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Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase I

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

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APPROVAL PAGE

Title: Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report-Phase I

Approval: M.E. Todd-Robertson
Manager, Waste Site Remedial Actions, Deactivation and Decommissioning Project

M.E. Todd-Robertson 7/5/06
Signature Date

J.G. Riddelle
Manager, Engineering, Groundwater Remediation Project

NOT REQUIRED MET-R
Signature Date

J.A. Winterhalder
Environmental Compliance Officer, Groundwater Remediation Project

J.A. Winterhalder 6/12/06
Signature Date

W.R. Thackaberry
Quality Engineer, Groundwater Remediation Project

W.R. Thackaberry
Signature Date

R.G. Bauer
Task Lead, Waste Site Remedial Actions, Deactivation and Decommissioning Project

R.G. Bauer 6/12/06
Signature Date

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EXECUTIVE SUMMARY

This terrestrial ecological data quality objectives (EcoDQO) summary report is the first in a series of three summary reports (Phases I, II, and III) for assessing ecological risks on the Hanford Site's Central Plateau. The activities described in this document will result in the acquisition of soil and biota data needed for informed waste site decision making and will provide information to evaluate the health or condition of the ecosystem across the range of Central Plateau habitats. Steps 3 and 4 of EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*, are included and represent the data quality objectives (DQO) process for ecological risk assessments. Much of the EPA/540/R-97/006 Step 3 and Step 4 information provided in this document is germane to Phases I, II, and III of this project. The list of contaminants and the resulting analytical suites are expected to differ from investigation phase to phase. The culmination of the phased DQOs/sampling and analysis plans and field characterization activities will be a final Central Plateau ecological risk assessment, planned for fiscal year 2007, as shown in Figure ES-1.

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) established a framework to ensure that environmental impacts 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 DQO is one of several being performed on the Hanford Site to ensure that ecological risks have been properly evaluated in support of remedial action decision making. This document only addresses potential terrestrial ecological impacts on the Central Plateau. It does not address Central Plateau human health or groundwater impacts, nor does it consider ecological impacts in other portions of the Hanford Site.

The Central Plateau EcoDQO is being implemented using a phased and tiered approach to characterize ecological risks. Phases are based on spatial domains where investigation areas will be located; tiers are types of data collected within those investigation areas. Phase I activities are

focused on the 200 East and 200 West Areas. Phase II will evaluate the need for ecological sampling in the US Ecology site, tank farms, the BC Controlled Area, and West Lake. Phase III is planned to evaluate the need for ecological sampling in habitat (non-operational) areas outside of the 200 East and 200 West Areas. Because of budgetary and schedule limitations that constrained the fiscal year 2004 activities, the spatial components of Phases I and II of the EcoDQO will be characterized in fiscal year 2005. Waste sites in the 200 East and 200 West Areas will be sampled concurrent with an evaluation of the areas targeted for Phase II.

Several contaminated media were considered for the Central Plateau EcoDQO, including soil (shallow or <4.6 m [15 ft], and deep or >4.6 m [15 ft]), air, groundwater, and wetlands. For the terrestrial environment on the Central Plateau, groundwater and wetlands typically are not relevant media. However, West Lake represents a unique aquatic environment compared to the Central Plateau, and its evaluation led to the development of a separate DQO (Appendix E). The West Lake DQO is planned to be revised based on assessment of available data in Phase III. And while ecological impacts associated with inhalation of contaminants are typically of minor concern (EPA 2003b, *Guidance for Developing Ecological Soil Screening Levels*, Attachment 1-3, *Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purposes of Setting EcoSSLs*), a diffuse carbon tetrachloride plume in the 200 West Area also was considered for possible ecological risks. Generally, the most important contaminated media for ecological risks are shallow zone soils and associated food web exposures; therefore, use of soil-screening values and terrestrial biota concentration guidelines based on these pathways are appropriate for identifying contaminants of potential ecological concern (COPEC).

COPECs were identified based on shallow zone data available from the *Hanford Environmental Information System*, a Hanford Site database, and/or from DOE/RL-2001-54, *Central Plateau Ecological Evaluation*. Analytes were included as COPECs if the maximum detected concentrations exceeded the soil-screening values or significantly contributed to the sum of fractions for radiological dose to terrestrial receptors. COPECs include 8 radionuclides (Am-241, Cs-137, Co-60, Pu-239, Ra-226, Ra-228, Sr-90, and U-238), 21 metals (antimony, arsenic, barium, bismuth, boron, cadmium, chromium, hexavalent chromium, copper, cyanide, lead, mercury, molybdenum, nickel, selenium, silver, thallium, tin, uranium, vanadium, and

zinc), and polychlorinated biphenyls (Aroclor-1254 and Aroclor-1260[1]). Carbon tetrachloride was identified as a COPEC in soil gas, based on available data on the soil-gas plume in the 200 West Area. Additional analytes that share the specified analytical techniques also will be reported if detected. Additional analytes may include Cs-134, Eu-152, and Eu-154 (gamma energy analysis) and Pu-238 (isotopic plutonium). Pesticides also will be analyzed with the polychlorinated biphenyl analysis.

Assessment endpoints were developed that are representative of terrestrial ecological receptors potentially at risk from COPECs in soil. Plants and soil macroinvertebrates are valuable assessment endpoint entities because, considering the lack of inorganic trophic transfer, they potentially are more exposed indicators for evaluating the adverse effects of inorganic COPECs. Central Plateau-specific receptors are suggested as ecological and societal relevant assessment endpoints that also address management goals. Central Plateau-specific receptors also are suggested as surrogates for the *Washington Administrative Code* feeding guilds, because they are at greater risk from COPECs in the toxicity evaluation. These feeding guilds include producers, soil biota, soil macroinvertebrates, middle-trophic-level vertebrates, and carnivorous reptiles, birds, and mammals. Some of these species will be selected for direct measures of exposure, effect, and ecosystem/receptor characteristics. Others species will be evaluated based on surrogates.

Risk questions were a logical outcome of COPEC refinement and consideration of assessment endpoint attributes, and they represent the conceptual model of how contaminant stressors are most likely to impact the Central Plateau ecosystem. Risk questions are posed to identify measures of effect, exposure, and ecosystem/receptor characteristics. Eight risk questions were developed, including the following:

1. Do COPECs in shallow zone soils decrease plant survival or growth?
2. Do COPECs in shallow zone soils affect decomposition by soil biota?
3. Do COPECs in shallow zone soils affect soil macroinvertebrate survival or growth?

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[1] Aroclor is an expired trademark.

4. Do COPECs in shallow zone soils and food decrease herbivorous, insectivorous, or omnivorous bird survival, growth, reproduction, or abundance or affect balanced gender ratios?
5. Do COPECs in shallow zone soils and food decrease insectivorous reptile abundance or biomass or affect size structure?
6. Do COPECs in shallow zone soils and food decrease herbivorous, insectivorous, or omnivorous mammal survival, growth, reproduction, abundance, or biomass or affect balanced gender ratios?
7. Do COPECs in shallow zone soils and food decrease carnivorous bird survival, growth, or reproduction?
8. Do COPECs in shallow zone soils and food decrease carnivorous mammal survival, growth, or reproduction?

Measures of effect, exposure, and receptor/ecosystem characteristics were selected. These measures form the basis of the data needs for the study design. Measures of exposure include COPEC concentrations in soil and biota. Measures of effect include laboratory toxicity testing, comparison of COPEC concentrations in soil to literature-derived adverse-effect level for plants and invertebrates in soil, modeled extrapolation of COPEC concentration in soil to literature-derived adverse-effect level for diet (wildlife only), comparison of COPEC concentrations in tissue to literature-derived adverse-effect level for assessment endpoint tissue concentration (wildlife only), and field study of the potential for adverse effects (conditional on field verification efforts). Ecosystem/receptor characteristics are identified by various Central Plateau habitat types.

A sampling design is provided in Chapter 9.0 that shows how the various data types (measures) relate to risk questions, the key features of the study design, and the basis for the design element. All 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). Because of the large scope of ecological sampling, data will be collected in three phases to evaluate ecological risks. The phased approach enables the assessment of specific study-design objectives over a broad spatial scale. A tiered approach to

data collection also is employed, because advanced stages of sampling will be based on the results of initial collection efforts.

Another important component of the conceptual model is the primary exposure medium, including the depth of biological activity. Data suggest that surface soil is important as an exposure medium for direct contact with wildlife, root uptake, and animal burrowing. Thus, surface samples (of the first 15 cm [6 in.]) can be collected along with specific biological samples to test for COPEC uptake. Collecting surface soil samples for the initial data collection activities has important practical advantages. Methods for collecting surface soil samples are less intrusive than those needed for deeper soil characterization (e.g., truck-mounted drill rigs) and therefore minimize the impacts of data collection on the shrub-steppe ecosystem. The conceptual model of possible upward mobility of buried waste through animal burrowing and plant uptake also will be initially assessed using radiological field-data collection. Soils interrogated by the field data will be biased toward areas with a high potential for mobilized subsurface waste (i.e., mammal burrow spoils and ant mounds).

The specific receptors targeted for initial sampling are mammals, lizards, and soil macroinvertebrates, because these organisms were viewed as having a high potential to accumulate site COPECs. As middle trophic level species, they also are important sampling subjects, because the detected contaminant concentrations in their body tissues can be used to estimate impacts to higher trophic level species by modeling. Plant tissue will be initially assessed for radionuclide uptake using radiological field data for gamma-emitting radionuclides. To help address trustee information needs, abnormalities will be noted for the animals handled during data collection. Additional data collection is dependent on the results of the initial investigation phases and may include characterization of soils deeper than 15 cm (6 in.), plant tissue concentrations, population measures for mammals and lizards, field verification for middle trophic-level birds, litterbag studies, and toxicity tests for plants and invertebrates.

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TERMS

AE	assessment endpoint
AUF	area-use factor
BCG	biota concentration guideline
bgs	below ground surface
BIV	bioaccumulation factor
BV	background value
BW	body weight
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
DDT	dichloro-diphenyl-trichloro-ethane
DRO	diesel-range organic
DQA	data quality assessment
DQO	data quality objective
EcoDQO	ecological data quality objective
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERAGS	EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*
FD	frequency of detects
GRO	gasoline-range organic
HEIS	*Hanford Environmental Information System* database
HI	hazard index
HQ	hazard quotient
LOAEL	lowest-observed-adverse-effect level
LOEC	lowest-observed-effect concentration
NA	not available/applicable
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
OU	operable unit
PCB	polychlorinated biphenyl
RQ	risk question
SAP	sampling and analysis plan
SOF	sum of fractions
SSV	soil-screening value
TEE	terrestrial ecological evaluation
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
TRV	toxicity reference value
WAC	*Washington Administrative Code*

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1.0 OVERVIEW: ECOLOGICAL RISK ASSESSMENT GUIDANCE FOR THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT OF 1980

This document is the terrestrial ecological data quality objectives (EcoDQO) Phase I summary report for the Hanford Site Central Plateau. It is the first in a series of three summary reports (Phases I, II, and III) for assessing ecological risks on the Central Plateau. The activities described in this document will result in the acquisition of soil and biota data needed for informed waste site decision-making and will provide information to evaluate the health or condition of the ecosystem across the range of Central Plateau habitats. The culmination of the phased data quality objectives (DQO)/sampling and analysis plans (SAP) and field characterization will be a final Central Plateau ecological risk assessment (ERA), planned for fiscal year 2007, as shown in Figure 1-1.

Primary Objectives for the Central Plateau Ecological Data Quality Objectives

1. Provide information to be used for waste site decision making.
2. Provide information to evaluate the health or condition of the ecosystem across habitats.

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) established a framework to ensure that environmental impacts 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 ERA supported by this DQO is one of several being performed on the Hanford Site to ensure that ecological risks have been properly evaluated in support of remedial action decision making. This document only addresses potential terrestrial ecological impacts on the Central Plateau. It does not address Central Plateau human health or groundwater impacts, nor does it consider ecological impacts in other portions of the Hanford Site.

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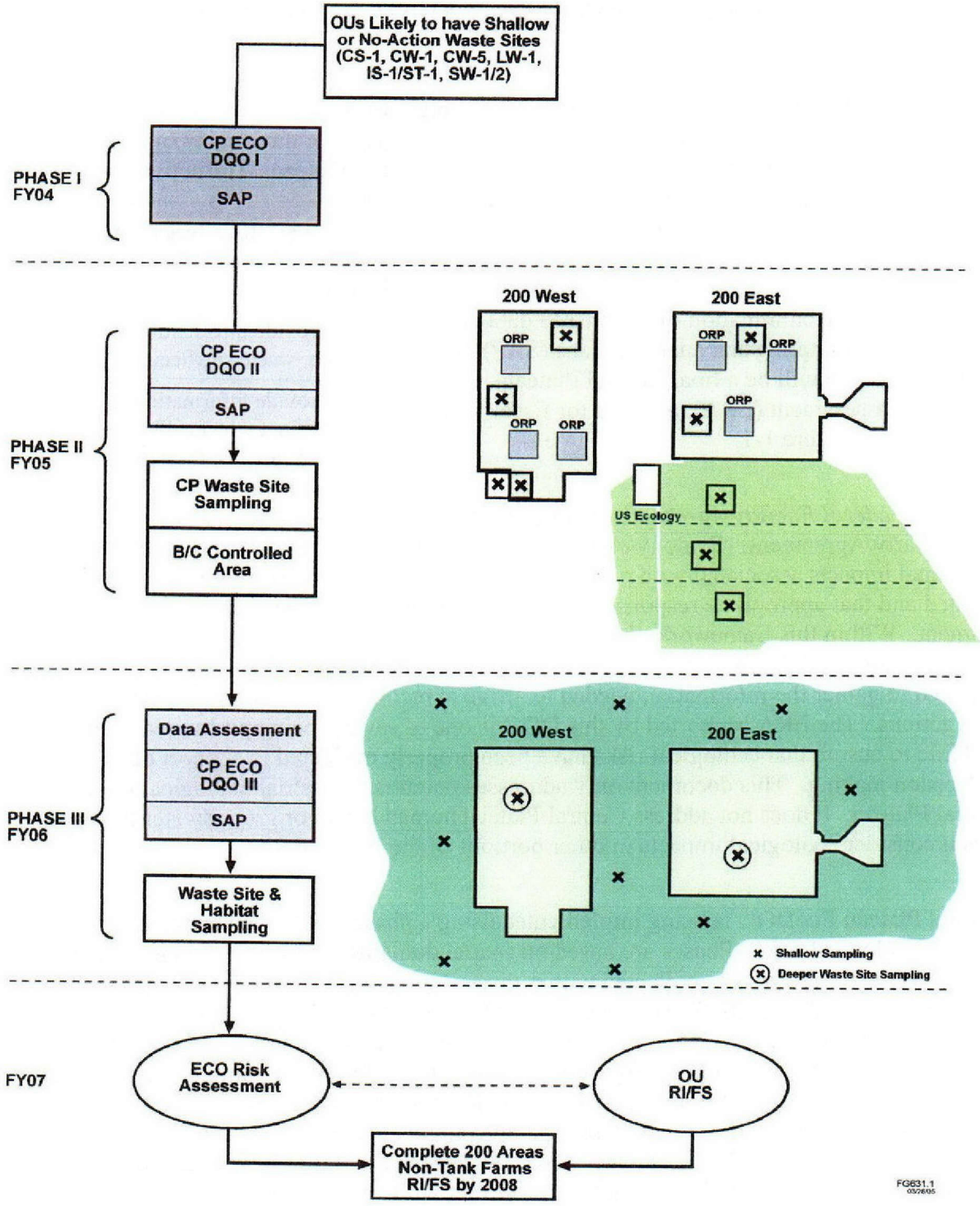
Figure 1-1. Phased Central Plateau Ecological Risk Assessment.



This document is based on Steps 3 and 4 of EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)* (ERAGS) (Figure 1-2), which represents the DQO process for ERAs. Chapters 2.0 through 6.0 of this document represent ERAGS Step 3, and Chapters 7.0 through 10.0 represent ERAGS Step 4.

In addition to following the ERAGS (EPA/540/R-97/006), relevant aspects of the more general ERA guidelines document (EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*) are included to support development of the assessment endpoints (AE) by considering management goals. EPA/630/R-95/002F also provides additional guidance on ecological measures that will be addressed in this document. In proceeding through ERAGS Step 3, there will be scientific-management decision points for agreement on four items:

- Contaminated media
- Contaminants of potential ecological concern (COPEC)
- Assessment endpoints
- Risk questions.

ERAGS Step 4 has scientific-management decision points on four additional aspects:

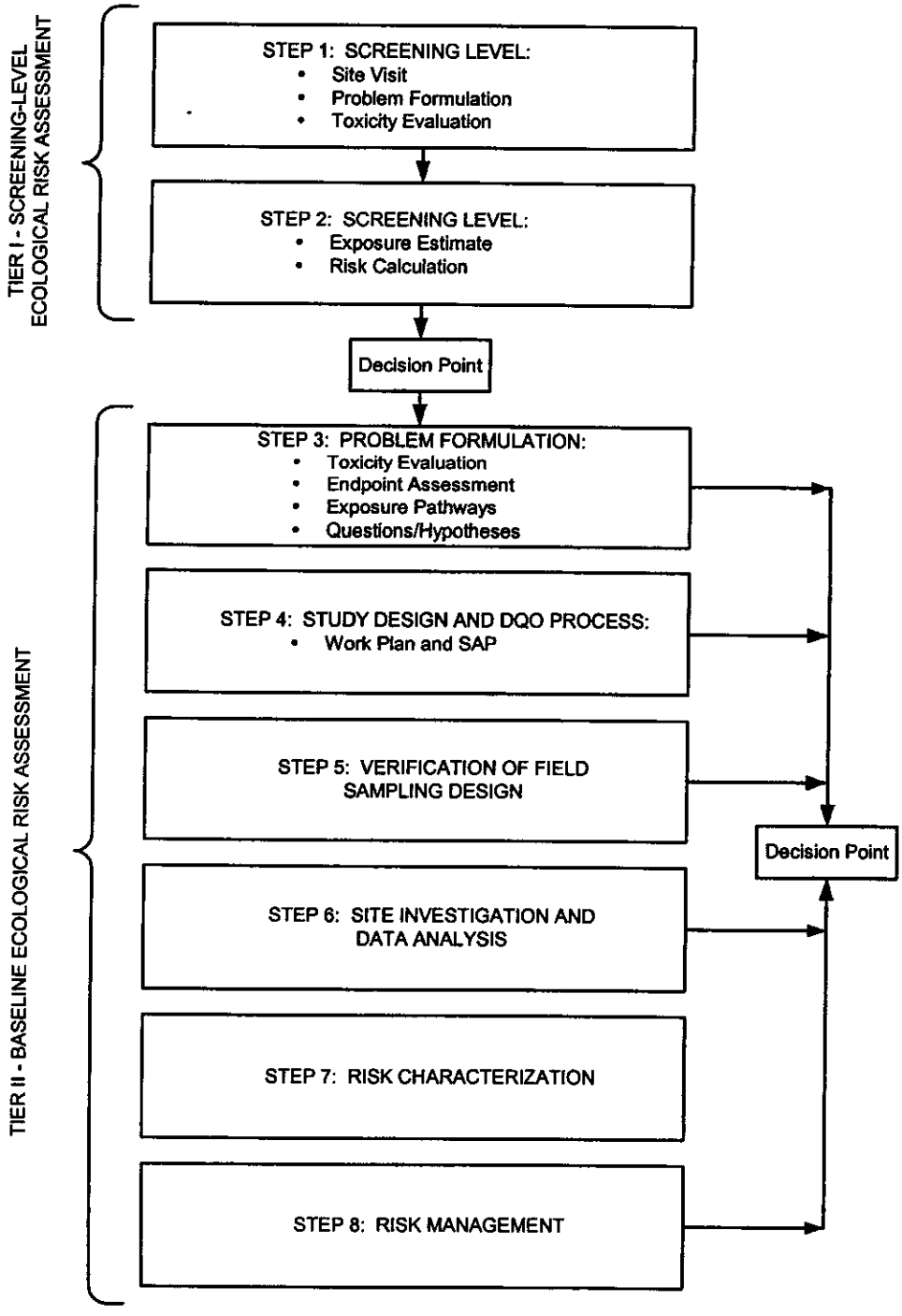
- Establishing measures
- Study design
- DQOs (including statistical considerations)
- The SAP, which will be provided as a separate document and therefore is not included in this document.

This summary report provides the basis for an ecological sampling design that will be carried forward into a SAP for field implementation. Ecological sampling data will assist in remedial action decision making where the consequences of remediation can be traded off against evidence for adverse ecological effects (Whicker et al. 2004, "Avoiding Destructive Remediation at DOE Sites"). Ultimately, ERAGS Step 8 (Figure 1-2) will be documented in a record of decision.

While this document has been developed for Phase I of the Central Plateau ecological risk evaluation, most of the EcoDQOs developed also will be applicable to Phases II and III. However, the list of COPECs and resulting analytical suites will be developed uniquely for each investigation phase.

Figure 1-2. U.S. Environmental Protection Agency Two-Tier, Eight-Step Ecological Risk Assessment Process.

(adapted From EPA/540/R-97/006).



