[7] 5 gallon plastic bucket
[8] Aseptically sampled split-barrel core - 2 ft. length, lexan liner
[9] 40 ml glass jar, amber w/septum, methanol preservative
[10] 125 ml glass jar - amber
[11] 250 ml (8 oz.) glass jar - clear
[12] 40 ml glass jar - amber
[13] 250 ml polypropolene jar - white
[14] 125 ml polypropolene jar - white

NOTE:
Bold numbers represent FIELD samples
Sample numbers in "( )" represent LAB samples split up from field samples

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WSU — Washington State University - Richland, WA

Rad Duplicates @ 55 ft
Trip Blanks @ 70 ft
VOA Duplicates @ 130 ft
Chem Duplicates @ 130 ft

Sample Method Key

A Photoionization Detector, Colorimetric Tube
B Alpha, Beta, Gamma Scanners
C Drive Barrel
D Split Barrel
E Aseptic Split Barrel
F Grab sample
G Core-Borer
H SEAMIST - Soil Gas Sampler
I Bore Sampler - Soil Gas Sampler

(a) Field sample is split into containers for lab analyses.

Table FSP 3-3. New Inclined Well Sample Matrix.

Depth Ft	Depth M																											
		Analysis	Screening		Physical						Supercritical Fluid Extr.		Microbial	VOA				Chemical			Radionuclides						Soil Gas	
		Laboratory	WHC		WHC					WSU / PNL	PNL		PNL	PNL				Data Chem			ITAS						WHC	PNL
		Contact	V. Rohay		V. Rohay					Conca/Serne	J. Amonette		M. Truex	K. Olsen				J. Julya			J. Julya						V. Rohay	S. Luttrell
		Sample Type	Field		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field		Field		F	Lab		Field	Lab	Lab	Lab	Lab	Lab	Field	Field
		Analyses	Wellhead/ Cuttings	Rad Survey	Archive Lithologic	Moisture CaCO3	Part. Size Dist.	Porosity Bulk Density	Air Perm.	Unsat. K Sat. K Pore Water Chem	Mineralogy Cation Ex. Cap.		Micro-biology	VOA Drive Barrel		VOA Split Barrel		SVOA (ABN) DB	SB	Ions, ICP Pb, Hg Cyn, TOC	(a)	Gross Alpha Gross Beta	Gamma Scan	Sr 90	PUIS	Amer	SEAMIST	Bore Sampler
		Sample Method	A	B	C	C	C	D	D	D	C	C	E	F	G	F	G	F	D	D	D	D	D	D	D	D	H	I
		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	9	9	9	9	10	10	11	6	12	13	14	14	14	1	1
Ft	M	Horizon																										
5	1.5	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
10	3.0	Hanford	1	1	2	1	1								1			1										
15	4.6	Hanford	1	1	2	1	1								1			1										
20	6.1	Hanford	1	1	2	1	1								1			1										
25	7.6	Hanford	1	1	2	1	1	1	1	1					1		2	1	(2)	(2)	2	(2)	(2)	(2)	(2)	(2)	1	1
30	9.1	Hanford	1	1	2	1	1								1			1										
35	10.7	Hanford	1	1	2	1	1								1			1										
40	12.2	Hanford	1	1	2	1	1								1			1										
45	13.7	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
50	15.2	Hanford	1	1	2	1	1								1			1										
55	16.8	Hanford	1	1	2	1	1								1			1										
60	18.3	Hanford	1	1	2	1	1								1			1										
65	19.8	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
70	21.3	Hanford	1	1	2	1	1								1			1										
75	22.9	Hanford	1	1	2	1	1								1			1										
80	24.4	Hanford	1	1	2	1	1								1			1										
85	25.9	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
90	27.4	Hanford	1	1	2	1	1								1			1										
95	29.0	Hanford	1	1	2	1	1								1			1										
100	30.5	Hanford	1	1	2	1	1								1			1										
105	32.0	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
110	33.5	Early Palouse	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
115	35.1	Early Palouse	1	1	2	1	1	1	1	1					1		2	1	(2)	(2)	1	(1)	(1)	(1)	(1)	(1)	1	1
120	36.6	Plio-Pleis.	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	1	1
125	38.1																											
130	39.6																											
135	41.1																											
		Total Samples	24	24	48	24	24	9	9	9	0	0	0	0	24	0	11	24	(11)	(11)	10	(10)	(10)	(10)	(10)	(10)	9	9

Container Key

[1] No Container - value entry in borehole log
[2] Headspace container
[3] Plastic Bag
[4] Glass mason jar - clear
[5] Metal moisture tin
[6] Split-barrel core - 6 in. length, lexan liner
[7] 5 gallon plastic bucket
[8] Aseptically sampled split-barrel core - 2 ft. length, lexan liner
[9] 40 ml glass jar, amber w/septum, methanol preservative
[10] 125 ml glass jar - amber
[11] 250 ml (8 oz.) glass jar - clear
[12] 40 ml glass jar - amber
[13] 250 ml polypropolene jar - white
[14] 125 ml polypropolene jar - white

NOTE:
Bold numbers represent FIELD samples
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PNL — Pacific Northwest Laboratory - Richland, WA
WHC — Westinghouse Hanford Co. - Richland, WA
WSU — Washington State University - Richland, WA

Trip Blanks @ 25 ft
No Rad Duplicates for this well
VOA Duplicates @ 115 ft
Chem Duplicates @ 115 ft

Sample Method Key

A Photoionization Detector, Colorimetric Tube
B Alpha, Beta, Gamma Scanners
C Drive Barrel
D Split Barrel
E Aseptic Split Barrel
F Grab sample
G Core-Borer
H SEAMIST - Soil Gas Sampler
I Bore Sampler - Soil Gas Sampler

(a) Field sample is split into containers for lab analyses.

Table FSP 3-4. New Deep Ground Water Monitoring Well Sample Matrix (sheet 1 of 3).

