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EXECUTIVE SUMMARY

This document is the Phase III terrestrial ecological sampling and analysis plan (SAP) for the Hanford Site Central Plateau. This SAP is the third in a series of three being implemented to assess ecological risks on the Central Plateau. The activities described in this document will result in contaminant and biotic data that will assist in waste-site decision-making. It will provide information to evaluate the health or condition of the ecosystem across the range of Central Plateau habitats. The plan is based in part on the data-assessment results of the Phase I and Phase II waste-site investigations. These investigations were based on ecological SAPs developed for Central Plateau waste sites, non-waste site areas, and the BC Controlled Area (DOE/RL-2004-42, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase I*, and DOE/RL-2005-30, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase II*, respectively). Phase III studies also will address data gaps on the distribution of radionuclides in soil, based on a review of literature and monitoring data for the Hanford Site. In addition, this plan is based on ecological data quality objectives (EcoDQO) that were developed for two spatial domains – the dispersed carbon tetrachloride plume in the 200 West Area and West Lake (216-N-8 Pond). The objectives of Phase III are summarized as follows.

- Collect information needed based on Phase I and Phase II results
  - More broadly evaluate the distribution of contaminants of potential ecological concern (COPEC) detected in biota samples
  - Reevaluate radionuclide contamination in the BC Controlled Area
  - Resurvey vegetative cover on waste sites.
- Assess the distribution of radionuclides related to air-stack emissions along data-limited air-flow paths in non-waste-site areas.
- Assess potential risks for the remaining spatial domains in the Central Plateau EcoDQOs.
  - West Lake – ecological risk associated with aquatic media, soil, and biotic tissues
  - Dispersed carbon tetrachloride plume – ecological risk of subsurface vapor inhalation by burrowing animals.

The Phase I and Phase II SAPs also were based on EcoDQOs developed for the Central Plateau, starting with WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase I*, and revised in WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase II*. The basis for this Phase III activity (e.g., spatial domains targeted for sampling) is described in WMP-29253, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase III*. The results of all three phases of the investigation will be documented in the Central Plateau Ecological Risk Assessment, planned for fiscal year 2007, as shown in Figure ES-1. The project has benefited from a wealth of existing information for the Hanford Site. In addition to Phase I and Phase II data, this investigation is making use of thousands of records on COPECs resulting from previous remedial investigations of operational areas as well decades of monitoring data for areas outside of waste sites (see Appendix C for an example of data available for non-waste-site areas).

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) established a framework to ensure that environmental effects associated with past and present activities at the Hanford Site are investigated and that appropriate response actions are taken to protect human health and the environment. Within this framework, the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* remedial investigation/feasibility study process is implemented to gather the information needed to arrive at records of decision that authorize remedial actions. The ecological risk assessment supported by this SAP is one of several being performed on the Hanford Site to evaluate ecological risks in support of remedial-action decision making. This document only addresses potential effects to terrestrial ecological receptors on the Central Plateau. It does not address Central Plateau human health or groundwater effects, nor does it consider ecological effects in other portions of the Hanford Site.

Ecological risks are being characterized for the Central Plateau using a phased and tiered approach. Phases are based on spatial domains where the investigation areas for this assessment are located (e.g., BC Controlled Area addressed in Phase II); tiers are types of data collected within these investigation areas (e.g., Tier 1 soil data are collected from 0 to 15 cm, while Tier 2 soil data are below 15 cm). Phase I activities focused on waste sites in the 200 East and 200 West Areas. Phase II evaluated ecological data needs in the US Ecology site, tank farms,

and the BC Controlled Area, with sampling occurring in the latter. As Figure ES-1 shows, waste sites were sampled concurrently in the 200 East and 200 West Areas and the BC Controlled Area. The Phase III activity discussed in this SAP evaluates and fulfills the need for supplemental waste site sampling and sampling in non-waste-site areas outside of the 200 East or 200 West Areas.

Phase III Data Collection Synopsis

Because the Phase III investigations are a logical continuation of Phase I and Phase II studies, the conceptual model, risk questions, assessment endpoints, and measures developed in Phase I (WMP-20570) and Phase II (WMP-25493) are applicable to the data collection plans in Phase III. Phase I and Phase II data collection were followed by a data assessment, which resulted in the identification of uncertainties as to whether COPECs can be eliminated from further consideration as a potential risk driver. These uncertainties likely would be resolved through supplemental data collection. Resurveys of plant cover are planned in Phase III for the Phase I sites, to determine if additional plant species will be documented following the wet winter/spring conditions at the Hanford Site. Supplemental data needs identified for Phase III include additional invertebrate cyanide data from reference sites and waste sites and also include additional sampling for 43 select polychlorinated biphenyl (PCB) congeners and strontium-90 in lizards and mammals. Supplemental data also will be collected for worst case conditions in the BC Controlled Area to assess the potential risk from cesium-137 and strontium-90. The previously planned Phase III activities include development of EcoDQOs for Phase III spatial domains, including risk characterization of West Lake, the 200 West Area dispersed carbon tetrachloride plume, and surface soil sampling in non-waste-site areas to evaluate the air deposition pathway for radionuclides (Table ES-1). Finally, two new provisions were added to the sampling activities to resolve concerns expressed by the Hanford Natural Resource Trustees and the Tri-Party Agreement agency decision-makers. The first is the installation of artificial animal burrows in the 200 West Area for CCl_4 vapor sampling. This is a contingency that will be performed if reconnaissance surveys do not identify animal burrows that intersect the 200 West Area dispersed CCl_4 vapor plume. The second is the addition of two offsite reference sites for soil sampling outside the Hanford Site boundary.

Figure ES-1. Phased Central Plateau Ecological Risk Assessment Emphasizing the Spatial Extent of the Investigations.

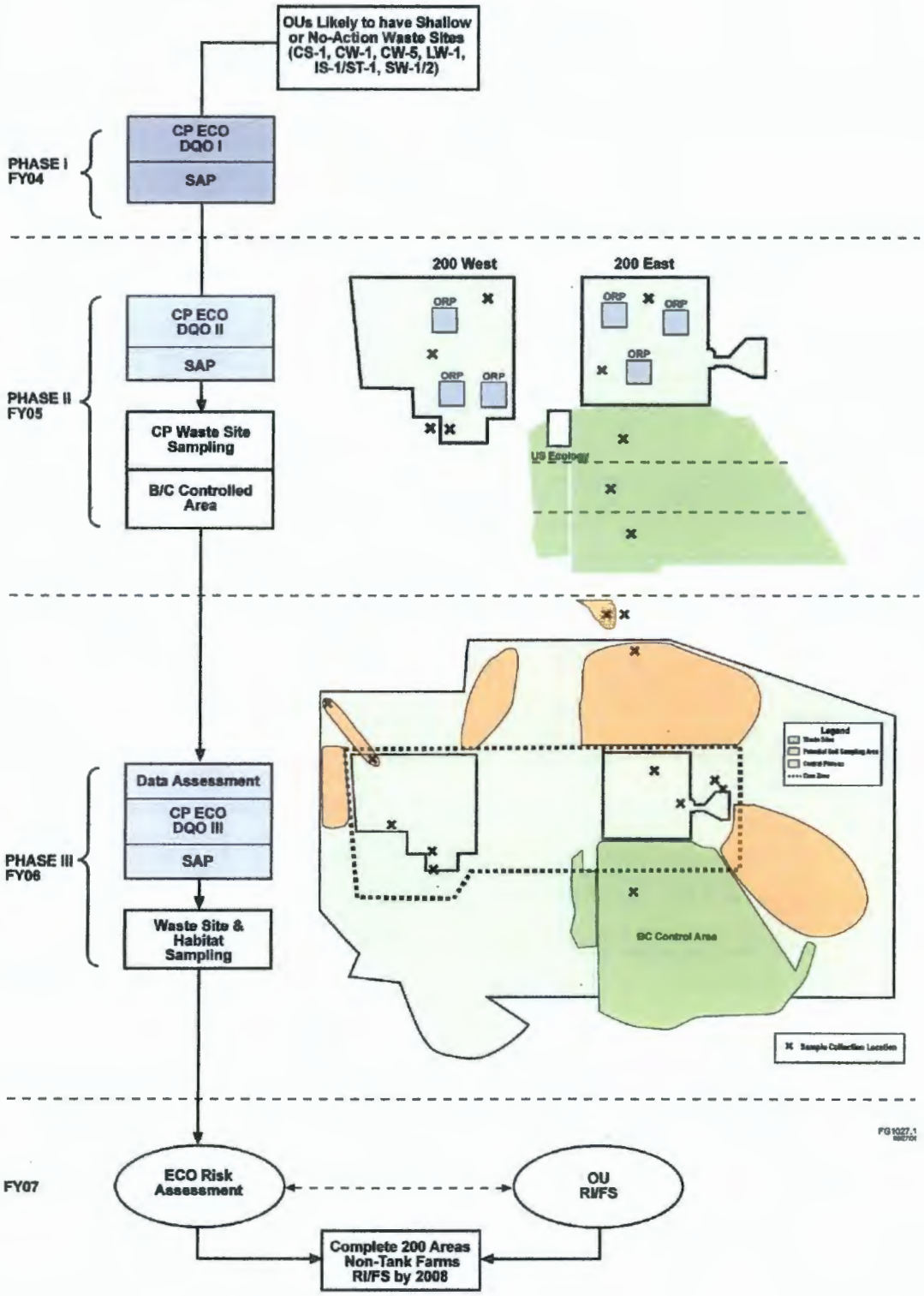

Table ES-1. Phase III Study Design Synopsis. (2 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Supplemental Waste-Site Sampling		
Invertebrate sampling for cyanide	Collect invertebrates in Phase I waste sites, Phase I and Phase II reference sites, and RCBRA reference sites for cyanide analysis (15 sites)	Determine significance of positive cyanide results in Phase I invertebrate samples and the general distribution of cyanide in tissues across the Hanford Site.
Lizard and small mammal sampling for 43 select PCB congeners	Collect lizards and mice in select Phase I investigation areas and four new sample sites near security roads that may have been sprayed with PCB-laden oils (8 sites).	PCB sampling conducted in Phase I was not conclusive. Determine concentrations of PCBs in biota at Phase I waste sites and where PCB laden oils may have been applied for dust control.
Lizard and small mammal sampling for Sr-90	Collect lizards and mice at select Phase I investigation areas and at an additional site (six sites).	Strontium-90 sampling conducted in Phase I was not conclusive. Determine concentrations of Sr-90 in biota at select Phase I investigation areas and at one additional site. This effort will assess the distribution of Sr-90 in vertebrate tissues in waste sites and from non-waste site areas, addressing the spatial extent of Sr-90 in the Hanford Site food web.
Reanalysis of Phase I small mammal tissues for Sr-90	Reanalyze 20% of mouse tissue samples collected from Phase I for Sr-90 using an independent laboratory.	Quality control samples to resolve uncertainties in the Phase I Sr-90 analytical results for biota.
Vegetative characterization in Phase I areas	Repeat vegetative characterization in Phase I areas (seven sites)	The wet conditions observed in 2006 are expected to yield greater numbers and a more complete characterization of Phase I plant species per plot.
Characterization in BC Controlled Area Zone A	Deploy one replicate Phase II investigation area (1 ha) in Zone A to assess ecological risks associated with Sr-90 and Cs-137.	Sum of fractions for Phase II investigation area in the high zone was close (0.083 rad/day) to the DOE dose threshold of 0.1 rad/day for terrestrial wildlife.
Non-Waste-Site Soil Radiological Sampling		
Soil sampling in non-waste-site areas around 200 East and 200 West Areas	Collect multi-increment shallow soil samples along transects near the Phase I and Phase II reference sites and in non-waste site locations outside of 200 East and 200 West Areas for analysis of Am-241, Cs-137, Pu-238, Pu-239/240, and Sr-90.	Multi-increment sample data collected near reference sites will be used to assess the adequacy of Central Plateau reference sites; multi-increment sample data collected in other non-waste-site areas will fill spatial data gaps in existing data sets for soil activity levels.
Offsite reference site sampling	Collect soil sites from two offsite reference sites in 1 ha sample plots. Collect two multi-increment samples from each, from the 0-1 in. and 1-2 in. depths. Collect 50 soil increments from each sample. Duplicate this sampling in the Phase I and Phase II onsite reference sites.	This responds to concerns expressed by the Hanford Natural Resource Trustees and the Tri-Party Agreement agency decision-makers over the use of reference sites within the Hanford Site boundary
Carbon Tetrachloride Sampling		
Passive gas measurements of carbon tetrachloride in surface soil	Collect EMFLUX® samples to screen for presence and relative magnitude of carbon tetrachloride at animal burrows targeted for pore-gas sampling.	Provide verification that carbon tetrachloride is present in soils around burrows targeted for active soil-gas measurements before initiating active gas-data collection.
Active gas measurements of burrow air	Quantify carbon tetrachloride concentration in burrows by actively withdrawing sample of burrow air.	Perform field verification of carbon tetrachloride concentration in animal burrows to evaluate exposures to burrowing receptors.

Table ES-1. Phase III Study Design Synopsis. (2 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Contingency installation of artificial animal burrows for active burrow air measurements	If animal burrows are not detected in the habitat areas during reconnaissance surveys, six artificial animal burrows will be installed for the collection of vapor samples.	Perform field verification of carbon tetrachloride concentrations in artificial animal burrows to evaluate exposures to potential burrowing receptors.
West Lake		
Soil radiation surveys	Perform radiological surveys around the perimeter of West Lake. Existing data show that 1 of 11 soil samples was above the screening value for Cs-137 in soil.	Determine if there are elevated radiological measurements in soils surrounding West Lake.
Surface water sampling	Collect multi-increment surface water samples from West Lake. Subsample into filtered and unfiltered sample. Analyze for radionuclides, metals, and anions. Perform non-COPEC analyses for chemical characterization of lake water.	Determine if existing data on unfiltered water is representative of surface water in West Lake. Pore water is collected on the assumption that it represents the most concentrated constituent conditions. Non-COPEC analyses will provide insight into the chemical/geological nature of West Lake.
Pore water sampling	Collect multi-increment pore water samples from West Lake. Subsample into filtered and unfiltered sample. Analyze for radionuclides, metals, and anions. Perform non-COPEC analyses for chemical characterization of lake water.	
Sediment sampling	Collect multi-increment sediment samples from the perimeter of the West Lake shoreline. Analyze for radionuclides and metals, total organic carbon, acid volatile sulfide, total sulfides.	Determine biotic exposure from sediments.
	Analyze sediment samples for semivolatile organic compounds, tributyl phosphate, and normal paraffin hydrocarbons.	Test the conceptual model that organic contaminants are not in West Lake.
Salt-crust sampling	Collect multi-increment salt-crust samples around the perimeter of West Lake. Analyze for radionuclides, metals, and anions. Perform non-COPECs analyses for total hydroxide and total carbonate, and for crystal structure.	Evaluate radiological dose and metal exposure to animals using the crust as a source of minerals. Non-COPEC analyses will provide insight into the chemical/geological nature of West Lake.
Brine fly sampling	Collect larvae or adult brine flies around West Lake and analyze for radionuclides and metals.	Determine contaminant uptake in brine flies for modeling effects on aerial insectivores (bats, birds).
Reconnaissance surveys	Perform monthly biological surveys at West Lake and aquatic macroinvertebrate collection. Include monthly measurements on conductance, pH, dissolved oxygen, and temperature at West Lake.	Determine biological use and diversity at West Lake.

®EMFLUX is a registered trademark of Beacon Environmental Services, Inc., Bel Air, Maryland.
COPEC = contaminant of potential ecological concern.
DOE = U.S. Department of Energy.
PCB = polychlorinated biphenyl.
RCBRA = River Corridor Baseline Risk Assessment.
Tri-Party Agreement = Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended.

Supplemental Waste-Site Data Collection. The assessment of cyanide in invertebrates and of PCBs in animal tissues, a survey of vegetation, and further investigation in the BC Controlled Area will yield the types of data that are needed to supplement Phase I and Phase II results from waste sites.

Cyanide in Invertebrates. The data assessment of Phase I and Phase II data identified cyanide as a COPEC requiring further investigation. Cyanide was not detected in soil data collected in Phase I and Phase II of the Central Plateau EcoDQO activity and has been detected infrequently in remedial-investigation sampling of waste-site soil (WMP-20570, Appendix D; overall detection rate <2 percent). Given the low detection frequency in soils, additional soil samples for cyanide analysis are not warranted. Cyanide was, however, regularly detected in biotic tissues (invertebrates, mice, and lizards) from Phase I waste sites and from the Phase I reference site. Consumption of cyanide-containing invertebrates was shown to pose a potential risk to insectivorous birds (killdeer) through exposure modeling. To address these uncertainties, invertebrate tissue samples will be collected at the Phase I and Phase II reference sites, the six Phase I waste sites, and at seven reference sites of the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment, for a total of 15 sites. Invertebrates from each location will be divided into three subsamples for analyses.

PCBs in Tissues. Sampling and analysis of 43 PCB congeners in biota is planned to address uncertainty regarding the nature and extent of PCBs in animal tissues. PCBs were detected at some Phase I investigation areas in lizards and mice, but PCBs were not detected in soil at these sites. To address these uncertainties, lizards and mice at four Phase I investigation areas will be sampled. Tissue samples also will be collected near old roads that may have been sprayed with PCB-laden oils to evaluate these as potential sources. For the Phase III PCB analyses, U.S. Environmental Protection Agency Method 8082 (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*) will be used to measure selected congeners, and then they will be summed to total the PCBs. This method has adequate sensitivity and is robust to the environmental weathering or food chain transport that could affect the ratios of congeners from the original Aroclor[1] mixture. Alternatively, Method 1668 will be considered. Details on the process used to select the congeners are presented in Chapter 1.0 of this SAP.

Strontium-90 in Tissues. Strontium-90 was detected in lizard and mouse tissue at the Phase I reference site and at Phase I and II waste sites. Because the detections at the reference site were

[1] Aroclor is an expired trademark.

unexpected, the remaining material (only mouse tissue was available) was reanalyzed by a second laboratory. Reanalysis of mouse tissue with the highest detections of strontium-90 resulted in non-detected concentrations, indicting potential analytical error with the original analyses. The samples are being submitted to a third laboratory for an independent assessment. While it would appear that strontium-90 is not a risk driver, strontium-90 will be analyzed in lizards and mice at select sites targeted for Phase III vertebrate sampling. In addition to collecting data from waste sites, this effort also will provide strontium-90 tissue results from reference sites and from non-waste site areas to address the spatial extent of strontium-90 in the Hanford Site food web in non-operational areas.

Vegetative Characterization. Vegetation cover and species composition is proposed to be resurveyed as part of the Phase III ecological risk assessment, to supplement data gathered to assess relationships of plant composition and cover with other measures of environmental quality that are identified in the SAP (e.g., population/community health attributes of plants, invertebrates, lizards, small mammals, birds). Surveys of Phase I waste sites occurred early in a dry year (2005), and the vegetation recorded may not be reflective of species typical of an average- or high-rainfall year. Plant species data gathered in 2006 should be collected during the spring (April-May), when conditions are favorable, to visually observe and identify a nearly complete list of plant species. This period was captured for Phase II sites during 2005, and they are not planned for surveys in 2006. Shrub canopy cover surveys will not be conducted during Phase III, because results generated during 2005 are not expected to change substantially after one year.

BC Controlled Area. Three zones were sampled in the BC Controlled Area in Phase II of the Central Plateau EcoDQO. The radionuclides cesium-137 and strontium-90 were the COPECs sampled. Strontium-90 uptake from soil to invertebrates was documented, and the sum of fractions (SOF) of both radionuclides approached the U.S. Department of Energy dose limit to be considered as a protective radiation threshold. Specifically, the area of highest contamination, Zone A, resulted in an SOF of 0.083 rad/day, and the threshold for terrestrial wildlife is 0.1 rad/day; rounding up, the Zone A SOF is equivalent to the dose limit. To address uncertainties with potential risk in the BC Controlled Area, Zone A will be resampled in Phase III for cesium-137 and strontium-90 in invertebrates, mice, lizards, and soil.

Non-Waste-Site Soil Radiological Sampling. Past Hanford Site operations released radionuclides through air-stack emissions, which represent a potential source for surface-soil contamination. A focus of the Phase III Central Plateau EcoDQO activity is to assess the ecological condition of non-waste-site areas that may have been impacted by air-stack emissions. These data also will supplement existing Near-Facility Monitoring Program and Surface Environmental Surveillance Project radionuclide data. This activity involves soil sampling in non-waste-site areas where data are limited on air-deposition radionuclides. Specifically, soil transects along presumed deposition pathways will be sampled for cesium-137, strontium-90, and isotopic plutonium. It will be determined whether mean concentrations of COPECs detected in surface-soil samples are greater than mean background values (DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*) or mean concentrations at reference sites.

Dispersed Carbon Tetrachloride Plume. Carbon tetrachloride was used extensively at the Hanford Site, mainly in the plutonium-recovery process. Discharges to the soil column have resulted in a dispersed groundwater carbon tetrachloride plume in the 200 West Area. Since 1994, the Hanford Site has been pursuing carbon tetrachloride remediation activities using soil-vapor extraction and groundwater pump-and-treat operations. Because carbon tetrachloride can partition into a gas phase, the focus of the carbon tetrachloride Phase III investigation is on the soil-gas exposure pathway to burrowing small mammals. While air inhalation is typically not a risk driver in ecological risk assessments (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*; EPA 2003, *Guidance for Developing Ecological Soil Screening Levels, Attachment 1-3, Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purposes of Setting EcoSSLs*, OSWER Directive 9285.7-55), air below ground may be an important exposure medium to burrowing receptors for volatile organic carbons emanating from the subsurface.

As part of the Phase III EcoDQO activity, available soil-gas and other relevant data from the Hanford Site soil-gas monitoring program were evaluated based on subsurface air as an exposure medium on the Central Plateau. Specifically, existing active-gas data on carbon tetrachloride in subsurface air were compared to an inhalation-based ecological screening level developed for carbon tetrachloride; this threshold was exceeded in many areas associated with the dispersed

carbon tetrachloride plume in the 200 West Area. Maps plotting carbon tetrachloride ecological screening-level exceedances will be used in field reconnaissance activities to identify candidate burrows for pore-gas measurements. EMFLUX[2] Sampler soil passive-gas measurements will be collected at animal burrows targeted for pore-gas sampling to verify that carbon tetrachloride is present in surface soils associated with the burrow. Based on this screening step, burrow gas will be measured in animal burrows by actively collecting gases from burrows to empirically determine the concentration of carbon tetrachloride and its chlorinated degradation products in burrow air.

West Lake. West Lake represents a unique and dynamic ecological feature at the Hanford Site. It is a small alkaline lake that predates the Hanford Site, and the lake's expanse has varied over time. During Hanford Site operations, wastewater discharges from the Plutonium-Uranium Extraction Plant and the B Plant elevated groundwater and subsequently expanded the size of West Lake. Subsurface discharge was discontinued (1995) in the 200 Areas, and subsequently the lake has decreased in size. In recent years, the lake has ranged from a water-covered expanse of hundreds of square meters to a small muddy pond. Thus, West Lake is responsive to long-term and short-term climatologic and seasonal conditions, such as wet years or large precipitation events.

Of concern are the possible effects of radionuclides and chemicals on the local ecosystem. Media previously sampled at West Lake include soil, water, sediment, and biological tissues. As part of the Phase I EcoDQO activity, a screening-level ecological risk assessment was conducted that identified surface water as a medium of concern for radionuclides, as well as several data gaps that need to be addressed. Existing soil data for West Lake had one result out of 11 samples that exceeded the cesium-137 ecological screening threshold. Consequently, soil radiation surveys will be performed around the perimeter of West Lake to better understand the extent of elevated radionuclide levels. Radiological survey data will be assessed to determine whether a more comprehensive soil-sampling campaign is needed.

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[2] EMFLUX is a registered trademark of Beacon Environmental Services, Inc., Bel Air, Maryland.

Despite annual surveillances and routine monitoring, West Lake data on inorganic chemicals in sediment and water are limited. Organic chemicals were used in the processes associated with the Plutonium-Uranium Extraction Plant and the B Plant, but organic chemicals have not been detected in groundwater wells near West Lake. However, the West Lake investigation will include analysis for semivolatile organic compounds in sediment, to confirm their presence or absence as COPECs. Multi-increment samples for metals and radionuclide analyses will be collected for sediment and surface water. The water samples will be differentiated into filtered and unfiltered fractions for separate analyses. In addition, sediment interstitial water (pore water) will be collected and analyzed for metals and radionuclides to capture the worst case conditions (highest concentrations) for contaminants in water. The salt crust around the perimeter of the lake will be sampled for radionuclides and metals, to estimate the dose to wildlife potentially using this substrate to obtain trace minerals. The chemical composition and mineralogical structure of the crust also will be assessed. Brine fly larvae or adults will be sampled for metals and radionuclides, to assess the potential food-web exposure route to insectivorous receptors (bats, birds) around West Lake.

There is little documentation of recent wildlife use of West Lake. Lacking sufficient biological information from West Lake, reconnaissance surveys will be conducted to better describe current biological pathways, as well as to estimate the duration each year that these pathways exist. Reconnaissance surveys will provide a basis for ecological exposure potential associated with West Lake sediments, soils, water, salt crust, and biota.

The idea of a reference site was proposed for West Lake but, considering the lake's unique nature, no equivalent bodies of water at the Hanford Site are available for comparison. In addition, none of the proposed measures or reconnaissance activities require a reference site to evaluate ecological risks. Consequently, West Lake will be sampled as a singular entity, and a West Lake reference site will not be employed.

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TERMS

AEA	alpha energy analysis
ALARA	as low as reasonably achievable
AVS	acid volatile sulfide
CCC	criteria continuous concentration
CFR	*Code of Federal Regulations*
COPEC	contaminant of potential ecological concern
DOE	U.S. Department of Energy
DQO	data quality objective
EcoDQO	ecological data quality objective
EPA	U.S. Environmental Protection Agency
ERAGS	*Ecological Risk Assessment Guidance for Superfund* (EPA/540/R-97/006)
ESL	ecological screening level
FE	fundamental error
FH	Fluor Hanford, Inc.
FSP	field sampling plan
GEA	gamma energy analysis
GM	Geiger-Müller
GPC	gas proportional counter
HEDR	Hanford Environmental Dose Reconstruction (Project)
HEIS	*Hanford Environmental Information System* database
ICP	inductively coupled plasma
LOEC	lowest observed effect concentration
MDL	minimum detection level
MIS	multi-increment sample/sampling
N/A	not applicable
NaI	sodium iodide (detector)
ORNL	Oak Ridge National Laboratory
PAM	portable alpha meter
PCB	polychlorinated biphenyl
ppmv	parts per million by volume
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCBRA	River Corridor Baseline Risk Assessment
RL	Richland Operations Office
SAP	sampling and analysis plan
SESP	Surface Environmental Surveillance Project
SOF	sum of fractions
SQuiRTs TEL	*Screening Quick Reference Tables* threshold-effect level (NOAA 1999)
SVOA	semivolatile organic analysis
SVOC	semivolatile organic compound

TAL	target analyte list
TBD	to be determined
TBP	tributyl phosphate
TDS	total dissolved solids
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
WAC	*Washington Administrative Code*
XRD	X-ray diffraction

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	Millimeters	millimeters	0.039	inches
inches	2.54	Centimeters	centimeters	0.394	inches
feet	0.305	Meters	meters	3.281	feet
yards	0.914	Meters	meters	1.094	yards
miles	1.609	Kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	Hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	Grams	grams	0.035	ounces
pounds	0.454	Kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	Milliliters	milliliters	0.033	fluid ounces
tablespoons	15	Milliliters	liters	2.1	pints
fluid ounces	30	Milliliters	liters	1.057	quarts
cups	0.24	Liters	liters	0.264	gallons
pints	0.47	Liters	cubic meters	35.315	cubic feet
quarts	0.95	Liters	cubic meters	1.308	cubic yards
gallons	3.8	Liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

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1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the rationale and strategy for the final phase (Phase III) of data collection being performed to characterize ecological risks associated with the Hanford Site Central Plateau. This SAP is modeled after the Phase I and Phase II ecological sampling and analysis plans developed for the Central Plateau (DOE/RL-2004-42, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan – Phase I*, and DOE/RL-2005-30, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase II*, respectively). The Phase I and the Phase II SAPs are based on ecological data quality objectives (EcoDQO), as documented in WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase I*, and WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase II*. The Phase III EcoDQOs are documented in WMP-29253, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase III*.

The sampling and analysis activities described in this document will provide contaminant and biotic data to support remedial-action decision making and will provide information to evaluate the health or condition of the ecosystem across habitats. The SAP has benefited from a wealth of existing information for the Hanford Site. In addition to Phase I and Phase II data, this investigation is making use of thousands of records on contaminants of potential ecological concern (COPEC) resulting from previous remedial investigations of operational areas as well decades of monitoring data for areas outside of waste sites (see Appendix C for an example of data available for non-waste-site areas). These data will supplement other characterization activities being performed for the Central Plateau and may assist the Hanford Natural Resource Trustees in understanding the current condition of the Central Plateau ecosystem. In addition to the EcoDQOs (WMP-20570, WMP-25493, and WMP-29253), the characterization activities described in this SAP are based on EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)* (ERAGS), Steps 3 and 4, as a basis for data quality objective (DQO) Steps 1-7.

As part of the quality assurance project plan (QAPjP), the activities described in this document meet the project quality assurance (QA) requirements. The Hanford Site internal laboratory QA requirements implement the following governing documents:

- *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) QA requirements (Ecology et al. 1989)
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, as amended.

1.1 BACKGROUND

The Hanford Site became a Federal facility in 1943, when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980s, when the mission changed from producing nuclear

materials to cleaning up the radioactive and hazardous wastes that had been generated during the previous years. The Central Plateau consists of approximately 75 mi^2 (195 km^2) near the middle of the Hanford Site. It contains approximately 900 excess facilities formerly used in the plutonium production process. A more complete description of the operations and waste streams associated with the Central Plateau within the industrialized Core Zone is summarized in the Phase I and Phase II SAPs (DOE/RL-2004-42 and DOE/RL-2005-30, respectively). Figure 1-1 presents a map of the Hanford Site Central Plateau, including waste site and Core Zone boundaries.

1.2 PHASED APPROACH

The Central Plateau ecological risk assessment consists of three phases. Phases I and II were conducted between 2004 and 2005. An overview of the phased sampling approach and the spatial extent of the investigation phases are shown in Figure 1-2. The spatial components of both Phase I and Phase II of the EcoDQO were characterized in fiscal year 2005, as depicted in Figure 1-2.

Phase I activities focused on the Central Plateau in the industrialized Core Zone.[3] Phase II expanded the consideration of sampling domains to the US Ecology site, tank farm areas, and the BC Controlled Area. Data collection for Phases I and II was followed by a data assessment. This SAP addresses uncertainties encountered during the data assessment for the Phase I and II investigation areas, as well as those associated with the Phase III spatial domains of West Lake, the dispersed carbon tetrachloride plume in the 200 West Area, and surface soil sampling in non-waste site areas.

Results of all three phases of investigation will be documented in the Central Plateau Ecological Risk Assessment, planned for fiscal year 2007, as shown in Figure 1-2. The risk assessment will employ relevant data from the literature (both from the Hanford Site and from other locations) and all data collected in association with the Central Plateau EcoDQO activity.

[3]This application of the Core Zone boundary is defined in the Tri-Parties response ("Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area" [Klein et al. 2002]) to the HAB advice (HAB 132, "Exposure Scenarios Task Force on the 200 Area"), and in the *Report of the Exposure Scenarios Task Force* (HAB 2002).

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Figure 1-1. Spatial Boundary for the Central Plateau Ecological Data Quality Objectives.