There are several unique considerations for performing an ERA at the scale of the Central Plateau. For example, ERAs typically are performed for individual waste sites. The risks posed by multiple chemicals and radionuclides associated with more than 700 waste sites grouped into operable units (OU) on the Central Plateau will need to be integrated in a comprehensive assessment to determine the potential for adverse effects on terrestrial biota. In contrast to typical ERAs, however, the means of performing this integration are available. While ecological information often is lacking in ERAs, there are decades of environmental monitoring data on the plants and animals of the Central Plateau. Recent compilations of important ecological information also are available for the Hanford Site (Landeen and Crow 1997, *A Nez Perce Nature Guide: I am of this Land* Wetes pe m'e wes; PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, Rev. 15) and the Columbia Basin (O'Connor and Wieda 2001, *Northwest Arid Lands: An Introduction to the Columbia Basin Shrub-Steppe*). This wealth of ecological knowledge will be used to support remedial decision making for the cleanup of the Central Plateau waste sites.

A general understanding of the construction and operation of Central Plateau waste sites is relevant for understanding the potential for ecological risks from these sites. Waste sites in the Central Plateau consist of engineered features including cribs, trenches, and ponds. Many of these engineered features were installed below the ground surface, as shown in Figure 1-3, and now that these sites are inactive they have been covered with clean fill. The depth of fill varies between a thin cover and more than 3 m (10 ft). Typically, the sites with the greatest contaminant concentrations have more cover material. The configuration of the waste sites is the reason why concentrations of COPECs generally are low in shallow zone soils (0 to 4.6 m [0 to 15 ft) depth interval).

The development of the COPECs for this project was a multistep process that began with the identification of contaminants known to exist on the Central Plateau, based on the facility processes. The initial list of constituents was refined through a systematic evaluation process, resulting in a final COPEC list. A summary of the COPEC refinement process and list of the COPECs is provided in Chapter 3.0.

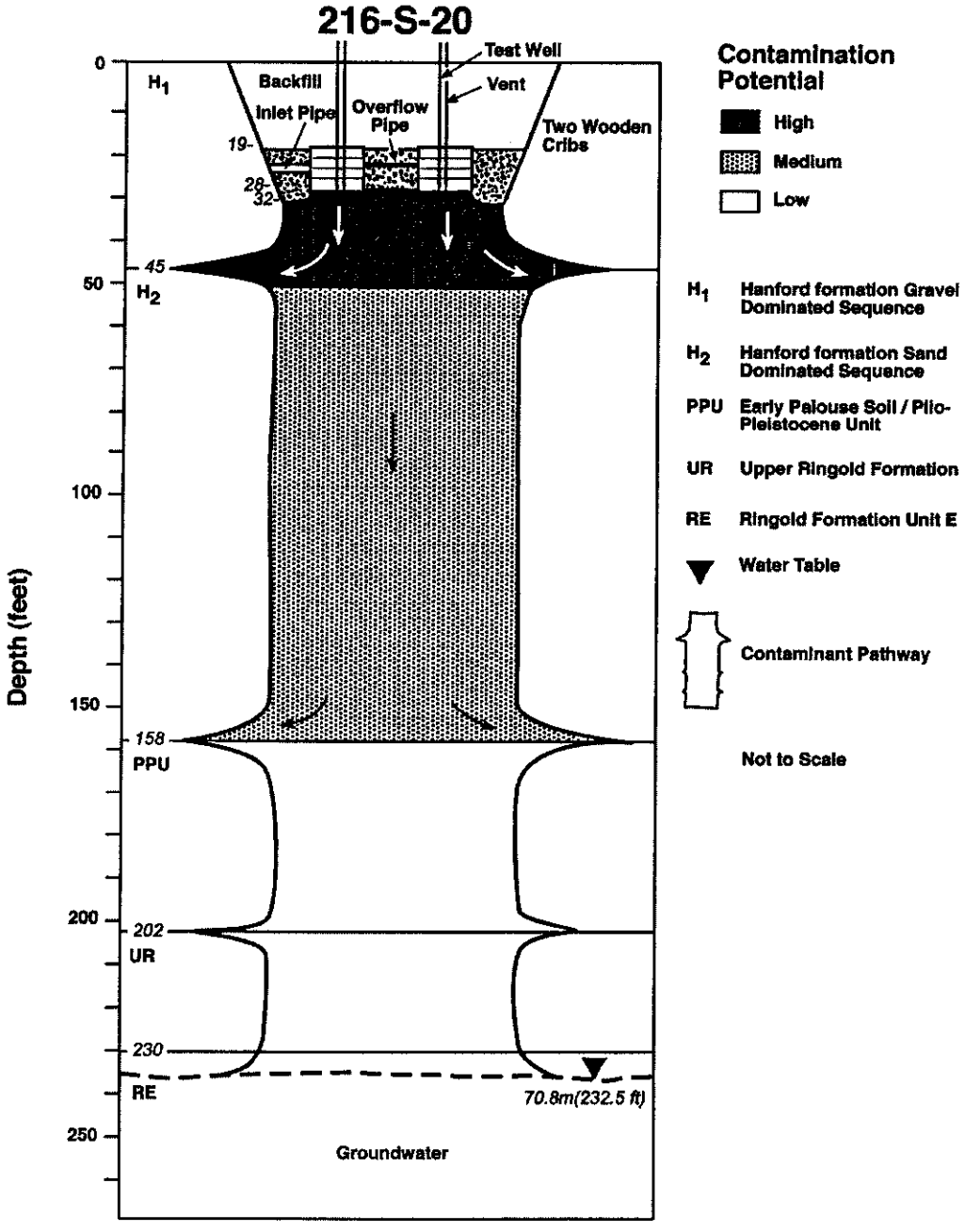
1.1 PROJECT SCOPE

The Tri-Party Agreement (Ecology et al. 1989) includes a site characterization and remediation strategy for the 200 Areas Central Plateau that addresses inactive waste sites, fuel reprocessing facilities, auxiliary buildings, planned and unplanned waste sites, and groundwater. The strategy is based on implementation of the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* remedial investigation/feasibility study process, leading to records of decision that authorize remedial actions. The ERA supported by this DQO is one of several being performed on the Hanford Site to ensure that both human health and ecological risks have been properly evaluated in support of remedial action decision making.

This document only addresses potential terrestrial ecological impacts on the Central Plateau. It does not address Central Plateau human health or groundwater impacts, nor does it consider ecological impacts in other portions of the Hanford Site. The relationship of the ERA supported

by this DQO with other Hanford Site risk assessments is addressed in detail in DOE/RL-2005-37, *Status of Hanford Site Risk Assessment Integration, FY 2005*.

Figure 1-3. Example Schematic of Waste Site Construction.



The scope of this project initially focused on the evaluation of Central Plateau non-tank farm waste sites, to determine ecological impacts from contamination in support of remedial action decision making. Through the DQO process, issues and concerns were identified by the Tri-Party Agreement decision makers, National Resource Trustee Council members, Hanford Advisory Board, and Tribal participants that resulted in significant changes to the project scope. As a result of those interactions, the project scope was expanded to include Office of River Protection tank farm property, the US Ecology site, and habitat surrounding the Central Plateau waste sites. These changes eliminated internal boundary lines, resulting in a contiguous Central Plateau study area as outlined and labeled in Figure 1-4.

Because of budgetary and schedule limitations that constrained the fiscal year 2004 activities, it was necessary to phase the ERA activities. As Figure 1-1 shows, Phase I activities are focused on the 200 East and 200 West Areas in the industrialized Core Zone; Phase II includes the US Ecology and Office of River Protection sites in the Core Zone and the BC Controlled Area; while Phase III addresses habitat outside of the 200 East and 200 West Areas and adjacent to the Core Zone. Phase I and II data collection will be followed by a Phase III data quality assessment (DQA), and subsequent investigations will be dependent on the results of the DQA. This phased approach supports Tri-Party Agreement milestone M-015-00 for completion of the remedial investigation/feasibility study process for all OUs by December 31, 2008.

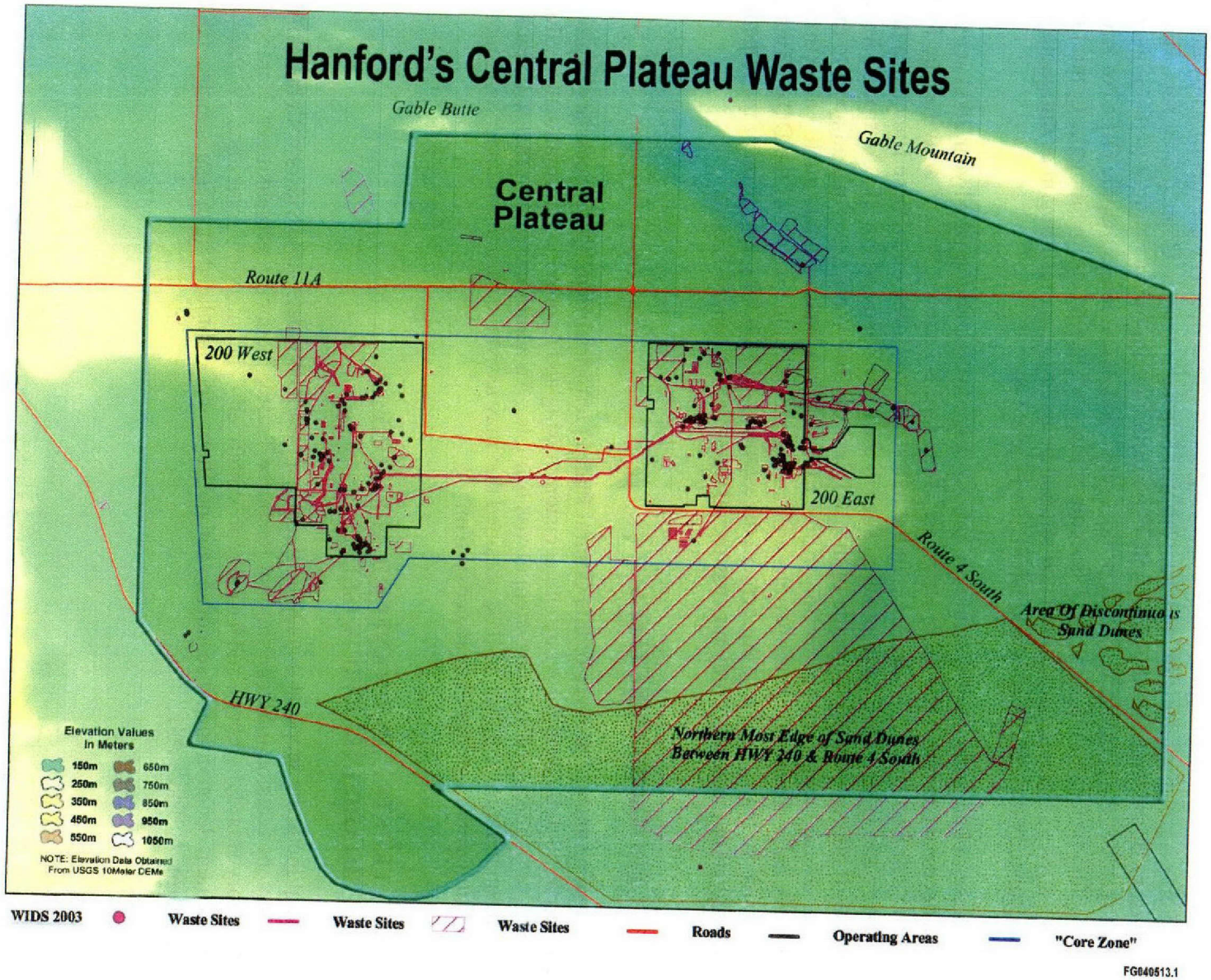
1.2 PROJECT OBJECTIVES

The two primary objectives of this Central Plateau terrestrial EcoDQO process are to provide information to be used for waste site decision making and to provide information to evaluate the health or condition of the ecosystem across habitats. An additional benefit that will result is that environmental information will be obtained that may assist the trustees in understanding the condition of the Central Plateau ecosystem.

1.3 TRUSTEE AND HANFORD ADVISORY BOARD INTERVIEW ISSUES

To help focus the scope of this DQO, the project team conducted interviews with the Tri-Party Agreement decision makers, National Resource Trustee Council representatives, Hanford Advisory Board members, and Tribal representatives. The interview issues and Tri-Party Agreement decision maker responses and positions were tabulated in an issues matrix table in Appendix A, Table A-1.

Figure 1-4. Hanford Central Plateau and Waste Sites.



2.0 REFINE CONTAMINANT FATE AND TRANSPORT INFORMATION

Information on how chemicals and radionuclides are transported or transformed physically, chemically, and biologically is used to identify exposure pathways that might lead to significant ecological effects (EPA/540/R-97/006). For example, some organic chemicals concentrate with each trophic transfer through a bioaccumulation process specifically referred to as biomagnification. Consequently, these chemicals are present at the highest concentrations in, and pose the greatest potential risk to, organisms at the top of the food web (e.g., upper trophic level predators).

2.1 CONTAMINATED MEDIA AND EXPOSURE PATHWAY

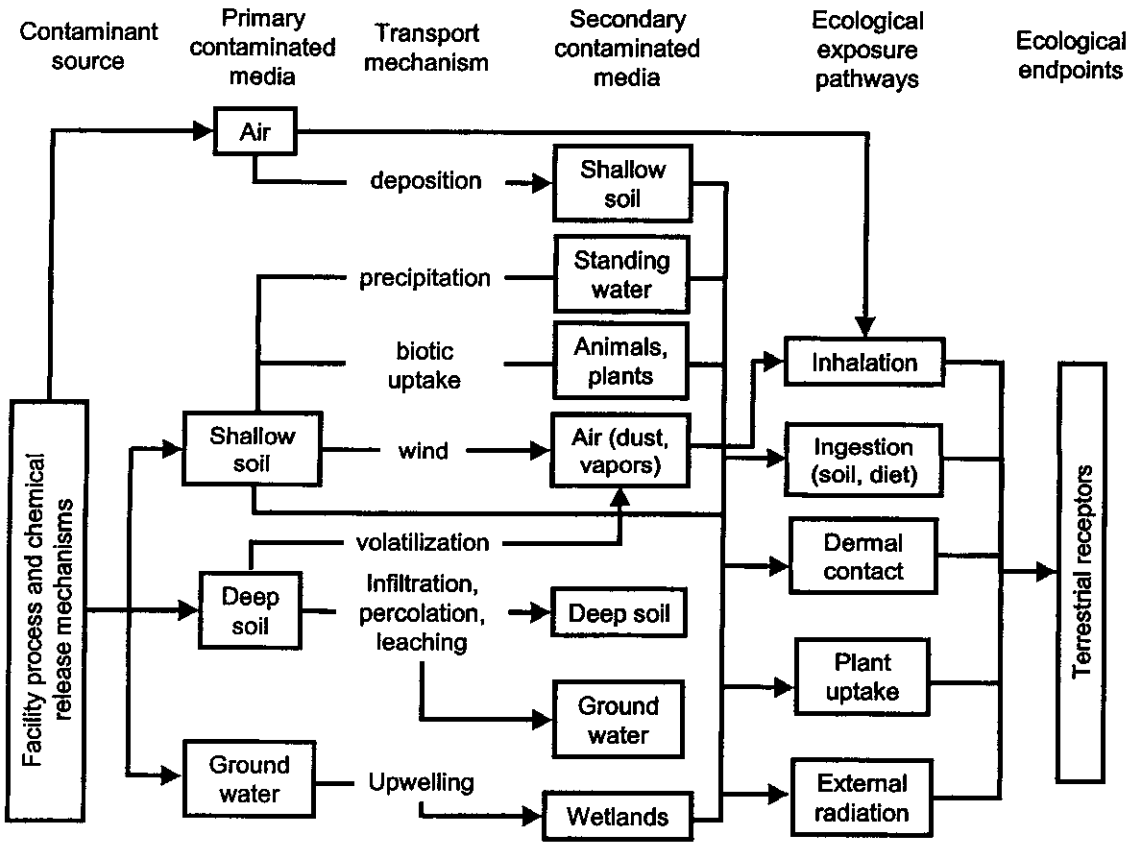
To provide a comprehensive analysis of contaminant exposure, four primary impacted media were considered for the EcoDQO: air, groundwater, deep soil, and shallow soil (Figure 2-1).

Considering air, direct releases have occurred from facility operations. These airborne releases typically represented acute inhalation exposures. Airborne releases also could result in long-term exposures after contaminants are deposited on surface soil. Inhalation of surface air is not typically a risk driver in ecological assessments (DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota*; EPA 2003b, *Guidance for Developing Ecological Soil Screening Levels*, Attachment 1-3, *Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purposes of Setting EcoSSLs*), but subsurface air may be an important exposure medium for solvents or other volatile organic chemicals emanating from the subsurface. For example, volatile organic chemicals, such as carbon tetrachloride, can partition from the surface or subsurface matrix into water and gas phases and emanate into animal burrows. Subsurface air as an exposure medium will be evaluated in Phase III based on available soil-gas data and other relevant monitoring data for volatile organic chemicals on the Central Plateau.

Considering groundwater, terrestrial plants and animals are unlikely to be exposed to this contaminated medium over most of the Central Plateau, because the shallowest depth to groundwater is approximately 61 m (200 ft) below ground surface (bgs) (PNNL-14187-SUM, *Summary of Hanford Site Groundwater Monitoring for Fiscal Year 2002*). Groundwater does not come to the surface at any site in the Central Plateau. Consequently, the pathway from groundwater to terrestrial receptors is largely incomplete (Figure 2-1). Terrestrial receptors can, however, be exposed to this medium where groundwater is discharged to the surface. West Lake is included in the scope of this EcoDQO and differs from other areas, because it is a wetland that partly resulted from groundwater discharges. West Lake exists at a lower elevation than the Central Plateau, and geologic features cause water-level fluctuations following changes in the water table (PNL-7662, *An Evaluation of the Chemical Radiological and Ecological Conditions of West Lake on the Hanford Site*). West Lake's salinity and alkalinity favor the establishment of halophilic (salt-loving) plants and animals. The trophic relationships and organisms of West Lake are atypical of the Central Plateau's terrestrial environment, and the saline conditions

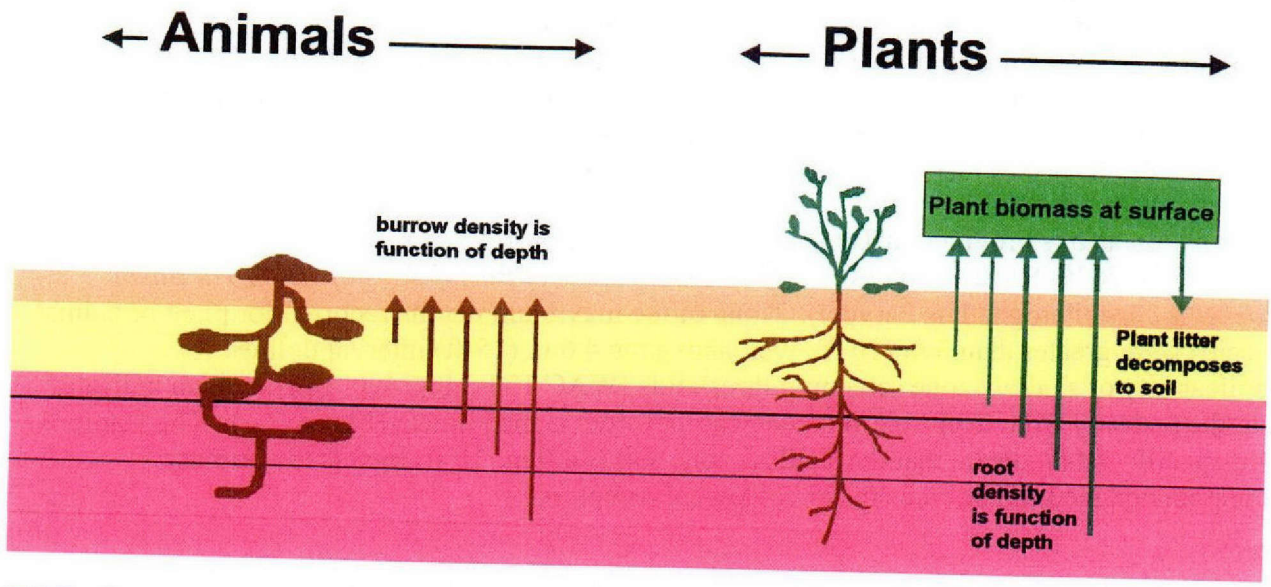
preclude the use of West Lake as a drinking water source for terrestrial wildlife. The EcoDQO for West Lake is developed separately (Appendix E) to simplify the focus of the main document on the terrestrial environment typical of the Central Plateau.

Figure 2-1. Conceptual Model of Contaminated Media and Biotic Exposure Pathways Associated with Hanford Facility Processes.



The above considerations suggest that the EcoDQO focus should be on contaminated soil. Because a component of the EcoDQO scope is to support remediation decisions, it is necessary to evaluate the soil depth where cleanup is required. The *Washington Administrative Code* (WAC) defines the soil cleanup depth (the standard point of compliance) as extending from the ground surface to 4.6 m (15 ft) bgs (WAC 173-340-7490[4][b], "Terrestrial Ecological Evaluation Procedures," "Point of Compliance," "Standard Point of Compliance"). This cutoff depth was chosen as a reasonable estimate of the soil depth that could be excavated and distributed at the soil surface as a result of site development activities that result in exposure by terrestrial receptors. The WAC also allows for a conditional point of compliance (1.8 m [6 ft]; WAC 173-340-7490[4][a], "Terrestrial Ecological Evaluation Procedures," "Point of Compliance," "Conditional Point of Compliance") to be set at the biologically active zone. The depths to which insects, animals (burrows), and plants (roots) are likely to occur define the biologically active zone. The working hypothesis is that biological activity is limited largely to the top 1.8 m (6 ft), and to test this hypothesis it is useful to construct a model of biotic activity (Figure 2-2).