Depth Ft	Depth M	Analysis / Laboratory / Contact / Sample Type / Analyses	Screening, WHC, V. Rohay, Field: Wellhead/Cuttings	Screening, WHC, V. Rohay, Field: Rad Survey	Physical, WHC, V. Rohay, Field: Archive Lithologic	Physical, WHC, Field: Moisture CaCO3	Physical, WHC, Field: Part. Size Dist.	Physical, WHC, Field: Porosity Bulk Density	Physical, WHC, Field: Air Perm.	Physical, WSU / PNL, Conca/Serne, Field: Unsat. K Sat. K Pore Water Chem	Supercritical Fluid Extr., PNL, J. Amonette, Field: Mineralogy	Supercritical Fluid Extr., PNL, Field: Cation Ex. Cap.	Microbial, PNL, M. Truex, Field: Micro-biology	VOA, PNL, K. Olsen, Field: VOA Drive Barrel F	VOA Drive Barrel G	VOA, Field: VOA Split Barrel F	VOA Split Barrel G	Chemical, Data Chem, J. Julya, F: SVOA (ABN) DB	Chemical, Lab: SVOA (ABN) SB	Chemical, Lab: Ions, ICP Pb, Hg Cyn, TOC	Radionuclides, ITAS, J. Julya, Field (a)	Radionuclides, Lab: Gross Alpha Gross Beta	Radionuclides, Lab: Gamma Scan	Radionuclides, Lab: Sr 90	Radionuclides, Lab: PUIS	Radionuclides, Lab: Amer	Soil Gas, WHC, V. Rohay, Field: SEAMIST	Soil Gas, PNL, S. Luttrell, Field: Bore Sampler
		Sample Method	A	B	C	C	C	D	D	D	C	C	H	F	G	F	G	F	D	D	D	D	D	D	D	D	H	I
		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	9	9	9	9	10	10	11	6	12	13	14	14	14	1	1
Ft	M	Horizon																										
5	1.5	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)				1	1
10	3.0	Hanford	1	1	2	1	1								1													
15	4.6	Hanford	1	1	2	1	1								1													
20	6.1	Hanford	1	1	2	1	1								1													
25	7.6	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)				1	1
30	9.1	Hanford	1	1	2	1	1								1													
35	10.7	Hanford	1	1	2	1	1								1													
40	12.2	Hanford	1	1	2	1	1								1													
45	13.7	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(2)	(2)				1	1
50	15.2	Hanford	1	1	2	1	1								1													
55	16.8	Hanford	1	1	2	1	1								1													
60	18.3	Hanford	1	1	2	1	1								1													
65	19.8	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)				1	1
70	21.3	Hanford	1	1	2	1	1								1													
75	22.9	Hanford	1	1	2	1	1								1													
80	24.4	Hanford	1	1	2	1	1								1													
85	25.9	Hanford	1	1	2	1	1	1	1	1					2		2	2	(2)	(2)	1	(1)	(1)				1	1
90	27.4	Hanford	1	1	2	1	1								1													
95	29.0	Hanford	1	1	2	1	1								1													
100	30.5	Hanford	1	1	2	1	1								1													
105	32.0	Hanford	1	1	2	1	1	1	1	1	1	1			1		1	1	(1)	(1)	1	(1)	(1)				1	1
110	33.5	Hanford	1	1	2	1	1								1						1	(1)	(1)				1	1
115	35.1	Hanford	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)				1	1
120	36.6	Early Palouse	1	1	2	1	1	1	1	1	1	1			1		1	1	(1)	(1)	1	(1)	(1)				1	1
125	38.1	Early Palouse	1	1	2	1	1	1	1	1			1		1		1	1	(1)	(1)								
130	39.6	Early Palouse	1	1	2	1	1	1	1	1					2		2	2	(2)	(2)								
135	41.1	Plio-Pleis.	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
140	42.7	Plio-Pleis.	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
145	44.2	Plio-Pleis.	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
150	45.7	Ringold	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
155	47.2	Ringold	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
160	48.8	Ringold	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)								
165	50.3	Ringold	1	1	2	1	1								1													
170	51.8	Ringold	1	1	2	1	1								1													
175	53.3	Ringold	1	1	2	1	1								1													
180	54.9	Ringold	1	1	2	1	1	1	1	1					1		1	1	(1)	(1)	1	(1)	(1)				1	1
185	56.4	Ringold	1	1	2	1	1								1													
190	57.9	Ringold	1	1	2	1	1								1													
195	59.4	Ringold	1	1	2	1	1			Ground Water Table					1							Ground Water Table						
Total Sediment Samples (Unsaturated Zone)			39	39	78	39	39	17	17	17	2	2	1	0	41	0	19	19	(19)	(19)	10	(11)	(11)	(0)	(0)	(0)	10	10

Table FSP 3-4. New Deep Ground Water Monitoring Well Sample Matrix (sheet 2 of 3).

		Analysis	Screening		Physical						Supercritical Fluid Extr.		Microbial	VOA			Chemical					Radionuclides								Soil Gas	
		Laboratory	WHC		WHC					WSU / PNL	PNL		PNL	PNL			Data Chem					ITAS								WHC	PNL
		Contact	V. Rohay		V. Rohay					Conca/Serne	J. Amonette		M. Truex	K. Olsen			J. Julya					J. Julya								Rohay	Luttrell
		Sample Type	Field		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field			F	Lab		Field		F	L	F	L	F	L	L	L	Field	Field
		Analyses	Wellhead/ Cuttings	Rad Survey	Archive Lithologic	CaCO3	Part. Size Dist.	Porosity Bulk Density	Air Perm.	Sat. K Pore Water Chem	Mineralogy Cation Ex. Cap.		Micro-biology	VOA				SVOA (ABN)	Ions,ICP Pb, Hg Cyn, TOC	ICP	Ions	(a)	Gross Alpha Beta		Gamma Scan		Sr 90	PU/S	Amer	SEA-MIST	Bore Sampler
														GW	DB	SB	GW	SB		GW	GW	SB		GW		GW					
		Sample Method	A	B	C	C	C	D	D	D	C	C	E	J	G	G	J	D	D	J	J	D	D	J	D	J	D	D	D	H	I
Depth		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	19	9	9	17	10	11	15	16	6	12	18	14	18	14	14	14	1	1
Ft	M	Horizon																													
200	61.0	Hanford	1	1	2	1	1	1	1	1				2	1	1	2	(1)	(1)	2	2	1	(1)	1	(1)	1					
205	62.5	Hanford	1	1	2	1	1																								
210	64.0	Hanford	1	1	2	1	1																								
215	65.5	Hanford	1	1	2	1	1																								
220	67.1	Hanford	1	1	2	1	1							1			1			1	1			1		1					
225	68.6	Hanford	1	1	2	1	1																								
230	70.1	Hanford	1	1	2	1	1																								
235	71.6	Hanford	1	1	2	1	1																								
240	73.2	Hanford	1	1	2	1	1							1			1			1	1			1		1					
245	74.7	Hanford	1	1	2	1	1																								
250	76.2	Hanford	1	1	2	1	1	1	1	1					1	1		(1)	(1)			1	(1)		(1)						
255	77.7	Hanford	1	1	2	1	1																								
260	79.2	Hanford	1	1	2	1	1							1			1			1	1			1		1					
265	80.8	Hanford	1	1	2	1	1																								
270	82.3	Hanford	1	1	2	1	1																								
275	83.8	Hanford	1	1	2	1	1																								
280	85.3	Hanford	1	1	2	1	1							1			1			1	1			1		1					
285	86.9	Hanford	1	1	2	1	1																								
290	88.4	Hanford	1	1	2	1	1																								
295	89.9	Hanford	1	1	2	1	1																								
300	91.4	Hanford	1	1	2	1	1	1	1	1				2	2	2	2	(2)	(2)	2	2	2	(2)	2	(2)	2					
305	93.0	Hanford	1	1	2	1	1																								
310	94.5	Hanford	1	1	2	1	1																								
315	96.0	Early Palouse	1	1	2	1	1																								
320	97.5	Early Palouse	1	1	2	1	1							1			1			1	1			1		1					
325	99.1	Early Palouse	1	1	2	1	1																								
330	100.6	Plio-Pleis.	1	1	2	1	1																								
335	102.1	Plio-Pleis.	1	1	2	1	1																								
340	103.6	Plio-Pleis.	1	1	2	1	1							1			1			1	1			1		1					
345	105.2	Ringold	1	1	2	1	1																								
350	106.7	Ringold	1	1	2	1	1	1	1	1					1	1		(1)	(1)			1	(1)		(1)						
355	108.2	Ringold	1	1	2	1	1																								
360	109.7	Ringold	1	1	2	1	1							1			1			1	1			1		1					
365	111.3	Ringold	1	1	2	1	1																								
370	112.8	Ringold	1	1	2	1	1																								
375	114.3	Ringold	1	1	2	1	1																								
380	115.8	Ringold	1	1	2	1	1							1			1			1	1			1		1					
385	117.3	Ringold	1	1	2	1	1																								
390	118.9	Ringold	1	1	2	1	1																								
395	120.4	Ringold	1	1	2	1	1																								
400	121.9	Ringold	1	1	2	1	1	1	1	1				1	1	1	1	(1)	(1)	1	1	1	(1)	1	(1)	1					
405	123.4	Ringold	1	1	2	1	1																								
410	125.0	Ringold	1	1	2	1	1																								
415	126.5	Ringold	1	1	2	1	1																								
420	128.0	Ringold	1	1	2	1	1							1			1			1	1			1		1					

Table FSP 3-4. New Deep Ground Water Monitoring Well Sample Matrix (sheet 3 of 3).