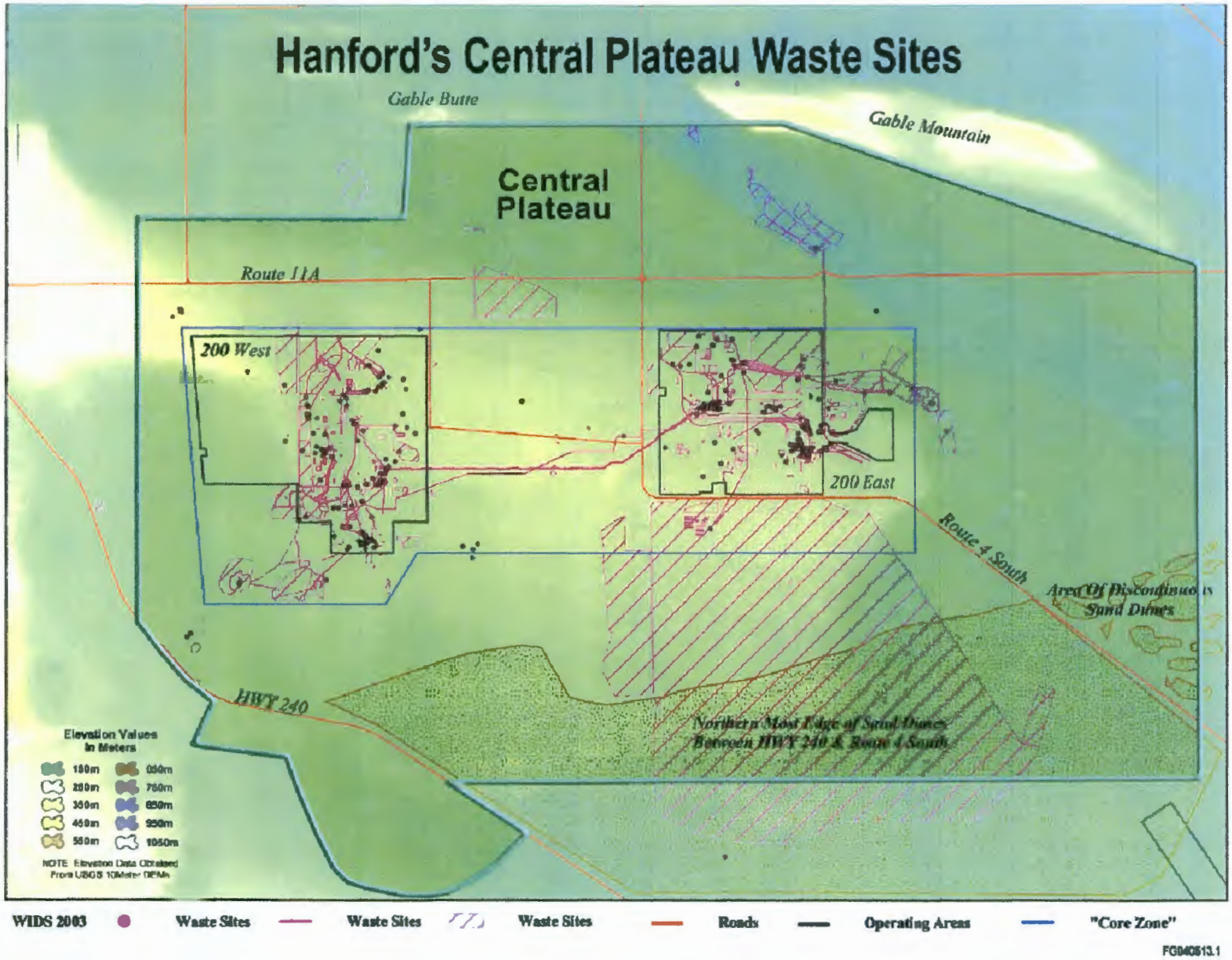
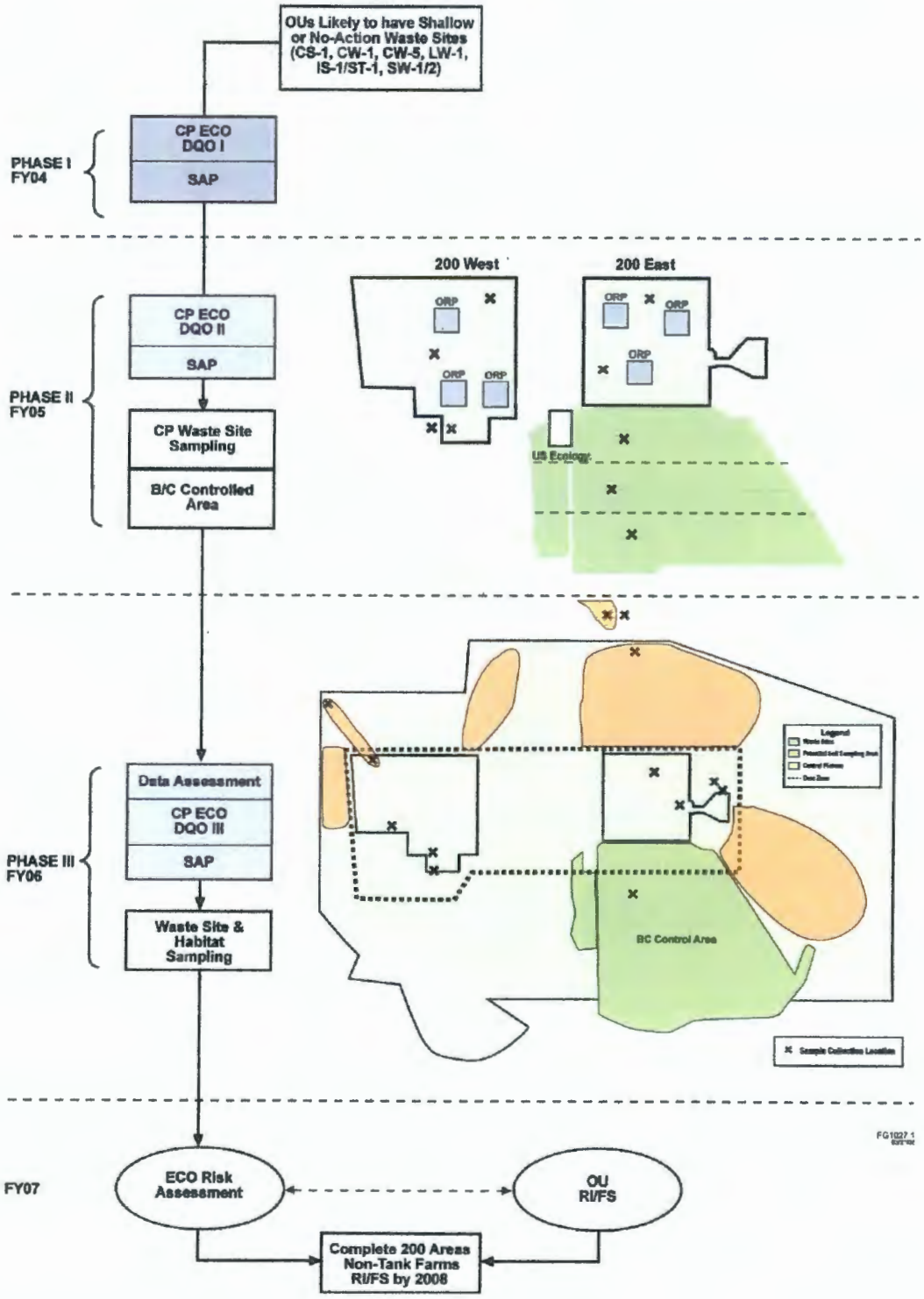


Figure 1-2. Phased Central Plateau Ecological Risk Assessment Emphasizing the Spatial Extent of the Investigations.



1.2.1 Phase I

Phase I characterized the exposure and ecological effects of COPECs from Central Plateau Core Zone waste sites (potentially affected locations) and reference areas (assumed unaffected areas), focusing on waste sites with existing soil COPEC concentration data, by collecting Tier 1 soil and biota data (where tier refers to the complexity of data):

- Collected surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (polychlorinated biphenyls [PCB], pesticides)
- Collected radiological field data for beta- and gamma-emitting radionuclides in soils (e.g., burrow spoils), ant nests, and plants to test the conceptual site model of upward contaminant transport
- Collected biological data including body burden analysis for metals, radionuclides, and organics (PCBs, pesticides) in small mammals, lizards, and invertebrates
- Documented any abnormalities in the field notes for the vertebrate animals collected, to provide qualitative information of the possible effects of COPECs on biota
- Performed reviews of literature and studies relevant to the Hanford Site, and collected exposure-parameter data relevant to the Hanford Site terrestrial receptors and exposure pathways.

1.2.2 Phase II

The spatial domain of the Phase II investigation included the BC Controlled Area, US Ecology site, and tank farm areas. The US Ecology Site and the tank farm areas were inappropriate for ecological sampling during the EcoDQO activities for the Central Plateau. The rationale for not sampling these locations is documented in the Phase II SAP (DOE/RL-2005-30). Consequently, Phase II involved consideration of ecological effects of COPECs from the BC Controlled Area only by collecting Tier 1 soil and biota data:

- Collected surface soil samples to a depth of 15 cm (6 in.) for radionuclides in the BC Controlled Area
- Collected radiological field data for beta- and gamma-emitting radionuclides in soils (e.g., burrow spoils), ant nests, and plants to test the conceptual site model of biological transport
- Collected biological data including body burden analysis for radionuclides in the BC Controlled Area in small mammals, lizards, and invertebrates
- Provided field documentation of abnormalities for the animals collected
- Reviewed studies and exposure-parameter data relevant to Hanford Site terrestrial receptors and exposure pathways.

1.2.3 Phase III

Phase III began with a data assessment of the results from the Phase I and Phase II data collection. The intent of Phase III is to test aspects of the conceptual model and define and fulfill data needs to complete the Central Plateau risk assessment. Specific objectives of Phase III are summarized below:

- Collect information needed based on Phase I and Phase II results
  - More broadly evaluate the distribution of COPECs detected in biota samples
  - Reevaluate radionuclide contamination in the BC Controlled Area
  - Resurvey the vegetative cover on waste sites
- Assess the distribution of radionuclides related to air-stack emissions along data-limited air-flow paths in non-waste-site areas
- Assess potential risks for the remaining spatial domains in the Central Plateau EcoDQO
  - West Lake – ecological risk associated with aquatic media, soil, and biotic tissues
  - Dispersed carbon tetrachloride plume – ecological risk of subsurface vapor inhalation by burrowing animals.

1.3 DATA ASSESSMENT OF PHASE I AND PHASE II DATA

Observations, conclusions, and recommendations of the data assessment for the Phase I and Phase II data are summarized below.

Observed exposure and ecological effects of COPECs from Central Plateau Core Zone waste sites (potentially affected locations), reference areas (assumed unaffected areas), and the BC Controlled Area include the following.

- Radiation surveys showed that elevated radionuclide activities were measured primarily at the BC Controlled Area "High" investigation area. Both gamma- and beta-radiation measurements were elevated at this area.
- Plant measures varied between Phase I and Phase II sites. The reference sites tended to have greater species diversity, and plant cover was highly variable between the waste sites. Animal relative abundance generally was similar among reference sites and waste sites. Relative abundance was variable, and one site did not have any lizards. The absence of lizards at the 2607-E6 Septic Tank and Tile Field was thought to be related to the low relative insect density and plant composition at this site; small mammals were captured at the site without lizards. At all sites, five mammal species were caught, and males outnumbered females.

- One potential uncertainty regarding the vegetative characterization is the timing of the surveys during a relatively dry year (2005). Vegetative characterization conducted in an average-to-wet year could yield more plant species in each plot; therefore, field reconnaissance for plants has been recommended for the Phase I sites surveyed early in 2005.

- Soil COPECs were identified by using statistical comparisons to reference site data and comparisons to Hanford Site background concentrations. Graphical plots were reviewed for outliers as another way to include an analyte as a COPEC (in this project, outlier simply refers to data that do not group within the primary distribution). This process resulted in 17 soil COPECs: arsenic, barium, boron, cadmium, chromium, copper, lead, molybdenum, nickel, zinc, Aroclor-1254,[4] Aroclor-1260, Cs-137, Ra-226, Ra-228, Pu-239/240, and Sr-90.

- Tissue (invertebrate, lizard, and small mammal) COPECs were identified based on statistical comparison of waste sites to reference sites, statistical evaluations to determine if tissue and soil data were correlated, and inspection of results to identify outliers. This process resulted in 18 tissue COPECs: arsenic, boron, cyanide, lead, molybdenum, nickel, silver, thallium, vanadium, zinc, Aroclor-1254, Aroclor-1260, Cs-137, Ra-226, Pu-239/240, Sr-90, U-234, and U-235.

- Sample results for the Phase I and Phase II reference sites were reviewed. Data for PCBs and Sr-90 resulted in the following conclusions and recommendations:

  - Aroclor-1254 was detected in reference site lizards. Aroclors were not detected in soil at the reference site or in any insect or asphalt samples. Aroclor-1254 was detected in two lizards, one at the 216-B-63 Ditch and the other at the 216-B-3 B Pond. Aroclor-1260 was detected in soil only at the 2607-E6 Septic Tank and Tile Field and was detected in small mammals only at the 216-B-63 Ditch. Thus, there is uncertainty regarding the source of Aroclors, and additional tissue data will be collected in Phase III to address these uncertainties

  - Strontium-90 originally was detected in two reference site mammals and one lizard. These results were suspect and, upon reanalysis, were not reproducible (for mammals only; there was not enough material to reanalyze for lizards). The project reanalyzed small mammal tissue from the two reference sites and two waste sites, and the original and reanalysis results are presented in Table 1-1. It is apparent that the original results generally were higher than those of the reanalysis. The reanalyzed samples are within the ranges expected, especially for the reference sites that were expected to be non-detects. A thorough investigation of the reason for this and its impact is under way. There may be uncertainty regarding the source of Sr-90 if these results are confirmed. Additional field collection of vertebrate tissue samples is planned.

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[4] Aroclor is an expired trademark.

Table 1-1. Summary of the Reanalysis of Strontium-90 in Small Mammal Tissues.

Site Name	Original HEIS ID	Original Sr-90 Result (pCi/g)	Reanalysis HEIS ID	Reanalysis Sr-90 Result (pCi/g)
2607-E6 Septic Tank and Tile Field	B1CVB3	34	B1CVB3A	-0.082*
Ref-1	B1CVC5	160	B1CVC5A	-0.042*
Ref-1	B1CVD0	15	B1CVD0A	-0.017*
BC Controlled Area-low	B1D9D3	31	B1D9D3A	1.12
Ref-2	B1D9F4	14	B1D9F4A	-0.095*

* = non-detect.
HEIS = *Hanford Environmental Information System* database.
ID = identification number.

Conclusions drawn from the Phase I/II sampling include the following.

- The ecological exposure analysis for the soil and tissue COPECs identified two COPECs (cyanide and thallium) with hazard quotients between 1 and 5.
- Six COPECs were identified in tissues only (cyanide, thallium, silver, vanadium, U-234, and U-235). Existing remedial-investigation waste-site data were reviewed along with other lines of evidence to determine if deeper soil sampling or additional lateral sampling were needed for these COPECs. The need for additional sampling was evaluated for cyanide, silver, thallium, vanadium, U-234, and U-235. A summary of this review is presented below.
  - Cyanide: Phase I non-detects in surface soil are consistent with the overall 2 percent detect rate for the remedial-investigation samples collected at waste sites (297 samples collected; WMP-20570, Appendix D). Cyanide was detected in waste site and reference site biota tissues. Many insects contain or produce natural cyanide; however, vertebrates do not, and detections in lizards and small mammal tissues are unexpected. Because a waste site source of cyanide was not identified via soil analyses, confirmation of the analytical validity of cyanide detection in tissues is being addressed by the laboratories responsible for tissue analyses. The data assessment indicated that cyanide in invertebrates posed a potential risk from dietary exposure to birds. To provide additional information on the nature and distribution of cyanide at the Hanford Site, sampling invertebrates at the Phase I and Phase II reference sites and performing analysis for total cyanide by using standard sample preparation and total cyanide analysis methods is proposed for Phase III.
  - Silver: Silver was undetected in soil, and reported non-detect levels were much less than soil background concentrations. There was a single outlier in a 2607-E6 Septic Tank and Tile Field mouse at roughly 10 times the next largest detect. In conclusion, deeper soil data for silver are not warranted, based on the single elevated value in tissue and because of the low overall detection frequency in waste-site characterization data (27 of 289 samples were above background; WMP-20570, Appendix D).

- Thallium: There were three outlier values in invertebrates (2 to 4 times larger than the next largest detect). Waste-site soil-characterization data for thallium were similar to global crustal abundance estimates. The data assessment indicated a potential risk to small mammals from thallium in invertebrate tissue. However, risks from thallium are overstated, because the thallium mammalian toxicity reference value is extremely protective, because it is based on thallium administered as a soluble salt in water. Of 200 total samples, 110 were non-detects (range was 0.29 to 1.6 mg/kg) and 90 were detects (range was 0.09 to 1.7 mg/kg) (WMP-20570, Appendix D). In conclusion, deeper soil data and small-mammal population studies for thallium are not warranted, based on the lack of thallium in Hanford Site processes and the low detection frequency around estimated background in waste-site characterization data.

- Vanadium: No waste-site soil vanadium concentrations were greater than background. In tissues there was a single outlier in a 216-U-10 U Pond mouse (30 percent larger than the next largest value). A weak statistical trend was observed between soil and lizard-tissue concentrations. Of 277 total samples, there was 1 non-detect, but only 2 of 276 detects were greater than background (WMP-20570, Appendix D). In conclusion, deeper soil data for vanadium are not warranted, based on the single elevated value in tissues and the low overall frequency of samples above background in waste-site characterization data.

- Uranium-234: No waste-site soil U-234 concentrations were greater than background. In tissues there was a single outlier in a 216-U-10 U Pond lizard (about 3 times larger than the next largest value). Of 55 total samples, 6 were non-detects, but only 10 of 49 detects were greater than background (including >1.8 m or 6 ft depth at U Pond) (WMP-20570, Appendix D). In conclusion, deeper soil data for U-234 are not warranted, based on a single elevated value in tissues and the low overall frequency and magnitude of samples above background in waste-site characterization data.

- Uranium-235: No waste-site U-235 concentrations were greater than background. In tissues there were four outliers in lizards from the 216-B-63 Ditch and the 216-U-10 U Pond locations (about 50 percent larger than the next largest value). There was a weak statistical correlation between mice and soil. Of 250 total samples, 229 were non-detects, but only 21 detects are greater than background (WMP-20570, Appendix D). In conclusion, deeper soil data for U-235 are not warranted, based on modestly elevated values in tissues and the low overall frequency and magnitude of samples above background in waste-site characterization data.

Based on the Phase III data assessment, additional sampling of Phase I waste sites and the reference sites is needed to address uncertainties identified during data assessment:

- Additional collection of invertebrates at reference sites for cyanide analysis
- Additional collection of lizard and mammal tissues for analysis of 43 PCB congeners and Sr-90
- Repeat vegetative characterization at Phase I sites during an average-to-above-average spring rainfall
- No Tier 2 (e.g., soil data below 15 cm) measures are planned for any receptors.

The estimated Cs-137 and Sr-90 dose contribution from Phase II soil data in the most highly contaminated portion of the BC Controlled Area approaches the DOE sum-of-fractions (SOF) dose limit. Therefore, additional characterization is recommended in Zone A to reduce uncertainty.

1.4 SUMMARY OF PHASE III ECOLOGICAL DATA QUALITY OBJECTIVES

The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. As part of the DQO process, the SAP is the basis for establishing the quantity and quality of data needed to support ecological risk-management decisions. EPA/600/R-96/055, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, was used to support the development of this SAP.

This section summarizes the key outputs resulting from ERAGS (EPA/540/R-97/006), which was used to implement the seven-step DQO process. Additional details are provided in the Phase I, Phase II, and Phase III EcoDQO documents (WMP-20570, WMP-25493. and WMP-292253). Sections 1.4.1, "Statement of the Problem," and 1.4.2, "Limits of Decision Error," pertain to all DQOs. The EcoDQOs specified for the Phase III evaluation are organized by spatial domain.

1.4.1 Statement of the Problem

The purpose of the EcoDQO document is to define the scope and data needs to support a baseline ecological risk assessment of the Central Plateau. Background documentation on the Central Plateau waste sites and the processes contributing to those waste sites and reference locations within the industrialized Core Zone is summarized in the Phase I and Phase II SAPs (DOE/RL-2004-40 and DOE/RL-2005-30, respectively). The spatial domains under consideration in Phase III include the dispersed carbon tetrachloride plume in the 200 West Area, West Lake, evaluation of surface soils in non-waste-site areas for air-stack deposition, and supplemental data collection from Phase I and Phase II waste sites (Figure 1-2). This SAP

describes the general approach and data to be collected in Phase III that are necessary to perform the ecological risk assessment for the Central Plateau. Brief summaries of the Phase III focus areas for sampling, the basis of the sampling activity, and the targeted COPECs are presented in the sections that follow.

1.4.2 Limits of Decision Error

The evaluation of uncertainty in ecological risk assessments requires more than simply calculating confidence limits on means used in exposure concentrations. Given the complexity of interpreting ecological data, professional judgment was used to structure the study design for this ecological risk assessment. A judgmental design is based on the reliability of the experts who are knowledgeable about the Central Plateau ecosystem.

While limits on decision errors will be qualitative, some aspects of the study design will benefit from randomization (e.g., selection of some sample locations). Data will be evaluated for statistical trends, and significance will be determined by probabilities of 0.05 or less; in addition, the upper confidence level of the mean values will be used in calculating exposure and doses.

Statistical power is a consideration in the interpretation of the results of hypothesis testing, but power is only one factor that should be evaluated when interpreting risk-assessment results. Over reliance on statistical hypothesis testing must be avoided, because it often is misapplied in ecological risk assessment (Suter 1996, "Abuse of Hypothesis Testing Statistics in Ecological Risk Assessment"). For example, statistical hypothesis testing is inappropriate for most field measurements because of pseudoreplication and the inability to randomly assign organisms to treatments. Instead, Suter (1996) recommends that ecological risk assessments provide information on exposure and effects, including an assessment of the uncertainty in exposure-effect relationships. While not stand-alone lines of evidence, statistical analyses can evaluate such relationships quantitatively through the calculation of significance levels or explained variance in regression models; more qualitative evaluations of uncertainty are assessed through the concordance or discordance of lines of evidence for various COPECs and endpoints. This is why the Phase I/II/III study design includes a gradient of exposure concentrations and a variety of measures.

This Central Plateau ecological risk assessment is focused on characterizing risks to middle-trophic-level receptors (i.e., invertebrates, lizards, and small mammals) using the weight-of- (or strength-of-) evidence approach to determine exposure and potential effects of hazardous substances (Fairbrother 2003, "Lines of Evidence in Wildlife Risk Assessments"; Menzie et al. 1996, "A Weight-of-Evidence Approach for Evaluating Ecological Risks: Massachusetts Weight-of-Evidence Workshop"). The weight-of-evidence approach will evaluate a combination of quantitative and qualitative information, including COPEC concentrations in abiotic and biotic media, comparisons of media concentrations between waste sites and reference sites, and modeling of bioaccumulation and dietary exposure to receptors.

1.4.3 Data Quality Objectives for Phase III

This section presents the EcoDQOs for each of the Phase III spatial domains, including discussion of contaminant sources, COPECs, receptors, and ecological risk questions. Spatial domains for Phase III include waste-site areas and non-waste-site areas that need to be evaluated, based on the results of Phase I and Phase II, the dispersed carbon tetrachloride plume in the 200 West Area, and West Lake, shown graphically in Figure 1-3. Supplemental waste-site data-collection needs resulting from the Phase I and Phase II data assessment also are addressed.

1.4.3.1 Supplemental Waste-Site Data Collection

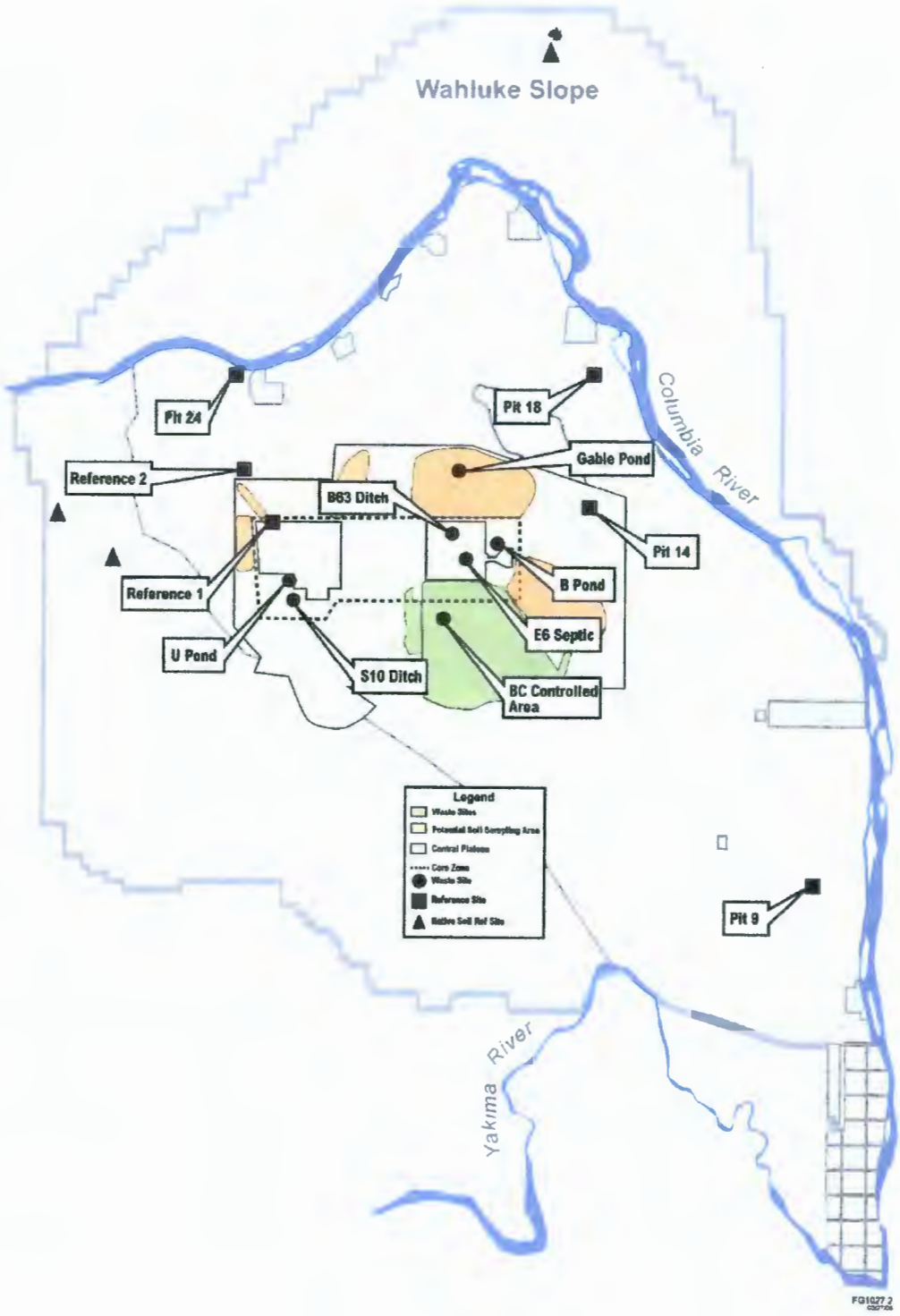
Because these Phase III studies are a logical continuation of Phase I and Phase II investigations, the conceptual model, risk questions, assessment endpoints, and measures developed in Phase I (WMP-20570) and Phase II (WMP-25493) are applicable to these supplemental data-collection plans in Phase III.

Cyanide in Invertebrates

Cyanide was identified for further investigation in the assessment of Phase I and Phase II data. Cyanide was not detected in soil data collected for Phase I and Phase II of the Central Plateau EcoDQO activity and has been detected infrequently in waste-site soil in years past (WMP-20570, Appendix D; overall detection rate of 2 percent). Additional soil samples for cyanide analysis are not warranted, given the low detection frequency in soils. Cyanide was, however, regularly detected in biotic tissues (invertebrates, mice, and lizards) from waste sites and from the Phase I reference site. This was a concern, because consumption of cyanide-containing invertebrates was shown to pose a potential risk to insectivorous birds (killdeer) through exposure modeling. The data assessment was structured to assess whether a receptor's ingestion of a contaminant exceeded a toxicity threshold; if so, population studies for potentially affected groups (in this case birds and lizards) would be considered.

Although cyanide was not detected in soil, it was detected at roughly the same levels in invertebrate and vertebrate tissues for Phase I waste sites and for the Phase I reference site (cyanide was not a Phase II COPEC). Existing remedial investigation data indicate that soils are not a source of cyanide contamination (297 samples and <2 percent detection rate; WMP-20570, Appendix D). These lines of evidence suggest that cyanide in tissues is an analytical laboratory artifact. There is not, however, enough information to rule out this possibility. In the case of cyanide analyses, it was considered that the method does not differentiate thiocyanides, which are naturally occurring, from total cyanide. The literature was examined to determine whether another method might be more suitable. Methods were found for blood; however, mice do not produce sufficient blood for the analytical method. In addition, there are no tissue-controls available to use to assess the type of cyanide in the small mammals or the invertebrates. Development of a new method for the tissues would require a significant research endeavor. It was therefore agreed that the current total cyanide method that is U.S. Environmental Protection Agency's (EPA) normal cyanide method would continue to be used.

Figure 1-3. Spatial Areas Evaluated for Phase III of the Central Plateau Ecological Data Quality Objectives Activities.



The most expedient means of assessing cyanide is to document the sitewide distribution of cyanide in invertebrates. A total of 15 locations will be sampled, including the two Phase I and Phase II reference sites, the six Phase I waste sites, and seven reference sites of the 100 Area and 300 Area component of the River Corridor Baseline Risk Assessment (RCBRA). Invertebrates from each location will be divided into three subsamples for analysis. Three replicate invertebrate measurements per investigation area provide the minimum number to determine differences in concentrations between investigation areas. The number of biota samples is sufficient for calculating the mean and standard deviation.

This activity will not address the cyanide analytical method accuracy or precision, but it will address the method's potential bias. By greatly expanding the data collection at River Corridor reference sites, adequate data will be available to statistically assess whether cyanide in tissues is related to Hanford Site operations. If the data from samples collected at additional reference sites confirm the previous tissue results, then the project will conclude that the cyanide is not from contamination but natural from occurrences.

Polychlorinated Biphenyls in Tissues

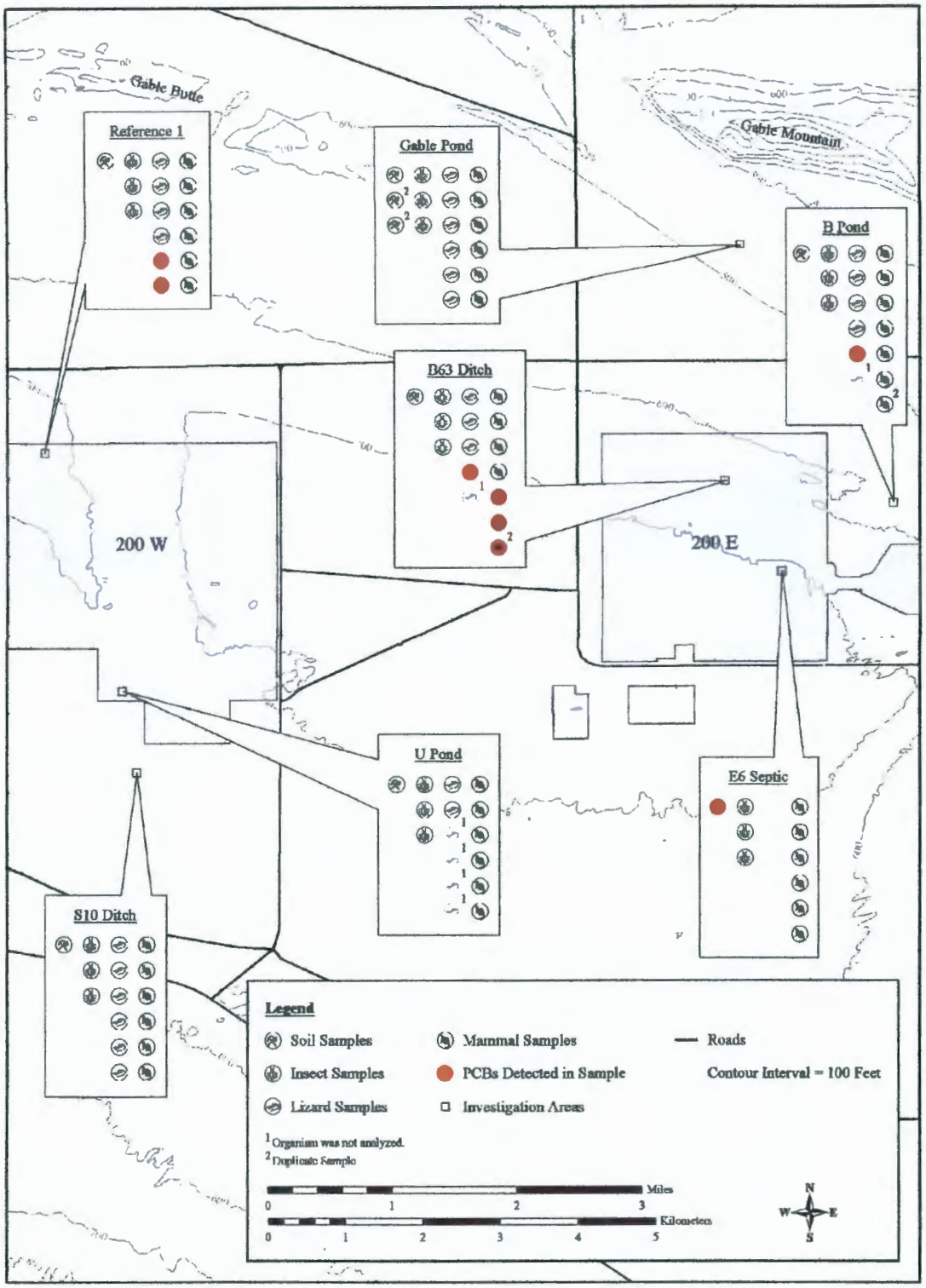
Across Phase I investigation areas, PCBs were detected in soil or mice or lizards. PCBs were detected only in soil from the 2607-E6 Septic Tank and Tile Field site, but were not detected in tissues collected from this site. PCBs were detected in two lizard tissue samples from the Phase I reference sites; PCBs also were detected in two mammal tissue samples (for three detections total in mammal tissue; one PCB detect was a duplicate) at another site (Figure 1-4). The reference detection in particular was unexpected and lent credence to the hypothesis that roads outside of operational areas may have been sprayed with PCB-containing oils to control dust.

The path forward is to broaden the collection of middle-trophic-level receptors outside of Central Plateau operational areas. Sampling and analysis for 43 PCB congeners in biota will address uncertainty in the nature and extent of PCBs in animal tissues. Sampling in all phases of the Central Plateau EcoDQO targeted the middle trophic level, with the expectation that receptors such as rodents and lizards would integrate exposure from soil and diet. For the case of bioaccumulative COPECs such as PCBs, sampling for PCBs in tissues is more efficient than sampling soils.

The Phase I samples were analyzed for PCBs using the Aroclor method, and only two of eight PCB Aroclor mixtures were detected: Aroclor-1254 and Aroclor-1260. This is consistent with the Aroclors routinely observed in waste samples from Hanford Site waste sites; of the nine PCBs sampled historically, only Aroclor-1254 and Aroclor-1260 have ever been detected in remedial investigation samples (WMP-20570, Appendix D). To address these uncertainties, lizards and mice at four Phase I investigation areas will be sampled. In addition, tissue samples will be collected at four non-waste locations (two in the 200 East Area and two in the 200 West Area) in the vicinity of roads that may have been sprayed with PCB oils as a dust-suppression measure to evaluate those areas as potential sources for PCBs.

The number of biota samples is based on the availability of these organisms for sampling and the minimum number of animals or replicates needed for making statistical inferences. Six lizards and six mammals are targeted at each non-waste site location, because it is believed that this is a reasonable number to collect from an investigation area; six values provide enough information to provide statistical power for detecting differences among sites.

Figure 1-4. Polychlorinated Biphenyls (as Aroclors) Results for Phase I Waste-Site and Reference-Site Sampling.



For the Phase III PCB analyses, EPA Method 8082 (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*) will be used to measure 43 selected congeners and then will be summed to total the PCBs. This method has adequate sensitivity and is sufficiently robust to the environmental weathering or food-chain transport that could affect the ratios of congeners from the original Aroclor mixture. The congener selection process focused on those with dioxin-like properties as proposed by institutions such as the World Health Organization (Ahlborg et al. 1994, "Toxic Equivalency Factors for Dioxin-Like PCBs: Report on a WHO-ECEH and IPCS Consultation"; Van den Berg et al. 1998, "Toxic Equivalency Factors (TEF) for PCBs, PCDDs, PCDFs for Humans and Wildlife"). Alternately, EPA Method 1668 will be considered.

Additionally, congeners recommended by EPA for ecological risk assessment and the congeners with the highest and second highest potential toxicity and frequency of occurrence in animal tissue were added. In addition to the above sources, the congeners were added that are present in Aroclors 1254 and 1260 in the highest weight percents that uniquely identify these Aroclors. These Aroclors were detected in Phase I Hanford Site samples. In total, 43 congeners were selected for analysis in mouse and lizard tissue samples (WMP-29253). Table 1-2 lists the congeners and the reference list for each congener.