Figure 2-2. Conceptual Model Of Biotic Activity In The Soil Environment.



While aboveground activity is essential for many animals and terrestrial plants, in arid environments like the Hanford Site, exploitation of the subsurface also is required for survival (PNL-4140, *Habitat Requirements and Burrowing Depths of Rodents in Relation to Shallow Waste Burial Sites*). Burrowing is a successful life-history strategy for animals in dry lands (Meadows and Meadows 1991, *The Environmental Impact of Burrowing Animals and Animal Burrows*), and many desert animals burrow for shelter from environmental conditions, reproduction, foodstuff procurement, and water conservation (Rundel and Gibson 1996, *Ecological Communities and Processes in a Mojave Desert Ecosystem: Rock Valley, Nevada*). Burrowing results in significant soil turnover, and much of this reworking is caused by the fossorial activity of pocket gophers, ground squirrels, mice, and kangaroo rats. In addition, predators of burrowing mammals, particularly foxes, coyotes, and badgers, contribute to turnover of the top 1.8 m (6 ft) of soil (Chapman and Feldhamer 1982, *Wild Mammals of North America: Biology, Management, Economics*).

Soil macroinvertebrates also burrow extensively in deserts. For example, some species of spiders are known to burrow (e.g., trap-door spiders) albeit shallowly (usually less than 15 cm [6 in.]), which also is the case for many species of arid system beetles such as the ubiquitous *Eleodes spp.* and other darkling beetles. Considering the Hanford Site, harvester ants are likely the deepest burrowing animals that occur on the Central Plateau. Five colonies of *Pogonomyrmex owyheei* were excavated on the Hanford Site at depths ranging from 1.7 to 2.7 m (5.6 to 8.8 ft), with an average depth of 2.3 m (7.5 ft) (PNL-2774, *Characterization of the Hanford 300 Area Burial Grounds: Task IV – Biological Transport*).

Plants, of course, rely on extensive belowground biomass to capture nutrients and water. The extent of the rooting systems for species in the 200 Areas was evaluated by the Pacific Northwest Laboratory (PNL-5247, *Rooting Depth and Distribution of Deep-Rooted Plants in the 200 Area Control Zone of the Hanford Site*). This study concentrated on plant species suspected of having

deep root systems and species that have been reported in previous studies to contain radionuclides in aboveground parts. Maximum depths for several of the deepest rooted plant species at the Hanford Site are presented in Table 2-1 (PNL-5247). These maximum rooting depths are consistent with the majority of plant species in a literature review of rooting depth by vegetation types (Canadell et al. 1996, "Maximum Rooting Depth of Vegetation Types at the Global Scale"). This review indicates that 194 of 253 species had maximum rooting depths of 2 m (6.6 ft) or less, but maximum depths extended to greater than 20 m (66 ft) for some species. Tree and shrub species were reported to have the deeper maximum rooting depths.

Information also is provided in Table 2-1 for the deeper burrowing mammal and ant species (PNL-2774; RHO-SA-211, *Intrusion of Radioactive Waste Burial Sites by the Great Basin Pocket Mouse (*Perognathus Parvus*)*). None of the maximum depths reported for plant or animal species were greater than 3 m (10 ft), well above the 4.6 m (15-ft) interval defined for applicability of shallow zone screening thresholds (WAC 173-340-7490[4][b]), which indicates that the pathway from deep soil to ecological receptors is incomplete (Figure 2-1). The Hanford Site-specific data indicate that the shallow zone soil (<4.6 m [15 ft) bgs) is the primary contaminated medium of concern for ecological receptors.

Table 2-1. Maximum Plant-Rooting Burrowing Depth for Hanford Site Receptors.

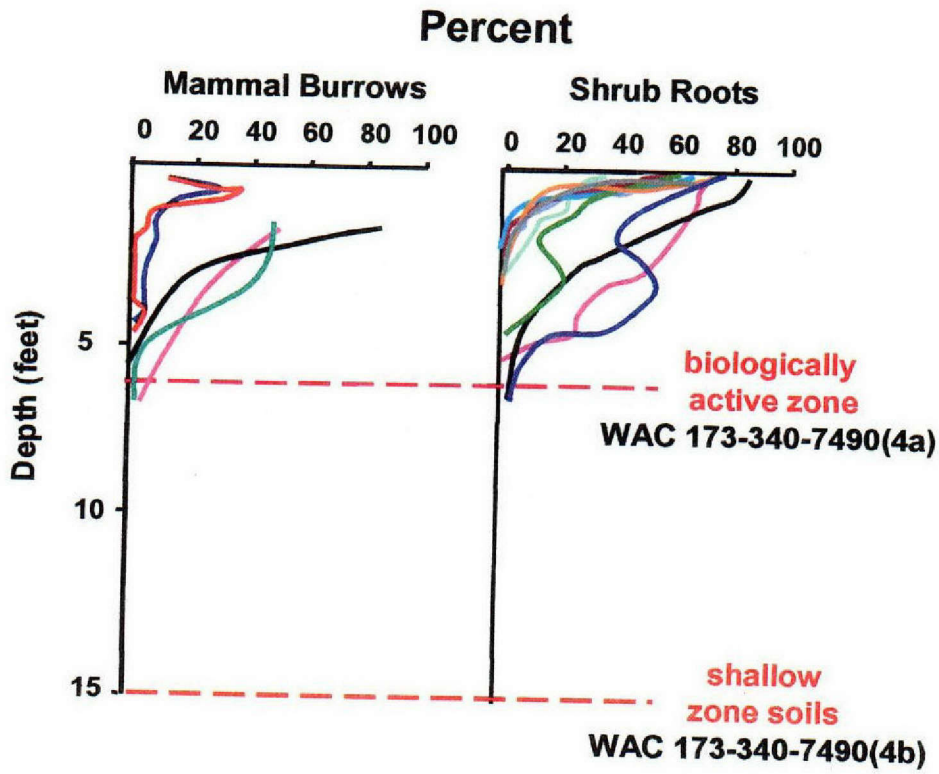
Species	**Maximum Depth**		**Reference**
	(cm)	**(ft)**	
Plants			
Antelope bitterbrush	300	9.8	PNL-5247
Big Sagebrush	200	6.6	PNL-5247
Spiny hopsage	195	6.4	PNL-5247
Russian thistle	172	5.6	PNL-5247
Mammals			
Great Basin pocket mouse	200	6.6	RHO-SA-211
Soil biota			
Harvester ants	270	8.8	PNL-2774

PNL-2774, *Characterization of the Hanford 300 Area Burial Grounds: Task IV – Biological Transport.*
PNL-5247, *Rooting Depth and Distribution of Deep-Rooted Plants in the 200 Area Control Zone of the Hanford Site.*
RHO-SA-211, *Intrusion of Radioactive Waste Burial Sites by the Great Basin Pocket Mouse (*Perognathus Parvus*).*

Shallow zone soils consequently are the focus of further exposure assessment for Central Plateau terrestrial receptors. In considering the subsurface extent of plant roots or animal burrows, it is important to realize that burrow and root density are not continuous from the soil surface to the

maximum reported depths. The burrow fraction is heavily weighted to shallow soils and dramatically declines with depth from the ground surface; similarly the density of plant roots declines with depth (Figure 2-3). The data used to generate this figure are provided in Appendix F.

Figure 2-3. Burrow and Root Density as a Fraction of Depth Below the Ground Surface.



Kennedy et al. 1985, "Biotic Transport of Radionuclide Wastes from A Low-Level Radioactive Waste Site") and Reynolds and Laundré 1988, "Vertical Distribution of Soil Removed by Four Species of Burrowing Rodents in Disturbed and Undisturbed Soils," present data for pocket mice, kangaroo rats, pocket gophers, and ground squirrels to illustrate how burrow density is a function of depth (Figure 2-3). The y-axis represents the burrow density above a given depth in the subsurface. For example, 90 percent of the burrow density is located above a depth of 140 cm (55 in.). Excepting the kangaroo rat, these arid-adapted mammals are all Hanford Site species (PNNL-SA-32196, *Hanford Site Ecological Monitoring & Compliance*, "Hanford Site Species Listings," last updated December 11, 2000, http://www.pnl.gov/ecomon/Species/Mammal.html). The root mass of deeply rooting desert shrubs also is weighted toward greater density near the surface and, similar to mammalian burrow density, root mass declines with depth. Thus, while certain plants and animals have maximum rooting or burrowing depths many feet into the subsurface, it is clear that most of the biotic activity for these species is in the top few feet of the soil column.

Following precipitation events, shallow soil can contribute to a drinking water dose for wildlife in the form of suspended soil particles in standing water (Figure 2-1). Shallow soil also is a

potential source for contaminated air via aeolian processes (Figure 2-1). While there is a potentially complete exposure pathway via inhalation of particulates, a U.S. Environmental Protection Agency (EPA) exposure pathway analysis (Table 2-2) indicates that inhalation of particulates is a minor exposure route for terrestrial receptors. For example, inhalation of particulates is < 0.001 percent of total exposure for the meadow vole (EPA 2003b), the terrestrial mammalian herbivore identified in the WAC terrestrial ecological evaluation (TEE) (see WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," for TEE procedures). In fact, incidental soil ingestion (e.g., through preening, fur cleaning) and dietary ingestion represent more than 99.8 percent of total vole exposure for the chemicals in Table 2-2. Ingestion through the diet accounts for eating contaminated plants. The Hanford Site conceptual exposure model (Figure 2-1) explicitly accounts for bioaccumulation and trophic transfer (i.e., ingestion of contaminated plants and animals) of site contaminants.

Table 2-2. Relative Dose Contributions for the Meadow Vole Associated with Shallow Soil Exposure (EPA 2003b).

Analyte	Exposure (%)			
	Soil Ingestion	Plant Ingestion	Dermal	Inhalation
Lead	38	63	0.02	<0.001
Fluoranthene	37	63	0.2	<0.001
DDT	79	21	0.1	<0.001

EPA 2003b, *Guidance for Developing Ecological Soil Screening Levels*, Attachment 1-3, *Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purposes of Setting EcoSSLs*.
DDT = dichloro-diphenyl-trichloro-ethane.

A complete pathway exists for dermal contact from shallow soil, but the fur and feathers of wildlife serve as an effective barrier to soil exposure (EPA 2003b). Consequently, dermal contact is a less important component of total exposure relative to direct ingestion pathways (Table 2-2). Foliar and dermal contact or root uptake is important to ecological receptors such as plants and soil invertebrates, considering their close association with soil. For wildlife, however, the low contribution of the inhalation and dermal exposure pathway to total exposure justifies focusing on the ingestion pathways in developing and prioritizing AEs and risk questions for the Central Plateau ERA. An understanding of dietary exposure involves an assessment of biological trophic level linkages for the Central Plateau.

2.2 CONTAMINATED MEDIA AND EXPOSURE PATHWAY SYNOPSIS

The major points covered in Chapter 2.0 are as follows.

- Shallow zone soil (<4.6 m [15 ft]) is the contaminated medium with the greatest exposure potential for Central Plateau terrestrial receptors and is therefore the most relevant to deriving COPECs, AEs, and risk questions.

- West Lake's ecology is distinct from that of the Central Plateau, and the problem formulation/study design for West Lake is considered in Appendix E of this document.
- Evaluation of surface or subsurface air as an exposure medium, and inhalation/respiration of vapors as an exposure pathway, to burrowing mammals will be evaluated.

Complete pathways of lesser importance, like dermal contact and inhalation of particulates, will be considered in a qualitative manner in the risk assessment.

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3.0 REFINE CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Analytes considered for COPEC refinement are defined by process knowledge and ecological risk and are presented with the refinement logic in Appendix B. COPECs and resulting analytical suites are developed specifically for Phase I based on an evaluation of existing data. The COPECs are refined based on shallow zone data available from the *Hanford Environmental Information System* (HEIS) database and/or from DOE/RL-2001-54, *Central Plateau Ecological Evaluation*, and the data evaluated for COPEC refinement are provided as Appendix C. COPEC refinement also includes a consideration of Hanford Site background concentrations, because background comparisons typically are included in ERAGS Step 3. A similar step for organic chemicals is proposed by only retaining analytes as COPECs if they are detected more than once. COPEC refinement is inclusive of a literature review to address ecotoxicological data gaps. This refined toxicity evaluation has been updated in this document with data from additional Central Plateau remedial investigations (Appendix D).

Refined COPECs are identified based on the process outlined in Section 3.2. In particular, COPECs are identified when the ratio of the soil-screening value (SSV) to the maximum concentration is greater than one. This ratio is referred to as a hazard quotient (HQ).

$$HQ_{ij} = Exposure_{ij} / SSV_{ij}$$

where

HQ_{ij} = shallow soil hazard quotient for receptor i and COPEC j (unitless)

$Exposure_{ij}$ = exposure concentration for receptor i and COPEC j

SSV_{ij} = soil screening value for receptor i and COPEC j.

Toxicity information is summarized as HQs to provide an indication of risk for evaluated ecological receptors. To provide an indication of potential impact from exposure to all COPECs, receptor-specific HQs can be summed to provide a hazard index (HI) for each ecological receptor. This is a qualitative evaluation, because the magnitude of the value is not necessarily commensurate with the severity of potential ecological effects. A more detailed assessment of COPECs is presented in Appendix D, including evaluation of COPECs that were identified in the issues matrix (Appendix A).

The SSVs from WAC 173-340-900, "Tables," Table 749-3, are pertinent to the risk assessment in that they provide useful evaluation systems and numerical values. The SSVs not provided in WAC 173-340-900, Table 749-3, were calculated using WAC methodology (WAC 173-340-900, Table 749-4) as described in the next section. The SSVs, supplemental SSVs, and biota concentration guidelines (BCG) are used as screening benchmarks in this assessment.

3.1 LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS

Data gaps on ecotoxicological information are filled through a literature search on known ecological effects. This literature search also provides information on which ecological receptors are most likely to be at risk from COPECs. Effects-related information includes toxicity reference values (TRV) and transfer factors. In compiling this type of ecological data, EPA/540/R-97/006 recommends consulting a toxicological database. Los Alamos National Laboratory has created such a database to address continuing ERA ecotoxicity data needs. The *ECORISK Database* V-2.0 (LANL 2003) represents a comprehensive and up-to-date compilation of toxicity information on 134 chemicals. Online literature databases (e.g., EPA *ECOTOX Database* at www.epa.gov/ecotox/ecotox_home.htm; *MEDLINE*, database of medical abstracts at www.medline.com; *PubMed*, list of medical citations at www.ncbi.nlm.nih.gov/PubMed) and bibliographies (e.g., Oak Ridge National Laboratory technical reports) were searched to find primary literature relevant for deriving TRVs. To date, 879 primary toxicity study evaluations have been collated for terrestrial receptors. Detailed information from each study was scored and ranked in a tiered-review system, and a primary toxicity value was calculated based on the published dose-response relationship. Thus, this literature review meets the intent of ERAGS problem formulation to obtain and review primary literature and also is consistent with the approach taken by the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* to develop ecological soil-screening levels (EPA 2003a, *Draft Guidance for Developing Ecological Soil Screening Levels*, OSWER Directive 9285.7-55).

3.2 DATA EVALUATION

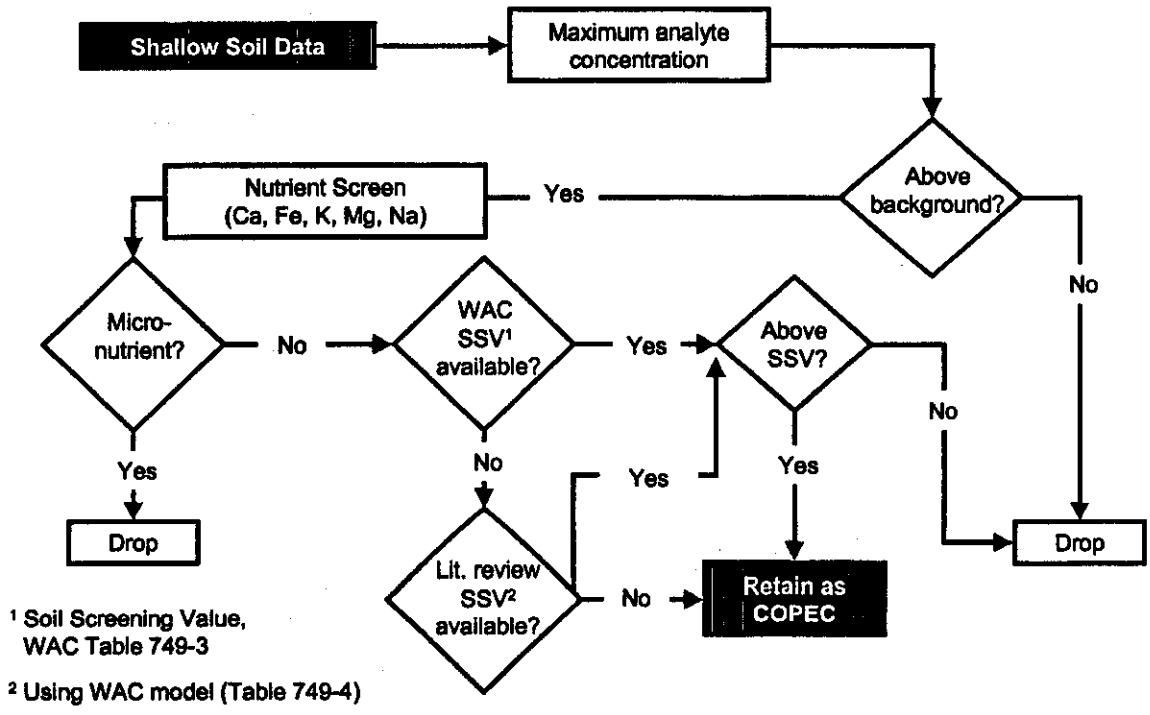
The HEIS database was queried for all OU and Sampling Authorization Form data in the top 4.6 m (15 ft) of soil from 1998 to 2003. These data were supplemented with earlier data from 1991 to 1994 (DOE/RL-2001-54). Inorganics, organics, and radionuclides are presented separately, because there are differences between these analyte groups in the COPEC refinement process. For the purposes of identifying COPECs for further investigation, the maximum detected concentration is compared to SSVs. This is appropriate and will be inclusive of all potential ecological risk drivers. However, it is important to distinguish the use of the maximum detected concentration for COPEC refinement versus the use of a representative concentration in risk characterization. An appropriate representative concentration is the 95 percent upper confidence limit of the mean over an ecologically relevant exposure area. Other considerations for risk characterization include WAC 174-340-740(7)(c), "Unrestricted Land Use Soil Cleanup Standards," "Compliance Monitoring," data assessment requirements for non-detects and distribution evaluations, and methods for calculating the mean and the 95 percent upper confidence limit of the mean.

3.2.1 Inorganics

Inorganic analytes lacking SSVs in WAC 173-340-900, Table 749-3, have been augmented to the extent possible with a literature review of exposure and toxicity information. In addition, SSVs for chemicals not listed in WAC 173-340-900, Table 749-3, have been added. All wildlife SSVs are calculated using the WAC 173-340-900, Table 749-4, exposure models (i.e., shrew,

vole, and robin). While the shrew and vole are not present on the Central Plateau and the robin is not common in sage-steppe habitat, these species are protective (e.g., have higher exposure potential) representatives of the mammalian and avian receptors. As previously discussed, this literature review is accommodated by information contained in the *ECORISK Database* (LANL 2003). Wildlife exposure data from the *ECORISK Database* consists of invertebrate and plant transfer factors as well as TRVs. Regarding toxicity information, the *ECORISK Database* provides no-observed-effect concentrations (NOEC) and no-observed-adverse-effect levels (NOAEL), either as critical study values or as geometric means of such values. Because WAC 173-340-900, Table 749-5, employs TRVs based on lowest-observed-adverse-effect levels (LOAEL) and WAC 173-340-900, Table 749-3, employs plant/soil biota SSVs based on lowest-observed-effect concentrations (LOEC), the augmented SSVs are protective values. The process for screening inorganics is illustrated in Figure 3-1.

Figure 3-1. Contaminants of Potential Ecological Concern Refinement Process for Inorganic Chemicals in Shallow Soil.



Inorganic analytes were dropped from the initial COPEC list if they were within the range of background concentrations[2] (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*), are below applicable SSVs, or are nutrients. Background comparisons for inorganics employ the Hanford Site background data on nonradioactive analytes (DOE/RL-92-24). Ecology 94-115, *Natural Background Soil Metals*

[2] 90% upper confidence limit in Table 2 of DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

Concentrations in Washington State, also was used for background concentrations where no site-specific background concentrations were available (e.g., cadmium). Additionally, the Washington State natural background concentration for arsenic (WAC 173-340-900, Tables 740-1 and 745-1) was employed.

The nutrient screen involves evaluating whether calcium, iron, potassium, magnesium, and sodium are present at potentially toxic levels. This evaluation will be addressed on an *ad hoc* basis, given the lack of SSVs for these nutrients. The only nutrient evaluated by EPA for ecotoxicological properties to date is iron (EPA 2003c, *Ecological Soil Screening Level for Iron, (Interim Final)*, OSWER Directive 9285.7-69). Iron is not expected to be toxic in soils characterized by oxidized conditions and circumneutral pH (EPA 2003c). Other nutrients that lack SSVs (calcium, potassium, magnesium, and sodium) are evaluated through a qualitative evaluation of statistical outliers as presented in Appendix G. There were between one and four outliers for the nutrients, and concentrations were not greatly different from the typical concentrations of the nutrients with the exception of two larger calcium results. Thus, exposures to nutrients sampled in Central Plateau waste sites are basically the same as exposures at background locations. It is worth noting that many other inorganics (e.g., copper, zinc) also are nutrients, but these chemicals have SSVs and, therefore, a toxicological assessment is possible.