		Analysis	Screening		Physical									Microbial	VOA			Chemical					Radionuclides								Soil Gas	
		Laboratory	WHC		WHC					WSU / PNL	PNL		PNL	PNL			Data Chem					ITAS								WHC	PNL
		Contact	V. Rohay		V. Rohay					Conca/Seme	J. Amonette		M. Truex	K. Olsen			J. Julya					J. Julya								V. Rohay	S. Luttrell
		Sample Type	Field		Field	Field	Field	Field	Field	Field	Field	Field	Field	Field			F	Lab		Field		F	L	F	L	F	L	L	L	Field	Field
		Analyses	Wellhead/ Cuttings	Rad Survey	Archive Lithologic	CaCO3	Part. Size Dist.	Porosity Bulk Density	Air Perm.	Sat. K Pore Water Chem	Mineralogy Cation Ex. Cap.		Micro-biology	VOA			SVOA (ABN)		Ions,ICP Pb, Hg Cyn, TOC	ICP	Ions	(a)	Gross Alpha Beta		Gamma Scan		Sr 90	PUIS	Amer	SEA-MIST	Bore Sampler
														GW	DB	SB	GW	SB		GW	GW	SB		GW		GW					
		Sample Method	A	B	C	C	C	D	D	D	C	C	E	J	G	G	J	D	D	J	J	D	D	J	D	J	D	D	D	H	I
Depth		Container Key	1, 2	1, 3	4	5	4	6	6	6	4	7	8	9	9	9	10	10	11			6	12		13		14	14	14	1	1
Ft	M	Horizon																													
425	129.5	Ringold	1	1	2	1	1																								
430	131.1	Ringold	1	1	2	1	1																								
435	132.6	Ringold	1	1	2	1	1																								
440	134.1	Ringold	1	1	2	1	1							1			1			1	1			1		1					
445	135.6	Ringold	1	1	2	1	1																								
450	137.2	Ringold	1	1	2	1	1	1	1	1					1	1		(1)	(1)			1	(1)		(1)						
455	138.7	Ringold	1	1	2	1	1																								
460	140.2	Ringold	1	1	2	1	1							1			1			1	1			1		1					
465	141.7	Ringold	1	1	2	1	1																								
470	143.3	Ringold	1	1	2	1	1																								
475	144.8	Ringold	1	1	2	1	1																								
480	146.3	Ringold	1	1	2	1	1							1			1			1	1			1		1					
485	147.8	Ringold	1	1	2	1	1																								
490	149.4	Ringold	1	1	2	1	1																								
495	150.9	Ringold	1	1	2	1	1																								
500	152.4	Ringold	1	1	2	1	1	1	1	1				1	1	1	1	(1)	(1)	1	1	1	(1)	1	(1)	1					
505	153.9	Ringold	1	1	2	1	1																								
510	155.4	Ringold	1	1	2	1	1																								
515	157.0	Ringold	1	1	2	1	1																								
520	158.5	Ringold	1	1	2	1	1							1			1			1	1			1		1					
525	160.0	Ringold	1	1	2	1	1																								
Total Sediment Samples (Saturated Zone)			66	66	132	66	66	7	7	7	•	•	•	•	8	8	•	8	8	•	•	8	8	•	8	•	•	•	•	•	•
Total GW Samples			•	•	•	•	•	•	•	•	•	•	•	19	•	•	19	•	•	19	19	•	•	18	•	18	•	•	•	•	•

Container Key

[1] No Container - value entry in borehole log
[2] Headspace container
[3] Plastic Bag
[4] Glass mason jar - clear
[5] Metal moisture tin
[6] Split-barrel core - 6 in. length, lexan liner
[7] 5 gallon plastic bucket
[8] Aseptically sampled split-barrel core - 2 ft. length, lexan liner
[9] 40 ml glass jar, amber w/septum, methanol preservative
[10] 125 ml glass jar - amber
[11] 250 ml (8 oz.) glass jar - clear
[12] 40 ml glass jar - amber
[13] 250 ml polypropolene jar - white
[14] 125 ml polypropolene jar - white
[15] 500 ml polypropolene bottle
[16] 125 ml polypropolene bottle
[17] 2000 ml polypropolene bottle
[18] 1000 ml polypropolene bottle
[19] 40 ml glass - amber

Laboratory Key

Data Chem — Data Chem Laboratories - Richland, WA
ITAS — IT Analytical Services - Richland, WA
PNL — Pacific Northwest Laboratory - Richland, WA
WHC — Westinghouse Hanford Co. - Richland, WA
WSU — Washington State University - Richland, WA

Trip Blanks @ 65 ft and 300 ft
Rad Duplicates @ 45 ft
VOA Duplicates @ 130 ft and 200 ft
Chem Duplicates @ 130 ft

Sample Method Key

A Photoionization Detector, Colorimetric Tube
B Alpha, Beta, Gamma Scanners
C Drive Barrel
D Split Barrel
E Aseptic Split Barrel
F Grab sample
G Core-Borer
H SEAMIST - Soil Gas Sampler
I Bore Sampler - Soil Gas Sampler
J Teflon Bailer

(a) Field sample is split into containers for lab analyses.

NOTE:
Bold numbers represent FIELD samples
Sample numbers in "( )" represent LAB samples split up from field samples

Sample Handling	Associated Activities (and data handling)	Responsible Personnel	Location
Sample Equipment decon	Equipment decon documentation	Sampler or Laborer	Laboratory or Drill Site
Sample collection Rad analysis sample	HEIS numbers assigned Chain of Custody forms generated	Sampler, Site Geologist	Drill Site
rad release		HPT	222 Lab
Sample Division	New Chain of Custody forms generated	PNL Sampler WHC Sampler	Mobile Lab
Sample Transport	Samples in cooler, with thermometer	PNL Sampler WHC Sampler	
		Custody transfer	
Sample Distribution		PNL Sampling Staff	Sigma 5
		Custody transfer	
Sample Analysis	Analyses Results Returned to PNL	laboratory personnel or principal investigator	Analytical Laboratories
Sample Disposal		laboratory personnel or sampler	Drill Site or Analytical Laboratory
	Results entered into HEIS	PNL HEIS data management staff	Sigma 5
	Analysis Results prepared in report form or Analysis Results published		

Figure FSP 5-1. Sample Processing.

All samples that are to be removed from the drill site must be released by the responsible Health Physics Technician (HPT). The evidence of this release is a sticker, which is placed on the sample container by the HPT. Effective communication with the HPT is required so that samples are released and transported in a timely manner.

Sediment samples must be unconditionally released, which requires laboratory analysis of sediment from the sampled interval. For samples that must be transported within holding times, this entails arranging laboratory analysis time with the HPT before the sample is collected. When the sample is cleared for transport, a sticker is generated to notify sample handlers that the sample is free of radioactive contamination.

Ground water samples will be released for transport, which requires an onsite screening using field instruments. This can be completed as soon as the samples are taken. When the sample is cleared for transport, a sticker is generated to notify sample handlers that the sample is free of radioactive contamination. Samples cannot be removed from the site without a Radiation Release Record signed by the responsible HPT.

Chain-of-custody forms will be generated for every solid and liquid sample taken. There may be more than one sample on a chain-of-custory form. Chain-of-custory forms are not filled out for gas samples. A soil-gas field sampling/laboratory analysis record is filled out instead (see Section 5.8).

Included on each chain-of-custory form will be:

- chain-of-custody number
- chain-of-custody number = temporary well number (ex: CT-4 or ID-4) and sampling interval for WHC and PNL generated forms not going to an analytical laboratory
- chain-of-custody number = PNL Sampling and Analysis Group generated number for forms going to analytical laboratory
- name(s) of person(s) to contact
- person(s) collecting sample
- date and time of sample collection
- well number and depth of sample or sampled interval
- depth as meters
- HEIS number of sample
- specific sample type, container, and depth
- information about sample contamination and unique collection conditions
- preservation method and temperature at which samples are refrigerated
- method of shipment
- sign and date form when sample custody is transferred.

When samples are divided into new containers or transferred to a new chain-of-custody form for any other reason, this information must be transferred from the old chain-of-custody form to the new one:

- old chain-of-custody number
- date and time of sampling
- sampler
- well number and depth
- HEIS number
- preservative/temperature.

The old chain-of-custody form will be marked with all new chain-of-custody numbers that samples were transferred to.

All chain-of-custody forms generated for each sample must be filed together in their respective well folders. Figures FSP 5-2 through 5-4 are examples of completed chain-of-custody forms. Figure FSP 5-2 is a WHC chain-of-custody form for original physical, chemical, volatile organic analysis (VOA), and radiological samples. Figure FSP 5-3 is a PNL chain-of-custody form for samples to be transported to analytical laboratories. Figure FSP 5-4 is a PNL chain-of-custody form for microbiological samples.