Table 1-2. Congeners for Analysis in Tissue and Soil. (2 Pages)

Chemical Abstracts Service Number	BZ 1983	Dioxin-Like	BTAG List [a]	MCHP List [a]	MC2P List [b]	Aroclor 1254	Aroclor 1260
34883-43-7	8		X				
37680-65-2	18		X		X		
7012-37-5	28		X				
38444-90-5	37				X		
41464-39-5	44		X		X		
41464-40-8	49				X		
35693-99-3	52		X		X		
32598-10-0	66		X				
32598-11-1	70				X		
32690-93-0	74				X		
32598-13-3	77	X	X	X			
70362-50-4	81	X	X		X		
38380-02-8	87			X			
68194-07-0	90			X			
38380-01-7	99					X	
37680-73-2	101		X	X		X	X
32598-14-4	105	X	X	X			
38380-03-9	110					X	
74472-37-0	114	X	X		X		
31508-00-6	118	X	X	X		X	

Table 1-2. Congeners for Analysis in Tissue and Soil. (2 Pages)

Chemical Abstracts Service Number	BZ 1983	Dioxin-Like	BTAG List [a]	MCHP List [a]	MC2P List [b]	Aroclor 1254	Aroclor 1260
56558-17-9	119				X		
65510-44-3	123	X	X		X		
57465-28-8	126	X	X	X			
38380-07-3	128		X	X			
38380-05-1	132			X			
35065-28-2	138		X	X		X	X
38380-04-0	149						X
52663-63-5	151				X		
35065-27-1	153		X	X			X
38380-08-4	156	X	X	X			
69782-90-7	157	X	X		X		
74472-42-7	158				X		
52663-72-6	167	X	X		X		
59291-65-5	168				X		
32774-16-6	169	X	X	X			
35065-30-6	170		X	X			
35065-29-3	180		X	X			X
52663-69-1	183			X			
74472-48-3	184			X			
52663-68-0	187		X		X		
39635-31-9	189	X	X		X		
52663-78-2	195		X	X			
40186-72-9	206		X	X			

[a] Congener 209 is not included (not analyzed by EPA Method 8082, gas chromatography) and is not a major risk contributor.
[b] Congener 199 is not included (not analyzed by EPA Method 8082, gas chromatography) and is not a major risk contributor.
EPA Method 8082 is found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*.
Aroclor is an expired trademark.
Aroclor 1254 and 1260 – Representative congeners from the most commonly detected Aroclors at the Hanford Site.
BTAG – Congeners recommended for analysis by US EPA Region 9's Biological Technical Assistance Group.
BZ Number – Theoretical "corrected" polychlorinated biphenyl congener number (Ballschmiter and Zell, 1980, "Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography"), consistent with Schulte and Malisch, 1983, "Berechnung der Vahren PCB-Gehalte in Umweltproben I. Ermittlung der Zusammensetzung Zweier Technischer PCB-Gemische." BZ number is consistent with International Union of Pure and Applied Chemistry number.
MC2P – Congeners recommended for analysis by McFarland and Clarke, 1989, "Environmental Occurrence, Abundance and Potential Toxicity of PCB Congeners: Consideration for a Congener-Specific Analysis," as having the second highest priority as described in the text of this report.
MCHP – Congeners recommended for analysis by McFarland and Clarke as having the highest priority as described in the text of this report.

Strontium-90 in Tissues

Strontium-90 was detected in two Phase I reference site mammals and one lizard. Reanalysis of mouse tissue with the highest detections of Sr-90 resulted in non-detected concentrations, indicting potential analytical error with the original analyses. The samples are being submitted to a third laboratory for independent assessment of the material. While it would appear that Sr-90 is not a risk driver, Sr-90 will be analyzed in lizards and mice at select sites targeted for Phase III vertebrate sampling. In addition to collecting data from waste sites, this effort will provide Sr-90 tissue results from reference sites and from non-waste site areas to address the spatial extent of Sr-90 in the Hanford Site food web in non-operational areas.

Vegetative Composition

Vegetation cover is planned to be resurveyed at Phase I investigation areas. The goal is to gather representative data for Phase I flora. The vegetation composition surveys may not have captured all potential diversity on Phase I waste sites because of the timing of the surveys and the relatively dry winter conditions preceding the 2005 sampling. Plant cover/diversity will be recorded again in 2006 for the Phase I waste sites for a more representative assessment of community composition, as part of the Phase III field activities, to supplement data gathered to assess relationships between plant composition and cover with other measures of environmental quality identified in the SAP (e.g., population/community health attributes of plants, invertebrates, lizards, small mammals, birds).

Plant-species data gathered in 2006 should be collected during the spring (April-May), when conditions are favorable to visually observe and identify a nearly complete list of plant species there. This period was captured for Phase II sites during 2005, and the sites do not need to be resampled in 2006. In addition, shrub canopy-cover surveys will not be conducted during Phase III, because the results generated from 2005 are not expected to change substantially between two consecutive years.

To help address Hanford Natural Resource Trustee Council information needs, any abnormalities on animals handled during data collection will be noted. Phase III data collection will help address gaps in our understanding of the health status of Central Plateau biota.

BC Controlled Area Sampling

The BC Cribs and Trenches received wastes primarily from the Uranium Recovery Project and secondarily from 300 Area wastes (WMP-18647, *Historical Site Assessment of the Surface Radioactive Contamination of the BC Controlled Area*). Biotic intrusion into trenches was discovered in the late 1950s. The BC Cribs and Trenches were covered in 1969 to prevent animal intrusion. This rock and dirt cover was used to prevent contaminant spread, not to implement a final remedy. The land outside of the BC Cribs and Trenches Area that may be influenced by wastes from the BC Cribs and Trenches is referred to as the BC Controlled Area, the aerial extent of which is 34.7 km^2 (13.4 mi^2). The BC Cribs and Trenches were included in the Phase I EcoDQO (WMP-20570). The BC Controlled Area was featured in the Phase II EcoDQO (WMP-25493).

The BC Controlled Area has been spatially delineated into three zones of relative radioactive contamination, as shown in Figure 1-5. These zones are south of the BC Cribs and Trenches Area and include Zone A, with the highest contamination levels; Zone B, showing intermediate contamination levels; and Zone C, which exhibits near-background conditions (Figure 1-5). All three zones were sampled in Phase II of the Central Plateau EcoDQO for Cs-137 and Sr-90. A positive relationship between soil Sr-90 and uptake in invertebrates was documented, and the SOF of both radionuclides approached the U.S. Department of Energy (DOE) dose limit considered to be a protective radiation threshold. Specifically, the area of highest contamination, Zone A, had an SOF of 0.083 rad/day, against the threshold of 0.1 rad/day for terrestrial wildlife. Rounding up, the Zone A SOF is equivalent to the dose limit.

To address uncertainties with potential risk in the BC Controlled Area, Zone A will be resampled in Phase III for Cs-137 and Sr-90 in invertebrates, mice, lizards, and soil.

1.4.3.2 Non-Waste-Site Soil Radiological Sampling

Past Hanford Site operations released radionuclides through plant-stack deposition, which presents a potential source for surface-soil contamination (DOE/RL-2005-49, *RCBRA Stack Air Emissions Deposition Scoping Document*). A focus of the Phase III Central Plateau EcoDQO activity is to assess the ecological condition of non-waste-site areas. Fourteen sources for non-waste-site data on radionuclides were compiled and reviewed (WMP-29253). There is a wealth of existing radionuclide data, especially for soil and vegetation. However, sampling data near the Phase I and Phase II reference sites and other areas on the Central Plateau are sparse, as illustrated in Figure 1-6.

Near-Facility Monitoring Program and Surface Environmental Surveillance Project (SESP) sampling have demonstrated higher concentrations (e.g., maximum 15 pCi/g of Cs-137 during the 2000 to 2004 period) within and near the Central Plateau Core Zone (locations proximal to the plant stacks). Thus, Phase I and Phase II reference sites are complemented by the 100/300 Areas RCBRA reference sites and Near-Facility Monitoring Program and SESP sampling. However, additional data are recommended to increase understanding of the spatial representation of radionuclides in soils. Sampling will be conducted in non-waste-site areas where data on plant-stack-emission radionuclides are limited; specifically, soils in five non-waste-site areas along presumed deposition pathways from the 200 Areas stacks will be sampled for Am-241, Cs-137, Sr-90, and isotopic plutonium analyses. These areas fill data gaps for radionuclides in recent soil sampling and provide additional information on surface radionuclide concentrations in the area of the Phase I and Phase II reference sites, the area to the north of the 200 East Area, and locations east and west of the Core Zone. Figure 1-7 shows the five non-waste-site areas identified for additional soil sampling.

Figure 1-5. Conceptual Site Model Zones Within the BC Controlled Area.

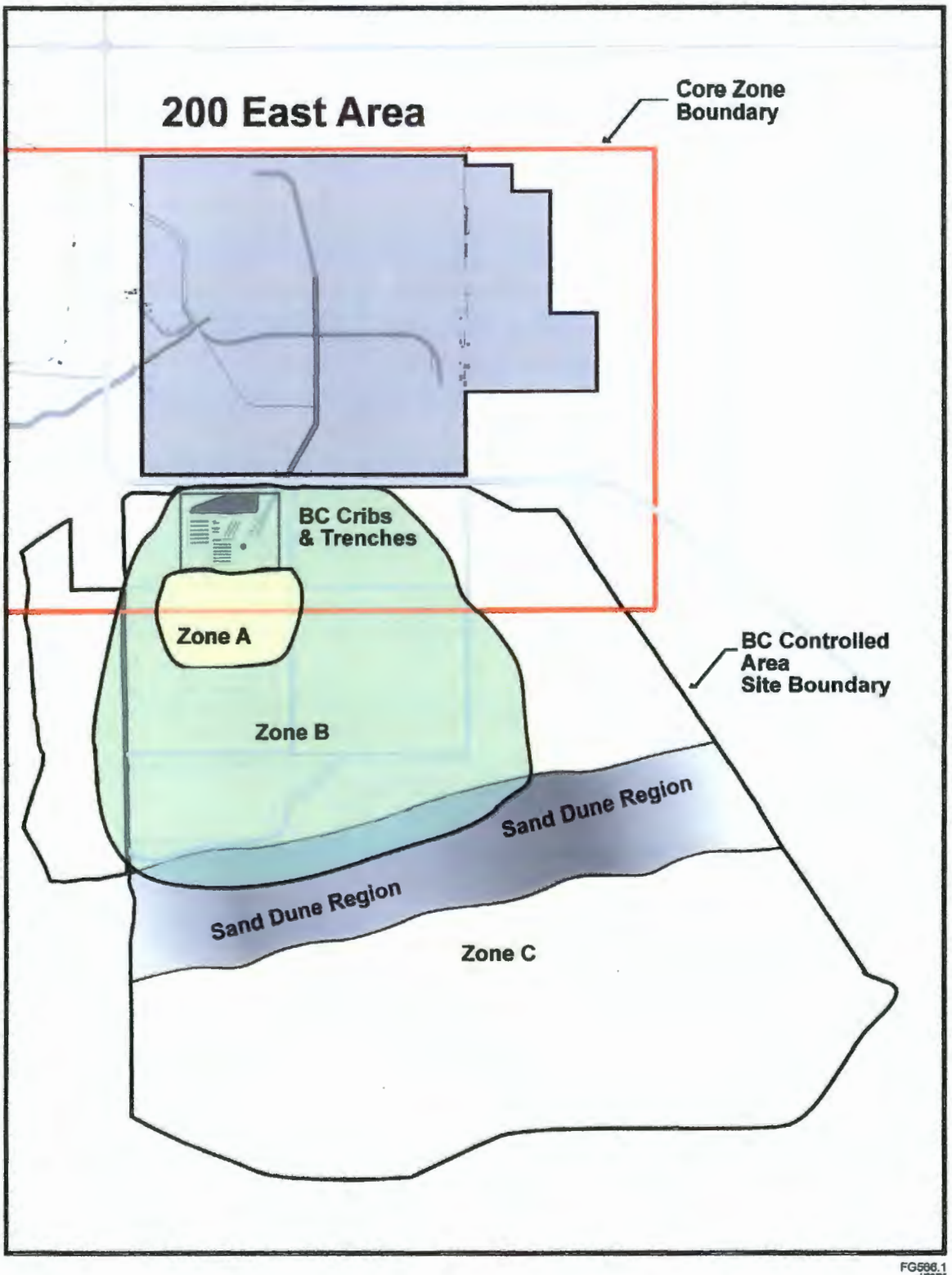


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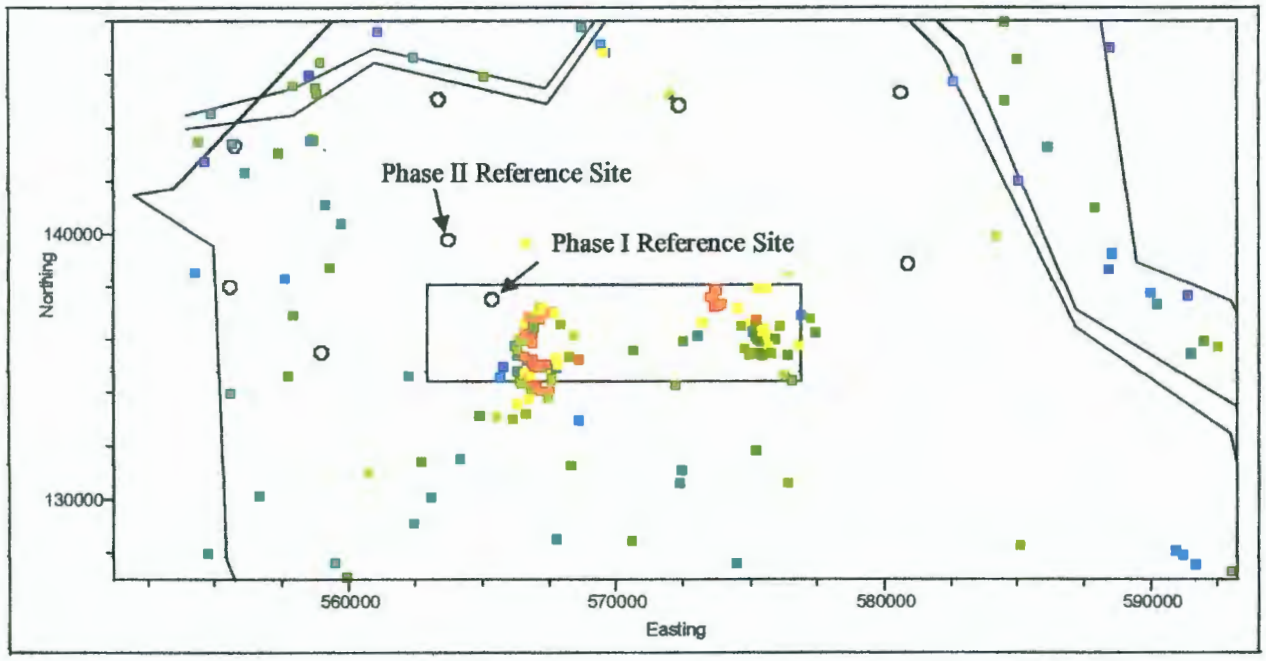
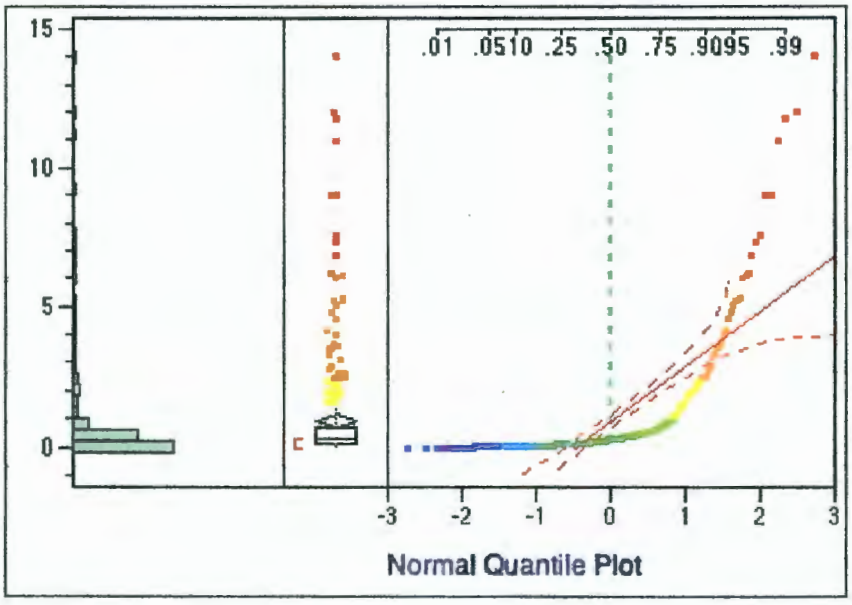
Figure 1-6. Spatial Plot of Cesium-137 in Soil; Maximum Concentrations from 2000 to 2005.

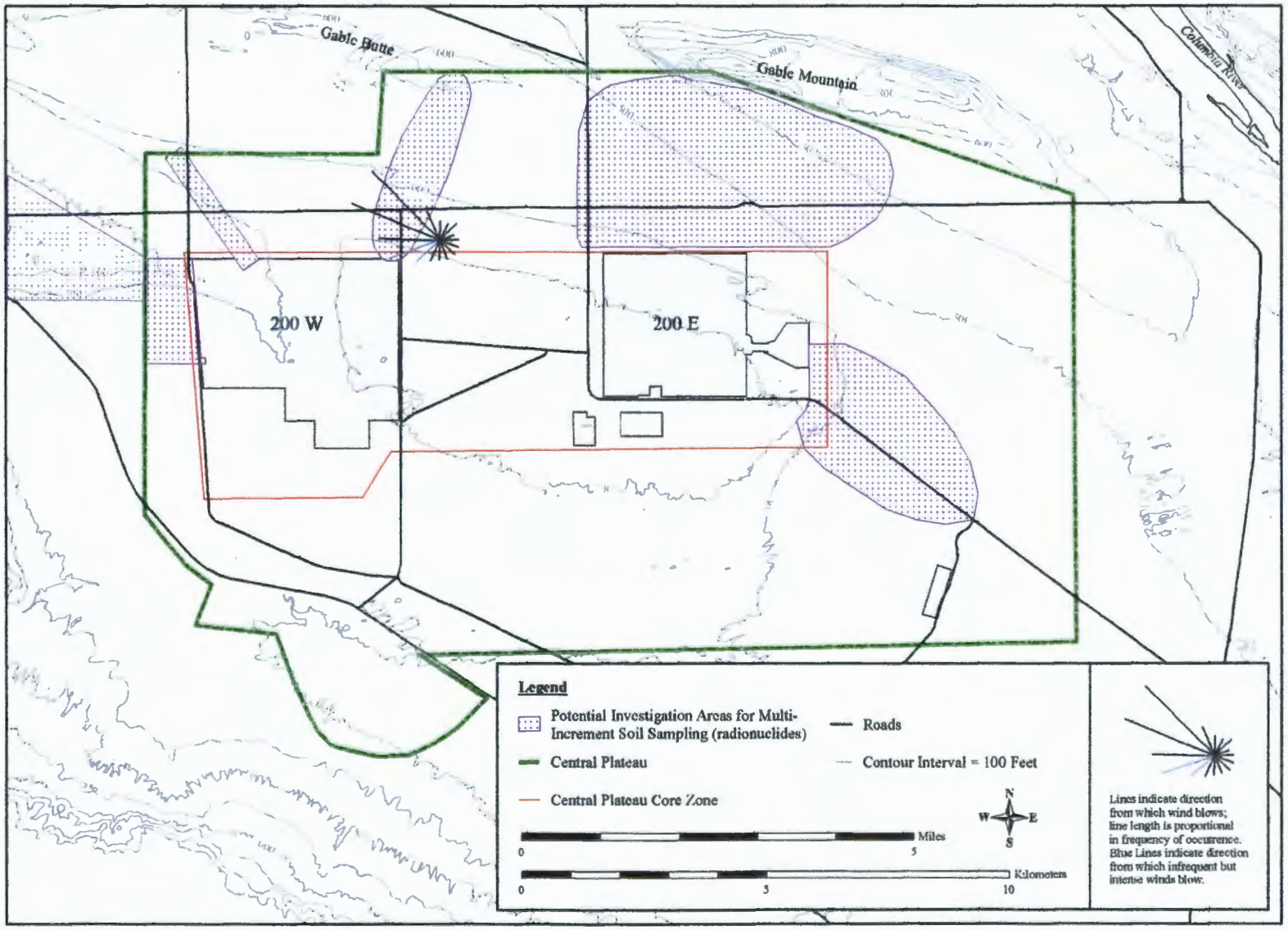
(Note that open circles are Central Plateau and 100/300 River Corridor Baseline Risk Assessment sites.)





Color Key:
Violet to Medium Blue <0.024 pCi/g
Light Blue = 0.024 to 0.085 pCi/g
Medium Green = 0.085 to 0.4 pCi/g
Light Green = 0.4 to 1.03 pCi/g
Yellow = 1.03 to 2.5 pCi/g
Orange = 2.5 to 6.07 pCi/g
Red > 6.07 pCi/g

Figure 1-7. Map Displaying Locations for Air-Stack Radionuclides in Non-Waste-Site Area Sampling.



Considering the COPECs selected for this project, stack contaminants primarily were radionuclides, including short-lived radionuclides such as Co-60 and I-131 (Hanford Environmental Dose Reconstruction Project) and longer half-life radionuclides (Am-241, Cs-137, I-129, Pu-239/240, Sr-90). Iodine-129 is not found in surface soils except in small concentrations near the stacks of the separations plants in the 200 Areas, and it is very mobile in water and easily transported through the soil column to groundwater. Therefore, I-129 was not typically measured in background or non-waste-site soil samples and will not be measured in this project. Cobalt-60 also is not included, because it has a 5-year half-life and is no longer routinely detected in Hanford Site soil and vegetation. Radionuclides considered as contaminants of interest are Am-241, Cs-137, Pu-239/240, and Sr-90. Plutonium-238 also will be evaluated, given its long half-life and its association with Hanford Site operations.

Regarding COPECs that are not being measured, organic chemicals were a relatively minor component of Central Plateau processing operations. Considering more predominant contaminants, focusing on radionuclides will provide a more protective measure than focusing on metals, given the greater sensitivity of radiation detection. For example, a metals concentration of Cs-137 at 1 ppm has an equivalent rad activity of 87×10^6 pCi/g. For Sr-90, 1 ppm is 139×10^6 pCi/g. Further, metals were not present in significant concentrations in the 200 Areas fuel reprocessing facilities. This is evident in the waste sites that received the liquid discharges. The detected metals concentrations are very low compared to the radionuclide activity levels.

In the Phase III data assessment workshop (February 22-23, 2006), consensus opinion indicated that multi-increment sampling (MIS) was the preferred method to obtain surface soil radionuclide-concentration data for this project. It was acknowledged that MIS soil samples were different from, but could be compared to, the local composite samples used by the Near-Facility Monitoring Program and SESP to characterize soil concentrations. The EcoDQOs for the MIS identify sample depth, the particle size of interest for ecological exposure considerations, the spatial scale over which the MIS should be performed, and the number of increments needed to adequately characterize the area. The depth should be 0 to 2.5 cm (0 to 1 in.) to be consistent with Near-Facility Monitoring Program and SESP samples; a shallow 2.5 cm (1 in.) depth is consistent with characterizing air deposition. The particle size should be the less-than-2-mm size fraction that was used for other MIS performed for the Central Plateau project. The 2 mm fraction is consistent with the definition of soil and is representative of the incidental-ingestion and soil-to-food exposure pathways.

The Phase I and Phase II soil samples were collected over a 1 ha spatial area, because this area was representative of the spatial scale appropriate for populations of middle-trophic-level species. A 1 ha area would ensure that exposure of multiple animals from soil could be evaluated. The objective of the proposed study, however, is to assess spatial patterns of contaminant deposition. Because the focus is not on assessment population areas, units smaller than the Phase I and Phase II 1 ha investigation areas will be sampled. One benefit of a smaller unit is that it will better correspond to the 1 m^2 spatial area sampled by the Near-Facility Monitoring Program and SESP. An area of 0.0625 ha or 625 m^2 is selected because this area corresponds to the size of the pocket mouse and deer mouse home ranges (0.05 and 0.077 ha). This area is approximately equal to the typical size of a residential lot (500 m^2).

The number of increments needed to characterize this area can be based on several factors: historical information on the between-year variation in radionuclide concentrations from Near-Facility Monitoring Program and SESP monitoring data, physical factors leading to variable deposition and contaminant redistribution, and logistical considerations in sample collection and processing. Analysis of the variation in Cs-137 concentrations shows that between-year variation is small (9 percent of the total) compared to between-location variation (accounts for 80 percent of the variation in Cs-137 concentrations). One simple approach is to consider a grid composed of 25 cells to characterize the 0.0625 ha area. Systematic samples with a random start would characterize soil concentrations across the area with an equal chance of collecting samples from different microsite types (e.g., cryptogam, under shrubs, between sites, burrow spoils). To obtain sufficient mass for laboratory analyses, it is necessary to collect two co-located increments from each cell. Note that 50 increments would be equal to the cumulative number of composite samples collected from each location over a 10-year sampling period, thus making these MISs more comparable to the average radionuclide concentrations from the last 10 years.

Non-Waste-Sites Area Ecological-Risk Questions

The following risk questions are relevant to the non-waste-site data being collected in Phase III.

- Are radionuclide concentrations greater than Hanford Site background concentrations?
- What is the spatial distribution of radionuclides associated with air-stack emissions along potential emissions paths in data-limited, non-waste-site areas?

1.4.3.3 Dispersed Carbon Tetrachloride Plume

Carbon tetrachloride was used extensively at the Hanford Site, mainly in the plutonium-recovery process. Soil contamination resulted in a groundwater contamination plume in the 200 West Area. Since 1994, the Hanford Site has been pursuing remediation activities using soil-vapor extraction and groundwater pump-and-treat operations. Because carbon tetrachloride can partition into the gas phase, potential inhalation risks are being evaluated. While air inhalation typically is not a risk driver in ecological risk assessments (DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses to Aquatic and Terrestrial Biota*; EPA 2003, *Guidance for Developing Ecological Soil Screening Levels*, Attachment 1-3, *Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purposes of Setting EcoSSLs*, OSWER Directive 9285.7-55), air below ground may be an important exposure medium to burrowing receptors.

Plants, invertebrates, reptiles, birds, and mammals all use below-ground habitat to escape extremes in environmental conditions, procure food, and maintain moisture. Burrowing is a particularly successful life history strategy for organisms inhabiting arid environments like the Hanford Site. The Great Basin pocket mouse is representative of a Hanford Site receptor that burrows in arid soils (Kenagy 1973, "Daily and Seasonal Patterns of Activity and Energetics in a Heteromyid Rodent Community"). While the pocket gopher is not as prevalent as other burrowing animals at the Hanford Site, the gopher was selected as a protective fossorial receptor, because its primary habitat is subsurface and would be relatively more exposed to vapor-phase contaminants, such as carbon tetrachloride, in burrow air.

To initiate the characterization of carbon tetrachloride inhalation risks, available soil-gas and other relevant data from the Hanford Site soil-gas monitoring program were assessed based on subsurface air as an exposure medium on the Central Plateau. Specifically, existing data on carbon tetrachloride in subsurface air were compared to an inhalation-based ecological screening level (ESL) developed for carbon tetrachloride and based on the pocket gopher. This threshold was exceeded in many areas associated with the dispersed carbon tetrachloride plume in the 200 West Area (Figure 1-8). Spatially identified carbon tetrachloride ESL exceedances will be used in field reconnaissance activities to identify candidate locations for burrow-air measurements. Figure 1-9 depicts the logic diagram for data assessment of carbon tetrachloride.

Carbon Tetrachloride Ecological Risk Question

The carbon tetrachloride investigation was developed through the EcoDQO process to characterize ecological risks.

- Are burrow-air carbon tetrachloride concentrations greater than the carbon tetrachloride ESL?

Candidate burrows will be screened using passive gas samplers (EMFLUX[5] tubes) to ensure that detectable levels of carbon tetrachloride are present before active gas measurement is collected, following the methodology of Spring et al. 2004, "Effects of Trichloroethylene and Perchloroethylene on Wild Rodents at Edwards Air Force Base." It will be important to move beyond the existing soil-gas data and empirically determine carbon tetrachloride concentrations in the burrow, because animals construct their subsurface habitat to optimize subsurface-air flushing. To avoid suffocation, fossorial mammals design burrows to maximize exchange of subsurface air with the atmosphere above, thus diluting gasses that may otherwise build up in the burrow (Vogel and Bretz 1972, "Interfacial Organisms: Passive Ventilation in the Velocity Gradients Near Surfaces"; Vogel et al. 1973, "Wind-Induced Ventilation of the Burrow of the Prairie-Dog, *Cynomys ludovicianus*"). In contrast to the screening step, which assumed that soil-gas data were equivalent to burrow air, actual measures of carbon tetrachloride and its chlorinated degradation products in the burrow are an ecologically realistic means of assessing vapor-phase contaminants, given the dilutional effect of burrow architecture on burrow-air composition. The passive soil-gas results will be evaluated, or representative burrows will be chosen for active gas measurements of burrow air.

[5] EMFLUX is a registered trademark of Beacon Environmental Services, Inc., Bel Air, Maryland.

Figure 1-8. Carbon Tetrachloride Ecological Screening Level Exceedances in the 200 West Area.

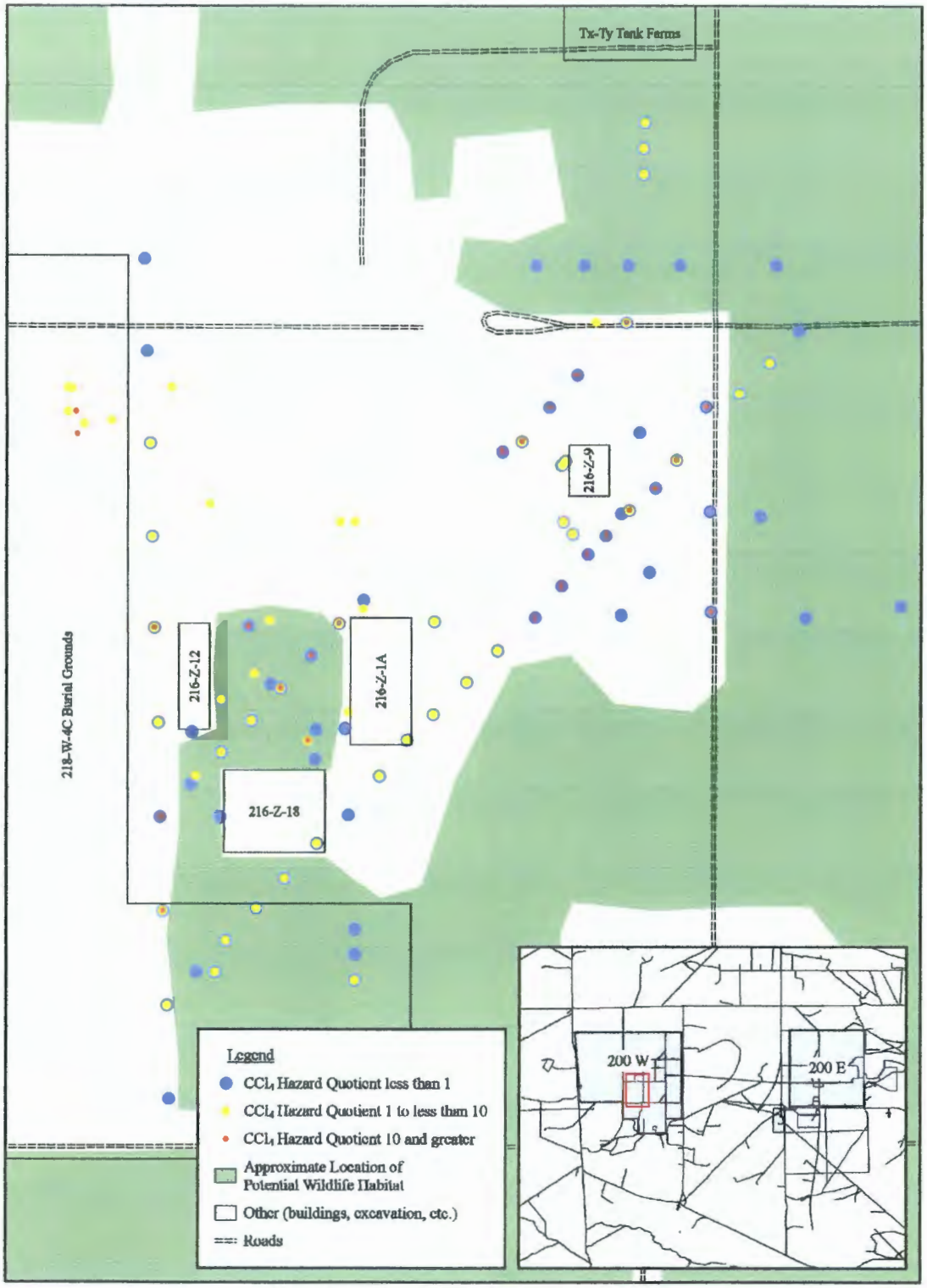
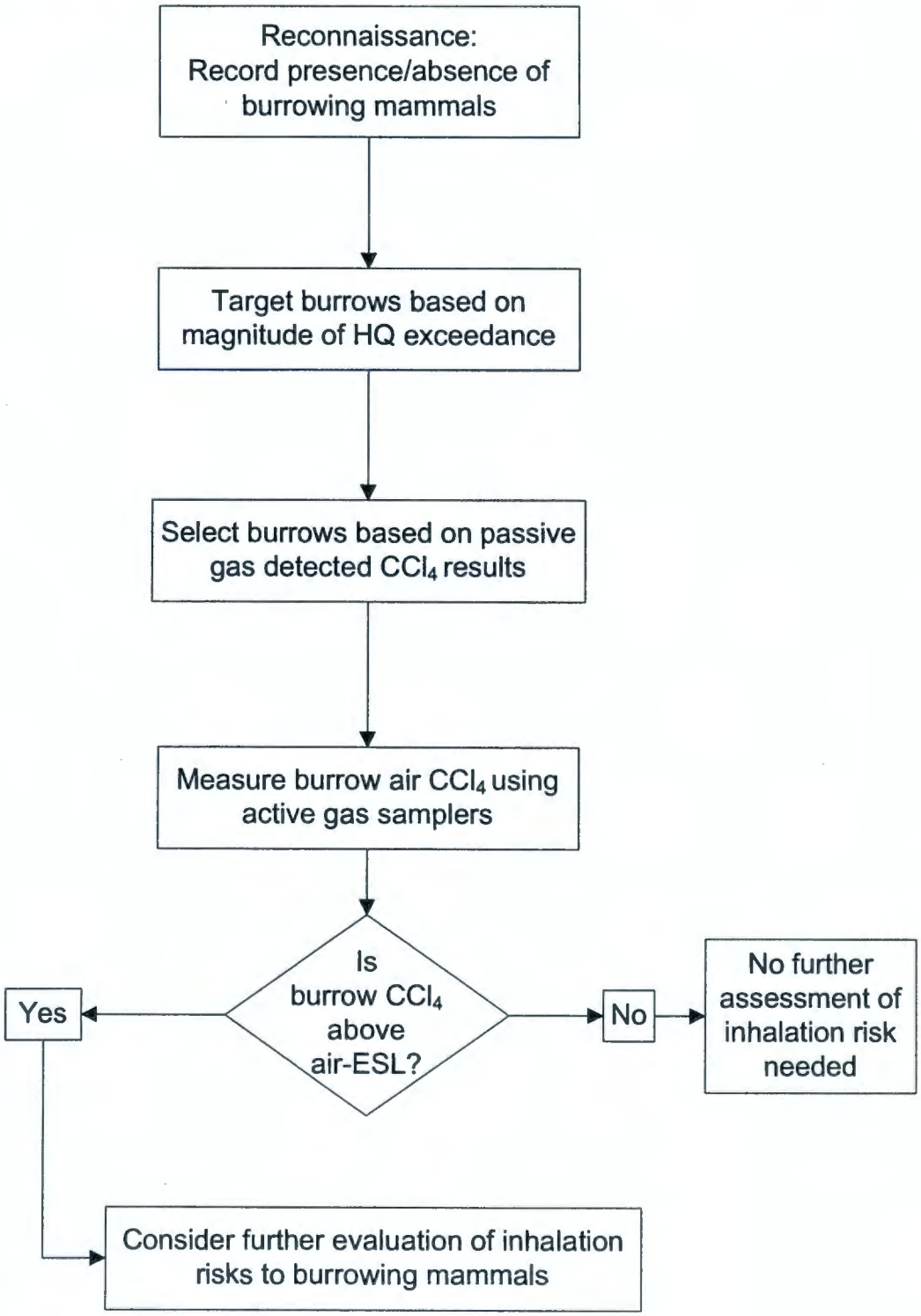


Figure 1-9. Logic Diagram of Carbon Tetrachloride Data Assessment.