Metals exert toxic effects through a variety of mechanisms. The current estimate of risk from inorganics compares shallow zone soil concentrations to literature toxicity and exposure (e.g., transfer factor) information. It is important to realize that much of the primary literature on heavy metal toxicity deals with highly bioavailable chemical forms, such as soluble metal salts. Because bioavailability of inorganics typically decreases as the soil weathers (Allen 2001, *Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants*), the years or decades since contaminants were released to Central Plateau soils will decrease contaminant bioavailability. Consequently, metals historically released to soils of Central Plateau waste sites may not represent the equivalent toxicity or biotic transferability of freshly applied soluble metal salts as reported in published toxicity studies. Estimates of site-specific bioavailability will provide ecological realism in exposure estimates for Central Plateau biota.

3.2.2 Radionuclides

For radionuclides, toxicity data are not radionuclide–specific when expressed as dose limits (e.g., 0.1 rad/d). These dose limits can, however, be translated into radionuclide-specific concentrations (e.g., picocuries per gram) for a defined exposure scenario, as detailed in DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing A Graded Approach to Biota Dose Evaluation* and in DOE-STD-1153-2002. This DQO uses BCGs developed by the U.S. Department of Energy's Biota Dose Assessment Committee, contained in DOE-STD-1153-2002, for the purpose of evaluating radiation as a stressor to biota and ecosystems. BCGs are pertinent to the risk assessment in that they provide useful evaluation systems and numerical values. Thus, BCGs are being used within the broader ERAGS framework, because Central Plateau waste sites have both radionuclide and nonradionuclide contaminants of potential concern (COPC).

Radionuclides were screened for inclusion as COPECs for the Central Plateau by evaluating the maximum detected radionuclide concentrations in the 0 to 4.6 m (0 to 15-ft) soil depth zone. Use of the maximum soil concentrations is expected to be protective of adverse effects on both populations and the more sensitive individuals in these populations (DOE-STD-1153-2002; DOE/EH-0676).

COPEC identification is part of ERAGS Step 3 "COPEC refinement," which has the objective of determining the contaminants that warrant additional investigation to evaluate ecological risks. A conceptual model is developed and AEs are defined based on COPECs and the ecological receptors potentially at risk. This information leads to the formulation of risk questions and measures of exposure, effect, and ecosystem/receptor characteristics needed to evaluate the risk questions. A study design is developed based on the COPECs, AEs, risk questions, and measures. Because dose from radionuclides is additive, the contribution of radionuclides known to be associated with Hanford Site processes was calculated. This calculation is based on the sum-of-fractions (SOF) method, and the contributions of various radionuclides were reviewed to determine their contribution to dose.

$$SOF = \sum_{j=1}^{n} Exposure_j / BCG_j$$

where

SOF = sum of fractions

$Exposure_j$ = exposure concentration for radionuclides

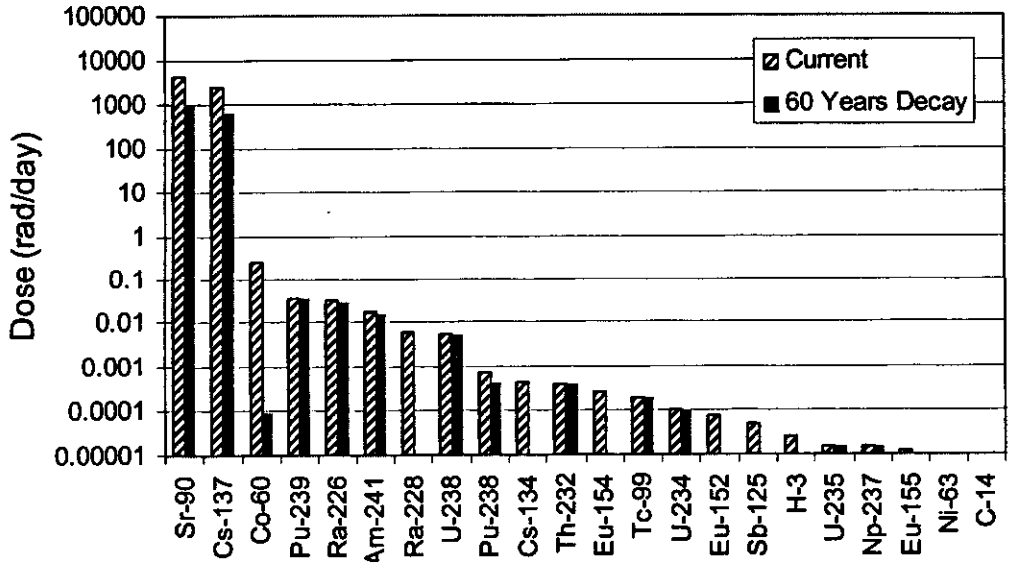
BCG_j = biota concentration guideline for $radionuclide_j$.

The process for evaluating radionuclides includes the SOF calculation and comparison to background. The SOF was calculated based on the maximum concentrations divided by the BCG for all radionuclides identified as COPCs for Central Plateau waste sites (see Appendix B for the rationale for identifying COPCs). If the SOF is not greater than 1, then no radionuclide COPECs are identified. The SOF, based on the maximum Central Plateau waste concentrations, was 68,700. Because the SOF was greater than 1, radionuclide concentrations were compared to background. If the maximum was not greater than background based on the 90th percentile values from DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Table 5-1, then the radionuclide was eliminated as a COPEC. The remaining radionuclides were identified as COPECs if they contributed significantly to dose (Figure 3-2).

The radionuclide evaluation process considered the contribution of radionuclide COPCs to dose, because adsorbed dose rates of ionizing radiation are additive, and multiple radionuclides are being evaluated (Jones et al. 2003, "Principles and Issues in Radiological Ecological Risk Assessment"). Potentially significant dose contributors are identified as COPECs (Table 3-1). The radionuclide dose contribution evaluated in Figure 3-2 shows that eight radionuclides could have a more significant contribution to wildlife dose and that these radionuclides should be identified as COPECs, including Sr-90, Cs-137, and Co-60, Pu-239, Ra-226, Am-241, Ra-228,

and U-238. For comparison, the 14 other radionuclides contributed 0.00003% of the SOF, emphasizing the lesser importance of the radionuclides that were eliminated as COPECs. Although these other 14 COPCs are not retained as COPECs, sample results for some of these COPCs will be obtained with the laboratory analyses used to quantify the COPECs. For example, gamma spectroscopy will quantify Cs-134, Eu-152, Eu-154, Eu-155, Np-237, and Sb-125. Isotopic uranium will quantify U-234 and U-235, and isotopic plutonium will quantify Pu-238. Data for these additional analytes also will be evaluated.

Figure 3-2. Radionuclide Contribution to Dose in Shallow Soil, Based on Maximum Detected Concentrations Across Central Plateau Waste Sites.



[Note – decay is provided for information only]

Table 3-1. Draft Refined List of Central Plateau Contaminants of Potential Ecological Concern. (2 Pages)

Analyte	No. of Samples	No. of Detects	Maximum Detect	FD>BV[1]	FD>SSV[2]
Organics (mg/kg)[3]					
Aroclor-1254	227	10	52	NA	0.03
Aroclor-1260	229	12	77.6	NA	0.02
Carbon tetrachloride[4]	131	13	62.1[5]	NA	0.07
Inorganics (mg/kg)					
Antimony	192	29	13.5	NA	0.15
Arsenic	280	278	33.8	0.004	0.08
Barium	282	282	331	0.004	0.004

Table 3-1. Draft Refined List of Central Plateau Contaminants of Potential Ecological Concern. (2 Pages)

Analyte	No. of Samples	No. of Detects	Maximum Detect	FD>BV[1]	FD>SSV[2]
Bismuth	23	10	233	NA	NA
Boron	24	22	23.8	NA	0.13
Cadmium	290	150	28	0.12	0.03
Chromium	290	285	815	0.04	0.01
Hexavalent chromium	194	21	14.1	NA	0.11
Copper	288	283	244	0.06	0.03
Cyanide	296	5	4.1	NA	0.01
Lead	288	285	583	0.10	0.03
Mercury	277	66	9.1	0.05	0.12
Molybdenum	22	17	3.2	NA	0.05
Nickel	284	283	131	0.01	0.007
Selenium	306	86	4.7	NA	0.25
Silver	288	58	42	0.09	0.06
Thallium	200	90	1.7	NA	0.45
Tin	4	0	NA	NA	NA
Uranium	74	23	270	NA	0.01
Vanadium	276	275	101	0.007	0.996
Zinc	276	274	645	0.09	0.07
Radionuclides (pCi/g)					
Americium-241	408	71	649	NA	0
Cesium-137	310	215	529000	0.40	0.13
Cobalt-60	310	9	1700	0.03	0.003
Plutonium-239/240	270	76	2230	0.22	0
Radium-226	304	265	15.2	0.21	0
Radium-228	218	201	2.6	NA	0
Strontium-90	309	185	974000	0.53	0.061
Uranium-238	256	47	88	0.031	0

Aroclor is an expired trademark. NA = Not available/applicable.

[1] Frequency of detects (FD) greater than the background value (BV).

[2] Frequency of detects (FD) greater than the soil-screening value (SSV) out of all samples analyzed. Soil screening values for radionuclides are based on DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing A Graded Approach to Biota Dose Evaluation*, biota concentration guidelines for plants and for terrestrial wildlife.

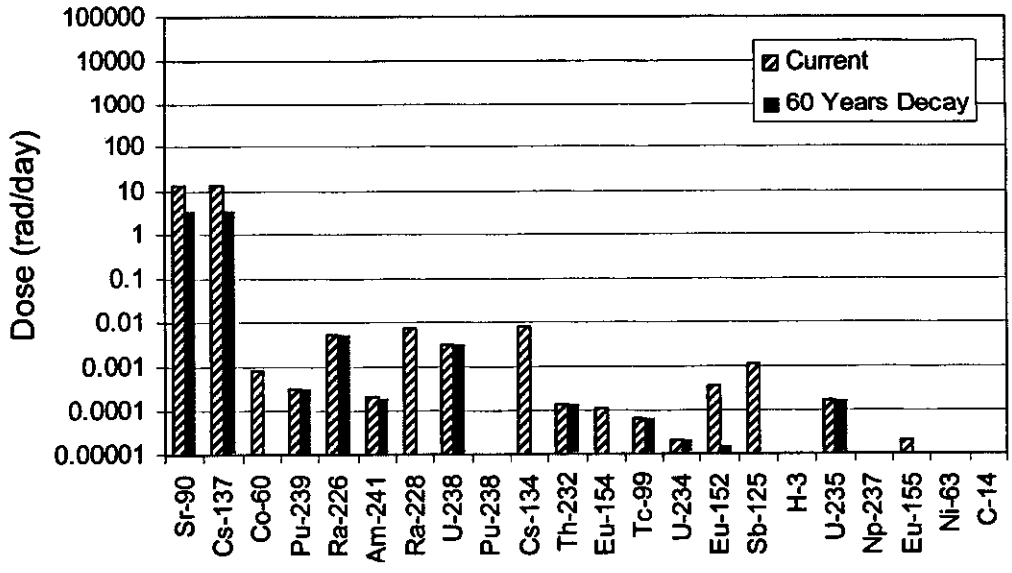
[3] Pesticides are included as additional analytes in the study design.

[4] Histopathology-based threshold obtained from chronic exposure to gaseous CCl_4 for mouse (ATSDR 2003, *Toxicological Profile for Carbon Tetrachloride: Health Effects*).

[5] Soil gas in units of parts per million by volume.

Figure 3-2 also shows how dose contributions are predicted to change, based on radiological decay of the maximum concentrations, revealing a similar ranking to dose for many radionuclides, although the shorter lived radionuclides such as Co-60 and Ra-228 obviously diminish in significance. There is a difference between considering detected radionuclide maxima and mean concentrations (of detects and non-detects). The difference may be understood by comparing Figures 3-2 and 3-3. The dose based on the mean concentration of detects is greater than the maximum detect for four radionuclides (Cs-134, Eu-152, Eu-155, and U-235), because data on non-detects also are included; however, the relative contribution of these radionuclides to dose is low and thus selection of COPECs is not impacted. Both the dose levels and the relative dose contribution change significantly between maxima and mean values over time. However, radiological decay was not considered in this assessment. It is presented for information only, to illustrate the dose contribution trends over time.

Figure 3-3. Radionuclide Contribution to Dose in Shallow Soil, Based on Mean Concentrations Across Central Plateau Waste Sites.

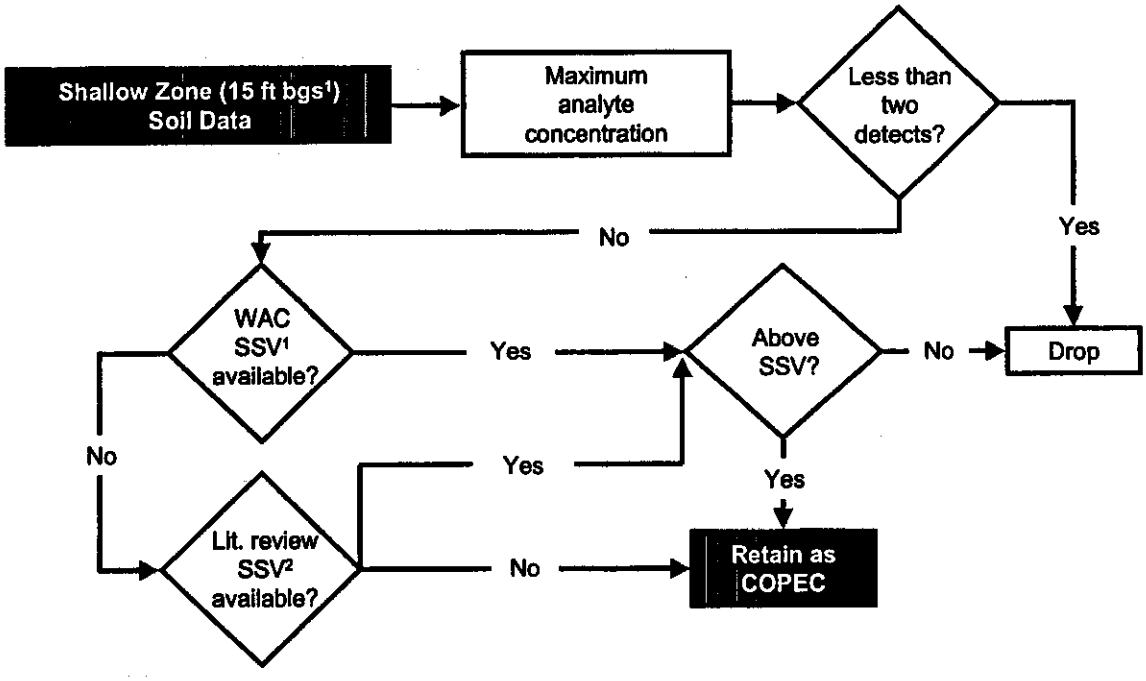


[Note – decay is provided for information only]

3.2.3 Organic Chemicals

The refinement process for organic chemicals is presented in Figure 3-4. The issue of eliminating organics with less than two detected values is based on an adequate sample size or 50 sample results for the analyte (Appendix D).

Figure 3-4. Contaminants of Potential Ecological Concern Refinement Process for Organic Chemicals in Shallow Soil.



[1] Below ground surface
[2] WAC Table 749-3
[3] Using WAC model (Table 749-4)

Polychlorinated biphenyls (PCB) are a detected class of organic chemicals retained as COPECs (Table 3-1). Also known as Aroclors[3], PCBs are considered persistent, bioaccumulative, and toxic chemicals of special ecological concern. More information on EPA's program for persistent, bioaccumulative, and toxic chemicals (EPA 2004, *U.S. Environmental Protection Agency, Prevention, Pesticides, and Toxic Substances, Pollution Prevention, Persistent Bioaccumulation and Toxic (PBT) Chemical Program*) can be found at http://www.epa.gov/pbt, and the Washington State strategy for persistent, bioaccumulative toxins (Ecology 02-03-030, *Ecology PBT Working List: Responses to Public Comments on Appendix E*) can be found at http://www.ecy.wa.gov/biblio/0203030.html . Carnivorous mammals of the family Mustelidae, including badgers, are more sensitive to PCBs than other mammals (EPA/630/P-03/002A, *Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans and Biphenyls in Ecological Risk Assessment, (External Review Draft)*). Considering Aroclor-1254, for example, the primary toxicity value selected (0.031 mg/kg/d) in the *ECORISK Database* (LANL 2003) concerns adverse reproductive effects in mink, specifically the number of mink whelped/number mated. Because the exposure potential is greatest for upper-trophic levels, the *ECORISK Database* has developed highly protective PCB TRVs for predators (carnivores) and more representative TRVs for other feeding guilds.

[3] Aroclor is an expired trademark.

Although pesticides were not identified as COPECs, it is recommended that an analytical method that can quantify both PCBs and pesticides be used as a cost-effective way to obtain additional data. This will address a concern about the adequacy of pesticides sample data that was raised by public participants (see Appendix A).

Another concern raised by the public participants was that fuels and fuel constituents were not identified as COPECs (see Appendix A). SSVs are available for total petroleum hydrocarbons (TPH) gasoline-range organics (GRO) and diesel-range organics (DRO), and there are SSVs for some of the fuel constituents (e.g., individual polycyclic aromatic hydrocarbons). Maximum detected concentrations were less than wildlife SSVs for fuels or fuel constituents. In addition, the maximum concentrations of kerosene and motor oil-range TPHs were less than the TPH-GRO or TPH-DRO wildlife SSVs. The TPH kerosene-range maximum detect was 440 mg/kg and is less than the TPH-GRO wildlife SSV of 5,000 mg/kg or the TPH-DRO wildlife SSV of 6,000 mg/kg. The TPH motor oil-range maximum detect was 760 mg/kg and is less than the TPH-GRO wildlife SSV of 5,000 mg/kg or the TPH-DRO wildlife SSV of 6,000 mg/kg. Thus, concentrations of fuels and fuel constituents measured at Central Plateau waste sites do not suggest any potential for ecological risks. For this reason, fuels and fuel constituents are not identified as COPECs.

In addition, a preliminary analysis was performed for the volatile, non-bioaccumulative chemicals carbon tetrachloride and chloroform on data collected in the 200 West Area near the dispersed carbon tetrachloride plume (see CP-13514, *200-PW-1 Operable Unit Report on Step I Sampling and Analysis of the Dispersed Carbon Tetrachloride Vadose Zone Plume*). The analysis indicates that soil gas is generally at or below the no-effect levels, based on mammalian (rodent) toxicity information; however, shallow zone soil gas concentrations in the 218-W-4C Burial Ground exceed the CCl_4 threshold by more than ten times. In considering this, note that the TRVs for soil-gas constituents are highly protective. For example, they are based on effects that are not directly linked to population-level impacts, because information is not available concerning the effects on survival, growth, and mortality from inhalation of volatile organic chemicals. Also, the exposure concentration is assumed to equal the soil-gas concentration, which is a very protective assumption. 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*"). DQOs for the inhalation pathway are planned to be developed in Phase III.

3.2.4 Summary

The refined COPECs that result from the screening processes described were presented in Table 3-1.

The COPEC refinement is summarized in terms of analytes that were retained on the basis of inorganic, organic, and radionuclide refinement steps. Table 3-1 presents this summary in terms of total samples, number of detected samples, the frequency of detected samples exceeding a background value (if applicable) out of all samples for that analyte, and the frequency of detected

samples exceeding a soil screening value out of all samples for that analyte. Table 3-1 shows that radionuclides and inorganics (metals) constitute most of the Central Plateau COPECs. A comprehensive presentation of the COPEC refinement is presented in Appendix D.

The problem formulation described in Step 3 provides the framework for assessing the risks posed by the COPECs identified in Table 3-1. Primary exposure pathways to ecological receptors from metals and radionuclides include external radiation, direct contact (e.g., root uptake), incidental ingestion of soil, and ingestion of food. Metals and radionuclides are generally nonvolatile and therefore present less exposure through inhalation to wildlife (see Table 2-2). To consider the risks from the oral exposure route in wildlife requires an understanding of the chemical properties of COPECs. While metals can accumulate in the tissues of animals and plants, they do not increase in concentration through the food web. Metal accumulation in biological tissues and metal toxicity are related to bioavailability. Current estimates of metal uptake and toxicity are based on highly bioavailable metal forms. These forms may not be representative of the forms that persist in highly weathered Central Plateau shallow zone soils.

Biomagnification is characteristic of some lipophilic organics (e.g., PCBs) that are sequestered in fat cells. Organisms higher in the food web are at increased risk from chemicals that biomagnify, because their dietary exposure can be orders of magnitude greater than what a representative of a lower trophic-level feeding guild would receive. Because inorganics do not typically increase in concentration through trophic transfers, the risks posed to higher trophic-level organisms are generally of less concern than risks to organisms lower in the food web, assuming that toxicity does not increase to organisms higher in the food web. To the extent that inorganics do accumulate in biotic tissues, there is a greater propensity for them to be taken up by invertebrates, compared to plant uptake (WAC 173-340-900, Table 749-5). Therefore, relative to plant-eating wildlife (or to wildlife that eat a variety of foodstuffs), insectivorous wildlife should experience relatively greater exposure to radionuclides and metals.

During the development of the sampling design, the spatial extent of these draft COPECs is evaluated. Information on the depth of COPECs within the shallow zone soil also is considered in development of the study design.