5.1 WELLHEAD MONITORING AND FIELD SCREENING

5.1.1 Data Needs Defining the Sample Locations

Wellhead monitoring and field screening of drill cuttings for VOC and radionuclides will be required to aid sampling decisions by onsite personnel. High concentrations of VOC at depths other than the predefined sampling depths will indicate that additional samples will be taken. The initial VOC concentration (as detected with field monitoring equipment) used to signal the need for collection of an additional sample will be 1 ppm, if the background level is zero. Otherwise, an increase of one order of magnitude from the previous sample will indicate an additional sample may be required. Comparison of these results with VOA results will indicate if different action levels are required. Elevated radionuclide levels will indicate no further samples will be taken at that depth.

Wellhead monitoring and field screening of drill cuttings will be done at a minimum of once each 1.5-m interval. Because of variable VOC readings on drill cuttings due to atmospheric conditions, sampling of drill cuttings will be done from the sediment pile and in a headspace sampling container.

5.1.2 Sample Equipment

Sample equipment includes the following:

- photoionization detector (PID)
- colorimetric tubes for carbon tetrachloride
- alpha, beta, gamma detectors.

Figure FSP 5-2. WHC Chain-of-Custody Form.

Westinghouse Hanford Company	CHAIN OF CUSTODY

Custody Form Initiator ______________________

Company Contact ______________________ Telephone ____________

Project Designation/Sampling Locations ______________________ Collection Date ____________

____

Ice Chest No. ______________________ Field Logbook No. ____________

Bill of Lading/Airbill No. ______________________ Offsite Property No. ____________

Method of Shipment ______________________

Shipped to ______________________

Possible Sample Hazards/Remarks ______________________

____

Sample Identification

☐ Field Transfer of Custody	CHAIN OF POSSESSION	(Sign and Print Names)
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
	Final Sample Disposition	
Disposal Method:	Disposed by:	Date/Time:
Comments:		

A-6000-407 (12/90)

Figure FSP 5-3. PNL Chain-of-Custody Form for Laboratory Transmittal.

Surveyed : Yes _____ No _____ ? Less than 200 counts/minute: Yes _____ No _____ ? By (initials) _____

Battelle Pacific Northwest Laboratories Battelle Boulevard Richland, Washington 99352	CHAIN OF CUSTODY	Test User ID: C-of-C:

Company Contact: _____ Telephone: _____

Samples Collected by: _____ Date: _____ Time: _____

ID/Sample No.: _____

Ice Chest No.: _____ Field Logbook Page No.: _____

Remarks: _____

Possible Sample Hazard Identification: _____ Contract No.: _____

Destination: _____ Carrier/Waybill No.: _____

Ground-Water _____ Soil _____ Other _____

Shipping container internal temperature when samples sealed in it _____ .

Shipping container internal temperature when opened in laboratory _____ .

Sample Identification

Chain of Possession

Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
	Received by:	Date/Time:

PNL-MA-567, AD2

BD-1200-345 (10/91)

Figure FSP 5-4. PNL Chain-of-Custody Form for Microbiological Sample.

Battelle
Pacific Northwest Laboratories

CHAIN OF CUSTODY

Company Contact: ______________________ Telephone: __________

Samples Collected by: ______________________ Date: __________ Time: __________

Sample Location: ______________________

Ice Chest No.: ______________________ Field Logbook Page No.: __________

Remarks: ______________________

Method of Shipment: ______________________

Sample Identification

Chain of Possession

Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:

PNL-MA-567, AD2

BC-1200-345 (02/90)

5.1.3 Sampling Procedures

Sampling of wellhead gases and drill cuttings will be performed as outlined in Environmental Investigation Instruction (EII) 3.4, Field Screening (WHC 1988a) and the following (volatile organics only):

- Take wellhead readings as soon as drill string is out of the casing.
- Record sampling interval, instrument type, and instrument reading in field activity report and borehole log.
- Place drill cuttings in headspace sampling container.
- Agitate sample.
- Take drill cuttings reading from sediment pile.
- Record sampling interval, instrument type, and instrument reading in field activity report and borehole log.
- Insert sampling tube through lid opening of headspace container.
- Let instrument adjust for manufacturer's recommended stabilization period.
- Record sampling interval, instrument type, and instrument reading in field activity report and borehole log.

5.2 DRIVE-BARREL/HARD-TOOL LITHOLOGIC CHARACTERIZATION SAMPLING

Samples from drive-barrel or hard-tool sampling will be taken for the following analyses:

- moisture content
- archive lithologic
- $CaCO_3$ content
- particle size distribution.

5.2.1 Data Needs Defining the Sample Locations

Routine sampling to characterize the sediment lithology will be done every 1.5 m. These samples will be analyzed for $CaCO_3$ content, moisture content, and particle size distribution. $CaCO_3$ and particle size distribution samples will be collected from both the saturated and unsaturated zones. Moisture content samples will not be collected from the saturated zone or from the slurry recovered during hard-tool drilling. Particle size distribution samples will not be collected from the slurry recovered during hard-tool drilling.

5.2.2 Sample Equipment and Sample Containers

Sampling equipment includes:

- rubber gloves
- metal scoop
- waterproof markers
- teflon tape
- plastic bags.

Sample containers:

- metal containers (moisture content tin) with press-on lid
- pint glass jars with screw-on lid.

5.2.3 Sampling Procedures

Moisture Content and $CaCO_3$ Content Samples:

- Take samples at 1.5-m intervals from sediments recovered from the drive barrel or bailer. The sediments are first dropped into a sediment collection bucket.
- Use a metal scoop to transfer sediments to the moisture content tin as soon as the sediments have been dropped into the sediment collection bucket.
- Close the tins immediately and seal with teflon tape.
- On the tape, mark: (1) well number; (2) sampling interval; (3) date and time of sample; (4) "D" for drive barrel or "H" for hard tool; and (5) the sampler's first and middle initials and last name.
- Wrap the sample containers in plastic bags as described by PNL (1991, SA-7).

NOTE: Moisture content analyses will not be done for hard tool or saturated zone samples.

Archive Lithologic Samples:

- Take samples at 1.5-m intervals only from sediments collected with the drive barrel. The sediments are first dropped into a sediment collection bucket.
- Use a metal scoop to transfer sediments to the 2-pt glass jars after taking the moisture content/$CaCO_3$ content sample.
- Close the screw-on lid.
- On the top of the lid, mark: (1) well number; (2) sampling interval; (3) date and time of sample; (4) "D" for drive barrel; and (5) the sampler's first and middle initials and last name.

Particle Size Distribution Samples:

- Take samples at 1.5-m (5-ft) intervals only from sediments collected with the drive barrel. The sediments are first dropped into a sediment collection bucket.
- Use a metal scoop to transfer sediments to the pint glass jar after taking the moisture content/$CaCO_3$ content sample.
- Close the screw-on lid.
- On the top of the lid, mark: (1) well number; (2) sampling interval; (3) date and time of sample; (4) "D" for drive barrel; and (5) the sampler's first and middle initials and last name.

NOTE: Particle size distribution analyses will not be done for hard tool samples.

None of these samples require special preservation techniques.

Any samples taken for these analyses require unconditional radioactivity release before being removed from the drill site. Sediment from the sample interval must be submitted to the HPT for anlaysis.

5.3 POROSITY/BULK DENSITY AND AIR PERMEABILITY SAMPLING

5.3.1 Data Needs That Define Sampling Intervals

Samples are taken for to laboratory analysis of the physical properties of bulk density, porosity and air permeability. These analyses help to identify the rate of moisture movement through the sediment package. To recover sediment as representative of the actual depositional structures samples are taken with the split barrel sampler lined with a Lexan tube. One of four Lexan liners inside the 1.6-m split-spoon (a 15-cm length sample) is required to collect the sample for air permeability analysis, and another 15 cm Lexan encased core sample is required for both the bulk density and porosity samples. To define the variability of these physical parameters with depth, samples for analysis will be taken every 6 m.