1.4.3.4 West Lake

West Lake represents a unique and dynamic ecological feature at the Hanford Site. Documentation of the presence of West Lake predates the Hanford Site, and the lake's expanse varied greatly over time. Wastewater discharges from the Plutonium-Uranium Extraction Plant and the B Plant elevated groundwater and subsequently expanded the size of West Lake. There are anecdotal reports of West Lake (also known as Honey Hill Pond) being used as a dumping location for sewage and other Hanford Camp wastes in past years. The lake generally has been shrinking in size since subsurface discharge was discontinued in the 200 Areas. In recent years, the lake has ranged from a water-covered expanse of hundreds of square meters to a few square meters. West Lake is responsive to long-term and short-term climatological and seasonal conditions such as wet years or large precipitation events.

Media historically sampled at West Lake included soil, water, sediment, and biological tissues. Uranium-238 has been elevated in the sediment and unfiltered water samples from West Lake in the past and has been detected in the tissues of birds (Avocet) and invertebrate larvae and adults (Ephydridae [brine fly]) (PNNL-13487, *Hanford Site Environmental Report for Calendar Year 2000*). The Phase I EcoDQO document identified surface water as a medium of concern, as well as several data gaps that need to be addressed to evaluate the ecological risk. Existing data need to be supplemented, and exposure pathways need to be confirmed with the following specific objectives:

- Supplemental to Existing Abiotic Data
  - Define the extent of radionuclides in soil
  - Determine whether existing data are representative of surface water
  - Test the conceptual model that organics are not present in abiotic media
- Exposure Pathway Analysis
  - Survey wildlife use of West Lake
  - Evaluate the exposure pathways for different media (water, soil, sediment, salt, and biota) to wildlife.

Existing soil data for West Lake had one result out of 11 samples that exceeded the Cs-137 ESL. Consequently, soil radiation surveys will be performed around the perimeter of the lake to better understand the extent of elevated radionuclide levels. Radiological survey data will be assessed to determine whether more comprehensive soil sampling is needed. Previous surface-water characterization employed unfiltered water samples. These may not provide the most representative concentrations of contaminants in surface water. Unfiltered and filtered surface water, as well as pore water (likely the most concentrated condition), will be collected.

Organic chemicals were a minor component of the processes associated with the Plutonium-Uranium Extraction Plant and B Plant (WMP-20570, Appendix B), and organic chemicals have not been detected in groundwater wells near West Lake. However, the West Lake investigation will include analysis for semivolatile organic compounds, tributyl phosphate, and normal paraffin hydrocarbons as COPECs, given the lack of historical data for organic chemicals at West Lake.

There is sparse documentation of wildlife use of West Lake. Reconnaissance surveys will be conducted to better describe biological pathways present today and to estimate the percent of the year that these pathways exist.

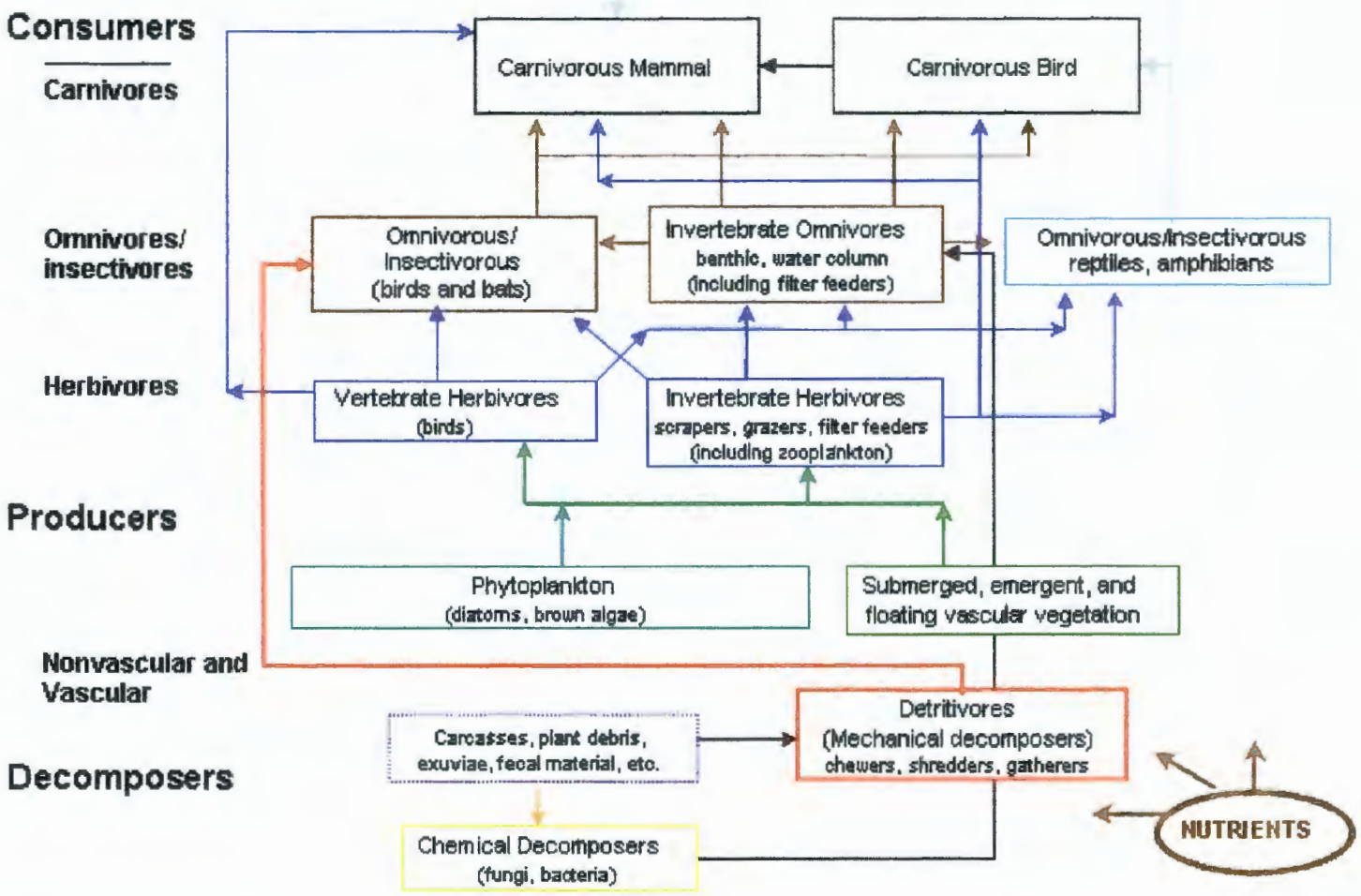
The general classes of COPECs identified at West Lake (radionuclides and metals) are similar to the COPECs identified for the Central Plateau (see Section 3.2.4 of WMP-20570). Because West Lake represents a unique habitat, however, the specific entities at risk are different from those associated with terrestrial waste sites on the Central Plateau. The food chain at West Lake (Figure 1-10) is simple and includes halotolerant algae at the food base; an invertebrate, the brine fly (*Ephydridae*) dominates the lower trophic level; brine flies in turn are preyed upon by aerial insectivores such as birds (e.g., killdeer) or several species of bats (e.g., the little brown myotis bat *Myotis lucifugus*) that forage primarily on emergent insects. Ecological receptors also may have incidental exposures to surface water, salt, and sediment.

In addition to reconnaissance surveys, this SAP outlines the plan to quantify ecological exposure potential associated with West Lake sediments, water (surface, pore), salt crust, and biota. The design uses MIS to characterize concentrations of COPECs in surface soil in the terrestrial environment and surface water, in the sediment, and in the salt crust associated with West Lake. By quantifying the sum of many individual increments (e.g., an individual MIS of sediment or salt comprises 40 increments), MIS methodology emphasizes obtaining a representative sample of the matrix of interest and reduces fundamental error.

Sediment will be analyzed for radionuclides, metals, organic compounds, and general chemistry parameters (acid volatile sulfide [AVS] and total sulfides) to determine biotic exposure. Surface water will be analyzed for radionuclides and metals. In addition, total organic carbon, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, total dissolved solids, and titrations for total hydroxide and total carbonate. Constituents in the surface water will be differentiated into filtered and unfiltered fractions.

In addition, sediment interstitial water (pore water) will be collected and analyzed for the same constituents as surface water to capture the worst case conditions (highest concentrations) for COPECs in water. Metals analyses will supplement the limited data on inorganic chemicals in sediment and water. The salt crust around the perimeter of the lake will be sampled for radionuclides and metals. In addition, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, titrations for total hydroxide and total carbonate and by X-ray diffraction (XRD; for crystal structure). These analyses enable estimates of potential dose to wildlife that might use this substrate as a salt lick and assessments of the physicochemical nature of the material. Brine fly larvae or adults will be sampled for metals and radionuclides, to assess the potential food-web exposure route to aerial insectivorous receptors (bats, birds) around West Lake.

Figure 1-10. West Lake Food Web.



Development of the EcoDQOs for West Lake (WMP-29253) resulted in the determination that a reference site is unnecessary for making inferences of ecological risk for several reasons. The lake is a unique geographic feature of the Central Plateau and there are no comparable reference sites at or near the Hanford Site. More importantly, however, the risk questions do not require a reference site for evaluating ecological risks.

West Lake Ecological Risk Questions

These data will help to resolve questions that have been developed through this phased and tiered approach to characterize ecological risks. The following questions are relevant to the West Lake data being collected in Phase III.

- Are there elevated radiation measurements from a beta/gamma field radiation soil survey?
- Are organic chemicals detected in sediments?
- Are metals in sediment, crust, and/or water (filtered and unfiltered) in excess of published toxicity values for marine organisms?
- Are metals in aquatic invertebrates above levels that would result in exceedances of an aerial insectivore (bird, bat) toxicity reference value?
- Are radionuclides in aquatic invertebrates above levels that would result in exceedances of radiological thresholds, based on a riparian receptor?
- Are radionuclides in water, sediment, or crust above radiological screening thresholds?
- What is the physicochemical nature of the crust material (e.g., is it reasonable to expect animals could use it as a salt lick)?
- What ecological receptors are using West Lake; e.g., can wildlife be documented as using the lake as a drinking-water or trace-mineral source?

1.5 STUDY DESIGN SUMMARY

A synopsis of the Phase III study design is provided in Table 1-3; it links the sample collection methodology, key features of the design, and the basis for sampling the various geographic areas targeted in this final phase of assessment. Aspects of the study design are subject to field verification, which may require selecting alternate measures for an assessment endpoint or other modifications to the study design (e.g., plot size, trapping density).

Table 1-3. Phase III Study Design Synopsis. (2 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Supplemental Waste Site Sampling		
Invertebrate sampling for cyanide	Collect invertebrates in Phase I waste sites, Phase I and Phase II reference sites, and RCBRA reference sites for cyanide analysis (15 sites).	Determine significance of positive cyanide results in Phase I invertebrate samples and the general distribution of cyanide in tissues across the Hanford Site.
Lizard and small mammal sampling for 43 select PCB congeners	Collect lizards and mice in select Phase I investigation areas and four new sample sites near security roads that may have been sprayed with PCB-laden oils (eight sites).	PCB sampling conducted in Phase I was not conclusive. Determine concentrations of PCBs in biota at Phase I waste sites and where PCB-laden oils may have been applied for dust control.
Lizard and small mammal sampling for Sr-90	Collect lizards and mice at select Phase I investigation areas and at an additional site (six sites).	Strontium-90 sampling conducted in Phase I was not conclusive. Determine concentrations of Sr-90 in biota at select Phase I investigation areas and at one additional site. This effort will assess the distribution of Sr-90 in vertebrate tissues in waste sites and from non-waste site areas, addressing the spatial extent of Sr-90 in the Hanford Site food web.
Reanalysis of Phase I small mammal tissues for Sr-90	Re-analyze 20% of mouse tissue samples collected from Phase I for Sr-90 using an independent laboratory.	Quality control samples to resolve uncertainties in the Phase I Sr-90 analytical results for biota.
Vegetative characterization in Phase I areas	Repeat vegetative characterization in Phase I areas (seven sites).	The wet conditions observed in 2006 are expected to yield greater numbers and a more complete characterization of Phase I plant species per plot.
Characterization in BC Controlled Area Zone A	Deploy one replicate Phase II investigation area (1 ha) in Zone A to assess ecological risks associated with Sr-90 and Cs-137.	Sum of fractions for the Phase II investigation area in the high zone was close (0.083 rad/day) to the DOE dose threshold of 0.1 rad/day for terrestrial wildlife.
Non-Waste Site Soil Radiological Sampling		
Soil sampling in non-waste site areas around the 200 East and 200 West Areas	Collect multi-increment shallow soil samples along transects near the Phase I and Phase II reference sites and in non-waste site locations outside of the 200 East and 200 West Areas for analysis of Am-241, Cs-137, Pu-238, Pu-239/240, and Sr-90.	Multi-increment sample data collected near reference sites will be used to assess the adequacy of Central Plateau reference sites; multi-increment sample data collected in other non-waste-site areas will fill spatial data gaps in existing data sets for soil activity levels.
Offsite reference site sampling	Collect soil sites from two offsite reference sites in 1 ha sample plots. Collect two multi-increment samples from each, from the 0-1 in. and 1-2 in. depths. Collect 50 soil increments from each sample. Duplicate this sampling in the Phase I and Phase II onsite reference sites.	This responds to concerns expressed by the Hanford Natural Resource Trustees and the Tri-Party Agreement agency decision-makers over the use of reference sites within the Hanford Site boundary
Carbon Tetrachloride Sampling		
Passive gas measurements of carbon tetrachloride in surface soil	Collect EMFLUX® samples to screen for the presence and relative magnitude of carbon tetrachloride at animal burrows targeted for pore-gas sampling.	Provide verification that carbon tetrachloride is present in soils around burrows targeted for active soil-gas measurements before initiating active gas-data collection.
Active gas measurements of burrow air	Quantify the concentrations of carbon tetrachloride and its chlorinated degradation products in burrows by actively withdrawing samples of burrow air.	Field verification of carbon tetrachloride and its degradation product concentrations in animal burrows to evaluate exposures to burrowing receptors.

Table 1-3. Phase III Study Design Synopsis. (2 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Contingency installation of artificial animal burrows for active burrow air measurements	If animal burrows are not detected in the habitat areas during reconnaissance surveys, six artificial animal burrows will be installed for the collection of vapor samples.	Perform field verification of carbon tetrachloride concentrations in artificial animal burrows to evaluate exposures to potential burrowing receptors.
West Lake		
Soil radiation surveys	Perform radiological surveys around the perimeter of West Lake. Existing data show that one of 11 soil samples was above the screening value for Cs-137 in soil.	Determine if there are elevated radiological measurements in soils surrounding West Lake.
Surface water sampling	Collect multi-increment surface water samples from West Lake. Subsample into filtered and unfiltered sample. Analyze for radionuclides, metals, and anions. Perform non-COPEC analyses for total chemical characterization of lake water.	Determine if existing data on unfiltered water are representative of surface water in West Lake. Pore water is collected on the assumption that it represents the most concentrated constituent conditions. Non-COPEC analyses will provide insight into the chemical/geological nature of West Lake.
Pore water sampling	Collect multi-increment pore water samples from West Lake. Subsample into filtered and unfiltered samples. Analyze for radionuclides, metals, and anions. Perform non-COPEC analyses for chemical characterization of lake water.	
Sediment sampling	Collect multi-increment sediment samples from the perimeter of the West Lake shoreline. Analyze for radionuclides and metals, TOC, acid volatile sulfide, total sulfides.	Determine biotic exposure from sediments.
	Analyze sediment samples for semivolatile organic compounds, tributyl phosphate, and normal paraffin hydrocarbons	Test the conceptual model that organic compound contaminants are not in West Lake.
Salt crust sampling	Collect multi-increment salt crust samples around the perimeter of West Lake. Analyze for radionuclides, metals, and anions. Perform non-COPEC analyses for total hydroxide, total carbonate and mineral structure.	Evaluate radiological and metal exposure dose to animals using salt as a source of minerals. Non-COPEC analyses will provide insight into the chemical/geological nature of West Lake.
Brine fly sampling	Collect larvae or adult brine flies around West Lake and analyze for radionuclides and metals.	Determine contaminant uptake in brine flies for modeling effects on aerial insectivores (bats, birds).
Reconnaissance surveys	Perform monthly biological surveys at West Lake and aquatic macroinvertebrate collection. Include monthly measurements on conductance, pH, dissolved oxygen, and temperature at West Lake.	Determine biological use and diversity at West Lake.

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Tri-Party Agreement = Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended.

COPEC = contaminant of potential ecological concern.
DOE = U.S. Department of Energy.
PCB = polychlorinated biphenyl.
RCBRA = River Corridor Baseline Risk Assessment.
TOC = total organic carbon.

In some cases, assessment endpoints will be evaluated by collecting data on the endpoint; e.g., PCB data on mice will be collected to evaluate the distribution of Aroclors in middle trophic level omnivores. In other cases, surrogates will be used to evaluate assessment endpoints, because data collection for that endpoint would be impractical. For example, while bats represent insect-eating mammals that may be exposed to potentially contaminated invertebrates in West Lake, bats are not targeted for tissue analyses, given logistical hurdles associated with

collecting these organisms. As an alternative, brine fly tissue (Ephydridae) data will be used to model ingestion to bats, to infer the effects on growth or survival of insect-eating mammals.

Specific receptors targeted for sampling include mammals and lizards (PCBs, radionuclides), soil macroinvertebrates (cyanide, radionuclides), and aquatic macroinvertebrates (radionuclides and metals), because these organisms had measurable COPEC levels in tissue or were viewed as having a high potential for accumulating COPECs. To help address Hanford Natural Resource Trustee information needs, any abnormalities on animals handled during data collection will be noted. Phase III data collection will address gaps in our understanding of the health status of Central Plateau biota.

2.0 QUALITY ASSURANCE PROJECT PLAN

The QAPjP establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. This QAPjP complies with the requirements of the following:

- DOE O 414.1C, *Quality Assurance*
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, as amended.

The following sections describe the quality requirements and controls applicable to this investigation. Correlation between EPA/240/B-01/003 (QA/R-5) requirements and information provided in the 200 Areas QAPjP and/or this chapter is provided in Table 2-1.

Table 2-1. Quality Assurance Crosswalk. (2 Pages)

EPA QA/R-5 Criteria	EPA QA/R-5 Title	Section in This Document
Project Management	Project/Task Organization	2.1 and 2.1.1
	Problem Definition and Background	1.2, 1.4
	Project Task Description	1.0 and 1.2
	Quality Objectives and Criteria	1.4, 2.2, 2.3
	Special Training/Certification	2.1.2
	Documents and Records	1.2, 2.1.1.2, 2.7, and 2.9
Data Generation and Acquisition	Sample Process Design	3.0, 3.2 through 3.8
	Sampling Methods	2.4, 2.10.5, 3.2 through 3.8, 3.10, 3.11
	Sample Handling and Custody	2.10, Tables 2-10 through 2-16, Section 3.10
	Analytical Methods	2.3, Tables 2-2 through 2-9
	Quality Control	2.2 and 2.3
	Instrument/Equipment Testing, Inspection and Maintenance	2.3.1 and 2.10.7
	Instrument/Equipment Calibration and Frequency	2.3.1, 2.5, 2.8
	Inspection and Acceptance of Supplies and Consumables	2.3.1
	Non Direct Measurement	Not applicable to Phase III
	Data Management	2.7
Assessment and Oversight	Assessment and Response Actions	2.6
	Reports to Management	2.6

Table 2-1. Quality Assurance Crosswalk. (2 Pages)

EPA QA/R-5 Criteria	EPA QA/R-5 Title	Section in This Document
Data Validation and Usability	Data Review, Verification and Validation	2.8
	Verification and Validation Methods	2.8
	Reconciliation with User Requirements	2.7 and 2.9

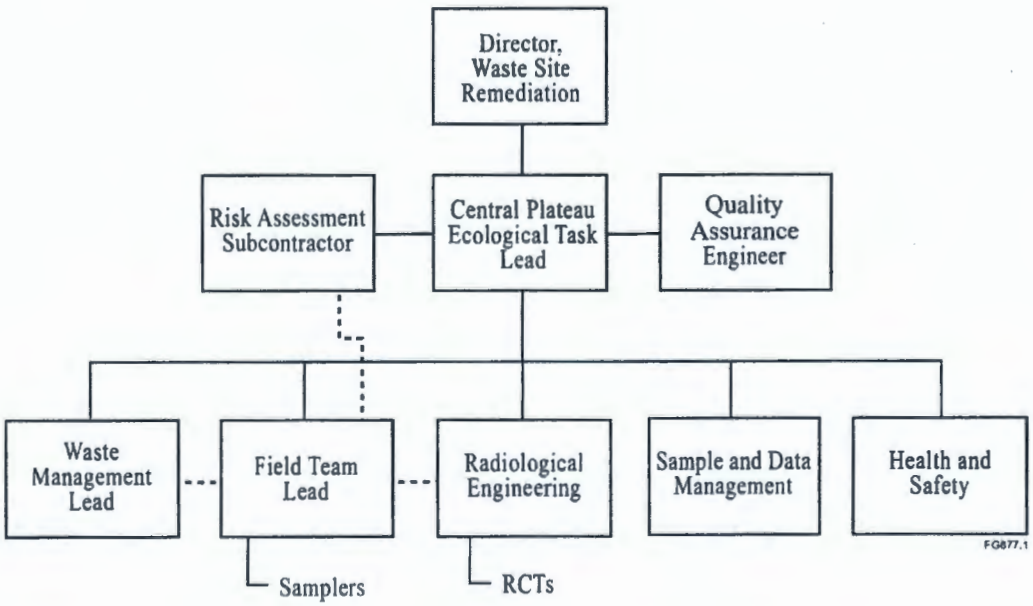
EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5.
EPA = U.S. Environmental Protection Agency.

2.1 PROJECT MANAGEMENT

This section addresses the basic areas of project management and will ensure that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planned outputs have been appropriately documented.

2.1.1 Project/Task Organization

Fluor Hanford, Inc. (FH), or its approved subcontractor, will be responsible for collecting, packaging, and shipping soil and biota samples to the laboratory. The project organization is described in the subsections that follow and is shown graphically below.



2.1.1.1 Director, Waste Site Remediation

The Director of Waste Site Remediation provides oversight for all activities and coordinates with the DOE Richland Operations Office (RL), regulators, and FH management in support of ecological sampling activities. In addition, support is provided to the Central Plateau Ecological Task Lead to ensure that the work is performed safely and cost-effectively.

2.1.1.2 Central Plateau Ecological Task Lead

The Central Plateau Ecological Task Lead is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The Ecological Task Lead ensures that the Field Team Lead, Samplers, and others responsible for implementation of this SAP and QAPjP are provided with current copies of this document and any revisions thereto. The Ecological Task Lead works closely with the Quality Assurance and Health and Safety organizations and the Field Team Lead to integrate these and the other lead disciplines in planning and implementing the work scope. The Ecological Task Lead coordinates with, and reports to RL, the regulators, and FH management on all ecological sampling activities.

2.1.1.3 Risk Assessment Subcontractor

The Risk Assessment Subcontractor is responsible for the performance of the EPA's eight-step ERAGS process that, for this project, results in the development of the ecological sampling design. Responsibilities include development and documentation of the ecological sampling DQOs, sampling design, associated presentations, and the resolution of technical issues.

2.1.1.4 Quality Assurance Engineer

The Quality Assurance Engineer is matrixed to the Central Plateau Ecological Task Lead and is responsible for QA on the project. Responsibilities include oversight of implementation of the project QA requirements; review of project documents including DQO summary reports, SAPs, and the QAPjP; and participation in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.5 Waste Management Lead

The Waste Management Lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include identifying waste management sampling/characterization requirements to ensure regulatory compliance and interpreting the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

2.1.1.6 Field Team Lead

The Field Team Lead has the overall responsibility for the planning, coordination, and execution of field characterization activities. Specific responsibilities include converting the sampling design requirements into field task instructions that provide specific direction for field activities. Responsibilities also include directing training, mock-ups, and practice sessions with field

personnel to ensure that the sampling design is understood and can be performed as specified. The Field Team Lead communicates with the Central Plateau Ecological Task Lead and the Risk Assessment Subcontractor to identify field constraints that could affect the sampling design. In addition, the Field Team Lead directs the procurement and installation of materials and equipment needed to support the field work.

2.1.1.7 Radiological Engineering

Radiological Engineering is responsible for the radiological engineering and health physics support for the project. Specific responsibilities include conducting as-low-as-reasonably-achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for all work planning. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels. Radiological Engineering interfaces with the project Health and Safety representative and plans and directs radiological control technician support for all activities.

2.1.1.8 Sample and Data Management

The Sample and Data Management organization selects the laboratories that perform the analyses. This organization ensures that the laboratories conform to Hanford Site internal laboratory QA requirements, or their equivalent, as approved by RL, the EPA, and the Washington State Department of Ecology. Sample and Data Management receives the analytical data from the laboratories, performs the data entry into the *Hanford Environmental Information System* (HEIS) database and arranges for data validation.

2.1.1.9 Health and Safety

The Health and Safety organization responsibilities include coordination of industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by Federal regulation or by internal FH work requirements. In addition, assistance is provided to project personnel in complying with applicable health and safety standards and requirements. Personal protective equipment requirements are coordinated with Radiological Engineering.

2.1.2 Special Training Requirements/Certification

Typical training or certification requirements have been instituted by the FH management team to meet training requirements imposed by the Project Hanford Management Contract, regulations, DOE orders, DOE contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers, *Washington Administrative Code*, etc. For example, training or certification requirements needed by sampling personnel will be in accordance with Site analytical requirements.

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

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

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

2.2 FIELD QUALITY CONTROL

Field quality control (QC) samples will be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC for sampling in the Central Plateau will require the collection of field replicates and equipment blanks. The QC samples and the required frequency for collection are described in this section.

2.2.1 Field Replicates

Field replicates are applicable to soil samples, but are not applicable to biota samples. Biota samples are independent samples and cannot be regarded as field replicates. Field replicates will be collected from a minimum frequency of 5 percent of total collected soil samples. Because soil, sediment, water, and salt-crust samples will be MISs, the field replicate for each medium will be an MIS. Two field replicate MIS will be collected from the BC Controlled Area sampling plot (Section 3.5) and from one of the five zones identified for transect placement in Section 3.6. Increments comprising the replicate sample will be retrieved from a random location that is different from the location of the original MIS increments. The multi-increment replicates for each medium will be collected in the same manner that the primary sample was collected, using the same equipment and sampling technique. Field replicates are used to evaluate laboratory consistency and the precision of field sampling methods.

2.2.2 Equipment Blanks

Equipment blanks are collected for any soil-sampling device that is reused. Biota will be rinsed of external soil before chemical or radiological analysis, and thus any bias associated with the trap or other collection device is not relevant. Equipment blanks will be collected for a minimum of 5 percent of the total collected soil samples and will be used to verify the adequacy

of sampling equipment decontamination procedures. The field team leader may request that additional equipment blanks be taken. Equipment blanks will consist of silica sand or analyte-free water poured over the decontaminated sampling equipment and placed in containers, as identified on the project Sampling Authorization Form.

Equipment blanks will be analyzed for the following:

- Cs-137
- Target analyte list metals.[6]

These analytes are considered to be the best indicators of decontamination effectiveness. Disposable equipment will be used for sampling aquatic media at West Lake, and thus equipment blanks are unnecessary.

2.2.3 Prevention of Cross-Contamination

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

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events.

2.3 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Quality objectives and criteria for soil and biota measurement data are presented in Tables 2-2 through 2-9 for media-specific COPECs. Detection limits are based on calculations presented in the Phase I, Phase II, and Phase III EcoDQO documents (WMP-20570, WMP-25493, and WMP-29253). The ability to meet practical quantitation limits is dependant on the amount of sample obtained (especially biota) and matrix interferences.

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[6] See SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*, for the target analyte list.

2.3.1 Measurement and Testing Equipment

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement-system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (such as parts lists and documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures (as appropriate). Calibration of laboratory instruments will be performed in a manner consistent with SW-846 or with auditable DOE Hanford Site and contractual requirements. Calibration of radiological field instruments is discussed in Section 2.8.

Consumables, supplies, and reagents will be reviewed per SW-846 requirements and will be appropriate for their use. Note that contamination is monitored by the QC samples discussed in Section 2.2.2.

2.3.2 Laboratory Sample Custody

Sample custody during laboratory analysis will be addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

2.3.3 Quality Assurance Objective

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by representativeness, comparability, accuracy, precision, and completeness. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. Each of these is addressed below.

2.3.3.1 Representativeness

Representativeness is a measure of how closely the results reflect the actual concentration and distribution of the radiological constituents in the matrix sampled. Sampling plan design, sampling techniques, and sample-handling protocols (e.g., storage, preservation, transportation) have been developed and are discussed in subsequent sections of this document. The documentation will establish that protocols have been followed and will ensure sample identification and integrity.

2.3.3.2 Comparability

Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be maintained using standard procedures, consistent methods, and consistent units. Tables 2-2 through 2-9 list the applicable fixed laboratory methods for analytes and target detection limits. Actual detection limits will depend on the sample matrix and the sample quantity available. Data will be reported as defined for specific samples.

2.3.3.3 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Radionuclide measurements that require chemical separations use this technique to measure method performance. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare results of blind audit samples against known standards to establish accuracy. Validity of calibrations are evaluated by comparing results from the measurement of a standard to known values and/or by generation of in-house statistical limits based on three standard deviations (+/- 3s). Tables 2-2 through 2-9 lists the accuracy provided for fixed laboratory analyses for the project.

2.3.3.4 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements or relative standard deviation for triplicates. Analytical precision for fixed laboratory analyses are listed in Tables 2-2 through 2-9.

2.3.3.5 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses.

2.3.4 Laboratory Quality Control

Laboratory duplicates will be analyzed. One additional laboratory QC sample will be analyzed from the primary MIS from the environmental medium sampled. For aquatic matrices, a laboratory duplicate will be measured on the primary MIS for surface water (filtered and unfiltered), pore water (filtered and unfiltered), sediment, and salt. A laboratory duplicate will be measured on soil MIS at the rate of 5 percent.

The laboratory method blanks and laboratory control sample/blank spike are defined in Chapter 1 of SW-846 and will be run at the frequency specified in Chapter 1 of SW-846.

2.4 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

Soil sample preservation, containers, and holding times for chemical and radiological analytes of interest are presented in Tables 2-10 through 2-16. Final sample collection requirements will be identified in the Sampling Authorization Form.

Table 2-2. Analytical Performance Requirements for Soil.

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Detection Limit Requirement		Matrix Specific Target Required Quantitation Limit [b] Soil	Precision (%)	Accuracy (%)
				MDL	PQL [a]			
Americium-241	14596-10-2	AEA	pCi/g	1	1	3890	±30 [c]	70-130 [d]
Cesium-137	10045-97-3	GEA	pCi/g	0.1	0.1	20.8	±30 [c]	70-130 [d]
Plutonium-238 [e]	13981-16-3	Plutonium isotopic – AEA	pCi/g	1	1	54 [e]	±30 [c]	70-130 [d]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/g	1	1	6,110	±30 [c]	70-130 [d]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	1	22.5	±30 [c]	70-130 [d]

[a] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[b] Values are Biota Concentration Guidelines (*RESRAD BIOTA*, ANL 2003) except where noted.
[c] Precision criteria for batch laboratory replicate sample analyses.
[d] Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method.
[e] Value for plutonium-238 from DOE/RL-2005-40, *100-B/C Pilot Project Risk Assessment Report*.

AEA = alpha energy analysis.
GEA = gamma energy analysis.
GPC = gas proportional counter.
MDL = minimum detection level.
N/A = not applicable.
PQL = practical quantitation limit.

Table 2-3. Analytical Performance Requirements for Vertebrates. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes [a]	Chemical Abstracts Service #	Name/Analytical Technology	Units	Detection Limit Requirement (PQL) [b]	Matrix-Specific Target-, Required Quantitation Limits for Ecological Receptors (fresh weight)	Precision (%)	Accuracy (%)
Radionuclides for Lizards and Mice from BC Controlled Area, Select Phase I Investigation Areas, and Non-Waste Site Area							
Cesium-137	10045-97-3	GEA	pCi/g	0.1	2,290	±30% [c]	70-130%
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	1,710	±30%	70-130% [d]
Total PCBs for Lizards and Mice Collected to Supplement Phase I and II Data [e]							
BZ 8	34883-43-7	Method 8082 [f]	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 18	37680-65-2	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 28	7012-37-5	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 37	38444-90-5	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 44	41464-39-5	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 49	41464-40-8	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 52	35693-99-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 66	32598-10-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 70	32598-11-1	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 74	32690-93-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 77	32598-13-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 81	70362-50-4	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 87	38380-02-8	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 90	68194-07-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 99	38380-01-7	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 101	37680-73-2	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 105	32598-14-4	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 110	38380-03-9	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 114	74472-37-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]

Table 2-3. Analytical Performance Requirements for Vertebrates. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes [a]	Chemical Abstracts Service #	Name/Analytical Technology	Units	Detection Limit Requirement (PQL) [b]	Matrix-Specific Target-, Required Quantitation Limits for Ecological Receptors (fresh weight)	Precision (%)	Accuracy (%)
BZ 118	31508-00-6	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 119	56558-17-9	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 123	65510-44-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 126	57465-28-8	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 128	38380-07-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 132	38380-05-1	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 138	35065-28-2	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 149	38380-04-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 151	52663-63-5	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 153	35065-27-1	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 156	38380-08-4	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 157	69782-90-7	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 158	74472-42-7	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 167	52663-72-6	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 168	59291-65-5	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 169	32774-16-6	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 170	35065-30-6	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 180	35065-29-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 183	52663-69-1	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 184	74472-48-3	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 187	52663-68-0	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 189	39635-31-9	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 195	52663-78-2	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]
BZ 206	40186-72-9	Method 8082	mg/kg	0.05	0.1	±30 [c]	70-130 [g]

Table 2-3. Analytical Performance Requirements for Vertebrates. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes [a]	Chemical Abstracts Service #	Name/Analytical Technology	Units	Detection Limit Requirement (PQL) [b]	Matrix-Specific Target-, Required Quantitation Limits for Ecological Receptors (fresh weight)	Precision (%)	Accuracy (%)

[a] BZ represents a system of sequential numbers for the 209 PCB congeners (Ballschmiter and Zell 1980, "Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography." These numbers are consistent with the International Union of Pure and Applied Chemistry numbers from http://www.epa.gov/toxteam/pcdid/Bzviupac.htm.