3.3 CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN REFINEMENT SYNOPSIS

The major points covered in Chapter 3.0 are as follows:

- COPECs include radionuclides, metals, and PCBs.
- Inorganics can accumulate in plant and animal tissues but typically do not biomagnify.
- The exposure potential and toxicity of metals depend in large part on their bioavailability.
- Some carnivorous mammals, such as mustelids, are highly sensitive to PCBs.

- Internal dose dominates for the key radionuclides (Cs-137 and Sr-90) and is based on certain protective assumptions about diet and biological uptake of these radionuclides.
- Pesticides and radionuclides detected in the proposed analyses are included as additional analytes in the study design.

COPEC refinement suggests that inorganic COPECs may pose risks to plants, soil biota, and insect-eating wildlife.

4.0 ASSESSMENT ENDPOINTS

Assessment endpoints are a combination of an entity at risk and an attribute of the entity at risk. For example, some metal COPECs may affect native plants by manifesting toxicity as seedling mortality. Seedling survival is therefore an attribute of plants that are at risk. Stating AEs in this manner facilitates transparent and objective management goals. The attributes of Central Plateau AEs are selected in Chapter 5.0. The AEs developed for Phase I are expected to be applicable to the Phase II and Phase III investigations.

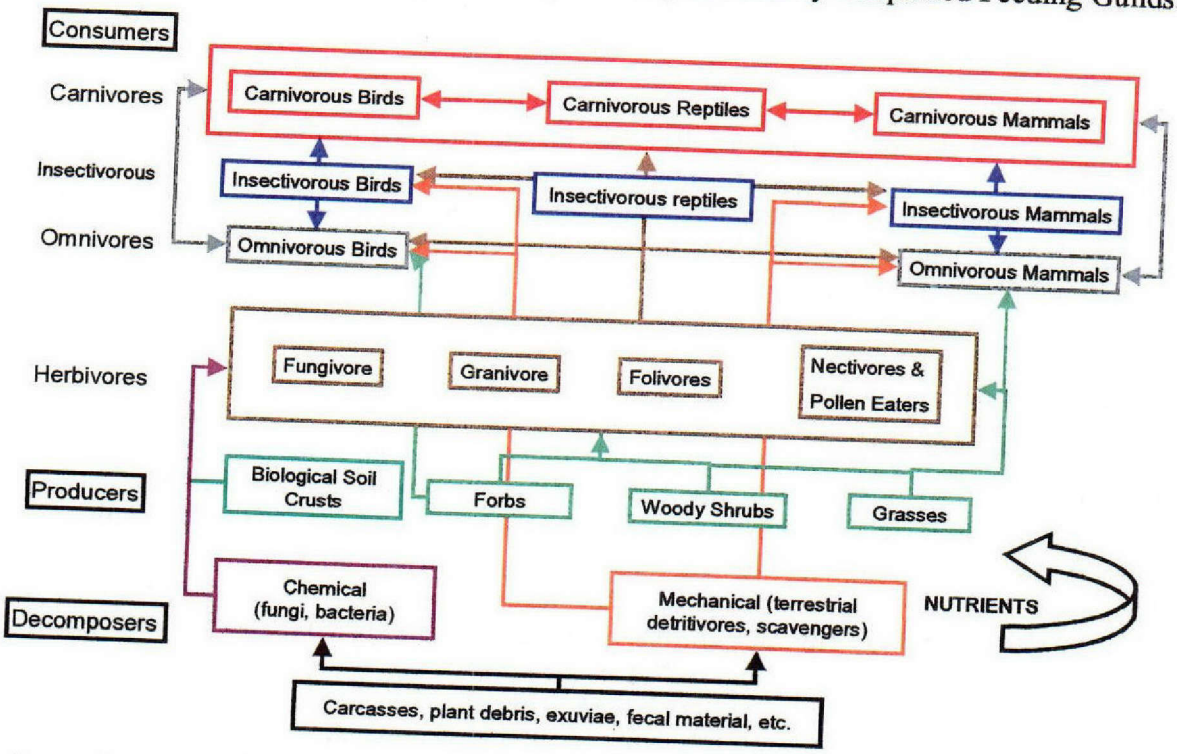
4.1 MANAGEMENT GOALS

Several management goals specific to the potential impact of contaminants on the Central Plateau ecological receptors have been proposed. Management goals include considering impacts to special status species, considering if contaminants are adversely impacting plants and invertebrates, maintaining the health of the Central Plateau ecosystem by maintaining soil fertility, and minimizing contaminant loading (or bioaccumulation) into Central Plateau biota. Special status species include migratory bird species, and some of these migratory bird species also are state-listed species. The primary ERA goal for the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota (EPA 1999, *Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites* (Memorandum), OSWER Directive 9285.7-28P). Thus, assessment of possible impacts of contaminants on ecological populations is needed. These management goals are integrated with the results of the physical model (contaminated media) and COPEC refinement to develop AEs. The entities selected as AEs are based on an understanding of ecological interactions among Central Plateau plants, soil biota, and wildlife as described in the next section. The evaluation of AEs may involve direct measures on the endpoint in question or, if this is logistically impractical, may involve measures on a surrogate for the AE.

4.2 BIOLOGICAL TROPHIC-LEVEL LINKAGES

Ingestion (dietary and incidental soil ingestion) and direct contact are the important exposure pathways for the Central Plateau COPECs, and these pathways are efficiently represented by a functional food web. Functional groups in conceptual models are represented as general classes of organisms sharing common characteristics. For example, ecological systems are composed of many feeding relationships. Some organisms prey on plants (herbivores), plants and animals (omnivores), or just animals (carnivores). More specific feeding classes exist with a particular trophic category. For examples, herbivores are represented by granivores (seed-eating animals), folivores (stem- and leaf-eating animals), fungivores (fungi-eating animals), and nectivores (nectar-drinking animals). In this case, the functional components of the ecosystem are defined on the basis of their role in the food web. EPA/540/R-97/006 recommends using this approach to describe ecological relationships and to develop a feeding-guild-based conceptual model of the Central Plateau terrestrial ecological system (Figure 4-1).

Figure 4-1. Terrestrial Ecological Food Web Represented by Simplified Feeding Guilds.



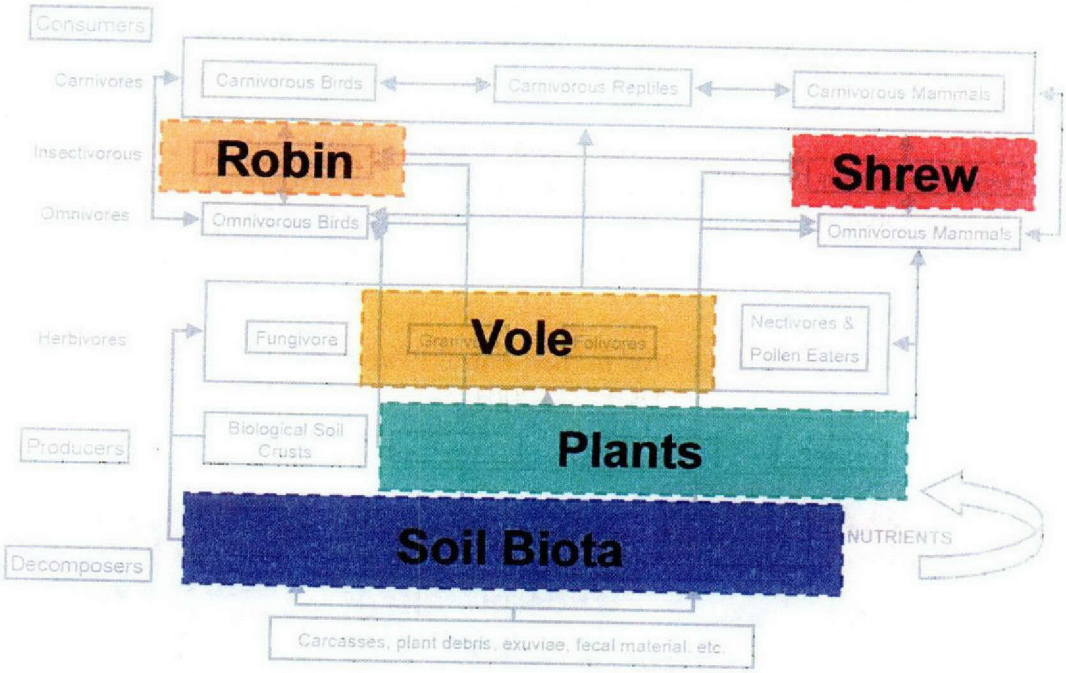
The Central Plateau food web is a simplification of the terrestrial ecosystem showing broad relationships limited to trophic transfer. One important simplification, such as depicting trophic-level relationships from a functional perspective, allows for ready identification of the feeding guilds most at risk from ingestion of contaminated plant and animal materials. The functional components of the ecosystem are defined on the basis of their role in the food web. These components, however, possess additional ecologically important attributes. For example, while shrubs may have leaves and seeds for food, they also provide structural habitat for nesting birds. And while nectar- and pollen-feeding animals may be relatively unimportant in terms of nutrient and energy transfer through the food web, they are important as plant pollinators. In evaluating potential AEs, adverse-effect potential is based on the toxicological characteristics of the COPECs, the sensitivity of the receptor, and the likely degree of exposure (WAC 173-340-7493(2), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step").

4.3 WASHINGTON ADMINISTRATIVE CODE TERRESTRIAL ECOLOGICAL EVALUATION RECEPTORS

Most of the Central Plateau waste sites are in the Core Zone, a largely industrial setting within the 200 East and 200 West Area fence lines. The ecological effects in the Core Zone need only be characterized for wildlife under the Washington State Department of Ecology's TEE process at industrial sites (WAC 173-340-7490(3)(b), "Terrestrial Ecological Evaluation Procedures," "Goal"). Many of the COPECs, however, have concentrations greater than plants and soil biota SSVs. Therefore, the risks to plants and invertebrates also will be considered in this document.

The WAC TEE receptors are superimposed on the Central Plateau food web as shown in Figure 4-2.

Figure 4-2. Washington Administrative Code Terrestrial Ecological Evaluation Receptors (WAC 173-340-900, Table 749-4)



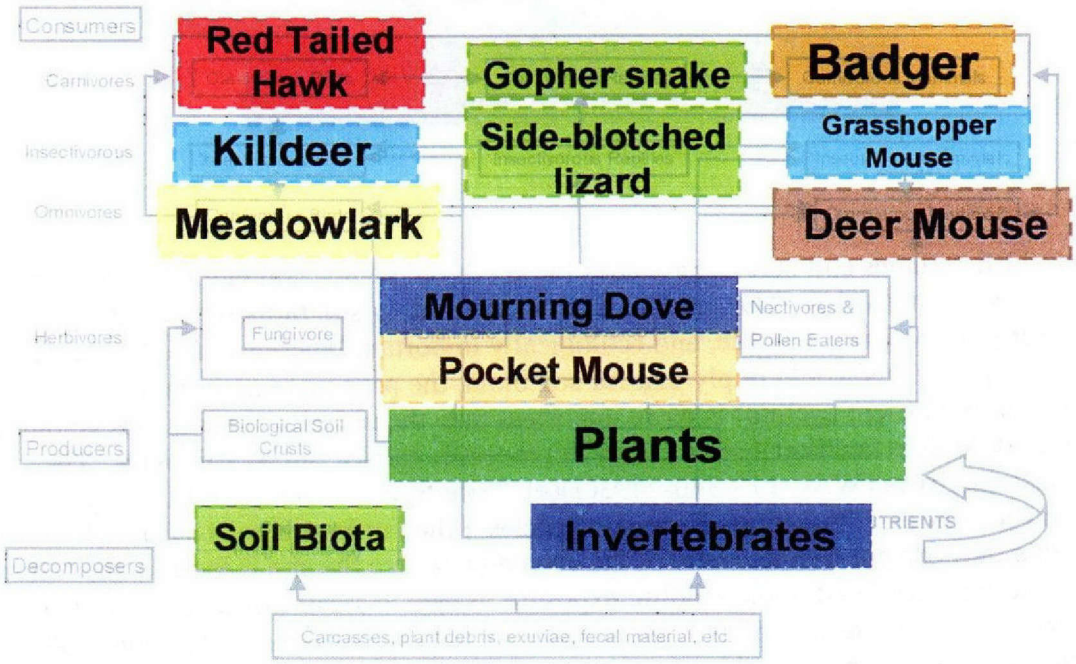
The WAC TEE includes soil-screening values for terrestrial plants, soil biota, and wildlife (WAC 173-340-7490 (3)(b)). The specific language regarding soil biota is "…protectiveness is evaluated relative to plants, wildlife, and ecologically important functions of soil biota that affect plants or wildlife." This would imply that for soil biota, the process (e.g., organic matter decomposition or nutrient cycling) is more important than the receptor species; this is logical given the considerable functional redundancy in processes carried out by soil biota. The guidance also indicates (WAC 173-340-7493(7)(e), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Substitute Receptor Species") that, unless there is clear and convincing evidence that they are not characteristic of the ecoregion where the site is located, the following groups should be considered in the wildlife exposure model: a small mammalian predator on soil-associated invertebrates, a small avian predator on soil-associated invertebrates, and a small mammalian herbivore, represented by the shrew, robin, and vole, respectively.

While shrews, robins, and voles may occur infrequently across the Central Plateau, it is important to note that they are conservative representatives of these feeding guilds. For example, the shrew's ingestion rate is 2.5 times greater than the ingestion rate of a more representative small mammal (deer mouse) of the Central Plateau (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*); in other words, the shrew is exposed to 2.5 times more contaminants through the diet than a deer mouse would be. This is an adequate approach for the initial screening of site contaminants. However, the assessment incorporates greater ecological realism by using receptors characteristic of the arid Central Plateau for developing AEs and risk questions.

4.4 CENTRAL PLATEAU ECOLOGICAL EVALUATION RECEPTORS

Receptors suggested in the Central Plateau ecological evaluation (DOE/RL-2001-54) are presented in Figure 4-3. In addition to the soil biota's nutrient-cycling aspects, soil biota also are considered in terms of individual species in this receptor diagram; in other words, they are considered soil macroinvertebrates. Darkling beetles are abundant and important components of the Central Plateau food web (Rogers and Fitzner 1980, "Characterization of Darkling Beetles Inhabiting Radioecology Study Areas at the Hanford Site in Southcentral Washington"; Rogers et al. 1988, "Diets of Darkling Beetles (Coleoptera: Tenebrionidae) Within A Shrub-Steppe Ecosystem") and have been suggested to represent soil macroinvertebrates (DOE/RL-2001-54). Harvester ants also could serve as suitable surrogates for this trophic level. Plants could include many species, like Sandberg's bluegrass and big sagebrush, as representatives for primary producers.

Figure 4-3. Receptors Suggested in the Central Plateau Ecological Evaluation. (DOE/RL-2001-54).



The Great Basin pocket mouse and the mourning dove can be considered the representative species for the mammalian and avian herbivores, respectively. The meadowlark and deer mouse can represent omnivores, insectivorous mammals can be represented by the grasshopper mouse, and insectivorous birds can be represented by the killdeer. Another insectivorous bird to consider is the sage sparrow. A suitable representative for insectivorous reptiles may be the side-blotched lizard. Selection of strict mammalian and avian insectivores is limited by animal abundance (e.g., grasshopper mouse represents <1 percent of small mammals [O'Farrell 1975, "Seasonal and Altitudinal Variations in Populations of Small Mammals on Rattlesnake Mountain, Washington"; O'Farrell et al., 1975, "A Population of Great Basin Pocket Mice (*Perognathus Parvus*) in the Shrub-Steppe of South-Central Washington"]) and exposure potential (e.g., killdeer is a transient species). More importantly, however, considerable dietary overlap exists among the middle trophic levels, because all species are, to some degree, opportunists. For example, many species such as the sage sparrow are primarily insectivorous only at times when insects are abundant (WDFW 2003, *Washington Department of Fish and Wildlife's Priority Habitat and Species Management Recommendations, Vol IV: Birds – Sage Sparrow,* Amphispiza belli). It would be an artificial distinction to focus on a specific category, given the dietary overlap. Therefore, it may be more appropriate to consider herbivory, omnivory, and insectivory together for evaluating impacts on middle-trophic-level species.

Top carnivores can be represented by the gopher snake, red tailed hawk, and badger. In many cases, selection of an alternative representative for trophic categories may be perfectly appropriate. In selecting AEs for an ERA, it is important to realize that the selection of a particular species is less critical than the identification of the associated trophic category that may be at risk.

The AEs historically employed at the Hanford Site can be used to address management goals for the Central Plateau. For example, assessing effects on plants and soil biota will provide a basis for considering potential impacts on the plant and invertebrate new-to-science species (TNC 1999, *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999*). Also, the goal of maintaining the Central Plateau ecosystem health by maintaining soil fertility may be assessed through nutrient cycling carried out by soil biota. Evaluation of insectivorous birds assesses the potential impact of contaminants on special status species (migratory birds). And consideration of the food web from plants and soil biota up to carnivores evaluates the potential for bioaccumulation from COPECs. Finally, the overarching goal of an ERA is to protect and maintain healthy populations of ecological receptors (EPA 1999). Table 4-1 illustrates the link between management goals and nine proposed AE entities.

Table 4-1. Management Goals Addressed by Central Plateau Assessment Endpoint Entities.

Management Goals	Assessment Endpoints Entities								
	Plants	Soil Biota	Soil Macroinvertebrates	Herbivorous, Omnivorous, Insectivorous Birds	Insectivorous Reptiles	Herbivorous, Omnivorous, Insectivorous Mammals	Carnivorous Birds	Carnivorous Reptiles	Carnivorous Mammals
	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8	AE9
Assess impacts on plants and invertebrates	+	+	+	-	-	-	-	-	-
Maintain soil fertility	+	+	+	-	-	-	-	-	-
Assess impacts on special status species	-	-	-	+	-	-	+	-	-
Minimize contaminant loading into biota	+	+	+	+	+	+	+	+	+
Protect populations of ecological receptors	+	+	+	+	+	+	+	+	+

Key:
"+" = assessment endpoint is applicable.
"-" = assessment endpoint is not applicable.
AE = assessment endpoint.

The AE entities (listed in Table 4-1) can be represented by the receptors listed in Figure 4-3, as described in Table 4-2.

Table 4-2. Illustration of Central Plateau Assessment Endpoint Entity with Representative Ecological Receptors.

AE #	Central Plateau Assessment Endpoint Entity	Representative Central Plateau Ecological Receptors
AE1	Plants	All plants
AE2	Soil biota	Microbial processes
AE3	Soil macroinvertebrates	Darkling beetles, ants
AE4	Herbivorous, Omnivorous, Insectivorous Birds	Mourning dove, meadowlark, sage sparrow, killdeer
AE5	Insectivorous reptiles	Side blotched lizard
AE6	Herbivorous, Omnivorous, Insectivorous Mammals	Great Basin pocket mouse, deer mouse, grasshopper mouse
AE7	Carnivorous birds	Red tailed hawk, loggerhead shrike
AE8	Carnivorous reptiles	Gopher snake
AE9	Carnivorous mammals	Badger, coyote

AE = assessment endpoint.

Assessment endpoints require more than specifying an entity to address management goals; attributes of the entity must be identified to facilitate the implementation of management goals. Lower trophic-level attributes of plants, soil biota, and soil macroinvertebrates could include survival, growth, and reproduction and the presence or absence of species, species diversity, primary and secondary productivity, decomposition, nutrient cycling, and respiration. Middle and upper trophic-level attributes of birds, mammals, and reptiles could include many of the same attributes and additional parameters like abundance, physical abnormalities, balanced gender ratios, and fledgling success and persistence (maintenance of a population for a period of time). Because the ultimate goal of an ERA is to protect and maintain healthy populations of ecological receptors (EPA 1999), attributes are selected based on relevance for population-level effects.

4.5 ASSESSMENT ENDPOINT SYNOPSIS

The major points covered in Chapter 4.0 are as follows.

- Plants and soil macroinvertebrates are valuable AE entities because, considering the lack of inorganic trophic transfer, they potentially are more exposed indicators for evaluating adverse effects of inorganic COPECs.
- Central Plateau-specific receptors are suggested as ecological- and societal-relevant AEs.
- Central-Plateau-specific receptors are suggested as surrogates for the WAC 173-340-900, Table 749-4, feeding guilds, because they are at greater risk from COPECs in the toxicity evaluation. These feeding guilds include producers, soil biota, soil macroinvertebrates, middle-trophic-level vertebrates, and carnivorous reptiles, birds, and mammals.
- Draft AEs address management goals.
- Assessment endpoints will be measured directly or evaluated through use of surrogates as described in Chapter 7.0.

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5.0 CONCEPTUAL MODEL AND RISK QUESTIONS

The conceptual model summarizes the problem formulation results in terms of cause and effect relationships that link stressors to endpoint receptors. Understanding these relationships requires identifying the contaminated media that pose the greatest risk to terrestrial biota. The toxicity information developed through the COPEC refinement is used to set up a series of working hypotheses on how contaminant stressors might affect ecological components of the natural environment. For example, lead is identified as a potential risk to insectivorous birds, because its maximum concentration results in exposures that are higher than levels considered protective of this group. A toxicity evaluation shows that lead has more than a 100-fold greater propensity to accumulate in invertebrates relative to plants (WAC 173-340-900, Table 749-5) and, based on our understanding of contaminated media in the Central Plateau, birds would be expected to receive their greatest exposure through ingestion of soil and contaminated food. Considering this, a logical risk question to ask would be:

> "Do elevated concentrations of COPECs in Central Plateau soils lead to decreased species diversity, population abundance, and/or persistence of avian ground insectivore feeding guild species?"