5.3.2 Sample Collection and Preservation Procedures

Samples for air permeability, bulk density, and porosity will be taken with a split-spoon sampler lined with four 15-cm Lexan tubes. The sampling equipment will be decontaminated per to EII 5.5, 1706 KE Laboratory Decontamination of RCRA/CERCLA Sampling Equipment (WHC 1988a). Two of the four Lexan tubes will be designated for these analyses; one for air permeability and one for bulk density and porosity. If the samples that are recovered with these physical property samples (in the other two Lexan tubes) are to be used for chemical analysis, decontamination of the sampling equipment per to the more stringent requirements of chemical sampling equipment will be in compliance with the decontamination requirements for these physical property samples.

Physical property samples must retain as much of the sediment structure intact during sample collection and transport. To ensure that the sediment structure of the samples taken for these analyses remain intact the Lexan liners in which these samples are collected must be completely full of sediment. The sampled core will be sealed inside the Lexan liner with liner caps once the sample has been retrieved from the subsurface and the split spoon opened. The sample containers will be marked with the sampling information, the HEIS number and the up direction. Samples should be protected from physical shock during both the sampling and transport process. Aside from this consideration, samples do not require special conditions during transport.

5.3.3 Sample Collection Equipment and Sample Containers

Equipment required for sample collection is identical to that required for collection of physical property samples.

5.4 PHYSICAL PROPERTY SAMPLING (INCLUDES PORE WATER ANALYSES

5.4.1 Data Needs That Define the Sampling Locations

Physical property characterization of sediments is being done to allow a better understanding of the transport and storage of carbon tetrachloride in the unsaturated zone. Physical property samples will be analyzed for volumetric moisture content, unsaturated hydraulic conductivity, clay mineralogy, diffusion coefficients, and particle size. Pore water will be extracted during the course of the analyses and analyzed for its chemical constituent content and carbon tetrachloride content.

The results of the Phase II activities have shown the highest concentrations of carbon tetrachloride to be present in the early "Palouse" soil or just above it. The physical properties of this lithologic unit and the surrounding sediments have specific influence over the distribution of the carbon tetrachloride. Consequently, the physical properties of the sediments of the Hanford formation directly overlying the early "Palouse" soil, early "Palouse" soil, the Plio-Pleistocene unit directly beneath the early "Palouse" soil, and the Ringold sediments directly beneath the Plio-Pleistocene unit are the focus of the Phase III portion of the physical property characterization.

5.4.2 Sample Collection and Preservation Procedures

The primary consideration during the physical property sampling is to ensure that the sediment structure is not disturbed during the sampling process. Representative unsaturated hydraulic conductivity measurements require the sediment structure to be intact. Moisture content analyses require samples that are isolated from atmospheric contact once collected. Clay mineralogy and particle size distributions require samples that have not been sorted with respect to size during the sampling process.

Samples taken for physical property analysis will be collected using a split-spoon sampling tool. The split-spoon tool is 0.60-m long and will be lined with four Lexan tubes that are 0.15 m in length. Three of the four Lexan tubes will be used for physical property analyses, porosity/bulk density analyses, and air permeability analyses. The other one will be used for chemical/radiological characterization. All samples will be capped upon recovery and sealed with tape. The well number, sampling interval, date and time of sample, and the sampler's initials will be marked on the tape. Sediments for physical property analyses must be recovered in the Lexan liners, and not placed in the liners after recovery. This will help ensure that the sediment structure is not destroyed during the sampling process. The Lexan liner containing sample material designated for physical property analyses must be completely full of sediment. Again, this will ensure that the sediment structure is not destroyed during transport. These requirements also ensure that sediment samples are representative of the particle size fraction present in the sampled interval and will allow accurate clay mineralogic characterization and particle size distribution measurements.

Chain-of-custody forms will be filled in for the samples. The physical property samples will be transported from the drill site to the Washington State University (WSU) Tri-Cities laboratory for analyses once released by the

HPT. A radioactivity sample must be taken from the sampled interval (one sample represents the 0.6-m split-spoon length) for analysis. Once analyzed and cleared, an HPT will release the sample and it can be transported offsite to the WSU Tri-Cities laboratory. During transport, the sample must be protected from physical shock to retain sediment structure integrity. Samples should not be refrigerated. There is no holding time limit for the physical property samples.

5.4.3 Sampling Equipment

The sampling equipment for these samples is listed under the chemical and radiologic sampling section because these samples are taken concurrently.

5.5 CHEMICAL AND RADIOLOGICAL SAMPLING

5.5.1 Data Needs That Define the Sample Locations

Samples will be collected to characterize the sediments of both the saturated and unsaturated zones. The samples will be collected routinely at 6-m intervals, or more frequently if there are changes in the lithology, detected contaminant concentrations, or other unusual factors. A split-spoon sampler will be used to retrieve the subsurface sediments.

5.5.2 Sampling Procedures

Samples will be taken using methods most capable of preserving the in situ environment. A 0.6-m split-spoon sampler lined with Lexan tube will be used to recover samples. Five Lexan tubes will be used to line the split spoon sampler: three of 15-cm length, and two of 7.5-cm length.

To prepare sampling equipment for use, decontamination is necessary. The split-spoons and the head will be washed with a nonphosphate detergent and raw water, rinsed with raw water, allowed to dry, and wrapped in plastic.

Equipment that requires decontamination per EII 5.5 will be decontaminated at the 100K laboratory. Laboratory cleaned equipment must be transported to the drill site before sampling proceeds. The split-spoon shoe, core-catcher, spacer, Lexan liners, and liner caps are decontaminated per EII 5.5 and wrapped in aluminum foil.

Split-spoons head, shoe, space, core-catcher, and Lexan liners will be assembled by personnel wearing new disposable rubber or plastic gloves. The entire assembly will be wrapped in plastic until it is needed.

Before the split-spoon assembly is attached to the drill string, the borehole will be cleaned out using either the core barrel or bailer. A depth-to-bottom measurement will be taken. The sampler will be attached to the drill string and lowered to the bottom of the borehole. The number of blow counts for the sampler to advance each 0.15 m will be recorded.

The split-spoon sampler will be retrieved from the bottom of the borehole after it has been advanced 0.60 m. The sampler will be placed on a plastic covered sampling table and opened. Immediately after separating the split-spoons, the core-borer will be used to extract sediment from the end of one Lexan liner. The core-borer will be inserted 2.5 cm into the sediment. The last 1.27 cm taken into the core-borer will be cut off and placed in a VOA vial (with methanol preservative) and sealed. Detailed VOA sampling methods are described in Section 5.5. Following this, the 7.5-cm length Lexan liner designated for SVOA will be capped and sealed. The sample for radioactivity determination will then be taken, placed in a plastic bag and the bag marked. The remaining Lexan liners will then be capped and sealed. Each Lexan liner (and the VOA sample) will be marked with the well number, the date and time of sampling, and its appropriate depth (or interval) and HEIS number. The Lexan liner designated for SVOA, the liner designated for chemical analysis, and the VOA vial will be refrigerated. The remaining Lexan liners will be designated as follows: two 0.15-m liners for physical property analysis, one 0.15-m liner for radiologic analyses, and one 0.075-m liner for chemical analyses.

Chain-of-custody forms will be filled in for all the samples. On one form will be the two physical property samples. A second form will be used to record the VOA sample, the SVOA sample, the chemical analyses sample, and the radiologic analyses sample. The sampling interval, type of sample, and HEIS numbers will be recorded in the borehole log.

5.5.3 Sampling Equipment

Sample collection equipment:

- laboratory cleaned and wrapped Lexan liners
- laboratory cleaned drill shoe and core catcher
- VOA vials prepared with methanol (under refrigeration)
- VOA core-borer sampler
- scoop to remove sediments for radiologic analysis and/or VOA samples
- aluminum foil (to isolate the ends of core samples)
- Lexan liner end caps (laboratory cleaned?)
- plastic baggies (for radiologic analysis samples)
- duct tape and/or teflon tape
- waterproof markers to mark sample containers
- cooler, with frozen blue ice, to transport samples
- plastic gloves
- chain-of-custody forms
- drilling and sampling procedures
- FSP and QAPP.