[b] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences. The PQL was obtained by back-calculating the concentration in prey necessary to exceed the WAC 173-340-900, "Tables," Table 749-5 toxicity reference values for PCB mixtures.

[c] Precision criteria for batch laboratory replicate sample analyses.

[d] Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method.

[e] Total PCBs will be addressed through analysis of PCB congeners.

[f] Method 8082 is found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. Alternately, EPA Method 1668 will be considered instead of Method 8082 for the vertebrate analyses.

[g] Accuracy criteria for associated batch laboratory control sample percent recoveries.

GEA = gamma energy analysis.
GPC = gas proportional counter.
PCB = polychlorinated biphenyl.
PQL = practical quantitation limit.

Table 2-4. Analytical Performance Requirements for Terrestrial Invertebrates.

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Matrix Specific Target Required Quantitation Limits, Invertebrates (fresh weight)	Precision (%)	Accuracy (%)
Radionuclides for Invertebrates from BC Controlled Area							
Cesium-137	10045-97-3	GEA	pCi/g	0.1	2,290	±30%	70-130% [c]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	1,710	±30%	70-130% [d]
Cyanide for Invertebrates Collected to Supplement Phase I and II Data							
Cyanide	57-12-5	Method 9010B, 9012A, 9013, or 9014	mg/kg	1	0.19 [e]	±30 [f]	70-130 [c]

[a] Methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
[b] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[c] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods.
[d] Accuracy criteria for associated batch laboratory control sample percent recoveries.
[e] WAC 173-340-707, "Analytical Considerations," allows use of the detection limit as the target quantitation limit where technology does not allow PQLs below the target limit.
[f] Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.
GEA = gamma energy analysis. GPC = gas proportional counter. PQL = practical quantitation limit.

Table 2-5. Analytical Performance Requirements for Aquatic Invertebrates. (2 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/Analytical Technology	Units	Detection Limit Requirement (PQL) [a]	Matrix-Specific Target-Required Quantitation Limits, Invertebrates (fresh wt) (WMP-29253)	Precision (%)	Accuracy (%)
Americium-241	14596-10-2	AEA	pCi/g	1	15.6	±30	70-130 [b]
Cobalt-60	10198-40-0	GEA	pCi/g	0.1	55.4	±30	70-130 [b]
Cesium-137	10045-97-3	GEA	pCi/g	0.1	352	±30	70-130 [b]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/g	1	18.3	±30	70-130 [b]
Radium-226	Ra-226	GEA	pCi/g	-	3.04	±30	70-130 [b]
Radium-228	Ra-228	GEA	pCi/g	0.2	2.63	±30	70-130 [b]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	283	±30	70-130 [b]
Uranium-238	U-238	Uranium isotopic – AEA (pCi)	pCi/g	1	5.89	±30	70-130 [b]
Antimony	7440-36-0	Metals [c]	mg/kg	3	1.27	±30	70-130 [b]
Arsenic	7440-38-2	Metals [c]	mg/kg	10/1 [f]	22.3	±30	70-130 [b]
Barium	7440-39-3	Metals [c]	mg/kg	1	349	±30	70-130 [b]
Bismuth	7440-69-9	Metals [c]	mg/kg	0.53	[d]	±30	70-130 [b]
Boron	7440-42-8	Metals [c]	mg/kg	0.21	13.8	±30	70-130 [b]
Cadmium	7440-43-9	Metals [c]	mg/kg	0.8	16.5	±30	70-130 [b]
Chromium (III)	7440-47-3	Metals [c]	mg/kg	1	23.7	±30	70-130 [b]
Copper	7440-50-8	Metals [c]	mg/kg	2	110	±30	70-130 [b]
Lead	7439-92-1	Metals [c]	mg/kg	20	53.6	±30	70-130 [b]
Mercury	7439-97-6	Metals [c]	mg/kg	0.05	4.27	±30	70-130 [b]
Molybdenum	7439-98-7	Metals [c]	mg/kg	10	167	±30	70-130 [b]
Nickel	7440-02-0	Metals [c]	mg/kg	4	94.2	±30	70-130 [b]
Selenium	7782-49-2	Metals [c]	mg/kg	20	4.29	±30	70-130 [b]

Table 2-5. Analytical Performance Requirements for Aquatic Invertebrates. (2 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/Analytical Technology	Units	Detection Limit Requirement (PQL) [a]	Matrix-Specific Target-Required Quantitation Limits, Invertebrates (fresh wt) (WMP-29253)	Precision (%)	Accuracy (%)
Silver	7440-22-4	Metals [c]	mg/kg	2	25.8	±30	70-130 [b]
Thallium	7440-28-0	Metals [c]	mg/kg	3 [e]	0.152	±30	70-130 [b]
Tin	7440-31-5	Metals [c]	mg/kg	10	32.3	±30	70-130 [b]
Uranium	7440-61-1	Metals [c]	mg/kg	30/5 [e,f]	131	±30	70-130 [b]
Vanadium	7440-62-2	Metals [c]	mg/kg	3	5.22	±30	70-130 [b]
Zinc	7440-66-6	Metals [c]	mg/kg	2	622	±30	70-130 [b]

[a] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.

[b] Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

[c] Method 6010 or 6020 or EPA Method 200.8 and extraction method 3050B. 4-digit methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*.

[d] No toxicity data on which to base a detection limit.

[e] WAC 173-340-707, "Analytical Considerations," allows use of the detection limit as the target quantitation limit when technology does not allow PQLs below the target limit.

[f] First value shown is via routine ICP; second value via "trace" ICP.

WMP-29253, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase III*.

AEA = alpha energy analysis.
GEA = gamma energy analysis.
GPC = gas-proportional counter.
ICP = inductively coupled plasma.
PQL = practical quantitation limit.

Table 2-6. Analytical Performance Requirements for West Lake Sediment. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
Americium-241	14596-10-2	AEA	pCi/g	1	5,150 [b]	RESRAD Biota	±30 [c]	70-130 [c]
Cobalt-60	10198-40-0	GEA	pCi/g	0.05	1,460 [b]	RESRAD Biota	±30 [c]	70-130 [c]
Cesium-137	10045-97-3	GEA	pCi/g	0.1	3,120 [b]	RESRAD Biota	±30 [c]	70-130 [c]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/g	1	-	-	±30 [c]	70-130 [c]
Radium-226	Ra-226	GEA	pCi/g	0.1	101 [b]	RESRAD Biota	±30 [c]	70-130 [c]
Radium-228	Ra-228	GEA	pCi/g	1.0	87.8 [b]	RESRAD Biota	±30 [c]	70-130 [c]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1 [b]	582 [c]	RESRAD Biota	±30 [g]	70-130 [g]
Uranium-238	U-238	Uranium isotopic – AEA	pCi/g	1.0 [b]	2,500 [c]	RESRAD Biota	±30 [g]	70-130 [g]
Antimony	7440-36-0	Metals [e]	mg/kg	6/ 0.6 [f]	2.0	SQuiRTs TEL	±30 [g]	70-130 [g]
Arsenic	7440-38-2	Metals [e]	mg/kg	10/ 1 [f]	7.2	SQuiRTs TEL	±30 [g]	70-130 [g]
Barium	7440-39-3	Metals [e]	mg/kg	2/ 0.5 [f]	-	SQuiRTs TEL	±30 [g]	70-130 [g]
Bismuth	7440-69-9	Metals [e]	mg/kg	0.53	-	SQuiRTs TEL	[g]	[g]
Boron	7440-42-8	Metals [e]	mg/kg	0.21	-	SQuiRTs TEL	[g]	[g]
Cadmium	7440-43-9	Metals [e]	mg/kg	1/ 0.2 [f]	0.68	SQuiRTs TEL	±30 [g]	70-130 [g]
Chromium (III)	7440-47-3	Metals [e]	mg/kg	1	52.3	SQuiRTs TEL	±30 [g]	70-130 [g]
Copper	7440-50-8	Metals [e]	mg/kg	6/ 0.6 [f]	18.7	SQuiRTs TEL	±30 [g]	70-130 [g]
Hexavalent chromium	18540-29-9	Method 7196A	mg/kg	0.5	-	-	±30 [g]	70-130 [g]
Lead	7439-92-1	Metals [e]	mg/kg	5/ 0.5 [f]	30.2	SQuiRTs TEL	±30 [g]	70-130 [g]
Mercury	7439-97-6	Method 7471	mg/kg	0.2	0.13	SQuiRTs TEL	±30 [g]	70-130 [g]
Molybdenum	7439-98-7	Metals [e]	mg/kg	10	-	-	[g]	[g]

Table 2-6. Analytical Performance Requirements for West Lake Sediment. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
Nickel	7440-02-0	Metals [e]	mg/kg	4	15.9	SQuiRTs TEL	±30 [g]	70-130 [g]
Selenium	7782-49-2	Metals [e]	mg/kg	10	-	-	[g]	[g]
Silver	7440-22-4	Metals [e]	mg/kg	1/ 0.2 [f]	0.73	SQuiRTs TEL	±30 [g]	70-130 [g]
Thallium	7440-28-0	Metals [e]	mg/kg	10	-	-	[g]	[g]
Tin	7440-31-5	Metals [e]	mg/kg	10	-	-	±30 [g]	70-130 [g]
Uranium	7440-61-1	Metals [e]	mg/kg	30/ 5 [f]	-	-	±30 [g]	70-130 [g]
Vanadium	7440-62-2	Metals [e]	mg/kg	2.5	-	-	±30 [g]	70-130 [g]
Zinc	7440-66-6	Metals [e]	mg/kg	1	124	SQuiRTs TEL	±30 [g]	70-130 [g]
Semivolatile organic compounds	Chemical-specific	SVOA-8270B	mg/kg	Chemical-specific	Chemical-specific	SQuiRTs TEL	±30 [g]	50-150 [g]
Tributyl phosphate	126-73-8	SVOA-8270B	mg/kg	3.3	-	-	[g]	[g]
Normal paraffin hydrocarbons	N/A	WTPH-Diesel and Kerosene	mg/kg	5.0	-	-	[g]	[g]
Acid soluble sulfide	N/A	Preparation - 9030B Analysis by either 9034 or 9215	mg/kg	1	-	-	[g]	[g]
Acid insoluble sulfide	N/A	Preparation - 9030B Analysis by either 9034 or 9215	mg/kg	1	-	-	[g]	[g]
Total sulfides	N/A	Preparation - 9030B Analysis by either 9034 or 9215	mg/kg	1	-	-	[g]	[g]

Table 2-6. Analytical Performance Requirements for West Lake Sediment. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
TOC	TOC	Method 9060	mg/kg	25	-	-	±30 [g]	70-130 [g]

[a] These methods may require alternation because of the salt content.
[b] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[c] Riparian animal Biota Concentration Guide from *RESRAD BIOTA* Version 1.0, ANL 2003.
[d] Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.
[e] Method 6010 or 6020 or EPA Method 200.8 and extraction method 3050B. 4-digit methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*.
[f] First value shown is via routine ICP; second value via "trace" ICP.
[g] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.

- = no value available.
AEA = alpha energy analysis.
GEA = gamma energy analysis.
GPC = gas proportional counter.
ICP = inductively coupled plasma.
N/A = not applicable.
PQL = practical quantitation limit.
SQuiRTs TEL = *Screening Quick Reference Table* threshold-effect level (NOAA 1999).
SVOA = semivolatile organic analysis.
TBD = to be determined.
TOC = total organic carbon.
WTPH = Washington total petroleum hydrocarbons.

Table 2-7. Analytical Performance Requirements for Salt Crust. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
Americium-241	14596-10-2	AEA	pCi/g	1	5,150 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Cobalt-60	10198-40-0	GEA	pCi/g	0.05	1,460 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Cesium-137	10045-97-3	GEA	pCi/g	0.1	3,120 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/g	1	-	-	±30 [d]	70-130 [d]
Radium-226	Ra-226	GEA	pCi/g	0.1	101 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Radium-228	Ra-228	GEA	pCi/g	1.0	87.8 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	1	582 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Uranium-238	U-238	Uranium isotopic – AEA	pCi/g	1.0	2,500 [c]	RESRAD Biota	±30 [d]	70-130 [d]
Antimony	7440-36-0	Metals [e]	mg/kg	6/ 0.6 [f]	2.0	SQuiRTs TEL	±30 [g]	70-130 [g]
Arsenic	7440-38-2	Metals [e]	mg/kg	10/ 1 [f]	7.2	SQuiRTs TEL	±30 [g]	70-130 [g]
Barium	7440-39-3	Metals [e]	mg/kg	2/ 0.5 [f]	-	SQuiRTs TEL	±30 [g]	70-130 [g]
Bismuth	7440-69-9	Metals [e]	mg/kg	0.53	-	SQuiRTs TEL	[g]	[g]
Boron	7440-42-8	Metals [e]	mg/kg	0.21	-	SQuiRTs TEL	[g]	[g]
Cadmium	7440-43-9	Metals [e]	mg/kg	1/ 0.2 [f]	0.68	SQuiRTs TEL	±30 [g]	70-130 [g]
Calcium	7440-70-2	Metals	mg/kg	10			±30 [g]	70-130 [g]
Chromium (III)	7440-47-3	Metals [e]	mg/kg	1	52.3	SQuiRTs TEL	±30 [g]	70-130 [g]
Copper	7440-50-8	Metals [e]	mg/kg	6/ 0.6 [f]	18.7	SQuiRTs TEL	±30 [g]	70-130 [g]
Hexavalent chromium	18540-29-9	Method 7196A	mg/kg	0.5	-	-	±30 [g]	70-130 [g]
Iron	7439-89-6	Metals	mg/kg	5	-	-	±30 [g]	70-130 [g]
Lead	7439-92-1	Metals [e]	mg/kg	5/ 0.5 [f]	30.2	SQuiRTs TEL	±30 [g]	70-130 [g]

Table 2-7. Analytical Performance Requirements for Salt Crust. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
Magnesium	7439-95-4	Metals	mg/kg	75	-	-	±30 [g]	70-130 [g]
Mercury	7439-97-6	Method 7471	mg/kg	0.2	0.13	SQuiRTs TEL	±30 [g]	70-130 [g]
Molybdenum	7439-98-7	Metals [e]	mg/kg	10	-	-	[g]	[g]
Nickel	7440-02-0	Metals [e]	mg/kg	4	15.9	SQuiRTs TEL	±30 [g]	70-130 [g]
Potassium	7440-09-7	Metals	mg/kg	400	-	-	±30 [g]	70-130 [g]
Selenium	7782-49-2	Metals [e]	mg/kg	10	-	-	[g]	[g]
Silver	7440-22-4	Metals [e]	mg/kg	1/ 0.2 [f]	0.73	SQuiRTs TEL	±30 [g]	70-130 [g]
Sodium	7440-23-5	Metals	mg/kg	50	-	-	±30 [g]	70-130 [g]
Thallium	7440-28-0	Metals [e]	mg/kg	10	-	-	[g]	[g]
Tin	7440-31-5	Metals [e]	mg/kg	10	-	-	±30 [g]	70-130 [g]
Uranium	7440-61-1	Metals [e]	mg/kg	30/ 5 [f]	-	-	±30 [g]	70-130 [g]
Vanadium	7440-62-2	Metals [e]	mg/kg	2.5	-	-	±30 [g]	70-130 [g]
Zinc	7440-66-6	Metals [e]	mg/kg	1	124	SQuiRTs TEL	±30 [g]	70-130 [g]
Alkalinity	ALKALINITY	Method 310.1/310.2	mg/kg	5	-	-	±30 [g]	70-130 [g]
Phosphorous in phosphate	PO4-P	Method 300	mg/kg	5	-	-	±30 [g]	70-130 [g]
Nitrate	14797-55-8	Method 300	mg/kg	2.5	-	-	±30 [g]	70-130 [g]
Nitrite	14797-65-0	Method 300	mg/kg	2.5	-	-	±30 [g]	70-130 [g]
Sulfate	14808-79-8	Method 300	mg/kg	5	-	-	±30 [g]	70-130 [g]
Chloride	16887-00-6	Method 300	mg/kg	2	-	-	±30 [g]	70-130 [g]
Fluoride	16984-48-8	Method 300	mg/kg	5	-	-	±30 [g]	70-130 [g]
Bromide	24959-67-9	Method 300	mg/kg	2.5	-	-	±30 [g]	70-130 [g]

Table 2-7. Analytical Performance Requirements for Salt Crust. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology [a]	Units	Detection Limit Requirement (PQL) [b]	Marine Sediment Reference Values for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Sediment	Source of Value		
Total carbonate/hydroxide titrations	3812-32-6/ 14280-30-9	Titration for carbonate and hydroxide	mg/kg	NA	-	-	NA	NA
XRD analysis	NA	X-ray diffraction crystallography	NA	NA	-	-	NA	NA

[a] These methods may require alternation because of the salt content.
[b] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[c] Riparian animal Biota Concentration Guide from *RESRAD BIOTA* Version 1.0, ANL 2003.
[d] Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.
[e] Method 6010 or 6020 or EPA Method 200.8 and extraction method 3050B. 4-digit methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*.
[f] First value shown is via routine ICP; second value via "trace" ICP.
[g] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.

For EPA Methods 310.1 and 310.2, see EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*.

- = no value available.
AEA = alpha energy analysis.
GEA = gamma energy analysis.
GPC = gas proportional counter.
PQL = practical quantitation limit.
SQuiRTs TEL = *Screening Quick Reference Table* threshold-effect level (NOAA 1999).
XRD = X-ray diffraction.

Table 2-8. Analytical Performance Requirements for Water. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Laboratory Detection Limit (PQL) [a]	Water Reference Value for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Water	Source of Value		
Americium-241	14596-10-2	AEA	pCi/L	1	428	RESRAD Biota	±30 [b]	70-130 [b]
Cobalt-60	10198-40-0	GEA	pCi/L	25	3,760	RESRAD Biota	±30 [b]	70-130 [b]
Cesium-137	10045-97-3	GEA	pCi/L	15	42.6	RESRAD Biota	±30 [b]	70-130 [b]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/L	1	-	-	±30 [b]	70-130 [b]
Radium-226	Ra-226	GEA	pCi/L	1	4.08	RESRAD Biota	±30 [b]	70-130 [b]
Radium-228	Ra-228	GEA	pCi/L	3	3.4	RESRAD Biota	±30 [b]	70-130 [b]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/L	1	278	RESRAD Biota	±30 [b]	70-130 [b]
Uranium-238	U-238	Uranium isotopic – AEA (pCi)	pCi/L	1	223	RESRAD Biota	±30 [b]	70-130 [b]
Antimony	7440-36-0	Metals [c]	µg/L	60/ 6 [d]	-	-	±30 [e]	70-130 [e]
Arsenic	7440-38-2	Metals [c]	µg/L	6 [f]	36	WAC 173-201A chronic value	±30 [e]	70-130 [e]
Barium	7440-39-3	Metals [c]	µg/L	20/ 5 [d]	-	-	±30 [e]	70-130 [e]
Bismuth	7440-69-9	Metals [c]	µg/L	53	20,000	ORNL 1997 wetland LOEC	[e]	[e]
Boron	7440-42-8	Metals [c]	µg/L	21	1,000	ORNL 1997 wetland LOEC	[e]	[e]
Cadmium	7440-43-9	Metals [c]	µg/L	5/ 2 [d]	8.8	EPA 2004 CCC value	±30 [e]	70-130 [e]
Calcium	7440-70-2	Metals	µg/L	1000	-	-	±30 [e]	70-130 [e]
Chromium (III)	7440-47-3	Metals [c]	µg/L	10/ 2 [d]	50	ORNL 1997 wetland LOEC	±30 [e]	70-130 [e]
Copper	7440-50-8	Metals [c]	µg/L	10	3.1	EPA 2004 CCC value	±30 [e]	70-130 [e]
Iron	7439-89-6	Metals	µg/L	50	-	-	±30 [e]	70-130 [e]

Table 2-8. Analytical Performance Requirements for Water. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Laboratory Detection Limit (PQL) [a]	Water Reference Value for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Water	Source of Value		
Lead	7439-92-1	Metals [c]	µg/L	50/ 5 [d]	8.1	EPA 2004 CCC value	±30 [e]	70-130 [e]
Magnesium	7439-95-4	Metals	µg/L	750	-	-	±30 [e]	70-130 [e]
Mercury	7439-97-6	Method 7470	µg/L	0.5	0.94	EPA 2004 CCC value	±30 [e]	70-130 [e]
Molybdenum	7439-98-7	Metals [c]	µg/L	10	500	ORNL 1997 wetland LOEC	[e]	[e]
Nickel	7440-02-0	Metals [c]	µg/L	40	8.2	EPA 2004 CCC value	±30% [e]	70-130 [e]
Potassium	7440-09-7	Metals	µg/L	4000	-	-	±30% [e]	70-130 [e]
Selenium	7782-49-2	Metals [c]	µg/L	10	71	EPA 2004 CCC value	[e]	[e]
Silver	7440-22-4	Metals [c]	µg/L	10/ 2 [d]	1.9	EPA 2004 CCC value	±30 [e]	70-130 [e]
Sodium	7440-23-5	Metals	µg/L	500	-	-	±30 [e]	70-130 [e]
Thallium	7440-28-0	Metals [c]	µg/L	2	50	ORNL 1997 wetland LOEC	[e]	[e]
Tin	7440-31-5	Metals [c]	µg/L	100	100,000	ORNL 1997 wetland LOEC	±30 [e]	70-130 [e]
Uranium	7440-61-1	Metals [c]	µg/L	3000/ 500 [d]	40,000	ORNL 1997 wetland LOEC	±30 [e]	70-130 [e]
Vanadium	7440-62-2	Metals [c]	µg/L	25	200	ORNL 1997 wetland LOEC	±30 [e]	70-130 [e]
Zinc	7440-66-6	Metals [c]	µg/L	10	81	EPA 2004 CCC value	±30 [e]	70-130 [e]
PH	pH	Method 9040	pH units	0.1	-	-	+/-0.1 pH units	+/-0.1 pH units
TOC	TOC	Method 9060	µg/L	25	-	-	±30 [e]	70-130 [e]
Alkalinity	ALKALINITY	Method 310.1/310.2	µg/L	5000	-	-	±30 [e]	70-130 [e]
Phosphorous in phosphate	PO4-P	Method 300	µg/L	500	-	-	±30 [g]	70-130 [e]
Nitrate	14797-55-8	Method 300	µg/L	250	-	-	±30 [g]	70-130 [e]
Nitrite	14797-65-0	Method 300	µg/L	250	-	-	±30 [g]	70-130 [e]
Sulfate	14808-79-8	Method 300	µg/L	500	-	-	±30 [g]	70-130 [e]
Chloride	16887-00-6	Method 300	µg/L	200	-	-	±30 [g]	70-130 [e]
Fluoride	16984-48-8	Method 300	µg/L	500	-	-	±30 [g]	70-130 [e]
Bromide	24959-67-9	Method 300	µg/L	250	-	-	±30 [g]	70-130 [e]

Table 2-8. Analytical Performance Requirements for Water. (3 Pages)

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Laboratory Detection Limit (PQL) [a]	Water Reference Value for the Protection of Ecological Receptors		Precision (%)	Accuracy (%)
					Marine Water	Source of Value		
Total dissolved solids	NA	Method 160.1	mg/L	10	-	-	±30 [g]	70-130 [e]
Total hydroxide/carbonate titrations	3812-32-6/ 14280-30-9	Titration for carbonate and hydroxide	mg/L	NA	-	-	NA	NA

[a] The ability to meet PQLs is dependant on the amount of sample obtained (e.g., especially biota) and matrix interferences.
[b] Accuracy criteria for associated batch laboratory control sample percent recoveries. For some radionuclide analytical methods, additional analysis-specific evaluations also are performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.
[c] Method 6010 or 6020 or EPA Method 200.8 and extraction method 3050B. 4-digit methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*.
[d] First value shown is via routine ICP; second value via "trace" ICP.
[e] Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation criteria based on laboratory statistical limits or fixed limits as defined in the referenced methods. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.
[f] Graphite furnace atomic absorption.

For EPA Methods 160.1, 310.1, and 310.2, see EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*.

EPA, 2004, *National Recommended Water Quality Criteria*.
ORNL 1997, ES/ER/TM-85/R3, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision*.
RESRAD biota values from *RESRAD BIOTA*, Version 1.0, ANL 2003.
WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

AEA = alpha energy analysis.
CCC = criteria continuous concentration.
EPA = U.S. Environmental Protection Agency.
GEA = gamma energy analysis.
GPC = gas proportional counter.
ICP = inductively coupled plasma.
LOEC = lowest observed-effect concentration.
ORNL = Oak Ridge National Laboratory.
PQL = practical quantitation limit.
TOC = total organic carbon.

Table 2-9. Analytical Performance Requirements for Soil-Gas.

Contaminant of Potential Ecological Concern or Additional Analytes	Chemical Abstracts Service #	Name/ Analytical Technology	Units	Detection Limit Requirement (PQL)	Matrix-Specific Target-Required Quantitation Limits (Burrow Air)	Precision (%)	Accuracy (%)
Carbon tetrachloride and degradation products [a]	56-23-5	EPA Method TO-15 [b]	ppmv	0.010	0.91	±35	65-135

[a] chloroform, methylene chloride, chloromethane.
[b] EPA Method TO-15 is found in EPA/625/R-96/010b, *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.*

EPA = U.S. Environmental Protection Agency.
MDL = minimum detection limit.
ppmv = parts per million by volume.
PQL = practical quantitation limit.

2.5 ONSITE MEASUREMENTS QUALITY CONTROL

The collection of QC samples for onsite-measurements QC is not applicable to the field screening techniques described in this SAP. Field screening instrumentation will be calibrated and controlled according to the procedures identified in Section 2.8.

2.6 ASSESSMENT/OVERSIGHT

Routine evaluation of data quality described for this project will be documented and filed along with the data in the project file.

2.6.1 Assessments and Response Action

FH Quality Assurance may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the QAPjP, procedures, and regulatory requirements.

Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. FH Quality Assurance coordinates the corrective actions/deficiencies in accordance with the FH QA program. When appropriate, corrective actions will be taken by the Central Plateau Ecological Task Lead.

2.6.2 Reports to Management

Management will be made aware of all deficiencies identified by self-assessments. Identified deficiencies will be reported to the FH Director of Waste Site Remediation, as appropriate.

2.7 DATA MANAGEMENT

Ecological and analytical data resulting from the implementation of this QAPjP will be managed and stored in accordance with the applicable programmatic requirements governing data management procedures. At the direction of the task lead, all analytical data packages will be subject to final technical review by qualified personnel before they are submitted to the regulatory agencies or included in reports. Electronic data access, when appropriate, will be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989).

Planning for sample collection and analysis will be in accordance with the programmatic requirements governing fixed laboratory sample-collection activities, as discussed in the sample team's procedures. In the event that specific procedures do not exist for a particular work evolution, or it is determined that additional guidance to complete certain tasks is needed, a work

package will be developed to adequately control the activities, as appropriate. Examples of the sample team's requirements include activities associated with the following:

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

Approved work-control packages and procedures will be used to document radiological measurements when this SAP is implemented. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information per 10 CFR 835, "Occupational Radiation Protection"

- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of FH radiological records

- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related records.

Ecological data will be cross-referenced to the analytical data and radiation measurements to facilitate interpreting the investigation results. Units for analytical sample results for biological tissues will be explicit in terms of fresh-weight and dry-weight measurements.

2.7.1 Resolution of Analytical System Errors

Errors reported by the laboratories are reported to the Sample and Data Management Project Coordinator, who initiates a Sample Disposition Record in accordance with FH procedures. This process is used to document analytical errors and to establish resolution with the project task lead. In addition, the FH QA Engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

2.8 VALIDATION AND VERIFICATION REQUIREMENT

Completed data packages will be validated by qualified FH Sample and Data Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation also will include evaluating and qualifying the results, based on holding times, method blanks, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate. No other validation or calculation checks will be performed.

Level C data validation as defined in the contractor's validation procedures, which are based on EPA functional guidelines (Bleyler 1988a, *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses*; Bleyler 1988b, *Laboratory Data Validation Functional*

Guidelines for Evaluating Organics Analyses), will be performed for up to 5 percent of the data by matrix and analyte group. For example, if 10 lizards and 10 mice are sampled for radionuclides, one mouse or lizard will be validated for radionuclide results. Analyte group refers to radionuclides, volatile chemicals, semivolatiles, PCBs, metals, and anions. The goal is to cover the various analyte groups and matrices during the validation.

When outliers or illogical results are identified in the data quality assessment, additional data validation will be performed. The additional validation will be up to 5 percent of the statistical outliers and/or illogical data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure that the data are usable. Note that Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the dataset. All data validation will be documented in data validation reports. An example of illogical data is the positive detections greater than the practical quantitation limit or reporting limit in animal tissue from a reference site that should not have exhibited contamination. Similarly, results below background would not be expected and could trigger a validation inquiry. With the exception of "R" qualified or rejected data, all data will be used.

At least one data validation package will be generated. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures. Relative to analytical data in biotic and abiotic media, physical data and/or field screening results are of lesser importance in making inferences of risk. Because of the secondary importance of such data, no validation for physical property data and/or field screening results will be performed. However, field QA/QC will be reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- Calibration of radiological field instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory, as specified in their program documentation.

- Daily calibration checks will be performed and documented for each instrument used to characterize areas that are under investigation. These checks will be made on standard materials that are sufficiently like the matrix under consideration that direct comparison of data can be made. Analysis times will be sufficient to establish detection efficiency and resolution.

The approval of field-data collection plans by the Radiological Engineering Manager represents the data validation and usability review for handheld field radiological measurements.

2.9 DATA ASSESSMENT

The data quality assessment process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. The EPA data quality assessment process, EPA/600/R-96/084, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA QA/G-9, QA00 Update, identifies five steps for evaluating data generated from

this project, as summarized below.

- **Step 1. Review Data Quality Objectives and Sampling Design**. This step requires a comprehensive review of the sampling and analytical requirements outlined in the project-specific DQO summary report and SAP.

- **Step 2. Conduct a Preliminary Data Review.** In this step, a comparison is made between the actual QA/QC achieved (e.g., detection limits, precision, accuracy, completeness) and the requirements determined during the DQO. Any significant deviations will be documented. Basic statistics will be calculated from the analytical data at this point, including an evaluation of the distribution of the data.

- **Step 3. Select the Data Analyses**. Using the data evaluated in Step 2, select appropriate statistical hypothesis tests or graphical data analyses and justify this selection.

- **Step 4. Verify the Assumptions.** Assess whether the assumptions underlying the data analyses are met or if the data set must be modified (e.g., transposed, augmented with additional data) before further analysis. If one or more assumptions is questioned, return to Step 3.

- **Step 5. Draw Conclusions from the Data.** The analyses are applied in this step, and the results will be used to draw conclusions in the risk assessment.

This section describes how resultant data from this SAP will be assessed for the risk assessment. During the process of data assessment, plots are used to determine the presence of outliers or other anomalous data that might affect statistical results and interpretations. Exploratory data-analysis plots allow visual inspection and summary of the data (Chambers et al. 1983, *Graphical Methods for Data Analysis*). Each plot provides a different visual presentation of the distributions of concentrations. The choice of plotting procedure(s) depends on the hypothesis being tested. The choice may depend on the type of difference that is to be displayed, such as an overall shift in concentration (shift of central location) or, when the centers are nearly equal, a difference between the upper tails of the two distributions (elevated concentrations in a small fraction of one distribution). The choice will accommodate characteristics of the data sets.

When there are both detects and nondetects in a data set, the convention used for plotting the nondetects is given. It is typical to use different plotting characters for detects and nondetects and to include nondetects at their reported detection limits or at half of the detection limit or estimated quantitation limit. The data from the investigation areas will be assessed for outliers and for differences in concentration between the investigation (potentially impacted and non-operational) areas. While many statistical approaches will be used, not all data are equally valid for all analyses.

Exposure modeling will make use of all tissue data collected in this study. Adverse effects are inferred by the ratio of exposure to effects levels (toxicity reference values). It is assumed that the exposure received orally for terrestrial wildlife can be described mathematically as follows:

$$E_{oral} = I_{food}[fs \cdot C_{soil} + C_{food}] \cdot AUF,$$

where:

E_{oral} is the estimated oral daily dose for a COPEC (mg-COPEC/kg-body weight/day)

I_{food} is the normalized daily dietary ingestion rate (kg-dry weight/kg-body weight/day)

fs is the fraction of soil ingested, expressed as a fraction of the dietary intake

C_{soil} is the concentration of chemical constituent x in soil (mg/kg dry weight)

C_{food} is the concentration of a COPEC in food (mg/kg-dry weight)

AUF is the area use factor for the receptor (ratio of the investigation area to the home range, but no larger than 1.0).

The equation assumes that a single food type is ingested and that exposure modeling must be specific for herbivores, omnivores, insectivores, and carnivores. This model is similar to WAC 173-340-900, "Tables," Table 749-4, "Wildlife Exposure Model for Site-Specific Evaluations," for evaluation of the ecological effects of contaminants on terrestrial wildlife (WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures").

Exposure modeling will be based on site-specific soil COPEC data and on COPECs detected in the three taxonomic representatives of middle trophic-level species (invertebrates, lizards, and small mammals) sampled for tissue analyses. Food ingestion rates and home ranges for Central Plateau receptors are provided in the Phase I EcoDQO document (WMP-20570). Avian and mammalian toxicity reference values for the COPECs being evaluating in this plan also were provided in the Phase I EcoDQO document (WMP-20570). The total PCB toxicity reference value in WAC 173-340-900, Table 749-5, "Default Values for Selected Hazardous Substances for Use with the Wildlife Exposure Model in Table 749-4," will be used for comparison to modeled intake of PCBs. Soil-ingestion values will be obtained from the literature for the receptors considered in the Central Plateau or from appropriate surrogate receptors (EPA 2005, *Guidance for Developing Ecological Soil Screening Levels*).

A framework for considering uncertainties in exposure-related (e.g., ingestion rate) and toxicity-related parameters is described in LA-UR-04-8246, *Screening-Level Ecological Risk Assessment Methods*, as well; this framework will be adopted for evaluating uncertainty in this SAP. Many factors are incorporated in the development of soil-screening levels, and uncertainty is associated with all aspects; among these, values for the exposure-related parameters and toxicity-related parameters are key considerations.

Considering exposure, the conceptual model for the Central Plateau terrestrial environment was reviewed as part of the data assessment to determine if significant complete pathways exist that were not included in the development of the screening levels. The exposure pathways addressed by the screening level and hazard-quotient analysis include all complete exposure pathways with

the exception of inhalation and dermal exposure. Inhalation risks are being addressed as outlined in this Phase III SAP. Although the dermal exposure contributes to the dose received by animals, the contribution is relatively small and does not interfere with COPEC determination (WMP-20570). Regarding the primary contribution to terrestrial-exposure ingestion, the screening levels overestimate the dose ingested if some of the pathways are not complete at the site; for example, if the contaminated media were buried at a depth inaccessible to wildlife receptors.