Collecting field data and evaluating historical site data can address this question. Risk questions are presented as corollaries of COPEC refinement (including the toxicity evaluation) and AEs. General risk questions are included that address multiple specific AEs. In addition, risk questions are developed from participant input (January 29, 2004, EcoDQO workshop) to address resource injury concerns. The conceptual model and risk question information will be applicable to all investigation phases.

The resource injury list was developed into attributes for describing ecological effects for Central Plateau receptors. Considering definitions of resource injury to soil (geologic) resources, effects are synonymous with what one would evaluate for lower biotic trophic levels (Figure 4-1) under ERAGS (EPA/540/R-97/006) and under the WAC's TEE process. Specifically, WAC 173-340-7490(3)(b) indicates that ecologically important functions of soil biota (i.e., soil processes) should be evaluated. Injury-related soil process effects include impedance of microbial respiration and inhibition of carbon mineralization; injuries to soil macroinvertebrates and plants simply involve toxicity. For upper trophic-level biological resources, injuries involve changes in viability. In an ERA context, the viability of a species typically is assessed with regard to impacts on reproduction, survival, and/or growth (EPA/540/R-97/006). Similarly, the goal of the WAC TEE is the protection of terrestrial ecological receptors from exposure to contaminated soil with the potential to cause significant adverse effects, where adversity is defined with regard to effects that impair reproduction, growth, or survival (WAC 173-340-7490(3)). These toxicological endpoints are addressed for plants, soil macroinvertebrates, birds, and mammals.

It is important to note, however, that while some biological resource injuries diverge from effects typically addressed in ERAs, these effects ultimately are captured as impacts on reproduction, survival, or growth. For example, the resource injuries of physical deformation, behavioral abnormalities, susceptibility to disease, and cancer ultimately could affect the viability of a

species by reductions in the growth, survival, or reproductive output of impacted individuals; these latter endpoints are typically the focus of ERAs, because they are most directly linked to population-level effects.

The following section describes the link between the conceptual model and COPEC refinement and the selection of AE attributes for development into risk questions. In many cases, the justification for selecting an attribute is based on best professional judgment. The attributes and resulting risk questions are coded for easy association to proposed measures in later stages of the ERA.

5.1 ASSESSMENT ENDPOINT ONE (AE1): PLANTS

Conceptual Model and COPEC Refinement: Shallow soil has the greatest exposure potential. The inorganic COPECs in shallow soil exceed levels considered protective of plants. The plant attributes that were selected for development into risk questions are shown in Table 5-1.

Table 5-1. Plant Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Cover	Yes	Plant cover provides an easily measured metric of ecosystem and receptor characteristics for evaluating abundance of animals. Plant cover also provides a measure of effect for the plant community. However, this measure must be interpreted carefully, because some waste sites are generally managed for particular kinds of plant cover.
Reproduction	No	Not resource effective to measure because, compared to tests yielding comparable information, it is expensive to evaluate plant reproductive toxicity, given the time involved.
Presence/ absence	No	Not resource effective to measure (confounding effects may contribute to presence/absence, limiting data interpretability).
Species diversity	No	Not a direct population-level effect; consequently, information on this parameter is not amenable to effects assessment for a particular species. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors (e.g., invasion of non-native species like cheatgrass), which limits the utility of such data in interpreting contaminant effects.
Primary productivity	No	Not a direct population-level effect, consequently information on this parameter is not amenable to effects assessment for a particular species.

Plant Risk Question (RQ):

RQ1 Do COPECs in shallow zone soils decrease plant survival or growth?

5.2 ASSESSMENT ENDPOINT TWO (AE2): SOIL

Conceptual Model and COPEC Refinement: Shallow soil has the greatest exposure potential. WAC guidance on soil biota emphasizes ecologically important functions of soil biota, such as nutrient cycling aspects (WAC 173-340-7490(3)(b)). The soil biota attributes that were selected for development into risk questions are shown in Table 5-2.

Table 5-2. Soil Biota Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Decomposition	Yes	Ecosystem process that allows for nutrient recycling, resource-effective to measure.
Nutrient cycling	No	Not resource-effective. While the measure is not particularly expensive to run, it is relatively insensitive to contaminant impacts, considering the functional redundancy of microbiota capable of cycling nutrients. Consequently, the information gained from this would be minimal
Respiration	No	Not resource effective. While the measure is not particularly expensive to run, it is relatively insensitive to contaminant impacts, considering the functional redundancy of microbiota capable of mineralizing carbon compounds. Consequently, the information gained from this would be minimal.

Soil Biota Risk Question:

RQ2 Do COPECs in shallow zone soils affect decomposition by soil biota?

5.3 ASSESSMENT ENDPOINT THREE (AE3): SOIL MACROINVERTEBRATES

Conceptual Model and COPEC Refinement: Shallow soil has the greatest exposure potential. Soil-dwelling macroinvertebrates are fairly resistant to adverse effects of ionizing radiation (Gano 1981, "Mortality of the Harvester Ant (*Pogonomyrmex owyheei*) after Exposure to ^{137}Cs Gamma Radiation"; DOE-STD-1135-2002) and site risks likely are manifest as metal chemical toxicity. The soil macroinvertebrate attributes that were selected for development into risk questions are shown in Table 5-3.

Table 5-3. Soil Macroinvertebrate Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Species diversity	Yes	Although species diversity is not a population-level effect, because this does not translate readily into effects on a given species population, it does provide useful information on ecosystem characteristics. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors (e.g., invasion of non-native species like cheatgrass), which limits the utility of such data in interpreting contaminant effects. Relative diversity information can be collected readily by measuring the biomass of soil macroinvertebrates collected for tissue analysis into family-level groups.
Reproduction	No	Not resource effective to measure because, compared to tests yielding comparable information, it is expensive to run soil macroinvertebrate reproductive toxicity tests because of the time involved.
Secondary productivity	No	Not a direct population-level effect, because this does not readily translate into effects on a given species population.

Soil Macroinvertebrate Risk Question:

RQ3 Do COPECs in shallow zone soils affect soil macroinvertebrate survival or growth?

5.4 ASSESSMENT ENDPOINT FOUR (AE4): HERBIVOROUS, INSECTIVOROUS, OR OMNIVOROUS BIRDS

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. Relative to plants, inorganics have a greater propensity to accumulate in invertebrates. Consequently, insectivorous birds should be at greater risk than herbivorous or omnivorous birds. Because COPECs like PCBs (chemicals known to adversely affect reproduction in vertebrates) biomagnify through the food web, the impact on middle trophic-level avian reproduction (e.g., affecting gender ratios) is of interest. This avian AE also is used to evaluate bioaccumulation of COPECs in upper trophic levels, thus addressing the management goal concerned with contaminant loading in Central Plateau biota. The herbivorous, insectivorous, or omnivorous bird attributes that were selected for development into risk questions are shown in Table 5-4.

Table 5-4. Herbivorous, Insectivorous, or Omnivorous Bird Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Reproduction	Yes	Direct correlation to population-level effects.
Balanced gender ratios	Yes	Correlation to population-level effects.
Abundance (no./ha)	Yes	Correlation to population-level effects.
Physical abnormalities	No	Not a population-level effect. However, abnormalities noted as component of routine field data collection efforts.
Fledgling success	No	Field information on fledgling success will be collected if possible and evaluated for reproductive effects.
Species diversity	No	Not a population-level effect, because this does not readily translate into effects on a given species population. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors, which limits the utility of such data in interpreting contaminant effects.
Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species.
Biomass (kg/ha)	No	Not a direct measure of impacts on populations. Also, evaluating this attribute requires capturing and handling birds and, therefore, it was decided that this would an undesirable and unnecessary perturbing effect and that other less intrusive attributes can be measured.

Herbivorous, Insectivorous or Omnivorous Bird Risk Question:

RQ4 Do COPECs in shallow zone soils and food decrease herbivorous, insectivorous, or omnivorous bird survival, growth, reproduction or abundance, or affect balanced gender ratios?

5.5 ASSESSMENT ENDPOINT FIVE (AE5): INSECTIVOROUS REPTILES

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. Relative to plants, inorganics have a greater propensity to accumulate in invertebrates. Consequently, insectivorous reptiles could be at risk. Because COPECs like PCBs (chemicals known to adversely affect reproduction in vertebrates) biomagnify through the food web, the impact on middle trophic-level reptile reproduction (e.g., affecting gender ratios) is of interest. This insectivorous reptile AE also is used to evaluate bioaccumulation of COPECs in middle trophic levels, thus addressing the management goal

concerned with contaminant loading in Central Plateau biota. The insectivorous reptile attributes that were selected for development into risk questions are shown in Table 5-5.

Table 5-5. Insectivorous Reptile Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Abundance (no./ha)	Yes	Correlation to population-level effects.
Biomass (kg/ha)	Yes	Noted as component of routine field data collection efforts.
Size structure (snout-vent length)	Yes	Noted as component of routine field data collection efforts. Provides information on population size structure.
Physical abnormalities	No	Not a population-level effect. However, abnormalities noted as component of routine field data collection efforts.
Survival	No	Not resource effective, because literature studies are not available to determine adverse-effect levels on reptiles, and special studies would be required.
Growth	No	Not resource effective, because literature studies are not available to determine adverse-effect levels on reptiles, and special studies would be required.
Reproduction	No	Not resource effective, because literature studies are not available to determine adverse-effect levels on reptiles, and special studies would be required.
Balanced gender ratios	No	Not resource effective, because it is difficult to determine the gender of reptiles in the field.

Insectivorous Reptile Risk Question:

RQ5 Do COPECs in shallow zone soils and food decrease insectivorous reptile abundance or biomass, or affect size structure?

5.6 ASSESSMENT ENDPOINT SIX (AE6): HERBIVOROUS, INSECTIVOROUS, OR OMNIVOROUS MAMMALS

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. Relative to plants, inorganics have a greater propensity to accumulate in invertebrates. Consequently, insectivorous mammals should be at greater risk than herbivorous or omnivorous mammals. Although large herbivores are generally most sensitive to radiation effects, the next most sensitive group includes small mammals (PNNL-9394, *Ecotoxicity Literature Review of Selected Hanford Site Contaminants*). Because COPECs like PCBs (chemicals known to adversely affect reproduction in vertebrates) biomagnify through the food web, the impact on middle trophic-level mammalian reproduction (e.g., affecting gender ratios) is of interest. The herbivorous, insectivorous, or omnivorous mammal AE also is used to evaluate bioaccumulation of COPECs in upper trophic levels, thus addressing the management goal concerned with contaminant loading in Central Plateau biota.

The herbivorous, insectivorous, or omnivorous mammal attributes that were selected for development into risk questions are shown in Table 5-6.

Table 5-6. Herbivorous, Insectivorous, or Omnivorous Mammal Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Reproduction	Yes	Direct correlation to population-level effects.
Balanced gender ratios	Yes	Correlation to population-level effects.
Abundance (no./ha)	Yes	Correlation to population-level effects.
Biomass (kg/ha)	Yes	Noted as component of routine field data collection efforts.
Physical abnormalities	No	Not a population-level effect. However, abnormalities noted as component of routine field data collection efforts.
Species diversity	No	Not a population-level effect, because this does not readily translate into effects on a given species population. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors, which limits the utility of such data in interpreting contaminant effects.
Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species.

Herbivorous, Insectivorous or Omnivorous Mammal Risk Question:

RQ6 Do COPECs in shallow zone soils and food decrease herbivorous, insectivorous, or omnivorous mammal survival, growth, reproduction, abundance, or biomass or affect balanced gender ratios?

5.7 ASSESSMENT ENDPOINT SEVEN (AE7): CARNIVOROUS BIRDS

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. In contrast to inorganics, organic chemicals like PCBs have a tendency to biomagnify through the food web. Relative to herbivores, omnivores and insectivores, carnivorous birds should be at greatest risk from PCBs. Because COPECs like PCBs (chemicals known to adversely affect reproduction in vertebrates) biomagnify through the food web, the impact on middle trophic-level carnivorous bird reproduction (e.g., gender ratios) is of interest. The carnivorous bird attributes that were selected for development into risk questions are shown in Table 5-7.

Table 5-7. Carnivorous Bird Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Reproduction	Yes	Direct correlation to population-level effects.
Species diversity	No	Not a population-level effect, because this does not readily translate into effects on a given species population. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors, which limits the utility of such data in interpreting contaminant effects.
Balanced gender ratios	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Abundance (no./ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Biomass (kg/ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Physical abnormalities	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species.

Carnivorous Bird Risk Question:

RQ7 Do COPECs in shallow zone soils and food decrease carnivorous bird survival, growth, or reproduction?

5.8 ASSESSMENT ENDPOINT EIGHT (AE8): CARNIVOROUS MAMMALS

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. In contrast to inorganics, organic chemicals like PCBs have a tendency to biomagnify through the food web. Relative to herbivores, omnivores and insectivores, carnivorous mammals, especially mustelids, should be at greatest risk from PCBs. Because COPECs like PCBs (chemicals known to adversely affect reproduction in vertebrates) biomagnify through the food web, the impact on upper trophic-level carnivorous mammal reproduction (e.g., gender ratios) is of interest. The carnivorous mammal attributes that were selected for development into risk questions are shown in Table 5-8.

Table 5-8. Carnivorous Mammal Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Survival	Yes	Direct correlation to population-level effects.
Growth	Yes	Direct correlation to population-level effects.
Reproduction	Yes	Direct correlation to population-level effects.
Species diversity	No	Not a population-level effect, because this does not readily translate into effects on a given species population. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors, which limits the utility of such data in interpreting contaminant effects.
Balanced gender ratios	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Abundance (no./ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Biomass (kg/ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Physical abnormalities	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas).
Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species.

Carnivorous Mammal Risk Question:

RQ8 Do COPECs in shallow zone soils and food decrease carnivorous mammal survival, growth, or reproduction?

5.9 ASSESSMENT ENDPOINT NINE (AE9): CARNIVOROUS REPTILES

Conceptual Model and COPEC Refinement: Of shallow soil pathways, ingestion represents the most significant exposure route. In contrast to inorganics, organic chemicals like PCBs have a tendency to biomagnify through the food web. Relative to insectivores, carnivorous reptiles should be at greatest risk from PCBs. The carnivorous reptile attributes that were selected for development into risk questions are shown in Table 5-9.

Table 5-9. Carnivorous Reptile Attributes Selected for Development into Risk Questions.

Attribute	Select	Justification
Species diversity	No	Not a population-level effect, because this does not readily translate into effects on a given species population. Species diversity is unlikely to provide definitive data on contaminant impacts, considering that the initial focus is on waste sites, and waste sites are basically wheatgrass monocultures. Also, species diversity may be influenced by a number of noncontaminant stressors, which limits the utility of such data in interpreting contaminant effects.
Survival	No	Not resource effective, given the basic research required to correlate toxicant effects of COPECs on survival.
Growth	No	Not resource effective, given the basic research required to correlate toxicant effects of COPECs on growth.
Reproduction	No	Not resource effective, given the basic research required to correlate toxicant effects of COPECs on reproduction
Balanced gender ratios	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas)
Abundance (no./ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas)
Biomass (kg/ha)	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas)
Physical abnormalities	No	Not resource effective, given the scale and associated efforts for collecting meaningful information (few individuals over large areas)
Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species

COPEC = contaminant of potential ecological concern.

Carnivorous Reptile Risk Question:

RQ9 In general, reptiles lack toxicity reference values, and this obviates our ability to infer effects from exposure dose or tissue concentration data. In addition, carnivorous reptiles, like other carnivores, are relatively scarce (compared to lower and middle-trophic-level receptors) on the Central Plateau. To make any conclusions about potential effects of COPECs, a tremendous effort would be required to collect enough specimens. Considering the logistical constraints associated with this AE, it is unrealistic to propose carnivorous reptiles as subjects for further investigation. However, this feeding guild can be assessed in the uncertainty analysis in comparison to calculated risks for other carnivores.

5.10 CONCEPTUAL MODEL AND RISK QUESTIONS SYNOPSIS

The major points covered in Chapter 5.0 are as follows.

- The draft risk questions are a logical outcome of COPEC refinement and consideration of AE attributes.
- The selection of attributes for development into risk questions is clearly justified.
- The draft risk questions are presented from an ERA remedial investigation perspective and from a resource injury perspective; the remedial investigation-specific questions are generally comprehensive of resource injury concerns.
- The draft risk questions represent the conceptual model of how contaminant stressors are most likely to impact the Central Plateau ecosystem.
- Risk questions are posed to identify measures of effect, exposure, and ecosystem/receptor characteristics.

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6.0 SCIENTIFIC MANAGEMENT DECISION POINT FOR PROBLEM FORMULATION

In summary, the problem formulation step of an ERA is described. Problem formulation represents a refinement of the initial conceptual model of the screening assessment. Conceptual models are based on contaminated media, and all potential exposure routes are evaluated to identify the contaminated medium of greatest exposure potential for terrestrial biota. Data then are reviewed to identify the COPECs from that medium. In addition, the relationships between contaminant stressors and endpoint receptors are developed into a set of working hypotheses on how the stressor might affect ecological components of the natural environment. These hypotheses are the risk questions that are used to identify the data needed to support the ERA and subsequent remedial action decision making. These information needs are satisfied through a SAP that is developed based on the study design described in the subsequent sections of the EcoDQO document. In transitioning to the next phase of the EcoDQO (ERAGS Step 4; Figure 1-2), concerns over the ERAGS Step 3 scientific management decision points synopsized in Chapters 2.0 through 5.0 are addressed.

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7.0 MEASURES

The framework for ecological measures is derived from EPA/630/R-95/002F. Data collection efforts will address measures of effect, measures of ecosystem and receptor characteristics, and measures of exposure and may include field, laboratory, and model data. The measures that address risk questions for Hanford Site-specific AEs are presented in Table 7-1. These measures are planned or are to be considered for Phases I, II, or III. These measures will provide multiple lines of evidence to assess the adverse effects from site COPECs. The following section links AE risk questions to appropriate ecological measures to address the question (Table 7-2).

Table 7-1. Proposed Measures of Exposure, Effect, and Ecosystem/Receptor Characteristics.

Code	Measure
Measures of Exposure	
M1	COPEC concentration in soil
M2	COPEC concentration in biota tissue
Measures of Effect	
M3	Laboratory toxicity testing
M4	Comparison of COPEC concentrations in soil to literature-derived adverse-effect level for plants and invertebrates in soil
M5	Modeled extrapolation of COPEC concentrations in soil to literature-derived adverse-effect level for diet (wildlife only)
M6	Comparison of COPEC concentrations in tissue to literature-derived adverse-effect level for assessment endpoint tissue concentration (wildlife only)
M7	Field study of potential for adverse effects (conditional on field verification efforts)
Ecosystem/receptor characteristics	
M8	Habitat types

COPEC = contaminant of potential ecological concern.
M = measure.

Table 7-2. Proposed Measures to Assess Adverse Effects in Central Plateau Assessment Endpoints. (2 Pages)

Risk Question (from Chapter 5.0)	Assessment Endpoint Attributes	M1: COPEC in Soil	M2: COPEC in Biota	M3: Toxicity Testing	M4: Compare COPEC in Soil to SSV	M5: Compare Modeled COPEC Exposure to SSV	M6: Tissue concentration Effects	M7: Field Study	M8: Habitat Type
Plants (AE1)									
RQ1	Survival, growth	+	+	+	+	-	-	-	+
Soil Biota (AE2)[1]									
RQ2	Decomposition	+	-	-	-	-	-	+[1]	+
Soil Macroinvertebrates (AE3)									
RQ3	Survival, growth	+	+	+	+	-	-	-	+
Herbivorous, Insectivorous or Omnivorous Birds (AE4)[2]									
RQ4	Survival, growth, reproduction	+	+	-	-	+	+	-	+
	Balanced gender ratios, abundance	+	+	-	-	-	-	+	+
Insectivorous Reptiles (AE5)[3]									
RQ5	Abundance, biomass, snout-vent length	+	+	-	-	-	-	+	+
Herbivorous, Insectivorous or Omnivorous Mammals (AE6)[4]									
RQ6	Survival, growth, reproduction	+	+	-	-	+	+	-	+
	Balanced gender ratios, abundance, biomass	+	+	-	-	-	-	+	+
Carnivorous Birds (AE7)[5]									
RQ7	Survival, growth, reproduction	+	+	-	-	+	+	-	+
Carnivorous Mammals (AE8)[6]									
RQ8	Survival, growth, reproduction	+	+	-	-	+	+	-	+

Key:
"+" = measure is applicable.
"-" = measure is not applicable.
AE = assessment endpoint.
COPEC = contaminant of potential ecological concern.
M = measure.
RQ = risk question.
SSV = soil-screening value.

Table 7-2. Proposed Measures to Assess Adverse Effects in Central Plateau Assessment Endpoints. (2 Pages)

Risk Question (from Chapter 5.0)	Assessment Endpoint Attributes	M1: COPEC in Soil	M2: COPEC in Biota	M3: Toxicity Testing	M4: Compare COPEC in Soil to SSV	M5: Compare Modeled COPEC Exposure to SSV	M6: Tissue concentration Effects	M7: Field Study	M8: Habitat Type

[1] Conditional on field verification for applicability of soil litterbag studies to assess adverse COPEC effects on decomposition.

[2] COPEC concentrations in biota are based on nonviable eggs. Modeled exposure estimate based on COPEC concentrations in plants and/or prey. Observation of fledglings in nest will provide information on reproduction (fledgling success) and observation of physical abnormalities proposed as a component of routine field work but conditional on field verification activities.

[3] Modeled exposure estimate could be based on COPEC concentrations in prey, but lack of reptile toxicity benchmarks makes this exercise impractical. Observation of physical abnormalities proposed as a component of routine field work but conditional on field verification activities.