Sample containers (for each sampled interval):

- three 0.15-m length, 0.10-m-diameter Lexan liners
- two 0.075-m length, 0.10-m-diameter Lexan liners
- 10 liner caps
- one 40-mL amber glass jar containing 5 mL methanol, with screw-on cap and teflon septum (VOA vials)
- three 100-mL plastic sample jars
- two 250-mL wide-mouth clear glass jar.

5.5.4 Sample Processing

Chemical, VOA, and SVOA samples will be refrigerated until analyzed.

Samples will be held onsite until unconditionally released by the HPT. Once released, samples will be divided in the onsite mobile laboratory/sample handling trailer into the respective amounts and containers that will be sent to Data Chem and ITAS for chemical and radiological analyses. When samples are divided, the chain of custody must be transferred to a new form. Information must be transferred from the old chain-of-custody form to the new chain-of-custody form. Copies of both chain-of-custody forms must be retained and filed together. Chemical and radiological samples must be transported to their respective laboratories for analysis within specified holding times. Those holding times begin at the time of collection.

Analysis	Holding Time	Laboratory
VOA	14 days	PNL
SVOA (ABN)	7 days	Data Chem
Total organic carbon	28 days	Data Chem
Cyanide (CN)	14 days	Data Chem
Ions	ASAP after collection	Data Chem
Mercury (HG)	28 days	Data Chem
Lead (PB)	6 months	Data Chem
ICP metals	6 months	Data Chem
Plutonium ions	25 business days	ITAS
Americium	25 business days	ITAS
Strontium-90	30 business days	ITAS
Gamma scan	20 business days	ITAS
Gross alpha	15 business days	ITAS
Gross beta	15 business days	ITAS

Once divided, the chemical and radiologic samples will be transported to Sigma V and custody transferred to the PNL sampling staff. These personnel will be responsible for distributing the samples to the laboratories, and receiving and distributing the analytical results.

Physical property samples will be transported to the WSU Tri-Cities laboratory. Custody will be transferred to J. Conca or laboratory personnel. There is no holding time limit on physical property samples.

5.6 VOA SAMPLING

5.6.1 Data Needs That Define the Sample Locations

VOA are done to identify the presence of carbon tetrachloride and other organic molecules that are sorbed to the sediments, or dissolved in ground water. Analytical results will be compared with soil-gas analyses from similar depth intervals. In addition, results of VOA are used to evaluate the effectiveness of the vapor extraction technology that is being used to remove gas phase carbon tetrachloride from the unsaturated zone. Because the results are important to overall understanding and evaluation of carbon tetrachloride storage and transport, VOA samples will be collected at 1.5-m intervals during all drilling operations.

5.6.2 Sample Collection and Preservation Procedures

Because the analytes are volatile, care must be taken to collect these samples as soon as the sediment has been removed from the borehole. Sediment will be placed in an amber jar containing a methanol preservative to fix the volatiles in the methanol solution. Once collected, sediment samples must be placed under refrigeration.

Sample containers must be kept refrigerated and vertical before and after sampling. Methanol will be added to the containers and weighed prior to samples being placed in them. If the methanol is released from the vial either by evaporation or by spilling, the measurement is inaccurate.

Four separate VOA samples will be taken and placed in four VOA vials so that two sampling methods can be compared to determine the most effective sampling technique. Two samples will be taken using the core-borer to remove sediment from the cored sample in the split-spoons. Once the sediment core has been bored from the larger core sampler, it is cut from the end of the core-borer and placed in the sample vial. The remaining two samples will be taken using a metal scoop. Sediment will be scooped from the sample immediately on recovery and placed in the sample container.

VOA will be done on ground water also. These samples will be taken according to the procedures that govern ground water sample collection, described in the ground water sampling section.

VOA sample vials containing methanol will be kept vertical and under refrigeration at all times. Only when the sample is actually extracted from the sediments should the VOA vial be out of a refrigerated container. Between 5 and 10 g of sediment is the optimum sample size. Tamper evident seals are not placed directly on VOA vials. The vials will be placed in a plastic bag and the seal placed on the bag opening. The samples will be released at the same time as the other samples.

5.6.2.1 <u>VOA Core-Borer Sampling from Split-Barrel</u>. If the core borer is used, it will be inserted with a turning motion at least 2.5 cm into the sediment. Once it penetrates to the 2.5-cm (or greater) depth, it will be pulled back with the sediment in the tool. A spatula is used to cut off the first 1.2 cm of sediment at the end of the tool, and drop it into the VOA vial containing the methanol. The lid will be placed on the vial immediately. This process will be repeated to take the second sample. The vials will be placed vertically in the shade, and transferred to a cooler as soon as possible. The time of sampling will be noted.

5.6.2.2 <u>VOA Sediment Scoop Sampling From Split-Spoon</u>. If the sample is collected with the sediment scoop, the process is similar. The VOA vials will be opened. A split between two of the Lexan liners will be identified as the sample location. The sediment will be dug out from the end of the cored interval using the scoop and making sure approximately 2.54 cm of sediment is penetrated. The sample will be dropped into the VOA vial immediately and the vial capped. The jar will be placed vertically in the shade, and transferred to a cooler as soon as possible. The second sample will be taken in the same manner.

Once all the sediment samples from the cored interval have been sealed, the VOA (and other) samples will be marked with the well number, depth of sampled interval, time and date of sampling, and the sampler's name.

5.6.2.3 VOA Samples From Drive-Barrel. Samples will be taken from sediment recovered while drilling is underway to advance the borehole. Two different sampling techniques will be used when samples for VOA are taken from sediment recovered during core barrel drilling. Core borer samples will be taken, as well as grab samples.

5.6.2.4 Core-Borer Sampling From Drive-Barrel. When the drive barrel is raised to the ground surface (and out of the borehole), a sample will be taken with the core-borer directly from sediments in the drive-barrel. The core-borer will be inserted with a twisting motion at least 2.5 cm into the sediment at the bottom of the drive barrel and withdrawn. 1.2 cm of sediment from the end of the core borer will be cut off and dropped into the (previously opened) VOA vial and the vial capped.

5.6.2.5 VOA Sediment Scoop Sampling From Drive-Barrel. A sediment scoop will also be used to take VOA samples from the drive-barrel while advancing the borehole. Once the sediments are retrieved, they will be dropped from the drive barrel into a bucket. Immediately after transfer to the bucket, the sediment scoop will be used to dig sediments out from at least 2.5 cm below the top of the sediment pile. The sediment sample will be dropped immediately into the VOA vial and the vial capped. Once the sample is collected, the sample container will be marked and refrigerated.

5.6.2.6 VOA Samples During Hard-Tool Drilling. During hard tool drilling, VOA samples will be taken from the slurry of sediment and added water. Samples will be collected using the metal scoop only. The core borer is not used to take slurry samples. Between 5 and 10 g of slurry will be placed into a VOA vial that does not contain methanol as a preservative. The vial will be sealed, refrigerated, and maintained in an upright position.

5.6.2.7 VOA Sample Handling and Analysis. VOA samples will be analyzed within 14 days after the sample is collected. Once the sample has been unconditionally released by the responsible HPT, custody will be transferred. Analyses may be conducted at Sigma V or in a mobile laboratory onsite. Custody transfer will take place at the location where analysis will occur.

5.6.3 VOA Sample Collection Equipment and Sample Containers

Sediment sample collection equipment and sample containers that will be deconned include:

- core borer
- spatula
- small sediment scoop
- cooler with frozen blue ice
- 40-mL amber vials with teflon septum caps, containing methanol

- box with dividers (to keep VOA vials in vertical position)
- waterproof markers
- tamper evident stickers.

5.7 SUPERCRITICAL FLUID EXTRACTION (SFE) SEDIMENT MATRIX CHARACTERIZATION SAMPLING

5.7.1 Data Needs That Define the Sample Locations

Samples will be collected for use in determining sediment properties that influence the laboratory extraction of lard oil and alkyl phosphates. Sediment matrix characterization is a component of the analyses to determine how best to extract alkyl phosphates and lard oil from sediment using supercritical fluid extraction. A total of six sediment samples will be taken in large volumes to be collected only, to allow the extraction methods to be tested repeatedly on the same sample type. To test the methods on a wide variety of sediments, samples will be collected with a wide range of mineralogic and textural properties. Fine grained sediments will afford the greatest volume percentage to be used for analyses. Dry samples will be collected from the core barrel during cable tool drilling.