For pathways used in exposure assessment, the equations used include terms for body weight, water intake, food intake, and inhalation rate. To provide a conservative estimate of the screening level, maximum estimates of intake factors (food, water, air) were combined with lower estimates of body weight. This approach maximizes the weight-specific dose to the receptor and is protective of all species within a feeding guild represented by a screening receptor. It may overestimate potential risk to larger-size species or to small-size species with lower intake rates than those used in the model. Risk to farther ranging species also may be overestimated, because the area use for development of screening levels is 100 percent. Depending on the size of the site, this value may be appropriate for small-size species but is likely to overestimate risk for larger size species with a home range greater than the size of the site.

Another key uncertainty is the availability of toxicity information for receptor groups (e.g., birds, mammals, plants, invertebrates). The toxicity data and uncertainty factors used to develop the screening levels potentially may overestimate the actual toxicity of a chemical to a receptor, particularly when those data are extrapolated from one species to another. In addition, the comparison of site concentrations to screening levels assumes that the chemical species or form occurring at the site is identical to the chemical species used in the toxicity analysis.

2.10 FIELD-SPECIFIC COLLECTION

Additional details regarding field-specific collection requirements are provided below.

2.10.1 Sample Location

Sample locations will be staked and labeled before the activity is started. After the locations have been staked, minor adjustments to the location may be made to mitigate unsafe conditions, avoid structural interferences, or bypass utilities. Locations will be identified as part of the work planning process for the collection of samples. Changes in sample locations that do not affect the EcoDQOs will require the approval of the project manager. However, changes to sample locations that result in impacts to the EcoDQOs will require decision-maker concurrence.

2.10.2 Sample Identification

The FH *Sample Data Tracking* database will be used to track the samples through the collection-and-laboratory-analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project. The radiological and physical properties of each sample will be

identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information, using a waterproof marker on firmly affixed, water-resistant labels:

- Sampling Authorization Form number
- HEIS number
- Sample collection date and time
- Name of person collecting the sample
- Analysis required
- Preservation method (if applicable).

2.10.3 Field Sample Log

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

2.10.4 Sample Custody

Sample custody will be maintained in accordance with existing Hanford Site protocols. The custody of samples will be maintained from the time the samples are collected until the ultimate disposal of the samples, as appropriate. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples (in a cooler) shipped to any laboratory. Wire or laminated waterproof tape will be used to seal the coolers. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time the responsibility for the custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before the sample is shipped and will transmit the copy to FH Sample and Data Management within 48 hours of shipping. A custody seal (i.e., evidence tape) will be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date.

2.10.5 Sample Containers, Preservatives, and Holding Times

Level I EPA pre-cleaned sample containers will be used for soil samples collected for radiological analysis. Container sizes may vary, depending on the laboratory-specific volumes needed to meet analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content within the sample exceeds levels acceptable to an offsite laboratory, the sampling lead can send smaller volumes to the laboratory after consultation with FH Sample and

Data Management to determine acceptable volumes. Preliminary container types, volumes, preservatives, and holding times are identified in Tables 2-10 through 2-16. The final container type and volumes will be provided on the Sampling Authorization Form. Where multiple analyses are performed for a matrix, especially matrices having the potential for sample mass limitations (e.g., invertebrate tissues), analyses with gamma spectroscopy are of the highest analytical priority, because gamma spectroscopy is a nondestructive analysis. The order for the remaining analyses is based on their importance for assessing potential ecological risks, based on hazard quotient analysis documented in WMP-20570.

This SAP defines a sample as a filled sample bottle for the purpose of starting the clock for holding-time restrictions.

2.10.6 Sample Shipping

The radiological control technician will measure both the contamination levels on the outside of each sample jar and the dose rates on each sample jar. The radiological control technician also will measure the radiological activity on the outside of the sample container (through the container) and will document the highest contact radiological reading in millirem per hour. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, "Transportation") and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to FH Sample and Data Management within 48 hours of shipping.

As a general rule, samples with activities of <1 mR/h will be shipped to an offsite laboratory. Samples with activities between 1 mR/h and 10 mR/h may be shipped to an offsite laboratory, although samples with dose rates within this range will be evaluated on a case-by-case basis by FH Sample and Data Management. Samples with activities of >10 mR/h will be sent to an onsite laboratory arranged for by Sample and Data Management.

2.10.7 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used to support the characterization described in this SAP, as appropriate. The following information will be disseminated to personnel performing work in support of this SAP, as appropriate:

- Instructions to the radiological control technicians on methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate. This will include direction to allow the radiological control technicians to calculate the number of quantities supporting sample analysis

- Information regarding the Geiger-Müller (GM) portable instrument, to include a physical description of the GM, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The GM instrument is a beta/gamma instrument

commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made

- Information regarding the portable alpha meter (PAM), to include a physical description of the PAM, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The PAM is an alpha instrument commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made

- Information regarding the sodium iodide (NaI) detector, to include a physical description of the NaI detector, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The NaI detector is a gamma detector commonly used on the Hanford Site for performing direct measurements

- Information on the characteristics associated with the hand-held probes to be used in the performance of direct radiological measurements includes a physical description of the probe, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The hand-held probe is an alpha instrument commonly used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are made.

Table 2-10. Sample Preservation, Container, and Holding Times for Soil Samples.

Analytes	Container		Volume [a]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Gamma spectroscopy	1	Plastic	500 g	None	None	N/A
Radiogenic strontium	1	Plastic	[b]	None	None	N/A
Isotopic americium	1	Plastic	[b]	None	None	N/A
Isotopic plutonium	1	Plastic	[b]	None	None	N/A

[a] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined on the Sampling Authorization Form.
[b] Analysis of all radionuclide suites will be accommodated with 500 g sample.
N/A = not applicable.

Table 2-11. Sample Preservation, Container, and Holding Times for Aquatic and Terrestrial Invertebrate Samples. (2 Pages)

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Terrestrial Invertebrates						
Radionuclides for Invertebrates from BC Controlled Area						
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Radiogenic strontium	1	Plastic	TBD	None	None	N/A

Table 2-11. Sample Preservation, Container, and Holding Times for Aquatic and Terrestrial Invertebrate Samples. (2 Pages)

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Cyanide for Invertebrates Collected to Supplement Phase I and II Data						
Cyanide	1	Plastic	TBD	None	Cool 4 °C	N/A
Aquatic Invertebrates Collected from West Lake						
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Radiogenic strontium	1	Plastic	TBD	None	None	N/A
ICP metals – 6010A (TAL plus Bi, Mo, Sn)	1	Plastic	TBD	None	None	N/A
Isotopic americium	1	Plastic	TBD	None	None	N/A
Isotopic plutonium	1	Plastic	TBD	None	None	N/A
Isotopic uranium	1	Plastic	TBD	None	None	N/A
Mercury	1	Plastic	TBD	None	Cool 4 °C	N/A

[a] For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
[b] Minimum sample size will be defined on the Sampling Authorization Form.
ICP = inductively coupled plasma. N/A = not applicable. TAL = target analyte list. TBD = to be determined.

Table 2-12. Sample Preservation, Container, and Holding Times for Vertebrate Samples.

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Radionuclides for Lizards and Mice from BC Controlled Area						
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Radiogenic strontium	1	Plastic	TBD	None	None	N/A
Total PCBs for Lizards and Mice Collected to Supplement Phase I and II Data						
PCBs analyzed as congeners/ 8082 or 1668	1	Amber glass [c]	TBD	None	Cool 4 °C	N/A

[a] For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
[b] Minimum sample size will be defined on the Sampling Authorization Form.
[c] Field preparation will involve an intermediary container (e.g., plastic bag).
N/A = not applicable. PCB = polychlorinated biphenyl. TBD = to be determined.

Table 2-13. Sample Preservation, Container, and Holding Times for Water Samples. (2 Pages)

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Strontium-90	1	Plastic	TBD	None	None	N/A
ICP metals – 6010A (TAL plus Bi, Ca, K, Fe, Mg, Mo, Na, Sn)	1	Plastic	TBD	None	None	N/A

Table 2-13. Sample Preservation, Container, and Holding Times for Water Samples. (2 Pages)

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Isotopic americium	1	Plastic	TBD	None	None	N/A
Isotopic plutonium	1	Plastic	TBD	None	None	N/A
Isotopic uranium	1	Plastic	TBD	None	None	N/A
Mercury	1	Plastic	TBD	None	Cool 4 °C	N/A
Anions	1	Plastic	TBD	None	Cool 4 °C	28 Days
Total dissolved solids	1	Plastic	TBD	None	Cool 4 °C	7 days
Total carbonate/hydroxide	1	Plastic	TBD	None	Cool 4 °C	NA

[a] For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
[b] Minimum sample size will be defined on the Sampling Authorization Form.
ICP = inductively coupled plasma. N/A = not applicable. TAL = target analyte list. TBD = to be determined.

Table 2-14. Sample Preservation, Container, and Holding Times for Sediment Samples.

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Strontium-90	1	Plastic	TBD	None	None	N/A
ICP metals – 6010A (TAL plus Bi, Mo, Sn)	1	Plastic	TBD	None	None	N/A
Isotopic americium	1	Plastic	TBD	None	None	N/A
Isotopic plutonium	1	Plastic	TBD	None	None	N/A
Isotopic uranium	1	Plastic	TBD	None	None	N/A
Mercury	1	Plastic	TBD	None	Cool 4 °C	28 days
Semivolatile organic compounds	1	Plastic	TBD	None	Cool 4 °C	14 days to extraction; 40 days to analysis
Tributyl phosphate	1	Glass	TBD	None	Cool 4 °C	14 days to extraction; 40 days to analysis
Normal paraffin hydrocarbon	1	Glass	TBD	None	Cool 4 °C	14 days to extraction; 40 days to analysis
Total organic carbon	1	Plastic	TBD	None	None	N/A
Acid volatile sulfide	1	Plastic	TBD	None	None	N/A
Total sulfides	1	Plastic	TBD	None	None	N/A

[a] For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
[b] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined on the Sampling Authorization Form.
ICP = inductively coupled plasma. TAL = target analyte list.
N/A = not applicable. TBD = to be determined.

Table 2-15. Sample Preservation, Container, and Holding Times for Salt Crust Samples.

Analytes [a]	Container		Volume [b]	Preservation	Packing Requirements	Holding Time
	Number	Type				
Gamma spectroscopy	1	Plastic	TBD	None	None	N/A
Strontium-90	1	Plastic	TBD	None	None	N/A
Isotopic americium	1	Plastic	TBD	None	None	N/A
Isotopic plutonium	1	Plastic	TBD	None	None	N/A
Isotopic uranium	1	Plastic	TBD	None	None	N/A
ICP metals – 6010A (TAL Bi, Ca, K, Fe, Mg, Mo, Na, Sn)	1	Plastic	TBD	None	None	N/A
Mercury	1	Plastic	TBD	None	Cool 4 °C	28 days
Alkalinity	1	plastic	TBD	None	Cool 4 °C	14 days
Anions	1	Plastic	TBD	None	Cool 4 °C	28 days/ 48 hours
Total carbonate/hydroxide	1	plastic	TBD	None	Cool 4 °C	NA
XRD analysis	1	plastic	TBD	NA	NA	NA

[a] For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*.

[b] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined on the Sampling Authorization Form.

ICP = inductively coupled plasma. TAL = target analyte list.
N/A = not applicable. TBD = to be determined.

Table 2-16. Sample Preservation, Container, and Holding Times for Soil-Gas Samples.

Analytes	Container		Volume	Preservation	Packing Requirements	Holding Time
	Number	Type				
Carbon tetrachloride, methylene chloride, chloroform, and chloromethane	1	Summa canister	6 L Summa canister	Ambient temperature and pressure	None*	14 days

*Do not chill Summa canisters to be sent offsite for analyses.
Summa is a trademark of Moletrics, Inc., Cleveland, Ohio.

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3.0 FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) addresses the study scope defined through the EcoDQO process and outlines the data collection needs in Phase III that will be necessary for completing the ecological risk assessment of the Central Plateau. The characterization planned for Phase III addresses uncertainties from Phases I and II of the EcoDQO activities (i.e., supplemental sampling) and investigates the risk questions posed for other Phase III spatial domains. The scope of the Phase III FSP includes the following:

- Supplemental waste site sampling – cyanide, PCBs, and Sr-90 in tissues, vegetative characterization
- Non-waste-site radiological soil sampling
- 200 West Area dispersed carbon tetrachloride plume
- West Lake abiotic and biotic sampling.

This FSP describes the design and implementation of the collection of abiotic and biotic media associated with supplemental sampling to fill Phase I and Phase II data gaps, non-waste-site radiological soil sampling, and the Phase III spatial domains (200 West Area carbon tetrachloride plume, West Lake). Section 3.1 describes general sampling-design attributes that are described in greater detail under their applicable spatial-domain subsections. Subsequent sections (Sections 3.2 through 3.7) of the FSP are organized by spatial domain and define the sampling objectives, sampling design, media, and COPECs evaluated for each location. Administrative subsections of the FSP include potential sample-design limitations (Section 3.8), sample handling, shipping, and custody (Section 3.9), sampling and onsite environmental measurements (Section 3.10), sample management (Section 3.11), and management of investigation-derived waste (Section 3.12).

3.1 GENERAL SAMPLING METHODS

A variety of sampling methods are required to ensure that the proper characterization data are collected from the diverse areas and media associated with Phase III sampling. The general sampling methods used in the Phase III focus areas include the following.

- **Reconnaissance Surveys** – Reconnaissance surveys (visual observations, radiological activity measurements, and mapping) will be conducted to determine locations, abundance, and availability of habitat and biotic sampling populations and soil characteristics. These surveys are to be conducted by ecologists experienced in the Central Plateau ecology. Obvious ecological effects (e.g., distressed vegetation) will be noted during reconnaissance and other field collection activities. These observations will be communicated to the project team for evaluation and to solicit recommendations on changes in sampling or analytical activities. The reconnaissance surveys will provide habitat characterization information for each of the investigation areas.

- **Systematic Grid Surveys** – Systematic grid surveys are based on a specified pattern, with samples taken at regular intervals along a defined pattern. Surveys may be designed for one, two, or three dimensions if the population characteristics of interest have any of the following spatial components:

  - Surveys along a line or transect represent sampling in one dimension

  - Surveys at every node on a grid laid over an area of interest represent sampling in two dimensions

  - Surveys representative of a depth profile at a node represent three-dimensional sampling.

  To ensure that the systematic surveys have a probability-based design, the initial unit for the first survey point of size n is chosen at random, and then the remaining (n-1) units are chosen so that all n are located according to the pattern.

- **Systematic Surveys with a Random Start** – This method is used for obtaining analytical results of abiotic media and is intended to ensure that the soils, sediment, salt crust, and water are fully and uniformly represented in the MISs. The random assignment of the initial locations for an MIS provides assurance that the sample truly represents the overall characteristics of the target population, which leads to an unbiased estimate of the mean.

- **Opportunistic Collections** – In some cases, biological samples can be collected opportunistically at locations within an investigation area. In such cases, the animal will be collected and the notes will be recorded on the specific location by referencing a grid node. An example is collecting a lizard in a pitfall trap intended for collecting invertebrates. Another example is hand-collecting invertebrates observed on the investigation area.

3.2 SUPPLEMENTAL WASTE SITE SAMPLING – CYANIDE IN INVERTEBRATES

One objective of Phase III invertebrate collection is to resolve uncertainties identified as a result of the data assessment of Phase I and Phase II data. The data assessment identified cyanide for further investigation. To resolve uncertainties pertaining to the results of the Phase I and Phase II data, additional data will be collected to document cyanide concentrations in invertebrate tissues at waste sites and reference sites. Invertebrate samples will be collected from eight Central Plateau locations (six Phase I waste site locations and the Phase I and Phase II reference sites) and from seven additional locations serving as reference sites for the 100 Area and 300 Area Component of the RCBRA (Figure 3-1). Central Plateau sampling locations and additional reference sites are listed in Table 3-1.

Figure 3-1. Phase III Invertebrate Sampling Locations Corresponding to the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment Locations.

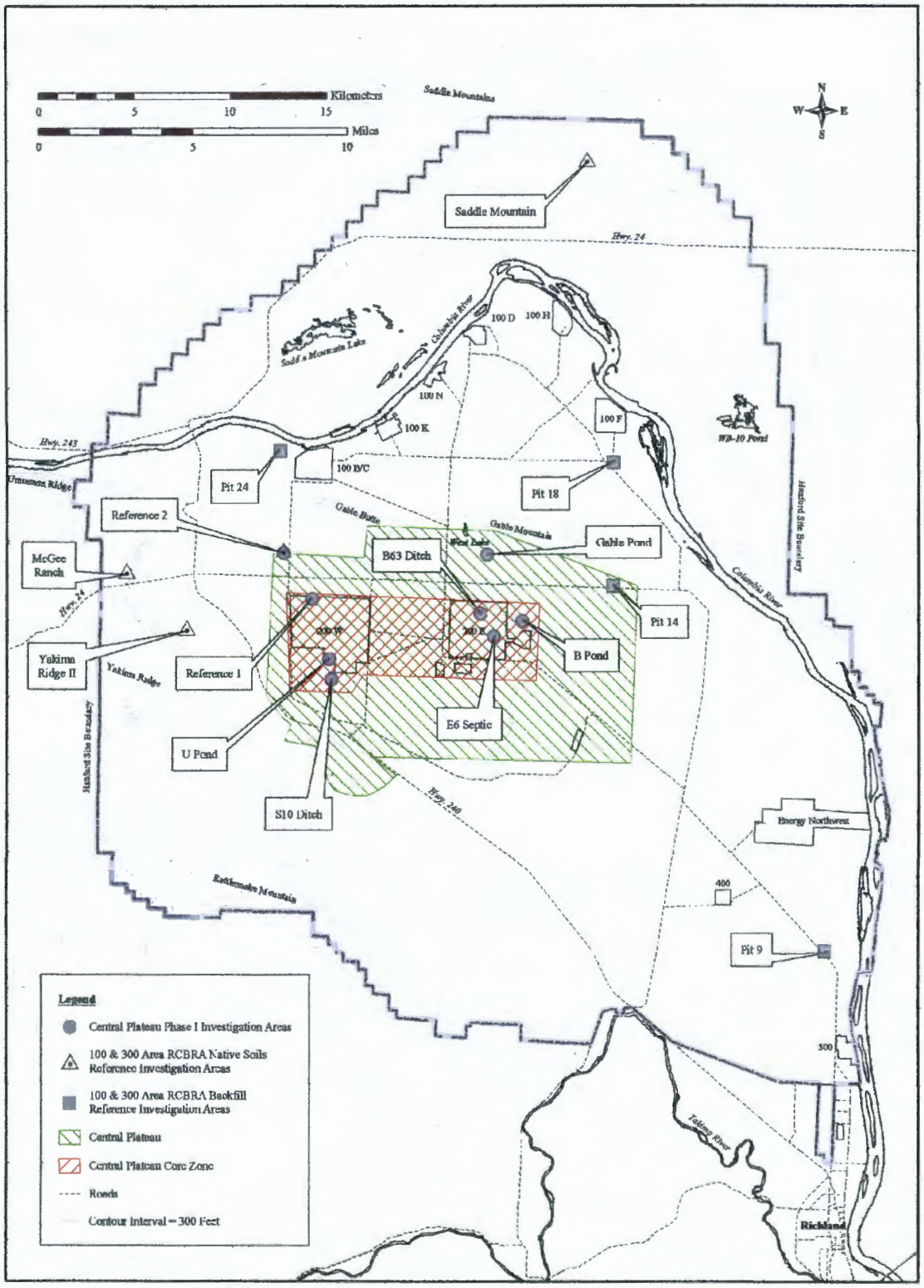


Table 3-1. Summary of Invertebrate Sampling Locations and Collection Requirements.

Site Identification	Invertebrate Subsamples
216-B-63 Ditch	3
216-S-10D Ditch	3
2607-E6 Septic Tank and Tile Field	3
216-B-3 (B Pond)	3
216-A-25 (Gable Mountain Pond)	3
216-U-10 (U Pond)	3
Central Plateau Phase I Reference Site	3
Central Plateau Phase II Reference Site	3
RCBRA Reference Site (Pit 9)	3
RCBRA Reference Site (Pit 14)	3
RCBRA Reference Site (Pit 18)	3
RCBRA Reference Site (Pit 24)	3
RCBRA Reference Site (Yakima Ridge II)	3
RCBRA Reference Site (McGee Ranch)	3
RCBRA Reference Site (Saddle Mountain)	3
Total	**45**

RCBRA = River Corridor Baseline Risk Assessment.

3.2.1 Sampling Design

Pitfall traps will be used to capture invertebrates for cyanide analysis. The pitfall traps will be located within a 70 by 70 m grid in the center of the 100 by 100 m grid (see Figure 3-1 of DOE/RL-2004-42). Pitfall traps or alternate methods (e.g., handpicking) will be used within the grid at each of the sampling locations to collect invertebrates. Pitfall traps consist of 3.8 L (1-gal) metal or plastic containers with covers, buried at grade.

Pitfall traps will be left open for at least five nights at each sampling area. Invertebrates caught during trapping will be collected and composited for each sampling area for contaminant analysis. Notes will be made on the invertebrate orders and/or families represented in the traps. Traps will be reset and checked again after another period (to be determined by the field team leader) if insufficient sample mass is obtained.

The invertebrates will be analyzed for cyanide only. Invertebrates will not be depurated, because these data are used mainly to assess risks to upper trophic levels, and depuration does not occur before predation. The invertebrate sample will be rinsed before analysis to remove any exterior contamination, to minimize any bias introduced from soil potentially accumulating in the pitfall traps. The specific protocol to be followed for collection of invertebrates is provided in the next section.

3.2.2 Animal Collection (Invertebrates)

- Identify the site.
- Identify the grid pattern.
- Place the traps for invertebrate collection.
  - The work instruction for this process will follow existing programs and procedures that will be implemented via existing processes.
- Record the number of days and traps used. Pool all invertebrates into a single sample for each investigation area.
- Record information on the invertebrate taxa present in the pooled sample. Split the pooled sample into three subsamples from each investigation area.
- Containerize and label the samples.
- Store samples in a custody-controlled freezer before they are submitted to the laboratory.
- The laboratory will prepare the samples for analysis, including a deionized water rinse to be analyzed for cyanide only.
- The results that are provided from the laboratory will constitute analytical data for the invertebrates.

A summary of the number of invertebrate samples to be collected is presented in Table 3-1.

3.3 SUPPLEMENTAL WASTE-SITE SAMPLING – POLYCHLORINATED BIPHENYL CONGENERS AND STRONTIUM-90 IN TISSUE

A goal of supplemental sampling is to more broadly evaluate the distribution of COPECs detected in biota samples. Results for two COPECs, PCBs and Sr-90, are not sufficient for making inferences of risk, and additional data collection is planned. To address uncertainty regarding the nature and sources of PCBs, lizards and mice will be sampled at four Phase I investigation areas (including the Phase I reference site) where PCBs were detected in soil or in tissue. Consideration of PCB sampling needs also involved consultation of Site maps (H-2-34762, *Area Map*; H-2-34761, *Area Map*) to identify roads where oil may have been applied. In addition, spatial overlap of potentially sprayed roads was reviewed against the Aroclors detected in biota tissue samples from the Phase I reference site, 216-B-63 Ditch, 2706-E6, and B Pond. Review of maps showed that a number of the older roads have been paved over, destroyed during remediation activities, or appropriated into other projects (e.g., Waste Treatment Plant). Nevertheless, two candidate locations were identified in the northwest corner of the 200 West Area, and two were selected east of the 200 East Area along the old road to B Pond for additional mammal and lizard sampling. Consequently, tissue samples also will be collected at four non-waste locations in the vicinity of the old security roads, to evaluate those areas as potential sources for PCBs. The Phase I PCB results, the

location of the planned Phase III PCB tissue sampling, and the old security roads (non-waste sites 1 and 2) are displayed on Figure 3-2.

For Sr-90, additional analysis will be performed on mice and/or lizard tissues at the sites targeted for PCB tissue sampling (Figure 3-2). Lizards from the Phase I reference site, 216-B-63 Ditch, 216-B-3 (B Pond), and non-waste site 1, will be analyzed for Sr-90 in tissues. Mice from the Phase I reference site and from the 216-B-63 Ditch also will be analyzed for Sr-90 in tissues. These sites were chosen to address potentially elevated initial Sr-90 results, reference site concerns, and spurious detections in mouse tissue. The validity of initial lizard results cannot be assessed because there is not enough material remaining to reanalyze. The non-waste sites 1 and 2 (location identified for PCB analysis near old security road; Figure 3-2) were selected to address reference site concerns, and because this location is more directly in the path of potential stack emissions than non-waste sites 3 or 4.

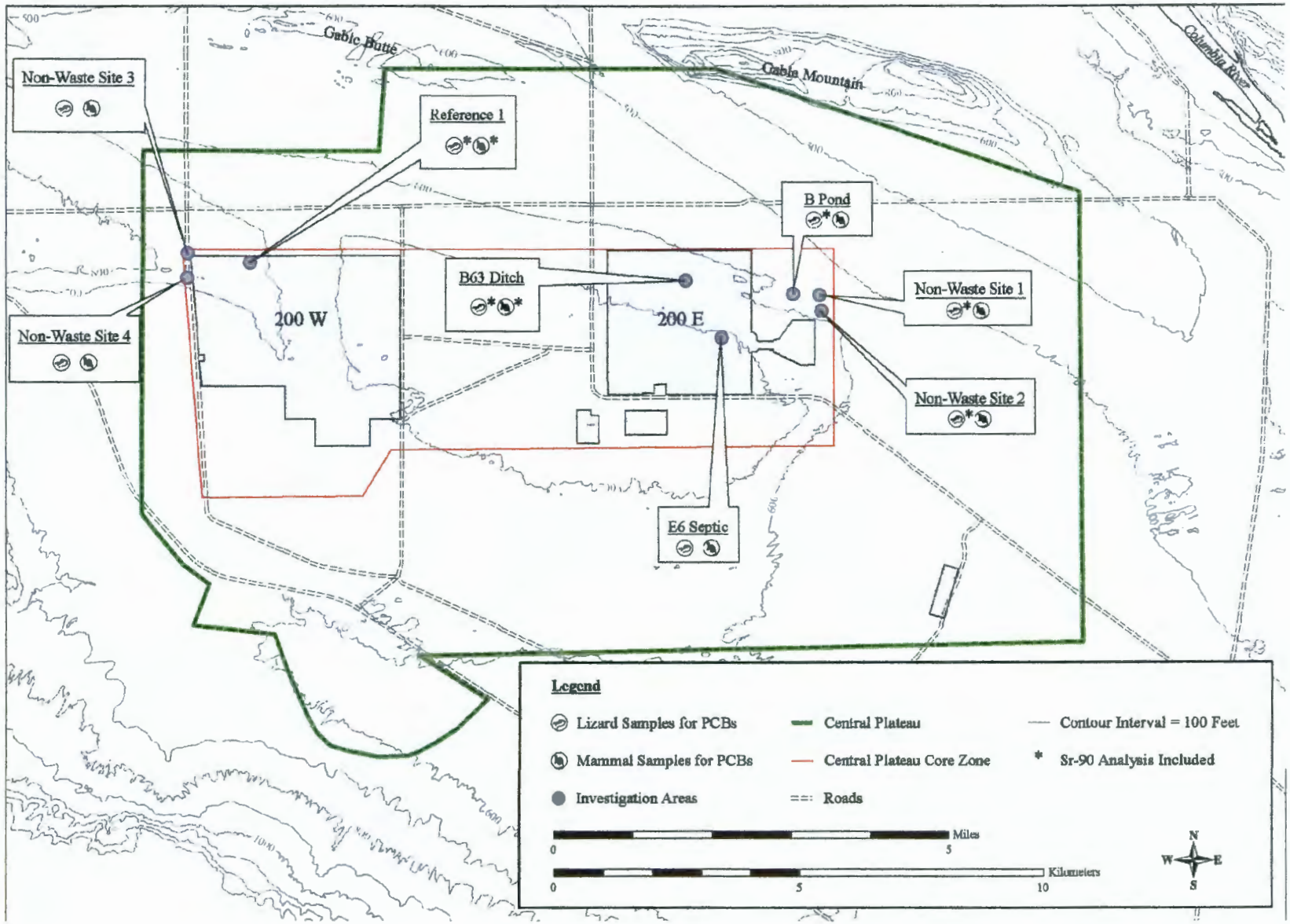
The activity required to collect the target number of lizards and mammals will be recorded. This information will provide a semiquantitative measure of the abundance of biota at each investigation area. This semiquantitative measure of abundance is similar to that used in wildlife or fisheries studies where catch is related to population density. For example, the number of trap days will be recorded, or the number of work hours spent trapping (where applicable) will be recorded for each data type. Animals caught opportunistically during other activities also will be noted in the sampling checklists or logbook. To the extent practicable, data will be recorded in a consistent manner. This may be accomplished most easily through the use of standardized data-entry forms (e.g., checklists).

3.3.1 Lizards

The field team will note the presence of lizards on their visits to the investigation areas when the radiological field data are collected, when soil samples are collected, and during the installation of the pitfall traps. Lizards will be captured by using the pitfall traps or alternate methods such as a noose or by stunning them with a rubber band. After capture, the entire lizard will be used as the sample. Only lizards that are located within the inner 70 by 70 m part of the investigation area will be captured and analyzed for PCBs.

The lizard sample will be rinsed with deionized water to remove any exterior contamination. Lizard tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models. In addition, the exposure models incorporate incidental soil ingestion, and rinsing the lizards prevents double counting soil ingestion in exposure-model calculations. Lizards will be captured and analyzed for PCBs at each targeted investigation area. The number of trap-days required to collect at least six lizards per species will be recorded. This will provide a relative measure of animal density. Captured lizards will be examined for physical abnormalities, and data on total length, snout-vent length, weight, and gender will be recorded. Abnormalities, which include coloration (e.g., albino), extra or missing digits, or two heads, should be photographed. Causes of abnormalities include disease, contaminants, missed predation, ultraviolet radiation, or a combination of these stressors (Blaustein and Johnson 2003, "The Complexity of Deformed Amphibians").

Figure 3-2. Locations Selected for Tissue-Sample Collection for Polychlorinated Biphenyl Congener and Strontium-90 Tissue Analyses.



3.3.2 Small Mammals

Deer mice and pocket mice likely are present in the Central Plateau, particularly where adequate vegetation exists. These mice are omnivores and granivores, respectively, and are considered the best Hanford Site-specific representatives for the mammalian predator guild (identified in WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," et seq.). Deer mouse and pocket mouse sampling will be accomplished using live traps arranged in the 70 by 70 m array in the center of the 100 by 100 m investigation area. Small mammal trapping will be conducted between April and September, when animals are most likely to be active.

Typically, two trap lines, each consisting of approximately seven Sherman live traps[7] (each approximately 8 cm wide by 9 cm high by 26 cm long) will be placed parallel with the edges of the 70 by 70 m array. Identical trapping methods will be employed in similar habitats at the reference locations. The number of trap lines, number of traps per line, line spacing, and trap spacing may be varied to maintain comparable trapping activities between sites and to ensure that results are comparable between the waste areas and reference locations. Such adjustments will be made as a function of the size of the area and type of the plant community in the vicinity.

Trapping arrays will be limited to one habitat type, if possible. The animals will be trapped over enough nights to obtain at least six small mammals from each investigation area. To the extent possible, the same species will be sampled at all Phase I and Phase II investigation areas. The number of trap days required to obtain at least six animals for a species will be recorded. This will provide a relative measure of animal density. Individuals of other species may be collected if insufficient numbers of one species can be captured to meet the minimum of six small mammals per investigation area. The team members will consistently record information on all animals captured by use of standardized data-entry procedures. Data recorded will include animal condition (e.g., species, sex, weight, reproductive class) and deformities. The relative density estimates will be interpreted with regard to field notes and weather conditions to make inferences about comparability of results among different investigation areas.

Information on species, age, sex, and reproductive status (subadults/adults, nonscrotal males/scrotal males, and nonlactating/lactating females) body weights (± 2.0 g), general external condition (any gross deformities, hair loss, infections, lesions, etc.), will be recorded for all captured animals. Animals captured and released (nontarget animals) should be marked so that the total number of new captures per trap-night (or day) can be used to best represent relative abundance estimates measured at each study site. Animals collected will be immediately sacrificed, placed in a plastic bag, and labeled with date, species, site name, and sample number (e.g., 1 of 6) and taken to the sample processing facility and placed in locked storage, at temperatures less than 0 °C.

The mammals (whole animal) will be analyzed for PCB congeners and Sr-90. The mammals will be rinsed with deionized water to remove any exterior contamination. Small mammal

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[7] Sherman trap is a trademark of the H. B. Sherman Company, Tallahassee, Florida.

tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models, which already incorporate incidental soil ingestion.

The specific protocol to be followed for collection of lizards and mice is provided in the next section.

3.3.3 Animal Collection (Lizards and Small Mammals)

- Identify the site.
- Identify the grid pattern.
- Place the traps for animal collection
  - The work instruction for this process will follow existing programs and procedures that will be implemented via existing processes.
- Record species, weight, and other information.
- Containerize and label the samples.
- Store samples in a custody-controlled freezer before they are submitted to the laboratory.
- The laboratory will prepare the samples for analysis, including a deionized water rinse, and the animals will be analyzed for PCB congeners for all animals from all locations and Sr-90 for mice and lizards or just lizards at select locations (Table 3-2).
- The results that are provided from the laboratory will constitute analytical data for the animals.

A summary of the number and types of biota samples to be collected is presented in Table 3-2.

Table 3-2. Summary of Projected Tissue Sample Collection Requirements (Number of Organisms) for Polychlorinated Biphenyl Congener and Strontium-90 Analyses.

Site Identification	PCBs in Small Mammals	PCBs in Lizards	Sr-90 in
2607-E6 Septic Tank and Tile Field	6	6	--
216-B-3 (B Pond)	6	6	Lizards
216-B-63 Ditch	6	6	Lizards and mice
Phase I Reference Site	6	6	Lizards and mice
Non-waste site #1	6	6	Lizards
Non-waste site #2	6	6	Lizards
Non-waste site #3	6	6	--
Non-waste site #4	6	6	--
Total	**48**	**48**	**42**

PCB = polychlorinated biphenyl. -- = vertebrate tissue not analyzed for Sr-90.

3.4 SUPPLEMENTAL WASTE SITE SAMPLING – VEGETATIVE CHARACTERIZATION

Vegetation cover is proposed to be resurveyed as part of Phase III to supplement data for assessing relationships between plant composition and cover with other measures of environmental quality.

3.4.1 Sampling Design

Vegetative cover found in each investigation area and the Phase I reference site identified in Phase I (7 sites total) will be estimated using a modified Daubenmire technique (Daubenmire 1959, "A Canopy-Coverage Method of Vegetational Analysis"), consisting of a series of visual estimates of the percent coverage by species found within 20 by 50 cm plots that are divided into 10 cm squares. Canopy cover will be estimated using finite values for all plant species with at least 2 percent areal coverage. Plant species encountered in each plot with less than 2 percent areal cover will be recorded and labeled "t" for trace amounts. The percent of the ground surface with cryptogamic crust, bare ground, and litter will be visually estimated after the ground surface has been sprayed with a mist of water to ensure that accurate cryptogram estimations are made.