[4] COPEC concentrations in biota are based on whole-body analysis. Modeled exposure estimate based on COPEC concentrations in plants and/or prey. Observation of physical abnormalities proposed as a component of routine field work but conditional on field verification activities.

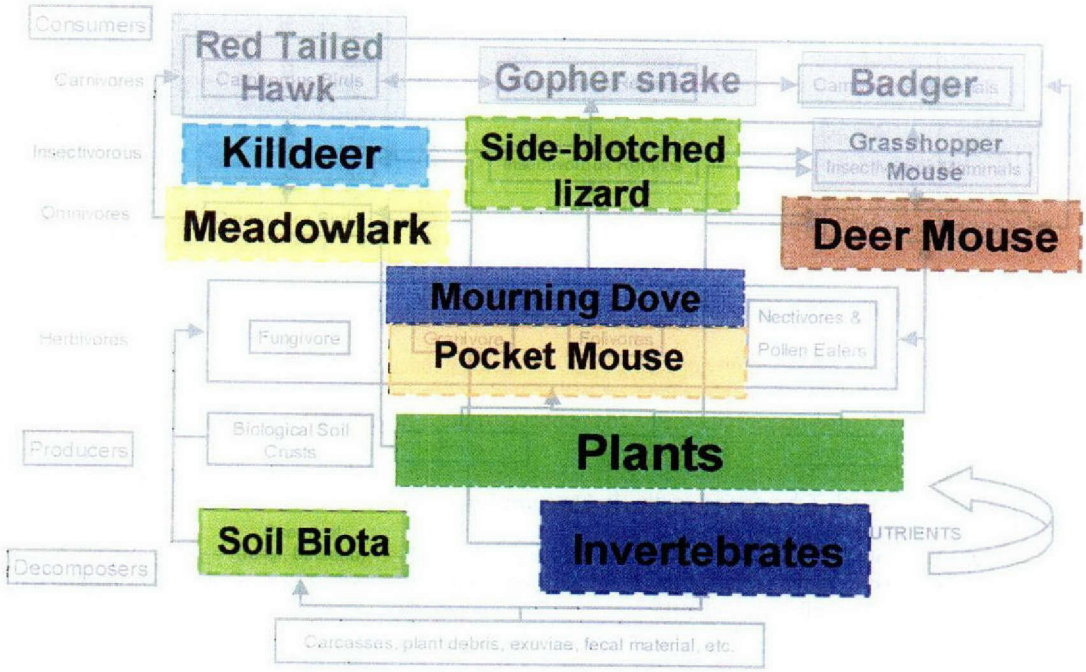
[5,6] Modeled exposure estimate based on COPEC concentrations in prey.

These measures either will support the ecological screening assessment (DOE/RL-2001-54) (e.g., through collection of additional soil data), or will add site specificity to initial risk assumptions. The degree of conservatism in the screening assessment is reduced with increased ecological realism provided in this stage of an ERA (Fairbrother 2003, "Lines of Evidence in Wildlife Risk Assessments"). For example, initial assumptions of 100 percent bioavailability will be reassessed with direct measures of concentrations of contaminants in wildlife diet items (plants and macroinvertebrates) and in wildlife tissue concentrations. This measure eliminates the imprecision inherent in literature-derived trophic transfer factors (e.g., WAC 173-340-900, Table 749-5) and also directly assesses variations in site-specific bioavailability (Fairbrother 2003).

7.1 MEASURES SYNOPSIS

Measures of effect, exposure, and receptor/ecosystem characteristics were selected. These measures form the basis of the data needs for the study design. Figure 7-1 illustrates the species included for direct measures (e.g., measure abundance or tissue residues), which potentially include all lower and middle trophic-level assessment-endpoint feeding guilds with the exception of insectivorous mammals and birds represented by the grasshopper mouse and killdeer. It is unlikely that sufficient numbers of grasshopper mouse and killdeer will be available for any direct measures. Risk for the upper trophic-level species will be evaluated indirectly (through information on their food and NOAELs). Recall that risk on upper trophic-level reptiles only will be evaluated qualitatively because of a lack of TRVs for reptiles.

Figure 7-1. Assessment Endpoint Receptors with Species Proposed for Direct Measures Highlighted (Effects on Gray-shaded Receptors are Evaluated Indirectly).



8.0 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS

ERAGS and the DQO process offer two complementary approaches to developing sampling and analysis plans. The DQO process is general and can be applied to any environmental problems. DQO Steps 1 and 2 ("state the problem" and "identify the decision") were considered in ERAGS Step 3 or problem formulation. The parts of the DQO process that complement the ERAGS study design include DQO Steps 3 through 6, which include "identify the inputs to the decision" (or ERAGS measures), "define the study boundaries," "develop a decision rule," and "limits on decision errors." DQO Step 7, "develop and optimize the design for collecting data," is started during ERAGS study design and is completed during ERAGS field verification (Step 5). DQOs are developed for Phases I, II, and III.

8.1 BOUNDARIES

Relevant ecological spatial boundaries are the areas encompassed by individuals and populations and the depth of biological activity. Information on receptors considered representative of the AEs is summarized in Table 8-1 and includes information on home range, dispersal distance, minimum critical patch size, population density, and assessment population area.

Home range is defined in terms of how individuals use the environment for breeding or feeding. Table 8-1 shows that the area of home range for Central Plateau ecological receptors varies between 0.1 and 1,800 ha. Figure 8-1 shows that there is a positive correlation between body weight and home range (meaning that larger animals require larger home ranges) and that there is a negative correlation between population density and body weight (meaning larger animals are less common). Population density information is an important consideration when selecting species to evaluate measures of effect and exposure. Some species are clearly predicted to be abundant on a hectare (e.g., Great Basin pocket mouse, side-blotched lizard), while others are vanishingly rare on a hectare (e.g., red-tailed hawk). Home range is used to calculate area-use factors (AUF) for individual ecological receptors, where AUFs are the ratio of the contaminated site area to the receptor's home range (EPA 2003a).

While effects on individuals need to be considered (especially for protected species) in an ERA, as stated in Section 4.1, the primary ecological risk management goal for the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* is the protection and maintenance of healthy populations of ecological receptors (EPA 1999). Consequently, information is needed on the area that populations encompass to assess population-level impacts. Specifically, population AUFs can be used to calculate COPEC exposure estimates for populations of ecological receptors.

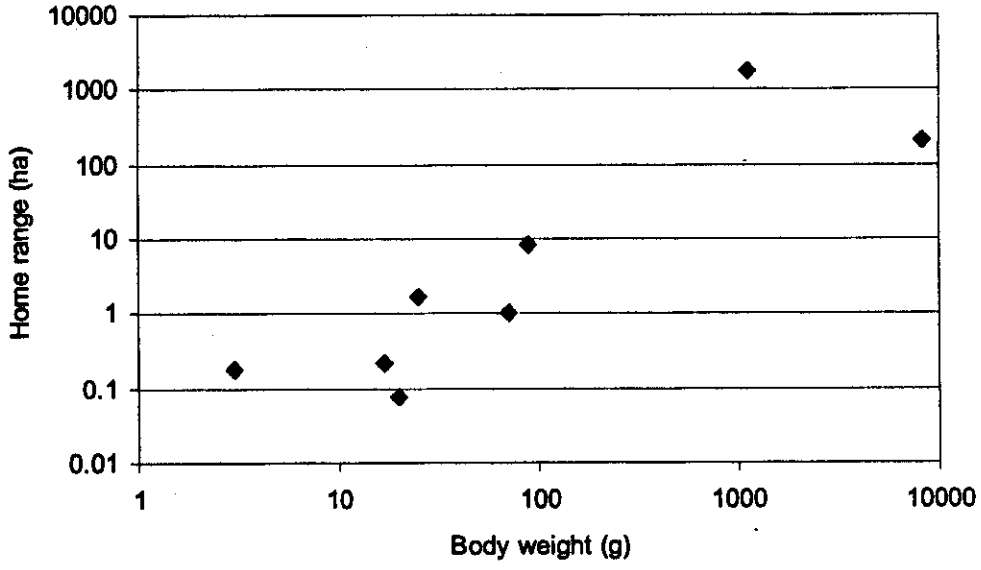
Table 8-1. Spatial and Other Receptor Information for Species Considered as Representatives for the Assessment Points.

Guild	Class	Scientific Name	Common Name	Body Weight (male, female) (g)	Home Range (ha)	Median Dispersal Distance (male, female) (km)	Maximum Dispersal Distance (male, female) (km)	Minimum Critical Patch Size (ha)	Popula-tion Density (No./ha)	Assess Popula-tion Area (ha)
Herbivore	Mammal	*Perognathus parvus*	Great Basin pocket mouse	(18, 16)	(0.05, 0.4)	NA	NA	NA	118	9
Herbivore	Bird	*Zenaida macroura*	Mourning dove	125	NA	NA	4.8	NA	3	NA
Insectivore	Mammal	*Onychomys leucogaster*	N. grass-hopper mouse	(24, 26)	1.725	NA	NA	NA	1	69
Insectivore	Bird	*Charadrius vociferous*	Killdeer	70	1	11.8	(596, 146)	NA	0.9	40
Omnivore	Mammal	*Peromyscus maniculatus*	Deer mouse	(20, 19)	0.077	(0.05, 0.15)	(0.883, 1.005)	NA	6	3.08
Omnivore	Bird	*Sturnella neglecta*	Western meadowlark	(102, 76)	8.5	NA	NA	25	0.3	340
Carnivore	Mammal	*Taxidea taxus*	Badger	8250	200	NA	110, 52	7000	NA	8000
Carnivore	Bird	*Buteo jamaicensis*	Red Tailed hawk	(1063, 1204)	1770	NA	NA	NA	0.0002	70800
Carnivore	Reptile	*Uta stansburiana*	Side-blotched lizard	3	0.175	NA	NA	NA	104	7

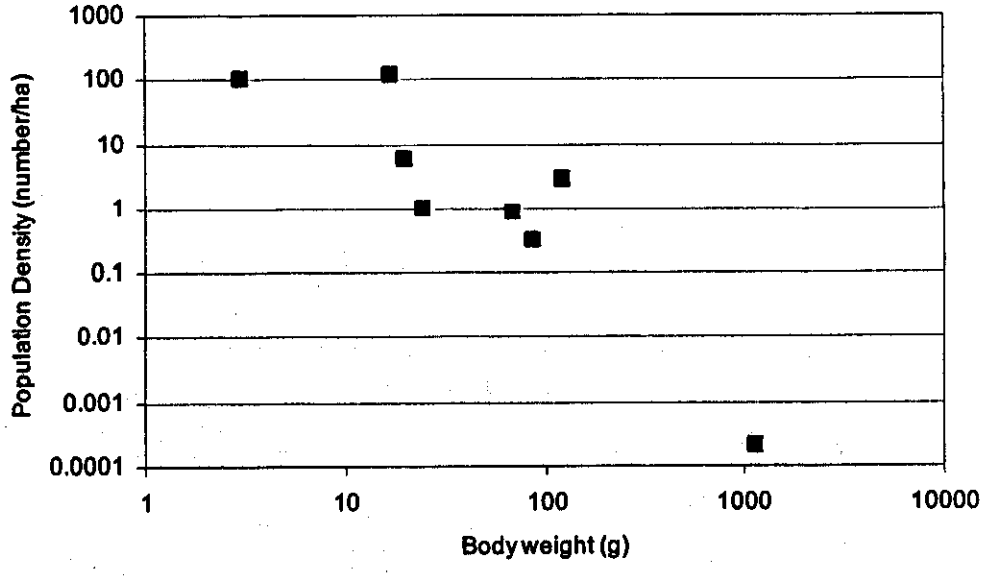
Note = 1 ha = 2.47 acres.
NA = not applicable.

Figure 8-1. Relationship Between Body Weight and Home Range or Density.

(a)



(b)



Wildlife assessment population boundaries can be based on a receptor's dispersal distance (Ryti et al. 2004, "Preliminary Remediation Goals for Terrestrial Wildlife"); for mammals, dispersal distance is strongly related to the linear dimension (square root) of home range. Dispersal distance provides a measure of the distance that animals may travel and therefore is an indicator of gene flow -- an important consideration in defining a biological population.

Information on dispersal distance is available from Bowman et al. 2002, "Dispersal Distance of Mammals is Proportional to Home Range Size" for mammals and from Sutherland et al. 2000, "Scaling of Natal Dispersal Distances in Terrestrial Birds and Mammals," for birds.

Assuming that wildlife are unlikely to disperse beyond some distance from their birth or natal site, dispersal distance can be thought of as the radius (r) of the assessment population's boundaries. Considering the population boundary as circular, it can be spatially defined by calculating the area of a circle (πr^2). Operationally, an assessment population is defined as the individuals within the area calculated from a receptor's (e.g., pocket mouse) dispersal distance. This general relationship is useful as a simple way to estimate assessment population areas for terrestrial animals and helps fill data gaps for wildlife without direct measurements of dispersal. Ryti et al. 2004 have shown that the assessment population area can be defined as 40 times the home range. For Central Plateau ecological receptors, the assessment population area varies between 3 and 70,000 ha (Table 8-1).

The minimum critical patch size is another measure of the area needed to maintain an animal population, and it varies between 25 and 7,000 ha (Carlsen et al. 2004, "The Spatial Extent of Contaminants and the Landscape Scale: An Analysis of the Wildlife, Conservation Biology, and Population Modeling Literature"), but minimum critical-patch size information is only available for two receptors (killdeer and badger). Minimum critical patch sizes for these animals are reasonably consistent with the estimated assessment population areas (killdeer critical patch is 10 times smaller than the assessment population area; badger critical patch is roughly equal to the assessment population area). The important observation from this spatial scale information is that ecological receptors and populations interact with the environment over a scale on the order of a single hectare to thousands of hectares. Thus, 1 ha is a reasonable minimum area to consider for averaging wildlife exposure. This area also is reasonable for invertebrates, but clearly individual plants interact with contaminated soil on a smaller spatial scale. In contrast, waste sites range in size from less than 0.1 ha to the area of the Central Plateau Core Zone (about 5,800 ha).

Ecological receptors interact with the environment over various lateral spatial scales, and this information is useful for understanding how COPECs might bioaccumulate in various species. As discussed in Section 2.1, biological activity also varies with soil depth through the shallow zone (0-4.6 m [0-15 ft] soil interval). However, exposure does not occur uniformly over this 4.6 m (15-ft) interval. The ground surface represents one important direct exposure medium for wildlife. Plants and burrowing animal activity vary with depth, and there is less activity with depth from the surface down through the shallow zone (Figure 2-2). Thus, there is a rationale for focusing data collection and assessment of more surficial soils (those in the zone of greater biological activity or the top 1.8 m [6 ft]).

8.2 SPATIAL DISTRIBUTION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

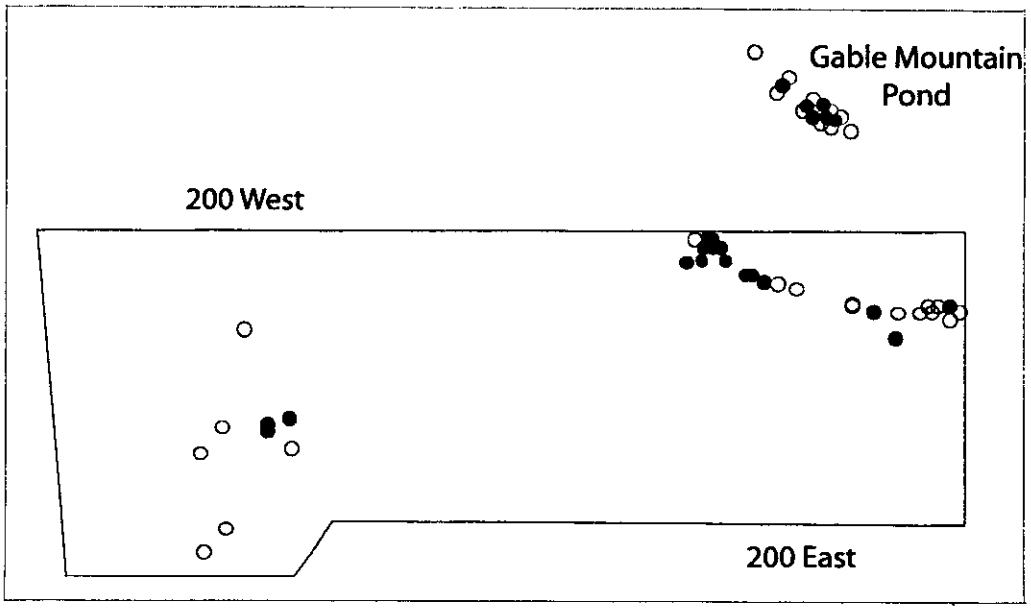
A subset of COPECs was considered in the statistical evaluations and study design. The study design COPECs must have 50 or more sample results, and more than 5 percent of the sample

results were greater than the SSV. Note that all COPECs are greater than background (or two or more detects for organics) and had at least one result greater than SSV or no SSV (Table 3-1). Thus, study design COPECs represent the more significant and potential ubiquitous soil contaminants for the Central Plateau waste sites. The study design COPECs included metals (antimony, boron, hexavalent chromium, mercury, selenium, silver, thallium, and zinc), organics (Aroclor-1254 and Aroclor-1260; Aroclor-1260 was included as a study design COPEC, because the WAC 173-340-900, Table 749-3, SSV is based on total PCBs), and radionuclides (Cs-137 and Sr-90). Information on the variation in concentrations between sample locations and the depth distribution of the study design COPECs is provided in Appendix G. The COPEC concentrations are greater at depth (below 1.8 m [6 ft]), and this is particularly true for the radionuclides (see Appendix G). Samples collected from Gable Mountain Pond generally had lower COPEC concentrations, although these differences also generally are small (see Appendix G).

The spatial distribution of the study design COPECs is evaluated by calculating HI values for analyte groups (radionuclides, organics, and metals). As noted in Chapter 3.0, HI values represent the sum of receptor-specific HQs. The HIs were calculated based on detected results and non-detected results (the detection limit was used as a protective estimate of concentration for non-detects). Spatial plots for metals were not generated, because the hazard index values for metals are universally elevated across the Central Plateau (see Appendix G). This is because background concentrations of these metals also generate large hazard index values and, therefore, metals toxicity is likely overstated by assuming bioavailable forms (see Chapter 3.0). Spatial distribution of radionuclides for the entire shallow zone data (<4.6 m [15 ft]) is provided in Figure 8-2, and Figure 8-3 shows the radionuclide data for the zone of increased biological activity (<1.8 m [6 ft]). Figures 8-2 and 8-3 show that the study design radionuclides (Ca-137 and Sr-90) are greater than the BCG in each of the major spatial subareas (Gable Mountain Pond, 200 West Area, and 200 East Area).

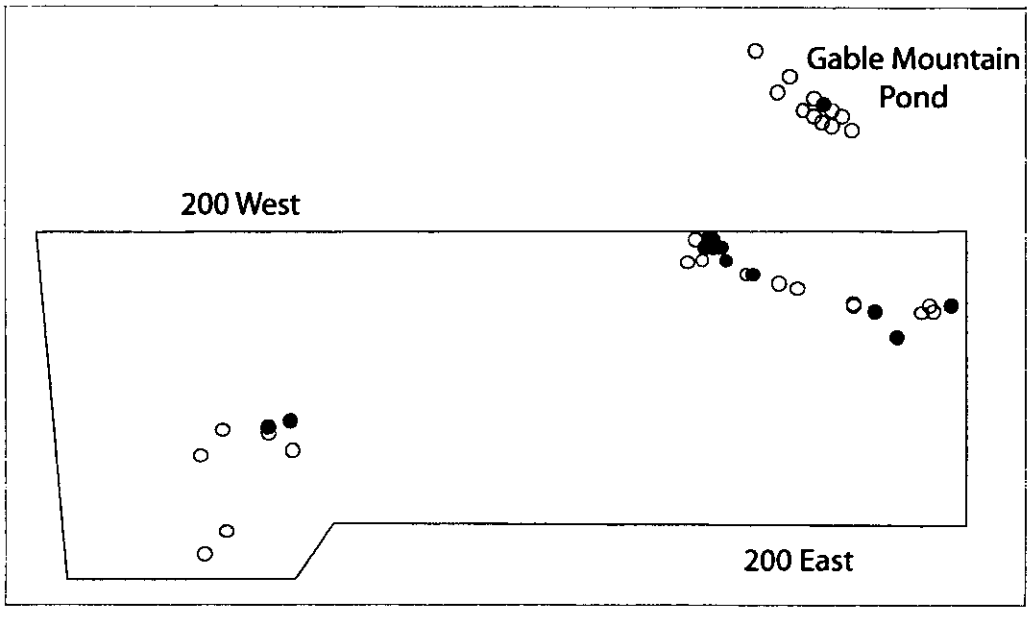
Spatial distribution of PCBs for the entire shallow zone data is provided in Figure 8-4, and Figure 8-5 shows the PCB data for the zone of increased biological activity (<1.8 m [6 ft]). Figures 8-4 and 8-5 show that PCBs are greater than shrew PCB SSV in selected locations in the 200 West Area and 200 East Area (no PCB concentrations exceed the shrew PCB SSV in Gable Mountain Pond). Figures 8-4 and 8-5 also show the approximate boundary of the carbon tetrachloride plume in the 200 West Area. Spatial distribution of PCBs for the entire shallow zone data is provided in Figure 8-6, and Figure 8-7 shows the PCB data for the zone of increased biological activity (<1.8 m [6 ft]). Figures 8-6 and 8-7 show that PCBs are greater than robin PCB SSV in some locations in the 200 West Area and 200 East Area (no PCB concentrations exceed the robin PCB SSV in Gable Mountain Pond). The spatial plots help to identify areas where existing data indicate the potential for adverse ecological effects and can be considered as sampling locations in the study design.