5.7.2 Sample Collection and Preservation Procedures

Both large- and small-volume samples will be taken. Large-volume samples will be collected during drilling, directly from the core barrel sampler into a 5-gal plastic bucket. Sample intervals will be defined by the sampling staff when a fine grain is encountered during core-barrel drilling. It is preferable to take SFE characterization samples adjacent to the intervals sampled for chemical and radiologic analysis, so that results can be compared. Small-volume samples will also be taken from drill cuttings recovered from core-barrel drilling. A radioactivity sample will be taken and submitted to the HPT for analysis and release. Then the sample container will be sealed and the samples stored onsite until released for transport. A chain of custody form will be filled in for the samples. Once analyzed and cleared, an HPT will release the sample and it can be transported offsite to PNL's Sigma V laboratory. Transport to the laboratory requires no specific preservation procedures. Samples will be delivered to the 1423 laboratory and custody will be transferred.

5.7.3 Sampling Equipment

Sample collection equipment and sample containers:

- sample container (50-g sample - either jars or plastic bags - to be determined)
- 5-gal plastic bucket and lid
- waterproof markers
- hammer (to seal bucket)
- plastic baggie (for radioactivity determination)
- metal scoop.

5.8 MICROBIOLOGIC SAMPLING

5.8.1 Data Needs That Define the Sampling Locations

Samples for microbiologic analysis are taken to assess what microorganisms are present in the subsurface, under what condition these organisms survive, and whether these organisms are capable of degrading carbon tetrachloride to less toxic substances. Phase II investigations have shown abundant microbial populations exist in the early "Palouse" soil. Phase III investigations will further examine the conditions that contribute to the growth of existing populations. The laboratory studies will focus on determining which nutrients present in sediments limit microbial growth. In addition, analyses will be conducted to determine what available sediment constituents are potential electron donors or acceptors for microbes during the degradation process.

Samples will be taken to characterize these parameters in both the saturated and unsaturated zones. A total of six samples will be collected, three from the early "Palouse" soil (unsaturated zone) and three from the saturated zone of the Ringold formation. The early "Palouse" soil will be the focus of the vadose zone study. Saturated zone samples will be collected as convenient with other sampling activities and the drilling operations.

5.8.2 Sample Collection and Preservation Procedures

Pristine sediment samples must be taken during the drilling operations to accurately assess the microorganisms present in the sediments. These samples will be recovered using sterilized sampling tools to retrieve subsurface sediment and then isolated from microbiologic or chemical contamination during transport to the laboratory.

Aseptic core samples will be taken using a split-spoon sampler having a Lexan liner. Aseptic sampling will be achieved using a sampling apparatus that is sterilized prior to sample recovery. The Lexan liner will be autoclaved in a laboratory and wrapped in sterile packaging before being brought out to the drill site. The liner must be picked up at the microbiology laboratory in the 324 Building. The "split-spoon" and head (used to attach to barrel to the drilling tools) are washed in a bleach solution. The shoe of the split-spoon assembly and the springs used to retain the sediment inside the split-spoon will be sprayed with ethanol and then flamed and air cooled. Just prior to taking the sample, the entire set of equipment will be assembled using sterile gloves, then wrapped and sealed in sterile paper.

To recover a sample representative of in situ microorganisms, the borehole will be cleared of all material capable of contaminating the sample prior to inserting the sterile split-spoon sampler. The bottom of the borehole will be cleared of slough by the drillers. The sterile assembly will be attached with the paper seal in place. When the drillers are ready to drill out the sample the sterile paper will be removed from the split-spoon assembly and the assembly lowered down the borehole. The sample will be drilled out of the formation and then pulled up out of the borehole. Once the sample is retrieved, the split-spoon will be placed on the clean plastic covered split-spoon table. The split-spoon will be opened and the Lexan liner containing the sample will be sealed with previously sterilized end caps. The sealed sample will be placed in a plastic liner bag and argon gas introduced and purged from the bag three times. Finally, the bag will be sealed under positive pressure and transported under refrigeration to the laboratory for analysis.

Analyses will be done in a "clean" laboratory. Samples with high VOC content will contaminate the laboratory, and will not be accepted for analysis. Concentrations above 100 ppm as determined by field screening of sampled core with PID in the vapor phase constitutes high volatile organic content.

5.8.3 Sampling Equipment

Sample collection equipment:

- laboratory sterilized Lexan liners (wrapped in sterile brown paper)
- laboratory sterilized liner caps (sealed in whirl pack bags)
- sterile plastic gloves
- laboratory sterilized brown paper
- ethanol and sprayer (to apply ethanol to sample equipment)
- striker (or matches or lighter)
- tray (for on site sampling equipment sterilization)
- chlorine bleach (for on site sampling equipment sterilization)
- buckets and brushes (for on site sampling equipment sterilization)
- tape and markers
- plastic liners (to place samples in once retrieved)
- argon tank (requires approved transport to site)
- argon regulator and tube
- large cooler (1.2-m length) and blue ice
- plastic baggies (for radioactivity sample determination).

Once collected, samples will be sealed inside the Lexan liners in which they are recovered. Additional sample containers will not be not used. Chain-of-custody forms will be filled in for the samples. Samples will be transported to the laboratory in the sealed Lexan liner and argon atmosphere within 48 hr of sampling.

5.9 GROUND WATER SAMPLING

5.9.1 Data Needs that Define the Sample Locations

Ground water analyses will be done on samples from only one of the boreholes to be drilled. That well will be drilled through the entire saturated zone. Water samples will be collected every 6 m in the saturated zone. The water table is at 59 m below ground surface and the impermeable basalt is at a depth of 160 m, making a total of 17 samples to be taken.

5.9.2 Sample Collection and Preservation Procedures

Ground water samples will be collected from specific depth intervals in the aquifer. Borehole will be bailed clean of cuttings at each sample interval and allowed to recover sufficiently for ground water sampling. Ground water samples will be collected using a teflon bailer that has been washed with laboratory cleanser and rinsed with deionized water. The ground water sampling tools will be set up over the borehole. This includes the tripod with calibrated pulley (to determine depth of sampling) and the line and motorized reel, which lowers and lifts the bailer from the borehole.

Ground water samples should be as free of sediment as possible. Two full bailers will be removed from the borehole and dumped into the purge water barrels before collecting the ground water samples. The actual sample water will be collected with the bailer, and poured from the bailer into opened sample jars, spilling and jostling the water as little as possible (as described by PNL (1991, GC-1).

Once collected, the samples will be kept under refrigeration. Bottles will be marked with the date, time, well number, depth, HEIS number and sampler. Tamper-evident tape will be placed over the lids. Volatile organic samples will be placed in plastic bags and the tamper-evident tape placed on the bag, not the jar. Chain-of-custody forms will be completed. Samples will be released for transport by the HPT before being moved from the drill site. Once released, samples will be transported to Sigma V and custody transferred to the PNL sampling staff, who will distribute the samples to the analytical laboratories.

5.9.3 Sample Collection Equipment and Sample Containers

Sample collection equipment includes:

- laboratory cleaned teflon bailer wrapped in plastic
- downhole sampling equipment including tripod and pulley, string and motorized reel (to raise and lower bailer)
- cooler and frozen blue ice (to transport samples)
- markers (to mark sample containers)
- plastic or rubber gloves
- tamper-evident stickers
- FSP and QAPP.

The sample containers and chain-of-custody forms will be prepared by PNL sampling staff. The containers used for each sampled interval are:

Analysis	Sample Container
ICP metals	500-mL plastic
ions	125-mL plastic
semivolatiles	2,000-mL amber glass
alpha, beta	1,000-ml plastic
gamma	1,000-mL plastic
volatile organics	two 40-mL amber glass

5.10 SOIL-GAS SAMPLING

5.10.1 Data Needs That Define Sample Locations

Soil-gas sampling will be done coincident with the VOA sediment sampling to allow comparison between sediment concentration, aqueous phase concentration and vapor phase concentration of carbon tetrachloride. Samples will be taken using the SEAMIST sampler and the borehole sampler from intervals adjacent to those sampled for chemical and radiologic analysis. Both these technologies were tested during Phase II of the VOC-Arid ID/ERA project. The test plan that is being written for the borehole sampler will include a similar sampling frequency to that specified in this document.