Plant cover will be systematically measured at every other grid point located in the core area of each investigation area. As such, twenty-five 0.1 m^2 plant cover samples will be measured within each investigation area (Table 3-3). Study-site grid points were removed in 2005 and will be relocated using a Global Positioning System (± 1 m) to locate the corner points, and tape meters will be used to help relocate the points in between the corner points. The bottom-left corner of the plot frame will be positioned in the direction of true north. Photographs of each investigation area and each Daubenmire plot will be taken again to document the overall vegetative characteristics found at these sites during the 2006 surveys.

Table 3-3. Summary of Vegetative Characterization Locations and Evaluation Requirements.

Site Identification	Daubenmire Plot Survey Locations
216-B-63 Ditch	25
216-S-10D Ditch	25
2607-E6 Septic Tank and Tile Field	25
216-B-3 (B Pond)	25
216-A-25 (Gable Mountain Pond)	25
216-U-10 (U Pond)	25
Central Plateau Phase I Reference Site	25
Total	175

3.5 SUPPLEMENTAL WASTE-SITE SAMPLING - REEVALUATION OF RADIONUCLIDE CONTAMINATION IN BC CONTROLLED AREA

An expanded investigation area will be characterized in the BC Controlled Area, Zone A, to provide supplemental data for assessing ecological risk from Cs-137 and Sr-90. The FSP in the Phase II Central Plateau SAP (DOE/RL-2005-30) is devoted exclusively to sampling Cs-137 and Sr-90 in the BC Controlled Area. Because some redundancy is inevitable, detailed information for sampling the BC Controlled Area, Zone A, is reproduced below in the interest of completeness. The sample design descriptions are provided in Table 3-4.

Table 3-4. Methods for Field Data Collection.

Targeted Field Data	Description
Soils	Use direct-reading radiological survey instrumentation for measuring on a systematic survey grid. Collect samples for a multi-increment sampling by soil corer or hand shovels, using a random start location in the systematic sampling grid.
Ant mounds	Characterize selected ant mounds at locations marked within the investigation area using direct-reading radiological instrumentation.
Burrow spoils	Characterize selected burrow spoils at locations marked within the investigation area using direct-reading radiological instrumentation.
Plants	Use direct-reading radiological instrumentation for measuring on a systematic survey grid. Use line transects to assess cover of dominant plants, bare ground, and cryptogams.
Invertebrates	Use pitfall traps along transects within the investigation area and for opportunistic collections.
Small mammals	Use live traps systematically placed along transects within the investigation area.
Lizards	Collect lizards, make measurements, and submit whole animal.

3.5.1 Soil-Sampling Procedures

As discussed in WMP-20570, the sampling design was based on the scale of middle-trophic-level biota. The species used as measures of exposure (e.g., small mammals) reflect relevant scales for BC Controlled Area impacts. The investigation area of 1 ha reflects the home range and dispersal distance of these species. Existing radiological field data are used to establish the areas of highest radiation for locating the hectare investigation area in the BC Controlled Area, Zone A. Using the characterization techniques identified in this SAP will yield meaningful radiological data. Surface soil (the top 15 cm [6 in.]) will be characterized by collecting an MIS that is representative of the entire 1 ha investigation area. The MISs will comprise 50 increments taken at 0 to 15 cm (0 to 6 in.). The samples will be collected at 50 of the hectare grid locations, using systematic sampling with a random start.

3.5.2 Field Sampling Implementation Process Examples

3.5.2.1 Soil Surface

- Identify the investigation area, based on the radiological field data showing the *highest relative levels of radioactivity.*
- Identify the grid pattern.
- Follow Environmental Radiological Survey Task Instructions (ERSTI) developed in Phase II for the radiological control technicians; these are specialized surveys that will be performed by radiological control technicians, based on specific guidance to the radiological control technicians. The task instruction will instruct the radiological control technicians on what to survey, how to survey a particular area, and what instrumentation/equipment to use. For example, this includes information on both NaI detectors (to perform an evaluation for Cs-137 contamination levels) and GMs (to perform an evaluation for gross beta/gamma contamination levels), as needed, for the investigation area under consideration.
- Survey the surface of the site by implementing the ERSTI, and produce a survey record that documents its implementation.
- Identify the soil samples that are needed within the grid boundary (i.e., a work instruction that says where to collect the soil samples).
- Within the investigation area, biologists will identify areas of interest (e.g., ant nests, animal burrows, areas where soil has been disturbed and/or removed) for surveys to be conducted (gross beta/gamma measurements with handheld instrumentation).
- Samplers will collect the individual soil samples and mix the increments ("containerize and label" the soil samples); radiological control technicians will use standard radiological field instrumentation for these samples to measure the gross contamination levels directly within the soil samples under consideration both for radiological safety/job control purposes and to measure the contamination levels associated with each sample.
- Perform sample preparation activities for transfer to the laboratory.
- The samples will be stored in chain-of-custody conditions until submitted to the laboratory for COPEC analyses. The laboratory will receive the MISs for additional processing.

3.5.2.2 Animals (Lizards, Small Mammals, and Insects)

- Identify the site.
- Identify the grid pattern.

- Place the traps and collect insects, lizards, and mammals; the work instruction for this process will follow existing programs and procedures that will be implemented via existing processes.
- Collect the animals via the traps (this process will use existing radiological controls for health and safety purposes).
- Following collection, the radiological control technicians will use field instrumentation to measure the contamination levels on the exterior of the animals both for health and safety purposes and for documenting measured contamination levels on the exterior of the animals (e.g., standard GM hand-held field instrumentation and/or NaI detector measurements per the survey task instructions).
- Record species-specific information, weight, and other information.
- "Containerize and label" the samples.
- Store samples in a custody-controlled freezer before they are submitted to the laboratory.
- Before they are submitted to the analytical laboratory, the samples will be prepared for analysis, including a deionized water rinse.
- The results that are provided from the laboratory will constitute analytical data for the animals.

3.5.2.3 Plants

- Identify the site.
- Identify the grid pattern.
- Within each grid, identify plants based on the characteristic of the species being evaluated. Collect and analyze the radiological information associated with the species per the work package instructions and the ERSTI requirements in the task instructions.

Detailed sampling techniques are described further in the following subsections.

3.5.3 Field Radiological Data Collection

Radiological instrumentation for field data collection that may be used is shown in Table 3-5.

Table 3-5. Field-Screening Methods.

Measurement Type	Emission Type	Method/Instrument or Equivalent [a]	Detection Limit
Contamination levels	Alpha/beta-gamma	SHP380-A/B scintillation probe or equivalent	100 d/min α 1,921 d/min [d] β–γ
Gamma measurements NaI detector field data (must be used for site surveys for assessment of variance)	Gamma isotopic emissions	NaI detector	~3 pCi/g for Cs-137

[a] Detection limit rating is for 100 cm^2 at a scan rate of 2 in./s.
[b] SHP380-A/B scintillation probe is a trademark of Eberline Instruments, a subsidiary of Thermo Electron Corporation, Waltham Massachusetts.

Existing radiological data will be used to locate the BC Controlled Area investigation area in Zone A. The field team will have the latitude to vary the aspect ratio of the investigation area, but the area is to be kept at 1 ha unless this is not feasible. Once the hectare investigation area is located, radiological field data will be collected in the areas between grid nodes, which will be staked with flags or wood posts containing the location numbers. A total of 121 nodes are located in each hectare plot.

Surface soil and plant radiological readings will be measured in a 1 m^2 area surrounding each flag and located within the 1 ha study site. The results from implementing the ERSTI will be documented on a radiological field record, per the task instructions. The plant nearest to the radiological field data location will be selected. If more than one plant is equidistant from the survey location, the tallest specimen (based on the assumption that the tallest plant is the deepest rooted) will be selected for the plant radiological field data. The species and dimensions (height and width) of the plant will be noted, as well as the radiological measurement used. Both beta and gamma measurements will be taken on the surface soil as well as on the plant material.

The investigation area will be surveyed for burrowing animal activity and ant mounds, with the objective of marking and making surface radiological measurements at these locations. From 30 to 50 locations with burrow spoils should be surveyed, and 15 to 20 ant mounds should be surveyed, subject to availability. One-quarter of the investigation plot initially should be inspected, and large ant mounds and burrow spoils should be marked. If more than enough of each type is located in the first 0.25 ha, then the radiation measurements will be made in this 0.25 ha, and the locations will be marked. The ambient radiological background levels and the radiation measurements for both ant mounds and burrow spoils will be recorded per the ERSTI, and the locations will be recorded using the node identification number. In addition, the location will be flagged for future reference. If additional measurements are needed for ant mounds or for burrows, then the next 0.25 ha section of the investigation plot will be surveyed, and ant mounds and/or burrows will be marked until the desired minimum numbers of each are obtained. The field team leader may select additional areas for radiological measurements that are outside the study site, either to meet the desired minimum survey locations or to obtain a more representative survey of the investigation area (with consultation of the radiological controls

supervisor). If sufficient numbers cannot be obtained, this deviation will be documented in the radiological field data documentation.

3.5.4 Soil Screening

An assessment population of small mammals will be exposed to contamination within a spatial area of approximately 1 ha (Ryti et al. 2004, "Preliminary Remediation Goals for Terrestrial Wildlife"). Animals range freely over the hectare and, as a result, integrate exposure from multiple locations. The parameter of interest is therefore the average soil concentration for the hectare. As such, the samples will be field screened for evidence of radioactive contamination by the radiological control technician. Surveys of these materials will be conducted with field instruments for both beta and gamma radiation. Potential screening methods and instruments are listed in Table 3-5 with their respective detection limits.

Before sampling begins, a local area background reading will be taken with the field-screening instruments at a background site to be selected in the field per established procedures. Field screening of the soil and visual observations of the soil (e.g., sediment/clay layer, organic debris) will be used to support worker health and safety monitoring.

Field-screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved procedures. The radiological control technician will record field-screening results on the radiological survey record associated with the survey area.

3.5.5 Multi-Increment Soil Sampling and Analysis

An assessment population of small mammals will be exposed to contamination within a spatial area of approximately 1 ha (Ryti et al. 2004). Animals range freely over the hectare and, as a result, integrate exposure from multiple locations. The parameter of interest is therefore the average soil concentration for the hectare. As such, the soil-sampling plan is based on MIS procedures that are designed to control the fundamental error (FE) for an average, based on collecting an adequate sample mass. The following steps are involved in determining an adequate sample mass to collect in the field and the proper particle size for the analytical laboratory to measure for radiological analysis.

1. The investigation area is 1 ha. The systematic grid used for radiological surveys provides 100 grid boxes. Of these, 50 grid box locations will be sampled, beginning with a random start.

2. Select or measure a reasonable maximum sample particle size in the field. Because soils typically are defined as comprising particles of $\leq$ 2mm, an assumption is made that the maximum particle size is 2 mm or 0.2 cm. This will be achieved by sieving the soil samples to exclude the >2 mm size particles.

3. Select the desired FE, which has been specified as 10 percent. This corresponds to a standard error of 10 percent on the mean concentration. This value was selected to be

low relative to other sources of error (analytical measurement error typically is 30 percent).

4. Calculate the mass of sample (M) needed based on the FE and particle size (d, in cm) as

$$M = 22.5\frac{d^3}{FE^2}.$$

If d=0.2 cm and FE=0.1 (10%), then M=18 g.

5. Using a scoop large enough to capture the maximum particle size, collect enough sample increments (k=50) to equal at least the mass calculated in step #4 and place them in a container, combining increments into one "sample" (m). Be sure to obtain consistent and representative samples for the desired sample depth, and form the MIS such that the material is representative of the particle-size fractions that are <2 mm. Collect sufficient sample mass for all laboratory analyses.

6. Repeat step #5 in the investigation area to obtain two field QC samples (as specified in Table 3-6) that will be used as a field duplicate, by sampling from two additional sets of 50 systematic locations, each with a different random start.

7. Deliver the samples and QC samples to the laboratory.

8. Because sufficient sample mass of <2 mm screened soil will be collected for all laboratory analyses, the laboratory is expected to analyze the entire mass for each test method. According to step #4, this is a minimum of 18 g per analysis.

9. Calculate the concentration from the sample.

10. The concentration represents average concentration or activity in the investigation area.

The multi-increment soil sampling will be based on the grid pattern used for radiological field data collection. Of the 100 grid boxes in each hectare plot, 50 grid boxes will be used for soil sampling. The soil-sample increments will be collected from each investigation area to provide a single MIS representing the 0 to 15 cm (6-in.) depth.

If the results of the gamma field data indicate that the investigation area is heterogeneous in COPEC concentrations, then the Field Team Lead may elect to subdivide the investigation area into more equal contaminant levels. Within each subarea, the MIS strategy will be employed. Each MIS will be submitted to the analytical laboratory for analysis of radionuclides (Cs-137 and Sr-90).

Information regarding the samples will be recorded in the sampler's field logbook. The sampling field logbook includes, but is not limited to, the soil description, sample depths, sample locations, HEIS database sample numbers, relevant and/or pertinent events, general information about the sample or locations, and any other information that may be useful to meet the objectives of the FSP.

The investigation-derived waste generated during this activity will be handled according to applicable procedures in Section 3.8 of this SAP.

3.5.6 Summary of Soil Sampling Activities

A summary of the number and types of soil samples to be collected is presented in Table 3-6.

Table 3-6. Summary of Projected Soil-Sample-Collection Requirements.

Site Identification	Primary Samples	Quality Control Samples
BC Controlled Area, Zone A	1 sample from 50 locations	-
Field replicates	-	2 additional samples from another 50 random locations within the investigation area
Equipment blank	-	1 sample of clean soil/sand or water
Laboratory quality control	-	2 additional samples; laboratory triplicate performed on primary MIS
Total	1	5
Total samples to analyze	6	

3.5.7 Biota Sampling Process

For each type of biological data collected, the activity required to collect the target number of organisms or sample mass will be recorded. This information will provide a semiquantitative measure of the abundance of biota at each investigation area. This semiquantitative measure of abundance is similar to that used in wildlife or fisheries studies where catch is related to population density. For example, the number of trap days will be recorded (where applicable), or the number of person-hours will be recorded for each data type. Animals caught opportunistically during other activities also will be noted in the sampling checklists or logbook. To the extent practicable, data will be recorded in a consistent manner. This may be most easily accomplished through use of a standardized data entry form or forms (e.g., checklists).

3.5.8 Plant Cover Surveys

It is proposed to use line transects to estimate canopy cover of dominant plant species, bare ground, and cryptogam cover. The following vegetation attributes typically are monitored using the line-transect method: canopy cover, frequency, and composition by canopy cover. The canopy cover only will be estimated visually. It is important that the same investigators collect these data to minimize differences in observer bias. The data will be consistently recorded to ensure that all pertinent information is noted in all areas sampled.

Each investigation area will be divided into 0.25 ha sections. Within each 0.25 ha subarea, four line transects will be placed using a systematic sampling array with a random start. Thus, cover

information will be recorded at 16 transects that encompass the entire investigation area. In addition, photographs will be taken at the start of each transect.

3.5.9 Insects

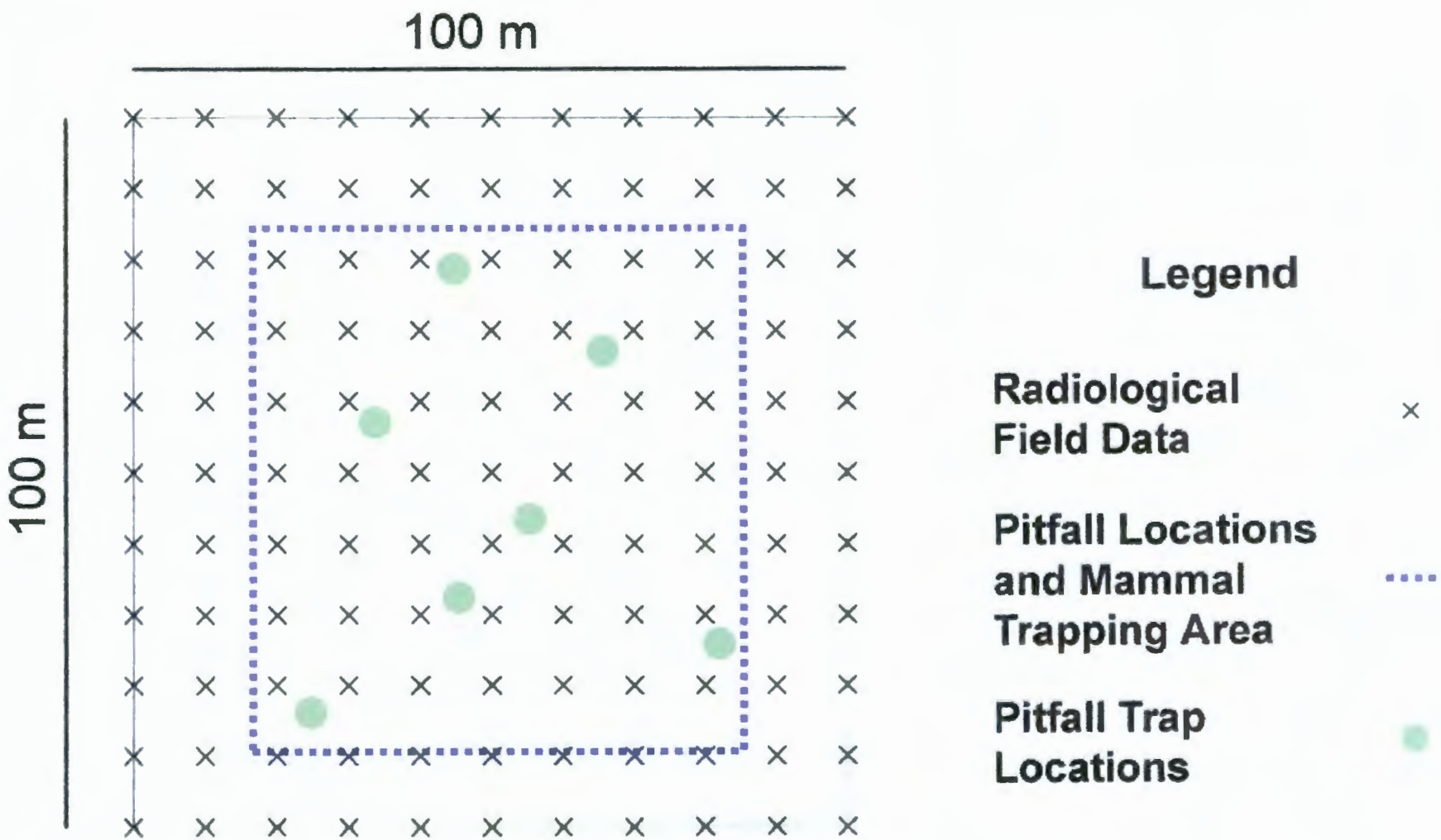
Pitfall traps will be used to capture invertebrates for COPEC analysis. The pitfall traps will be located within a 70 by 70 m grid in the center of the 100 by 100 m grid (Figure 3-3).

Ground-dwelling invertebrates such as darkling beetles, harvester ants, and spiders represent the soil-biota guild specified in WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." Individual pitfall traps or drift fences with traps at each end will be used within the grid at each of the investigation areas to collect invertebrates. Pitfall traps consist of 3.8 L (1-gal) metal or plastic containers buried at grade.

Pitfall traps will be left open for at least five nights at each sampling area. Invertebrates caught during trapping will be collected and composited for each sampling area for contaminant analysis. A trained entomologist will identify the invertebrate orders and/or families represented in the traps, and each fraction will be weighed. Pitfall trapping will continue until sufficient sample mass is obtained (to be determined by the field team leader). The number of trap days will be recorded for a relative measure of invertebrate abundance.

If insufficient sample mass is obtained from the pitfall traps, then invertebrates can be collected manually or by other means (e.g., sweep nets). If alternate methods are used for invertebrate collection, then each fraction will be sorted, weighed, and separated, and an approximate activity (person-days) will be recorded for each collection method. Coordinates for pitfall trap locations will be recorded to the nearest grid marker. The insects will be analyzed for radionuclides (Cs-137 and Sr-90). Invertebrates will not be depurated, because these data are used mainly to assess risks to upper trophic levels, and depuration does not occur before predation. The invertebrate sample will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination, to minimize any bias introduced from soil potentially accumulating in the pitfall traps.

Figure 3-3. Schematic Used to Illustrate Phase II Sampling of BC Controlled Area.



3.5.10 Lizards

The field team will note the presence of lizards on their visits to the investigation areas when the radiological data are collected, when soil samples are collected, and during the installation of the pitfall traps. Lizards will be captured in the pitfall traps or by alternate methods, such as using a noose or other resource-effective methods like stunning them with a rubber band. After capture, the entire lizard will be used as the sample. Only lizards that are located within the inner 70 by 70 m part of the investigation area will be captured. Within each grid, they will be analyzed for Cs-137 and Sr-90. Each lizard sample will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination. Lizard tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models. In addition, the exposure models incorporate incidental soil ingestion, and rinsing the lizards prevents double counting soil ingestion in exposure-model calculations. Coordinates for each lizard location will be recorded based on the nearest grid marker. At least six lizards will be captured and analyzed for COPECs at each investigation area. The number of trap days required to get at least six lizards per species will be recorded. This will provide a relative measure of animal density. Captured lizards will be examined for physical abnormalities, and data will be recorded on total length, snout-vent length, and gender. Abnormalities, which include coloration (e.g., albino), extra or missing digits, or two heads, and the animals themselves – both normal and abnormal – will be photographed.

3.5.11 Small Mammals

Deer mice and pocket mice likely are present in the BC Controlled Area, particularly where adequate vegetation exists. These mice are omnivores and granivores, respectively, and are considered the best representatives for the mammalian predator guild (as recommended in WAC 173-340-7490 et seq.). Deer mouse and pocket mouse sampling will be accomplished using live traps laid in the 70 by 70 m array in the center of the 100 by 100 m investigation area. Small mammal trapping will be conducted between April and September, when animals are most likely to be active.

Typically, two trap lines, each consisting of approximately seven Sherman live traps[8] 7.6 cm wide by 8.9 cm high by 23 cm long (3 in. wide by 3.5 in. high by 9 in. long) will be placed parallel with the edges of the 70 by 70 m array. Identical trapping methods will be employed in similar habitats at the reference locations. The number of trap lines, number of traps per line, line spacing, and trap spacing may be varied to maintain comparable trapping activities between sites and to ensure that results are comparable between the waste areas and reference locations. Adjustments will be made, such as function of the size of the area and type of the plant community in the vicinity. The grid location for the trap where the animal was captured will be noted in the field logbook.

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[8] Sherman trap is a trademark of the H. B. Sherman Company, Tallahassee, Florida.

Trapping arrays will be limited to one habitat type, if possible. The animals will be trapped over enough nights to obtain at least six small mammals from each investigation area; to the extent possible, the same species will be sampled at all Phase I and Phase II investigation areas. The number of trap days required to get at least six animals for a species will be recorded. This will provide a relative measure of animal density. Individuals of other species may be collected, if insufficient numbers of one species are captured, to meet the minimum of six small mammals per investigation area. The team members consistently will record information on all animals captured by use of standardized data-entry procedures. Data recorded will include animal condition (e.g., species, gender, weight, reproductive class) and deformities. Because the habitat of the BC Controlled Area is relatively undisturbed, it is expected that pocket mice will be more common than deer mice. It would, however, be ideal to collect six deer mice from each trapping array, so that mammal data are consistent with what is expected to be collected in the Phase I investigation areas. The relative density estimates will be interpreted with regard to field notes and weather conditions to make inferences about comparability of results among different investigation areas.

The mammals (whole animal) will be analyzed for Cs-137 and Sr-90. The mammals will be rinsed with deionized water at the analytical laboratory to remove any exterior contamination. Small mammal tissues are to be analyzed exclusive of external concentrations so that these data will be better suited to developing bioaccumulation models. In addition, the exposure models incorporate incidental soil ingestion, and rinsing the mammals prevents double counting soil ingestion in exposure model calculations.

3.5.12 Summary of Biota Sampling Activities

A summary of the number and types of biota samples to be collected is presented in Table 3-7.

Table 3-7. Summary of Projected Biota Sample-Collection Requirements in the BC Controlled Area.

Site Identification [a]	Invertebrate Samples [b]	Small Mammal	Lizards
Zone A	3	6	6
Total	**3**	**6**	**6**

[a] Site will be selected during initial reconnaissance activities.
[b] Assume sufficient mass for three samples.

3.6 NON-WASTE-SITE RADIOLOGICAL SOIL SAMPLING

Past Hanford Site operations released radionuclides and metals through air-stack emissions, which represent a source for surface-soil contamination. A focus of the Phase III Central Plateau EcoDQO activity is to assess the ecological condition of non-waste-site areas potentially affected by air-stack contaminant deposition. Stack contaminants primarily were radionuclides, including short-lived radionuclides such as Co-60 and I-131 (Hanford Environmental Dose Reconstruction Project) and longer half-life radionuclides (Cs-137, I-129, Pu-239/240, Sr-90). Iodine-129 is not found in surface soils except in small concentrations near the stacks of the separations plants in

the 200 Areas, and it is very mobile in water and easily transported through the soil column to groundwater. Therefore, I-129 was not typically measured in background or non-waste-site soil samples and will not be measured in this project. Cobalt-60 is not included, because it has a 5-year half-life and is no longer routinely detected in Hanford Site soil and vegetation.

Radionuclides considered as contaminants of interest are Cs-137, Pu-239/240, and Sr-90. Pu-238 also will be evaluated, given its long half-life and its association with Hanford Site operations. Evaluation of non-waste-site areas and the Phase I and Phase II reference sites will supplement existing Near-Facility Monitoring Program and SESP radionuclide data. This activity involves sampling soil transects in areas of limited data on air-stack-emission radionuclides, specifically soils in non-waste-site area transects along presumed emissions pathways in the Central Plateau Core Zone as shown in Figure 3-4.

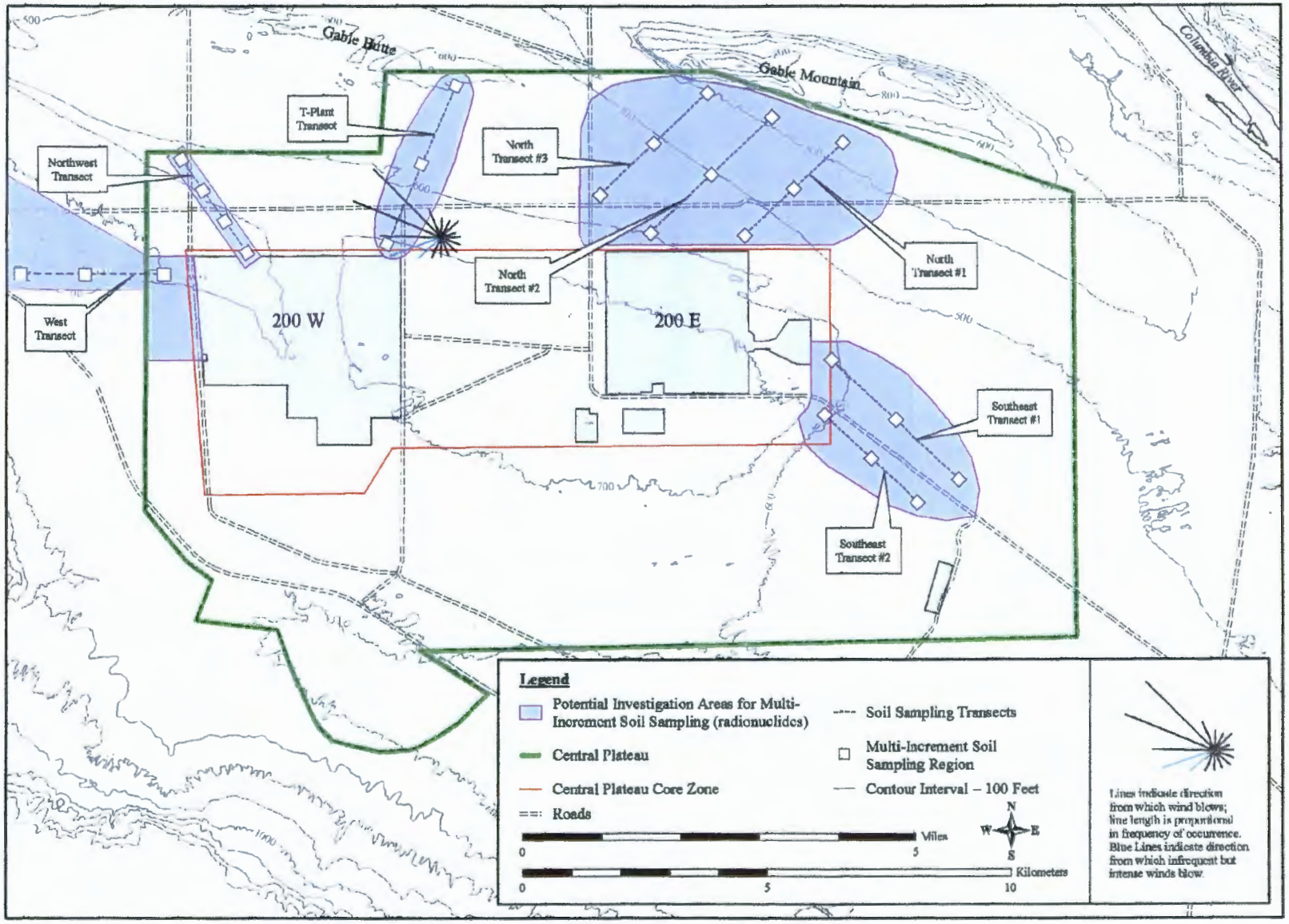
3.6.1 Sampling Design

Sample locations have been selected to the northwest and west of the 200 West Area and to the north and southeast of the 200 East Area in the Central Plateau Core Zone and to address deposition from T Plant (Figure 3-4). These locations were selected to supplement surface radiological data in the vicinity of the Phase I and Phase II reference sites and along a potential gradient of historical stack deposition from the 200 Areas. Transects will be set up in each non-waste-site area targeted for MIS soil sampling. One area sampled also will be characterized with a field duplicate MIS (i.e., the original MIS and two replicate samples) for QA purposes.

Based on feedback from consensus opinion at the EcoDQO workshop (February 22 and 23, 2006), it was decided that MIS was the preferred method for obtaining surface soil radionuclide-concentration data. While MIS soil samples were different from the local composite samples used by the Near-Facility Monitoring Program and the SESP to characterize soil concentrations, MIS data are comparable.

The EcoDQOs for the MIS identify sample depth, the particle size of interest for ecological exposure considerations, the spatial scale over which the MIS should be collected, and the number of increments needed to adequately characterize the area. The depth is 0 to 2.5 cm (1 in.) to be consistent with Near-Facility Monitoring Program and SESP samples; a shallow (2.5 cm [1 in.]) depth is consistent with characterizing air deposition. The particle size will be the <2 mm size fraction that was used for other MIS collected for the Central Plateau project.

Figure 3-4. Map Displaying Locations for Air-Stack Radionuclides in Non-Waste-Site Area Sampling.



The objective of this study is to assess spatial patterns of contaminant deposition. Because the focus is not on assessment population areas, units smaller than the Phase I and Phase II 1-ha investigation areas will be sampled. The area of 0.0625 ha was selected to be consistent with the pocket-mouse and deer-mouse home ranges. Surface soils will be characterized by collecting MISs that are representative of the entire 0.0625 ha location. The MIS will be a mixture of 50 increments taken at a depth of 0 to 2.5 cm (1 in.). 50 increments were selected to provide adequate coverage of various microsites within the sample area. Two co-located increments will be collected from each of the 25 cell locations in the 0.0625 ha investigation area using systematic sampling with a random start.

3.6.2 Soil Collection

Soil collection will consist of the following steps:

- Identify the location of transects based on locations displayed in Figure 3-4. This will be achieved by field reconnaissance efforts and consideration of factors potentially affecting deposition (e.g., topography)
- Identify the grid pattern.
- Identify the soil samples that are needed within the grid boundary (i.e., a work instruction that says where to collect the soil samples).
- Samplers collect and process the samples (containerize and label the soil samples); radiological control technicians will use standard radiological field instrumentation for these samples, to measure the gross contamination levels directly within the soil samples under consideration for both radiological safety/job control purposes and to measure the contamination levels associated with each sample.
- Perform sample preparation activities for transfer to the laboratory (Steps 1-6, Section 3.5.3).
- The samples will be stored in chain-of-custody conditions until submitted to the laboratory for COPEC analyses. The lab will receive the multi-increments for additional processing.

3.6.3 Multi-Increment Soil Sampling and Analysis

The soil-sampling plan is based on MIS procedures that are designed to control the FE for an average, based on collecting an adequate sample mass (Pitard 1993, *Pierre Gy's Sampling Theory and Sampling Practice: Heterogeneity, Sampling Correctness, and Statistical Process Control*, and Ramsey 2004, *Sampling for Environmental Activities*, EcoDQO Training Course). The following steps are involved in determining an adequate sample mass to collect in the field and the proper particle size for the analytical laboratory to measure for chemical and radiological analysis.

1. The sampling investigation unit size is 0.0625 ha. The sample location will be divided into a grid of 5 rows by 5 columns, yielding 25 = 5 x 5 grid cells, with a grid size of 5 by 5 m. Each of the 25 grid cells will be sampled, but with a random offset in each cell.

2. Select or measure a reasonable maximum sample particle size in the field. Because soils typically are defined as comprising particles of ≤2 mm, it will be assumed that the maximum particle size is 2 mm or 0.2 cm. This will be achieved by sieving the soil samples to exclude the >2 mm size particles.

3. Select the desired FE, which has been specified as 10 percent. This corresponds to a standard error of 10 percent on the mean concentration. This value was selected to be low relative to other sources of error (i.e., analytical measurement error typically is 30 percent).

4. Calculate the mass of sample (M) needed, based on the FE and particle size (diameter [d] in centimeters) as

$$M = 22.5\frac{d^3}{FE^2}.$$

   If d = 0.2 cm and FE = 0.1 (10 percent), then M = 18 g.

5. Using a scoop large enough to capture the maximum particle size, collect enough sample increments (k = 50) to at least equal the mass calculated in Step 4 and place them in a container, combining increments into one "sample" (M). Care will be taken to obtain consistent and representative samples for the desired sample depth, and the MIS will be formed such that the material is representative of the particle size fractions that are <2 mm. Sufficient sample mass will be collected for all laboratory analyses.

6. Repeat step 5 within the investigation area to obtain two field replicate samples (as specified in Table 3-8) by sampling from two additional sets of 50 systematic samples with a different random start for each replicate.

7. Deliver the soil samples and QC samples to the laboratory.

8. Because sufficient sample mass of <2 mm screened soil will be collected for all laboratory analyses, the laboratory is expected to analyze the entire mass for each test method.

9. If, however, grinding must be performed, the laboratory will calculate the particle size of sample needed based on the desired FE and the mass that the laboratory normally uses for a given analysis as

$$\sqrt[3]{\frac{M(FE)^2}{22.5}} = d.$$

   For example, if the required sample mass for the analytical measurement is 10 g and FE is 10 percent, then d = 0.16 cm. The analytical laboratory will perform

one-dimensional subsampling of the entire mass (spread the entire ground sample on a flat surface in a thin layer, then systematically or randomly collect sufficient small mass subsampling increments to equal the mass that the laboratory requires for an analysis; do likewise for each QC sample). Combine subsampling increments into the "sample," then digest/extract/analyze the sample and QC samples.