5.10.2 Sample Collection and Preservation Procedures

The SEAMIST tool and the borehole sampler use different sample collection. The SEAMIST isolates the sampled interval at the bottom of the borehole and withdraws gas from the space created by drilling out sediments. The borehole sampler is injected into the sediments at the bottom of the borehole and withdraws gas from the pore spaces between the sediments.

To compare the results of the two sampling methods, gas phase samples will be taken by the SEAMIST sampling tool and the borehole sampler. The samples will be pumped from the subsurface into glass bulbs. Samples do not require refrigeration before analysis. Samples will be analyzed within 24 hr from when they were extracted from the subsurface.

6.0 SAMPLE AND ANALYSIS

Samples will be handled and transported as specified in the procedures. Results of chemical, volatile organic, and radiological laboratory analyses will be sent to the sampling staff at PNL. Analysis results will be entered into the HEIS database. Results of physical property analyses, SFE sediment matrix characterization, and microbiological analyses will be published in report form. Results of soil gas sampling by different collection techniques will be compared and reported in a document evaluating the collection methods.

Once samples have been analyzed and the data validated, the samples will be disposed of by the sampling personnel, or the laboratory analysis personnel. Sampled material that remains on the Hanford Reservation will be disposed of at the drill site where it was collected. If samples are contaminated, dispose of per WHC (1988).

7.0 REFERENCES

PNL, 1991, *Procedures for Ground-Water Investigations*, PNL-MA-567, Pacific Northwest Laboratory, Richland, Washington.

WHC, 1988, *Solid Waste Management*, WHC-CM-5-16, Westinghouse Hanford Company, Richland, Washington.

APPENDIX B

HEALTH AND SAFETY PLAN

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HEALTH AND SAFETY PLAN

This health and safety plan (HSP) addresses potential health and safety issues in a generic manner for characterization during the Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID) and the 200 West Area Carbon Tetrachloride Expedited Response Action (ERA). The HSP consists of the site description, types/sources of contamination, general training and medial surveillance requirements, and plans for general site control and emergency actions.

Specific information such as personal protective equipment, monitoring strategies, and decontamination procedures will be specified in site- /task-specific safety plans taking the form of a job safety analysis (JSA) or a hazardous waste operations permit (HWOP). These safety plans will expand on subjects such as site control, emergency plans, and training requirements in more detail depending on the complexity and degree of hazard associated with each task. The key individuals who will be conducting these tasks will be specified, as will their responsibilities. The standard operating procedures used to carry out the major tasks are found in environmental investigations instructions (EII) (WHC 1988). No confined space entry will be required for this work.

Radiological safety requirements and controls are identified in site- or task-specific radiation work permits (RWP). The RWP identifies radiological conditions expected to be encountered, dosimetry and protective clothing requirements, and Health Physics Technologists (HPT) coverage.

SITE DESCRIPTION

The VOC-Arid ID/ERA is focused on three retired liquid waste disposal facilities associated with the Plutonium Finishing Plant (PFP) plutonium recovery processes: (1) the 216-Z-1A Tile Field, (2) the 216-Z-9 Trench, and (3) the 216-Z-18 Crib. The VOC-Arid ID/ERA activities include use of existing structures (e.g., boreholes, vents, and piping) and installation of wells located within and near these facilities. These three cribs received the bulk of the carbon tetrachloride disposed to the ground between 1955 and 1973, when soil column disposal of carbon tetrachloride associated with PFP processes ceased. Locations and descriptions of the cribs are summarized in this work plan, Section 2.1, Site Operations. Detailed information is available in the ERA proposal (DOE-RL 1991).

TYPES/SOURCES OF CONTAMINATION

The three principal carbon tetrachloride disposal sites received acidic and organic, actinide-bearing liquid wastes (work plan, Section 2.1). Based on existing information, the contaminants discharged to the cribs are both chemical and radiological.

Aqueous solutions discharged to three principal carbon tetrachloride disposal sites were concentrated, acidic, metal nitrate salt wastes. Organic material, including carbon tetrachloride, tributyl phosphate, dibutyl butyl phosphonate, and fabrication oil, were disposed in saturation amounts in the aqueous solution and also separately in batches. Carbon tetrachloride degradation products such as chloroform and methylene chloride, and tributyl phosphate degradation products such as dibutyl phosphate and monobutyl phosphate, are also likely. A cadmium nitrate solution was sprayed on the soil at the 216-Z-9 Trench.

The principal radiological contaminants in the unsaturated zone underlying the three disposal sites are plutonium-239/240 and americium-241. Minor amounts of cesium-137 and strontium-90 are also indicated in the Waste Information Data System database for the 216-Z-9 Trench and the 216-Z-1A Tile Field.

Ground water contaminants identified in the 200 West Area include carbon tetrachloride, chloroform, cyanide, fluoride, hexavalent chromium, trichloroethylene, nitrate, strontium-90, tritium, technetium-99, iodine-129, and uranium.

GENERAL SAFETY ISSUES

Aside from the chemical and radiological contamination present in the area, this project will involve a number of industrial safety issues. Some of the disposal sites involve the potential for cave-in. This could cause personnel injury or equipment damage and will be controlled through strict compliance with safety plans. Equipment used for some tasks will expose personnel to mechanical hazards such as pinch points and overhead hazards. Noise, possible flying objects, and lifting heavy tools and equipment will be involved. Potentially encountering underground utility lines is a concern when driving soil-gas probes or drilling holes; these activities are controlled by excavation permits/geophysical surveys. All equipment used will be in good condition and equipped with the proper safety devices. Safety plans will be developed for the specific work tasks and will adequately address both chemical and industrial safety issues. These plans are reviewed and approved by Westinghouse Hanford Company (WHC) internal safety organizations prior to work initiation.

TRAINING

Work crews at the site will have routine safety meetings and will have received the appropriate training based on the work being carried out. As a minimum, the Occupational Safety and Health Administration (OSHA) Hazardous Waste Worker Training (OSHA 1910.120) and WHC Radiation Worker Training will be required for all team members. Other specific training will be spelled out in safety plans as they are developed. All team members must participate in the Hazardous Waste Worker Medical Surveillance Program as required by EII 1.1, Hazardous Waste Site Entry Requirements (WHC 1988).

SITE CONTROL/EMERGENCY PLANS

With the exception of installation of new wells, field investigation tasks of the FY 93 site evaluation (work plan, Section 3.5) will require relatively few individuals to complete. Site control should not be an issue when inside the 216-Z-1A Tile Field because the tile field is fenced. Site control at the 216-Z-9 Trench, the 216-Z-18 Crib, and other areas will be controlled through the use of control zones where necessary. The field team leader/site safety officer will control and coordinate access to the site. Visitors will be kept at a safe distance from field activities at all times. Only trained team members will be allowed routine access to field activities. Further site control requirements will be identified in safety plans where necessary. Site access and training requirements for visitors are described by Laurenz (1992).

Response to possible emergencies at the site will generally require notification of emergency response personnel either by phone or plant radio. Minor personnel injuries can be treated at the 200 West Area first aid station. Site personnel will discuss actions to be taken in regular safety meetings held at the site. With the exception of installation of new wells, field investigation tasks will not require detailed emergency plans as they are relatively simple, low hazard tasks. As the remedial action decisions are made and tasks become more complex, both emergency plans and safety plans will become detailed.

REFERENCES

DOE-RL, 1991, Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume, DOE/RL-91-32, U.S. Department of Energy, Richland Field Office, Richland, Washington.

Laurenz, J. E., 1992, Field Access Guide for Visitors of the Volatile Organic Compounds - Arid Integrated Demonstration Site, WHC-SD-EN-AR-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, Environmental Investigations and Site Characterization Manual, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, WIDS Database Field Descriptions and Data, WHC-MR-0056, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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