10. Calculate the concentration from the sample.

11. The concentration represents average concentration or activity in the investigation area.

Each MIS will be submitted to the analytical laboratory for analysis of radionuclides (Cs-137, Sr-90, and isotopic plutonium).

Information including, but not limited to sample depths, sample locations, HEIS database sample numbers, relevant and/or pertinent events, general information about the sample or locations, and any other information that may be useful to meet the objectives of the FSP, will be documented in the sampler's field logbook.

The investigation-derived waste generated during this activity will be handled according to applicable procedures in Section 3.12 of this SAP.

A summary of the number and types of soil samples to be collected is presented in Table 3-8, which lists the specific locations.

Table 3-8. Summary of Projected Soil Sample Collection Requirements. (2 Pages)

Site Identification	Primary Samples	Quality Control Samples
Northwest transect #1	1 sample from 25 cells*	-
Northwest transect #2	1 sample from 25 cells*	-
Northwest transect #3	1 sample from 25 cells*	-
Northwest transect #4	1 sample from 25 cells*	-
T Plant transect #1	1 sample from 25 cells*	-
T Plant transect #2	1 sample from 25 cells*	-
T Plant transect #3	1 sample from 25 cells*	-
West transect #1	1 sample from 25 cells*	-
West transect #2	1 sample from 25 cells*	-
West transect #3	1 sample from 25 cells*	-
North transect #1A	1 sample from 25 cells*	-
North transect #1B	1 sample from 25 cells*	-
North transect #1C	1 sample from 25 cells*	-
North transect #2A	1 sample from 25 cells*	-
North transect #2B	1 sample from 25 cells*	-
North transect #2C	1 sample from 25 cells*	-
North transect #3A	1 sample from 25 cells*	-
North transect #3B	1 sample from 25 cells*	-

Table 3-8. Summary of Projected Soil Sample Collection Requirements. (2 Pages)

Site Identification	Primary Samples	Quality Control Samples
North transect #3C	1 sample from 25 cells*	-
Southeast transect #1A	1 sample from 25 cells*	-
Southeast transect #1B	1 sample from 25 cells*	-
Southeast transect #1C	1 sample from 25 cells*	-
Southeast transect #2A	1 sample from 25 cells*	-
Southeast transect #2B	1 sample from 25 cells*	-
Southeast transect #2C	1 sample from 25 cells*	-
Totals	25	
Field replicate	-	2 additional samples in the North area. Within target area, collect each MIS from another 25 systematic locations with a random start. Field team will select location.
Equipment blank	-	1 sample of clean soil/sand or water
Laboratory quality control	-	2 additional samples; laboratory triplicate performed on primary MIS from field quality control site
Total	25	5
Total samples to analyze	30	

*Each systematic sample will have a different random start consisting of 50 increments.
MIS = multi-increment sample.

3.7 DISPERSED CARBON TETRACHLORIDE PLUME

The Phase III assessment of the dispersed carbon tetrachloride plume includes an exposure assessment for burrowing animals residing in potentially affected locations. Available soil-gas data from the Hanford Site soil-gas monitoring program indicate that the CCl_4-inhalation ESL was exceeded in many areas associated with the dispersed carbon tetrachloride plume in the 200 West Area. This information will be used in field reconnaissance activities to identify candidate burrows for in situ burrow-air measurements (Figure 3-5).

Because soil-gas concentrations of carbon tetrachloride exceeded the inhalation ESL for fossorial small mammals in some locations, additional characterization is proposed to help interpret potential risks to these receptors. A tiered investigation approach has been applied that will evaluate habitat suitability and presence/absence of receptors at locations where soil-gas concentrations of carbon tetrachloride indicate potential risks (Figure 3-6). In the event that empirical burrow-air data exceed the carbon tetrachloride ESL, subsequent investigation, including potential health effects studies, may occur where suitable habitat and receptors are present in locations with elevated soil-gas concentrations of carbon tetrachloride.

Figure 3-5. Exceedances of Inhalation Ecological Screening Level for Carbon Tetrachloride and Habitat Characteristics of the 200 West Area.

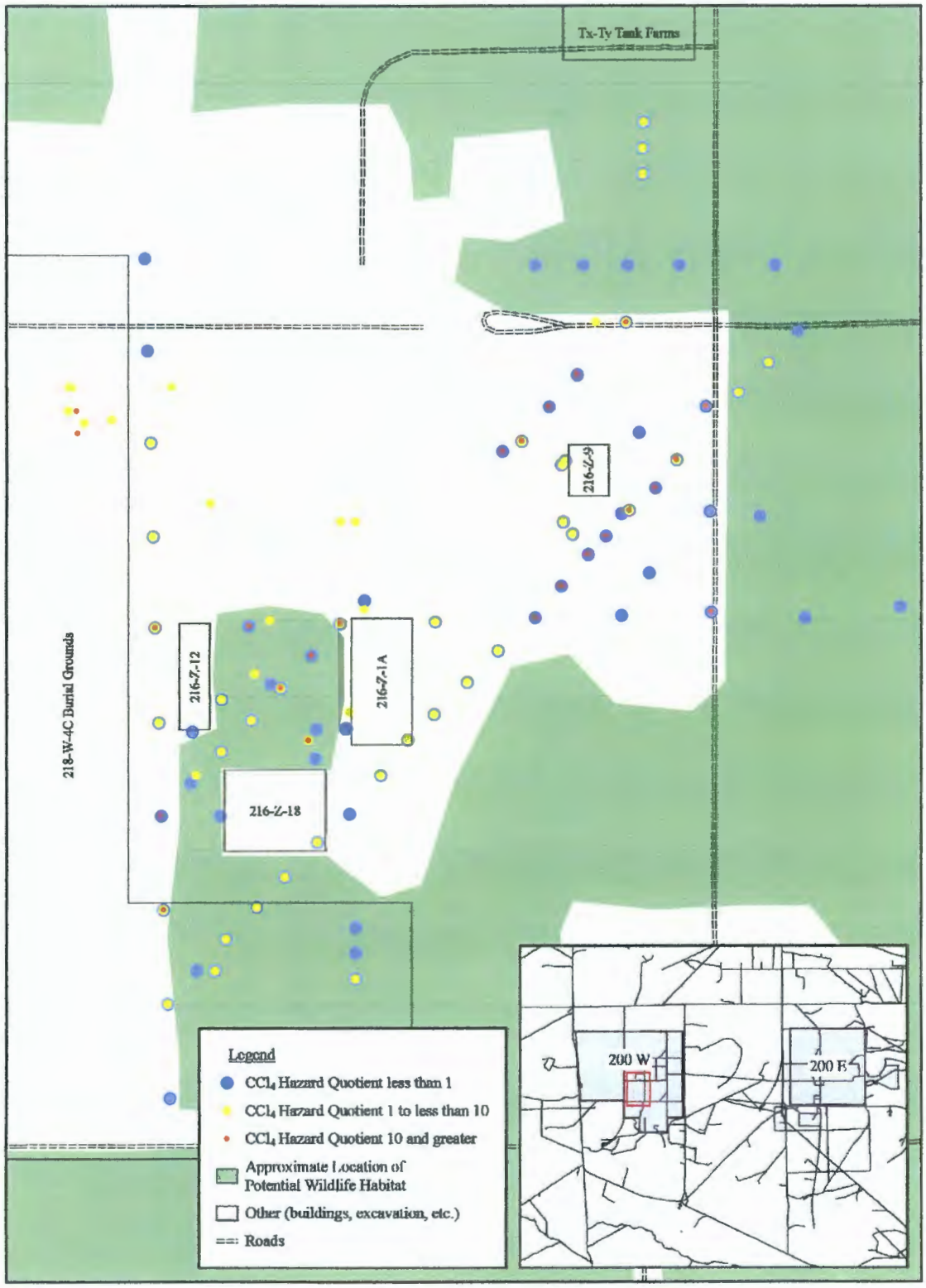
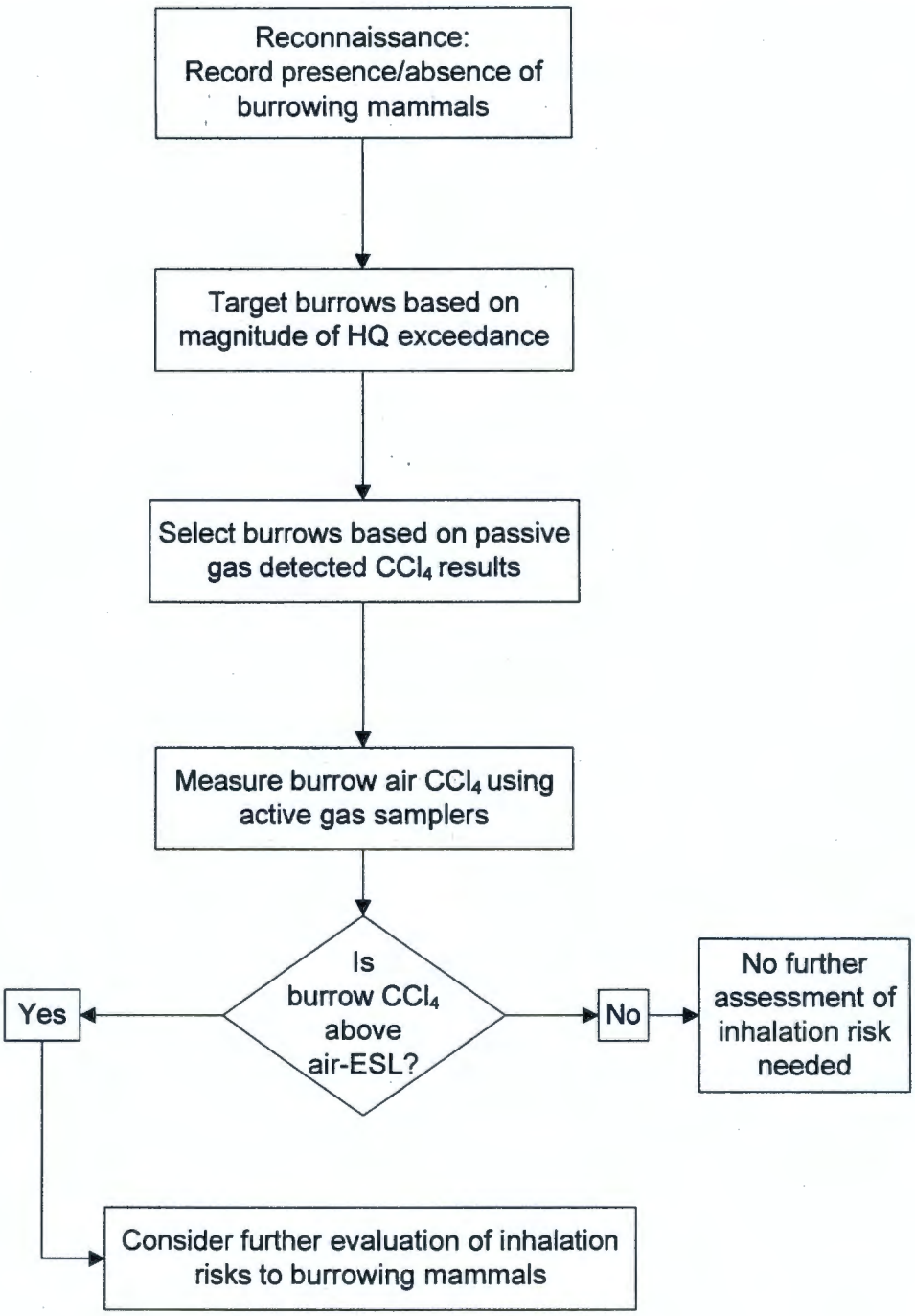


Figure 3-6. Logic Diagram for the Assessment of Potential Carbon Tetrachloride Inhalation Risks to Burrowing Receptors.



3.7.1 Sampling Design

Areas for investigation of inhalation risks to burrowing mammals will be identified based on the results of preliminary soil-gas data analysis and field reconnaissance activities to scope potential habitat. Initial selection of investigation areas is based on analytical data, including the magnitude and frequency of ESL exceedances (as represented by hazard quotients), and the presence of near-surface carbon tetrachloride reported by recent (2003 and 2004) passive-soil-gas survey results. The passive gas samples (EMFLUX) show where carbon tetrachloride was detected in the 0 to 1.5 m samples. Reconnaissance of habitat suitability and receptor presence/absence will be performed to determine the likelihood of exposure to burrowing small mammals in locations where carbon tetrachloride has been documented in soils. This information also may be used to select areas for burrow-gas sampling.

Habitat suitability for burrowing small mammals is a function of vegetation, soil type, and level of disturbance. Observations will be conducted to answer the following questions:

- Are areas of relatively elevated carbon tetrachloride concentrations encompassed or bordered by suitable habitat (i.e., vegetation, soil type)?
- Are areas of relatively elevated carbon tetrachloride concentrations situated in areas of low-to-moderate industrial development or human disturbance?

The presence of fossorial small mammals will be assessed visually, noting observations of burrow holes and mounds, runways, and small-mammal droppings. The approximate quantity and density of these indicators will be recorded. Because small-mammal populations fluctuate seasonally, reconnaissance surveys will be conducted during periods of optimal small-mammal activity. Reconnaissance activities will result in the identification of candidate burrows for burrow-air sampling.

Before the active burrow-gas measurements are collected, EMFLUX tube measurements will be collected at animal burrows targeted for gas sampling to verify that carbon tetrachloride is present in subsurface. The screening step will employ EMFLUX tubes placed in association with candidate burrows; burrows with higher readings will be targeted for active-gas measurements. Burrow air will be measured by actively collecting gases (Summa[9] canister) from within burrows to empirically determine the carbon tetrachloride gas concentrations to which fossorial animals are exposed. A summary of the carbon tetrachloride study design is presented in Table 3-5.

Burrow-air will be collected with the intent of capturing worst case conditions within the tube. The amount of air movement through burrows, and thus accumulation of carbon tetrachloride, may change with time and climatic factors such as wind speed and direction, changes in barometric pressure, soil moisture, depth in the soil, etc. Experts in soil-gas sampling are being

[9] SUMMA is a trademark of Moletrics, Inc., Cleveland, Ohio.

consulted to devise an appropriately representative protocol for burrow-air sampling. A summary of the burrow-air study design is presented in Table 3-9.

Table 3-9. Summary of the Design to Identify Candidate Burrows and Quantify Carbon Tetrachloride in Burrow Air.

Sample Type	Sample Number	Purpose
Passive gas samples	10 to 20	Carbon tetrachloride verification screening
Active gas samples	~ 10	Carbon tetrachloride confirmation in burrow air

If animal burrows are not detected in the habitat areas shown in Figure 3-5 during the reconnaissance surveys, six artificial animal burrows will be installed for the collection of vapor samples. Of these, three artificial burrows will be installed in worst case locations near the waste sites that discharged CCl_4. The other three artificial burrows will be installed at the onset of vegetation at the 218-W-4C Burial Ground Annex. The burrow tubes will be placed in narrow slit trenches. After installation and backfilling with the excavated soils, the burrows will be left in place for one week so that burrows and disturbed soils reach equilibrium vapor conditions with the surrounding soils prior to vapor sampling. In addition to the active vapor sampling in the burrows, EMFLUX tube passive gas samples will be collected from the soils near the artificial burrows to verify adjacent CCl_4 concentrations. If this activity is performed, the sampling design will be documented in an addendum to this sampling and analysis plan.

3.8 WEST LAKE

Three general types of information are needed to characterize West Lake during 2006 as part of Phase III of the Central Plateau EcoDQO investigation: (1) a field radiological investigation of the perimeter of West Lake, (2) an assessment of biological exposure pathways (reconnaissance), and (3) collection of surface water, pore water, sediment, salt crusts, and invertebrates (brine fly) for analyses of COPECs.

3.8.1 Field Radiological Survey

The field radiological survey of the perimeter of West Lake will be performed following the grid survey technique described in Section 3.1. Field survey equipment will be mounted on a mobile field unit with large tires to avoid damaging West Lake soils. The surface-radiation survey will be conducted by a qualified radiological control technician, in accordance with specific task instructions and other applicable approved procedures that will provide direction to the radiological control technician on how the areas under consideration are to be surveyed to meet the requirements as stated in this SAP. See Table 3-5 for a summary of the radiation survey methods for West Lake. Radiological instrumentation for field data collection that may be used also is provided in Table 3-5.

In the event that elevated radiological levels are recorded, the radiological control technician is empowered to collect a soil sample for laboratory analyses of radionuclides. In this case, elevated generally is defined as three times the background readings, but specific judgment on

relative elevation is left to the discretion of the technician. For this exercise, background will be based on an average of 20 readings.

3.8.2 Sampling Design for West Lake Biological Pathways (Reconnaissance)

Little biological information from West Lake is recorded. In the past, swallows, bats, and several species of shorebirds have been seen along the shoreline foraging for larvae (e.g., brine fly larvae [Ephydridae]). Surveys in 2000 found small sandpipers, killdeer, and American avocet (PNNL-13487). The seasonality and distribution of ground beetles (Coleoptera: Carabidae) at the Hanford Site have been studied, and they indicate that the greatest number of ground beetle species were at West Lake (Looney 2000 thesis, *Seasonality and Distribution of Ground Beetles* (Coleoptera: Carabidae*) on the Hanford Nuclear Reservation*). Over 20 types of ground beetles were trapped at West Lake over the two-year period of the study. West Lake and its adjacent wetlands were surveyed in 1997; native plant communities at West Lake appeared to be degraded (TNC 1999, *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999*). *Castillejea exilis* and many other species documented at West Lake (WHC-EP-0554, *Vascular Plants of the Hanford Site*) were not located during the 1997 survey. Much of the lake basin has been infested with weedy species, primarily *Bassia hyssopifolia* (smotherweed). Wetland vegetation found at West Lake is limited to scattered patches of emergent macrophytes, such as cattails (*Typha* spp.) and bulrushes (*Scirpus* spp.).

Reconnaissance surveys are needed to better describe the current biological pathways and to estimate the percent of the year that these pathways exist. These activities collectively include conducting periodic surveys of the wildlife that use West Lake between April and September. Biological pathway surveys will be conducted twice per month and will include both daylight and evening periods. The following specific tasks will be performed as part of this reconnaissance:

- Avian point counts
- Mammalian use/activity surveys
- Amphibian surveys
- Aquatic invertebrate surveys
- Plant species surveys
- Water quantity/quality monitoring.

Avian use will be monitored by conducting several 5-minute point counts at one or more fixed stations located near the edge of West Lake. Indirect evidence (e.g., scat, tracks, feathers) of avian use at West Lake will be recorded in the field record book or on the point-count survey forms. Relative abundance estimates, a complete species observation list, and types of avian use activities observed will be recorded.

Mammals using the West Lake habitats will be documented more qualitatively than avian species. Mammal use and activity observations will be accomplished by conducting a walk-through of the West Lake habitats during each daylight survey event. Indirect evidence (e.g., scat, tracks, burrows, evidence of browsing or licking salts, hair) will be recorded in the field record books. Indications of active animal use of West Lake also will be noted

(e.g., animals observed drinking water, foraging on grasses). Night-time surveys using an echo-location device will be conducted each month to record bat presence and, to a more qualitative degree, the relative abundance of bat activity over West Lake.

Amphibian surveys will be conducted during both daytime and evening periods. Daytime surveys will include visually examining West Lake for egg masses and/or adult salamanders, frogs, or toads. Artificial cover (plywood boards) will be placed at three sites along the shoreline of West Lake and checked each daytime survey period to help confirm the presence/absence of amphibians. In addition, several 5-minute point-count anuran breeding call surveys will be conducted during the nighttime survey periods.

Aquatic macroinvertebrates in West Lake will be assessed by opportunistically collecting specimens by hand or using a kick net (Turtox[10] bottom kick net, mesh 800 μm x 900 μm). Macroinvertebrates taxa may be identified down to Orders, Families, Genera, or in some cases the species. Numbers of individuals of each Order and in some cases Families of each Order will be documented on a datasheet, along with the date that the samples were collected.

A single reconnaissance survey will be conducted for unique saline-tolerant plants found in the riparian habitats surrounding West Lake. The reconnaissance survey will include a general description of the flora communities surrounding West Lake, noting the location and general numbers/areal extent of unique plant populations found there.

Water quantity/quality (pH, temperature, conductance, and dissolved oxygen) will be recorded each month, beginning in spring 2006, to help assess the water quality over the course of the spring and summer periods. Photographs of West Lake will be taken at three marked, fixed stations (an oblique aerial view from Gable Mountain and two points selected adjacent to West Lake) to help document changes in the lake size and availability of water over the spring and summer period.

3.8.3 Sampling Design for West Lake Contaminants of Potential Ecological Concern

Samples of surface and pore water (metals and radionuclides, TOC, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, total dissolved solids, and titrations for total hydroxide and total carbonate), sediment (metals, radionuclides, organic compounds, AVS, total sulfides), salt crust (radionuclides, metals, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, titrations for total hydroxide and total carbonate, and by XRD [for crystal structure]) and brine fly adults or larvae (metals, radionuclides) will be collected at West Lake (Figure 3-7).

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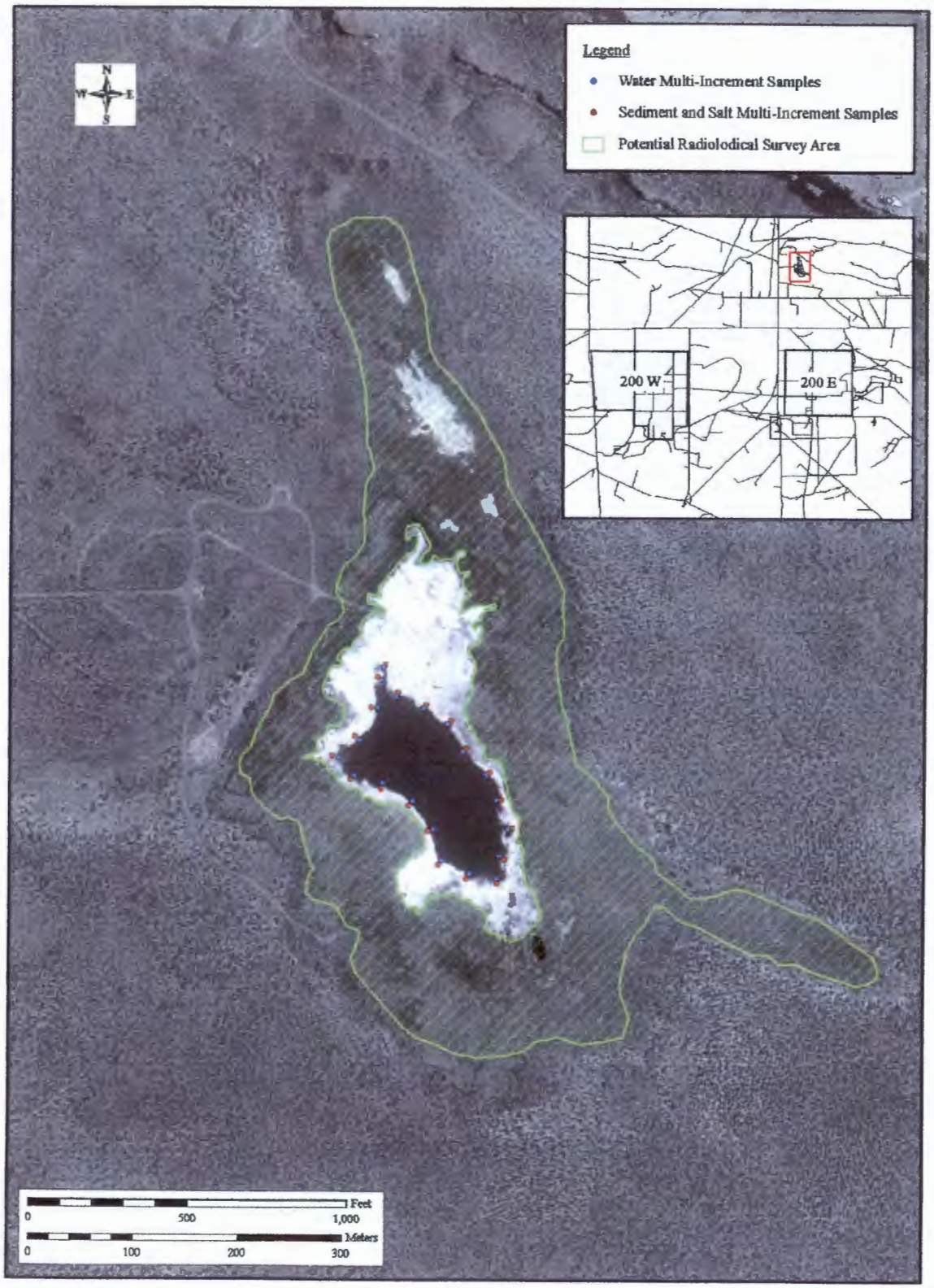
[10] Turtox is a trademark of Wildlife Supply Company, Buffalo, New York.

Figure 3-7. Sampling Design for West Lake Characterization.



Sampling is designed to capture exposure for wildlife using the lake as a potential source of drinking water or perhaps as a salt lick. Thus, the lake's perimeter is logical to characterize for wildlife exposure, because terrestrial organisms would not be expected to venture into the middle of the lake. Consequently, surface water will be sampled by collecting 20 increments around the lake's perimeter. If the lake is about 200 m by 50 m, and the stride length of the sampler is a meter, this equates to pulling a sample every 25 strides.

If the lake has receded when sampling occurs, samples will be pulled more frequently than every 25 strides to account for the necessary 20 increments. Approximately 1000 mL of water per sample (filtered and unfiltered each) will be needed; consequently, each increment should be approximately 100 mL. Increments will be collected with a wide-mouth plastic container attached to the end of an extension pole, extended out from the shore and dipped just under the surface of the lake water. Water will be filtered to exclude particles >0.45 μm size. The filtered sample and unfiltered sample will be drawn from the same surface water MIS.

Pore water also will be sampled after collecting multiple increments. A filtered and an unfiltered sample is desired. The lake's perimeter will be surveyed with a Global Positioning System, and points (± 1 m) will be systematically selected within the near-shore boundaries. A polyvinyl chloride pipe ~3.8 cm in diameter and 2 to 3 m long slotted with ~1.5 mm wide openings will be driven into sediment to a depth of 1 m. The portion of pipe above the sediment bed will not be slotted. Assuming that the sampling requirement for both filtered and unfiltered samples is 6 L, approximately 300 mL of water will be drawn from each point and placed into a common container. The filtered sample and unfiltered sample will be drawn from the same pore-water MIS.

Sediment will be sampled along the shoreline of West Lake in a fashion similar to the sampling of the surface water. Relative to water, a greater number of sediment (and salt) increments is planned, considering the greater spatial extent of exposed salt-crusted sediments. Forty increments of sediment will be collected along the shoreline of West Lake to a standard depth, combined in a single container, and tilled using Teflon[11] or a plastic scoop for approximately 1 minute. The sediment then will be spread evenly onto a stainless steel tray, and 30 subsamples will be systematically collected in approximately equal fractions and placed into each sample container prescribed by the analytical laboratories and within the mass requirements that would allow for complete digestion of the entire sample.

Mineral deposits or crystalline salt crusts with varying colorations from white to a dark yellow can be observed along the shoreline of West Lake and will be sampled as a separate matrix. Two total MIS will be collected for salt, including one field replicate. Salt crusts will be removed, minimizing contact with the underlying sediment, and analyzed as a separate sample. The salt sample will be analyzed for radionuclides, metals, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, titrations for total hydroxide and total carbonate, and by XRD.

Five brine fly (e.g., Ephydridae) sample will be collected for analyses of West Lake COPECs using sweep nets or black-light traps along the shorelines of West Lake. Sample material only

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[11] Teflon is a trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

will be rinsed if large quantities of sediment particles are present in the sample. Brine flies will be analyzed for metals and radionuclides.

A summary of the number and types of samples to be collected for West Lake is presented in Table 3-10.

Table 3-10. Summary of West Lake Sampling Activities. (2 Pages)

Matrix	Sample (n)	Field Replicate Sample (n)	Sample Type	Data Collected
Surface water (filtered and unfiltered)	1	1	MIS of 20 increments	Metals, radionuclides, TOC, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, total dissolved solids, and titrations for total hydroxide and total carbonate
Pore water (filtered and unfiltered)	1	1	MIS of >10 increments	
Sediment	1	1	MIS of 40 increments	Metals, radionuclides, SVOCs, TBP, normal paraffin hydrocarbon, TOC, acid volatile sulfide, total sulfides
	1	-	Equipment blank	Cesium-137, metals
Salt crust	1	1	MIS of 40 increments	Metals, radionuclides, alkalinity, calcium, potassium, iron, magnesium, sodium, anions, titrations for total hydroxide and total carbonate, and by X-ray diffraction
	1	-	Equipment blank	Cesium-137, metals
Brine fly	5	N/A	Grab samples	Metals, radionuclides
Total	11	4		
Total samples to analyze	15			

MIS = multi-increment sampling (see Section 3.5.3).
N/A = not applicable.
SVOC = semivolatile organic compound.
TOC = total organic carbon.
TBP = tributyl phosphate.

3.9 OFFSITE REFERENCE SITE SAMPLING

To address concerns expressed by the Hanford Natural Resource Trustees and the Tri-Party Agreement agency decision-makers over the use of reference sites within the Hanford Site boundary, two unimpacted offsite reference sites will be selected for soil sampling. These offsite reference sites will be located outside the Hanford Site boundary. Reference sites will be selected in the vicinity of the Yakima Firing Range and the Black Rock Reservoir or other suitable locations agreed to by the Tri-Party agencies.

The offsite reference site sampling will be performed within 1 ha sample plots similar to those used in the Phase I and Phase II sampling. Two multi-increment samples will be collected from each site. The first soil sample will be taken from the 0-1 in. depth and the second from the 1-2 in. depth interval. Each sample will consist of 50 soil increments. To provide a basis for

comparability, the Phase I and Phase II onsite reference sites will be resampled in an identical manner. The offsite sampling activities are summarized in Table 3-11.

All soil samples collected will be analyzed for Am-241, Cs-137, Pu-238, Pu-239/240, and Sr-90. These are the long-lived radionuclides analyzed in the Hanford Environmental Dose Reconstruction (HEDR) Project (PNL-7231 HEDR, *Selection of Dominant Radionuclides for Phase I of the Hanford Environmental Dose Reconstruction Project*, and BN-SA-3673 HEDR, *Determination of Radionuclides and Pathways Contributing to Cumulative Dose*) or known to exist in Hanford Site soils from plant stack releases. Although I-131 was one of the primary radionuclides in the HEDR study, it is not an analyte in the offsite reference sampling because of its very short (8.04 day) half-life.

Gridded radiological surveys will be performed in the offsite and onsite reference site hectare plots, using sodium iodide detectors, prior to soil sampling. The surveys will extend 10 m beyond the boundaries of the hectare plots for comparability with the surrounding soil.

Table 3-11. Offsite Reference Site Soil Characterization Activities.

Site Identification	Primary Samples	Sample Depth Interval (in.)	Quality Control Samples
Offsite Reference Site #1	1 MIS of 50 soil increments*	0-1	1 replicate MIS from another 50 systematic locations with a random start.*
		1-2	-
Offsite Reference Site #2	1 MIS of 50 soil increments*	0-1	-
		1-2	-
Onsite Reference Site #1	1 MIS of 50 soil increments*	0-1	1 replicate MIS from another 50 systematic locations with a random start.*
		1-2	-
Onsite Reference Site #2	1 MIS of 50 soil increments*	0-1	-
		1-2	-
Equipment blank	-		1 sample of clean soil/sand or water
Laboratory quality control	-		2 additional samples; laboratory triplicate performed on primary MIS from field quality control site
Total	8		5
Total samples to analyze	13		

*Each systematic sample will have a different random start.
MIS = multi-increment sample.

3.10 POTENTIAL SAMPLE DESIGN LIMITATIONS

The sample design developed for this SAP has several potential limitations that may affect the sampling results. Some of the factors that have the potential to affect the outcome of this sampling activity include the following:

- Ability to collect sufficient sample mass for analytical measurements of biota
- Timing of data collection to maximum abundance of biota.

This SAP includes an assessment of the contingency considerations to offset limitations potentially encountered during sampling in the Central Plateau. The FH task lead will evaluate the need to implement these contingencies on a case-by-case basis.

If an insufficient mass of invertebrates is obtained from the pitfall traps, then additional sampling duration will be added, or other methods, such as hand collection of invertebrates, will be used. If the target numbers of small mammals or lizards cannot be obtained, then additional sampling will be considered.

A limitation likely to be encountered pertains to the mass of individual lizards. The Phase I/II lizards ranged in body mass from 1-5 grams. The larger adult lizards are expected to meet the minimum mass requirement of 4 grams per lizard sample (for PCB congeners and Sr-90), but the juveniles are not. Consequently, a Phase III contingency has been developed to ensure that analytical detection limits are met. This SAP therefore allows compositing of individual lizards within a given waste site to meet the minimum mass requirement of 4 grams.

Detection limits higher than the levels in Chapter 2.0, or reduced analyte lists, are significant deviations and must be documented and communicated to the project team.

3.11 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS

All field-sample handling, shipping, and custody requirements will be consistent with established procedures. Sample transportation will be in compliance with the applicable regulations for packaging, marking, labeling, and shipping hazardous materials, hazardous substances, and hazardous waste that are mandated by the U.S. Department of Transportation (49 CFR 171-177, Chapter 1, "Research and Special Programs Administration, Department of Transportation," Part 171, "General Information, Regulations, and Definitions," through Part 177, "Carriage By Public Highway") in association with the International Air Transportation Authority, DOE requirements, and applicable program-specific implementing procedures. Sample custody during laboratory analysis is addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Sample preparation, packing requirements, and hold times will be consistent with those documented in the QAPjP, Tables 2-10 through 2-16.

3.12 SAMPLING AND ONSITE ENVIRONMENTAL MEASUREMENT PROCEDURES

Procedures for field measurements are specified in the subcontractor's or manufacturer's manuals. The sampling and onsite environmental measurement procedures to be implemented in the field will be consistent with established procedures.

3.13 SAMPLE MANAGEMENT

Sample management activities will be consistent with established procedures. Any laboratory performing work will be compliant with SW-846 requirements.

3.14 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed consistent with an established waste management plan. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," task lead approval is required before unused samples or waste are returned from offsite laboratories.

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4.0 HEALTH AND SAFETY

All field operations will be performed in accordance with Duratek Federal Services of Hanford, Inc., health and safety requirements and applicable portions of the *Washington Administrative Code* and RCW 43.21C, "State Government – Executive," "State Environmental Policy" (State Environmental Policy Act). Additionally, work control documents will be prepared that will further control site operations. The safety documentation will include an activity hazard analysis and applicable FH radiological work permits.

The sampling procedures and associated activities will implement ALARA practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in 10 CFR 835. All field operations will be performed in accordance with FH health and safety requirements. Duratek Federal Services of Hanford, Inc., will comply with the FH Radiological Protection Program.

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