Figure 8-2. Distribution of Study Design Radiological Hazard Index for All Sample Depths (<4.6 m [15 ft]).



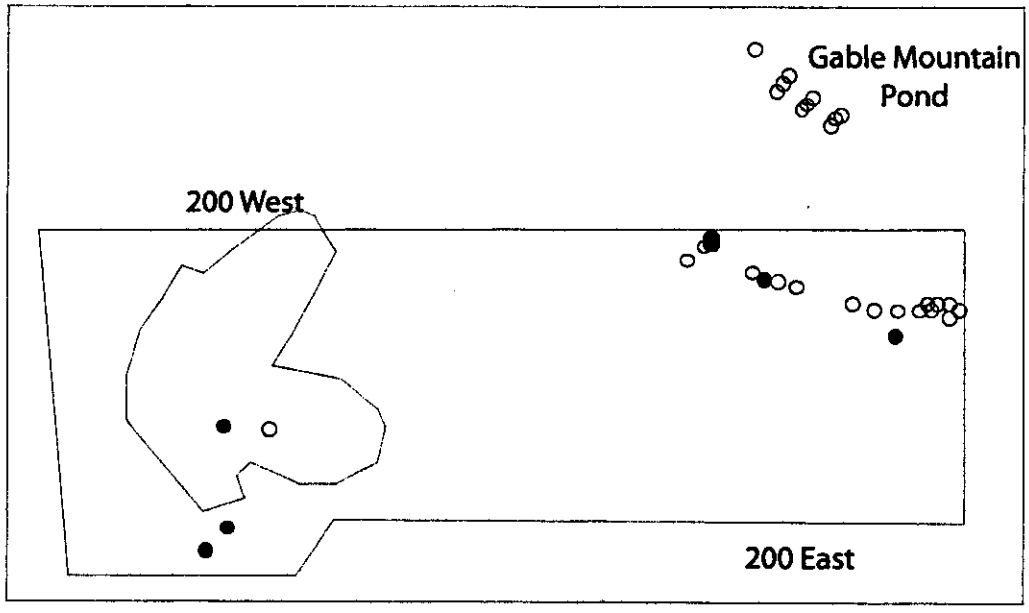
Filled circles have hazard index >1 for Cs-137 and Sr-90.

Figure 8-3. Distribution of Study Design Radiological Hazard Index for Zone of Increased Biological Activity (<1.8 m [6 ft]).



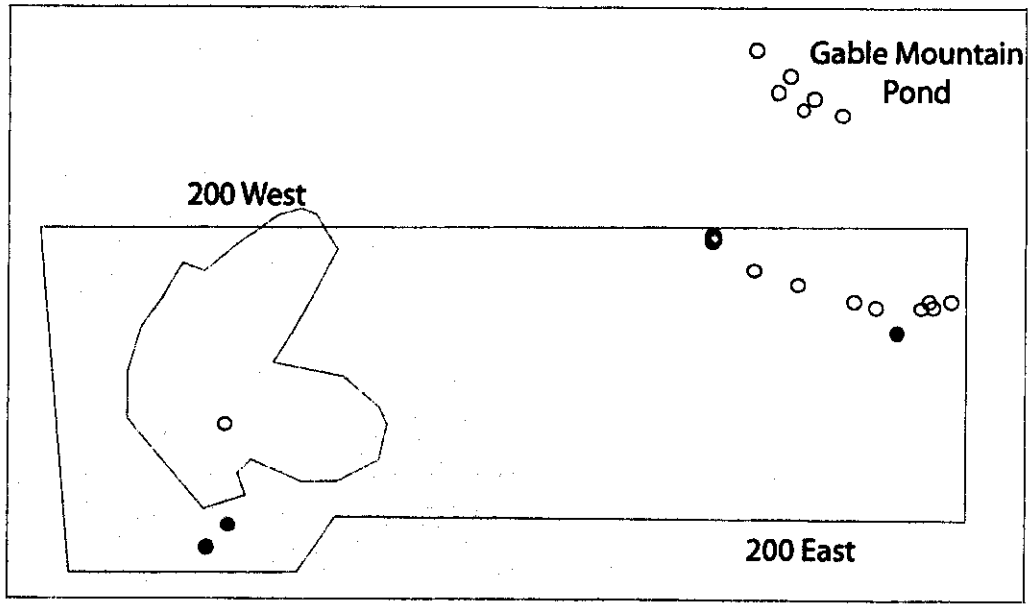
Filled circles have hazard index >1 for Cs-137 and Sr-90.

Figure 8-4. Distribution of Study Design Organic Shrew Hazard Index for All Sample Depths (<4.6 m [15 ft]).



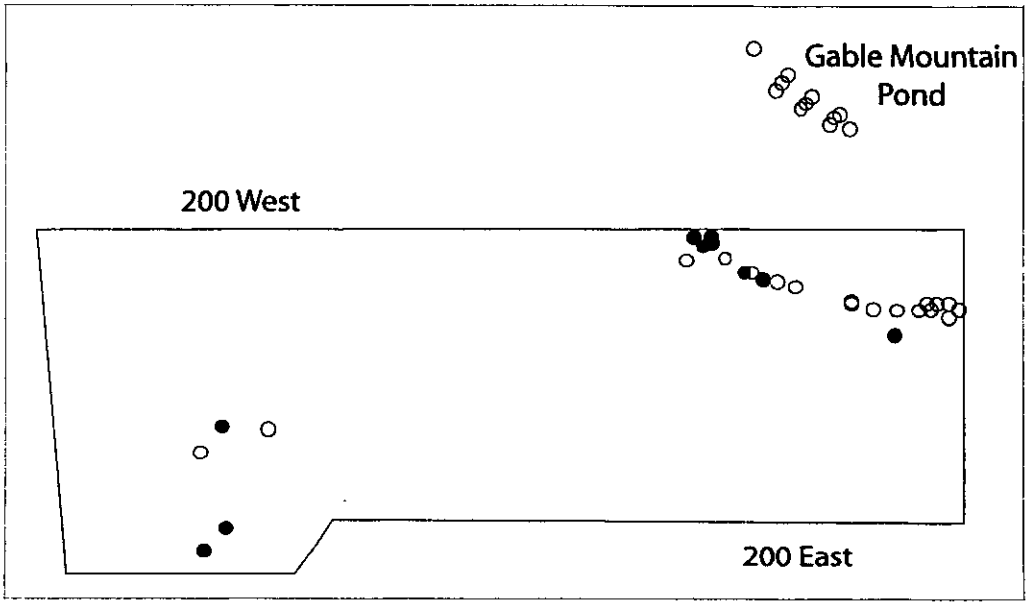
Filled circles have shrew hazard index >1 for PCBs (irregular outline in 200 West is the approximate carbon tetrachloride (CCl_4) plume boundary).

Figure 8-5. Distribution of Study Design Organic Shrew Hazard Index for Zone of Increased Biological Activity (<1.8 m [6 ft]).



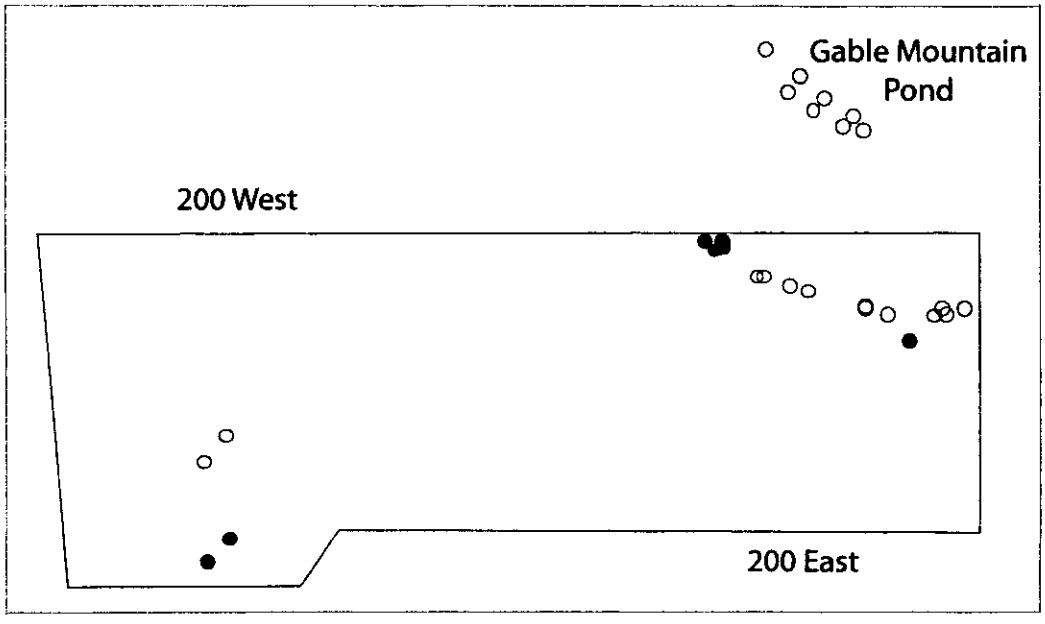
Filled circles have shrew hazard index >1 for PCBs (irregular outline in 200 West is the approximate carbon tetrachloride (CCl_4) plume boundary).

Figure 8-6. Distribution of Study Design Organic Robin Hazard Index for All Sample Depths (<4.6 m [15 ft]).



Filled circles have robin hazard index >1 for PCBs.

Figure 8-7. Distribution of Study Design Organic Robin Hazard Index for Zone of Increased Biological Activity (<1.8 m [6 ft]).



Filled circles have robin hazard index >1 for PCBs.

8.3 DECISION RULES (RISK QUESTIONS)

Decision rules or risk questions used for ecological risk characterization support a weight-of-evidence evaluation of the potential for ecological risk. The following risk questions have been developed to determine if COPECs on soil adversely affect the AEs. Thus, decision rules are developed for measures of effect. The risk questions are stated generically for a receptor, with receptors replaced by the relevant measure species for each AE. An exception is risk question #2, which is specific for soil biota and their role in nutrient cycling. All of the risk questions are based on a design with a reference site and a COPEC gradient.

1. This question is formulated differently for nonradionuclides and radionuclides:

    a. For nonradionuclides: Are mean concentrations in soil greater than mean concentrations in the reference site (or average background concentrations) and, if so, are they greater than SSVs or literature NOAELs (TRVs) for the **receptor** based on the effects of each individual COPEC or combined effects of COPECs where appropriate? (Note: this is the screening-level risk characterization question and forms the basis for COPEC refinement and the AEs and associated measures. The answer to this question is given less weight than the following questions, which are evaluated using data collected in the study design [see Chapter 9.0]).

    b. For radionuclides: Is the contribution to the SOF based on mean concentrations greater than 1 and also greater than the SOF based on mean concentrations for the reference site (or the SOF based on background mean concentrations)?

2. Does mean survival or growth of **receptor** decrease from those in the reference soil or along a gradient of increasing COPEC concentrations? (AE1, AE3)

3. Do mean rates of nutrient cycling for **soil biota** decrease from those in the reference soil or along a gradient with increasing COPEC concentrations? (AE2)

4. Does population abundance of **receptor** decrease from those in the reference site or along a gradient with increasing COPEC concentrations for the same habitat type? (AE4, AE5, AE6)

5. Do **receptor** reproductive rates decrease from those in the reference site or along a gradient with increasing COPEC concentrations for the same habitat type? (AE4, AE6)

6. Do **receptor** gender ratios deviate from equality in comparison to the reference site or along a gradient with increasing COPEC concentrations for the same habitat type? (AE4, AE6)

7. Do mean COPEC concentrations in the **receptor** increase compared to mean concentrations in reference site receptors or along a gradient with increasing COPEC concentrations (greater than published levels associated with toxicity)? (AE1, AE3, AE4, AE5, AE6)

8. Do mean COPEC concentrations in **receptor** diet increase from those in the reference site or along a gradient with increasing COPEC concentrations (greater than TRV)? (AE4, AE5, AE6, AE7, AE8)

Risks will be characterized based on the answers to these questions, and the answers to questions 2-8 will either refute or confirm the answer to question 1 (screening-level risk characterization). If the answer from more than one question is used to characterize ecological risks, then it is necessary to rank the lines of evidence in their importance to characterizing ecological risks. This is necessary to break ties between lines of evidence that may have contradictory conclusions. For the lower and upper trophic levels and middle trophic-level reptiles (AE1, AE2, AE3, AE5, AE7, AE8), risks will be characterized, with one question for each AE (although not the same question for each endpoint). Risks to the middle trophic-level bird and mammal AEs (AE4, AE6) will be assessed by multiple questions, which serve to emphasize the relative importance of the middle trophic levels to this ecological risk assessment. Inferences on the ecological effects on middle trophic-level birds and mammals are made based on differences in field measures of abundance, reproduction, and skewed gender ratios (risk questions #4, 5, 6) or a combination of animal/diet concentrations and the literature adverse-effect levels (risk questions #7, 8). Because animal abundance fluctuates greatly, less credence will be afforded to differences based on abundance, compared to reproduction or skewed gender ratios. Skewed gender ratios and reproduction will be given equal weight in terms of evaluating adverse effects. Field measures (risk questions #4, 5, 6) will be given greater weight than measures that depend on literature toxicity data (risk questions #7, 8).

8.4 LIMITS OF DECISION ERRORS

As discussed in Section 8.3, the decision rules for this assessment are being evaluated using a weight- (or strength-) of-evidence approach. This is particularly true for the middle trophic-level birds and mammals that are the focus of this assessment. Because uncertainty will be evaluated in a qualitative manner in this weight-of-evidence approach, a judgmental basis is selected for the study design. 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, randomization of test organisms to treatments). Data also 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.

8.5 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS SYNOPSIS

- The spatial boundaries for the receptors considered to be representative of the Central Plateau terrestrial AEs suggest that 1 ha is an appropriate scale for assessing ecological risks.
- Information on the horizontal distribution of COPECs can assist in selecting the area for ecological investigation.
- Information on the vertical distribution of COPECs and the depth profile of ecological activity provides a basis for selecting depths for characterization.
- Decision rules were developed to evaluate the various measures and AEs under consideration for the Central Plateau ecological risk investigations.

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9.0 STUDY DESIGN

A synopsis of the proposed study design is provided in Table 9-1; it shows how the various data types (measures) relate to risk questions, the key features of the study design, and the basis for the design element. All aspects of the study design are subject to field verification, which may require selecting alternate measures for an AE or other modifications to the study design (e.g., plot size, trapping density). Data will be collected in three phases to evaluate ecological risks (Table 9-1). A phased approach is taken to assess specific study design objectives over a broad spatial scale (Figure 9-1). A tiered approach to data collection also is employed, because advanced stages of sampling will be based on the results of initial collection efforts.

Using a phased approach to characterize ecological risks has the advantage of targeting data collection to those ecological receptors found to be at risk from Hanford Site processes and waste sites and the associated COPECs. Phasing also allows for testing aspects of the conceptual model that were used to develop the overall design. One key aspect of the conceptual model is the list of COPECs, which are based on existing sample data and process knowledge. Sampling for contaminants of interest can help to verify this aspect of the conceptual model.

Another important component of the conceptual model is the primary exposure medium, including the depth of biological activity. Data suggest that surface soil is important as an exposure medium for direct contact with wildlife, root uptake, and animal burrowing. Thus, surface samples (of 15 cm [6 in.]) can be collected, along with specific biological samples, to test for COPEC uptake. Collecting surface soil samples for the initial data collection activities has important practical advantages. Methods for collecting surface soil samples are less intrusive than those needed for deeper soil characterization (e.g., truck-mounted drill rigs) and, therefore, minimize the impacts of data collection on the shrub-steppe ecosystem. The conceptual model of possible upward mobility of buried waste through animal burrowing and plant uptake initially will be assessed using radiological field data collection. Radiological field data will be biased toward areas with a high potential for mobilized subsurface waste, such as mammal burrow spoils.

The specific receptors targeted for initial sampling are mammals, lizards, and soil macroinvertebrates, because these organisms were viewed as having a high potential to accumulate site COPECs. Plant tissue initially will be assessed for radionuclide uptake using radiological field data on gamma-emitting radionuclides. To help address trustee information needs, abnormalities will be noted on any animals handled during data collection. Additional data collection is dependent on the results of the initial investigation phases and may include characterization of soils deeper than 15 cm (6 in.), plant tissue concentrations, population measures for mammals and lizards, field verification for middle trophic-level birds, litterbag studies, and toxicity tests for plants and invertebrates.

Table 9-1. Central Plateau Ecological Data Quality Objective Sampling Design Summary Table Linking Proposed Measures to Risk Questions. (2 Pages)

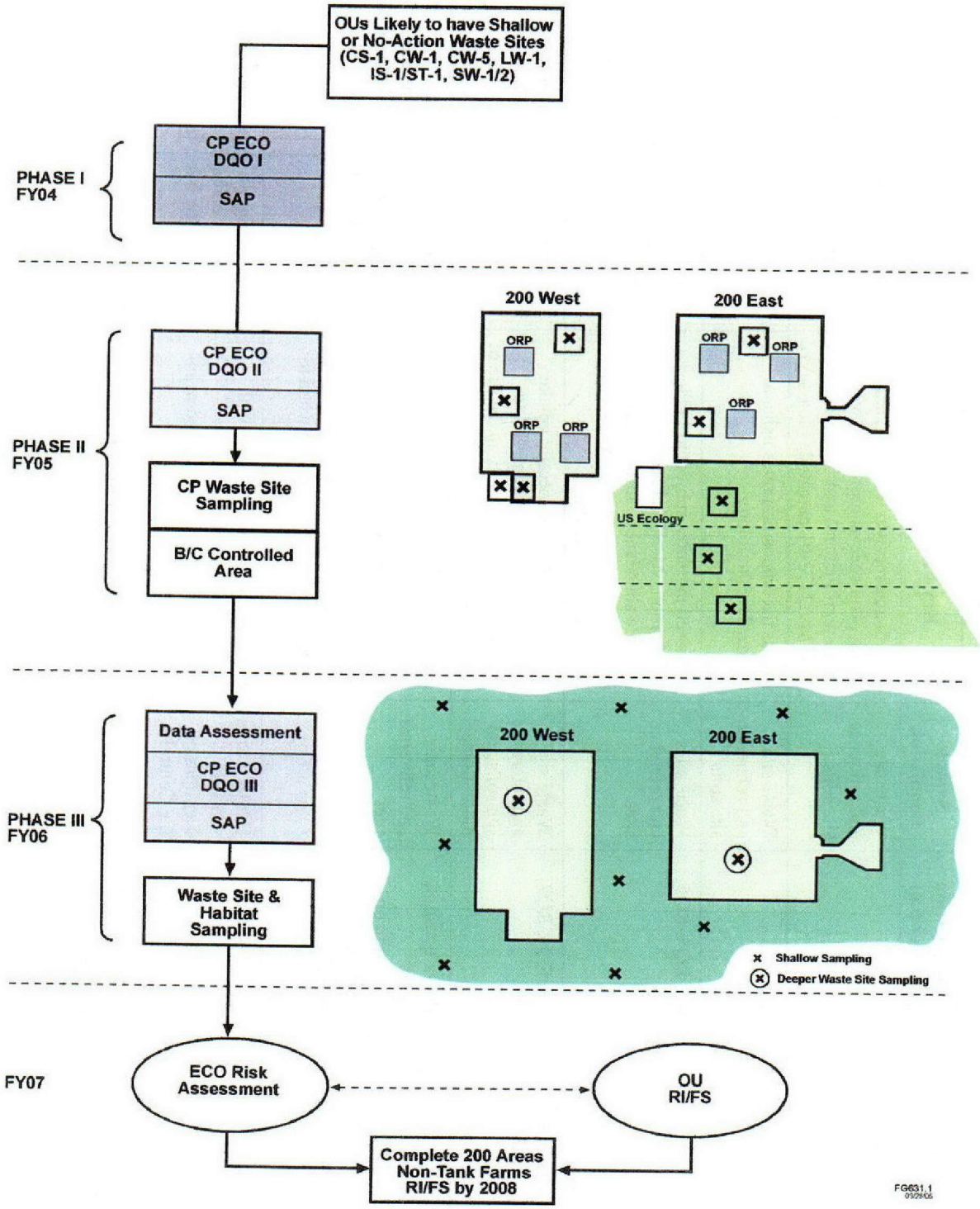
Phase[a]	Data Type	Risk Question (Chapter 5.0)	Sample Population	Key Features of Design	Basis for Study Design
I, II, III	Radiological field survey data for gamma-emitting radionuclides	All risk questions are dependant on soil data; because this is a precursor to soil collection, it affects all risk questions.	Waste-site soils and plant material	Used before soil sampling was performed.	Supports testing of the conceptual model of biological transport and allows an assessment of areas of elevated radioactivity.
I, II, III	Plant cover estimation	RQ1, RQ3, RQ4, RQ5	Waste-site and reference site plants	Provides a measure of effect for the plants and a measure of ecosystem characteristics for animals	Supports evaluation of animal abundance and provides a measure of habitat quality
I, II, III	Surface soil sampling	All risk questions will employ these data	Waste-site and reference site soils	Multi-increment samples representing 0 to 15 cm (0 to 6 in.).	Multi-increment samples for estimate of average exposure over sampling area.
III	Soil sampling	All risk questions will employ these data.	Waste-site and reference site soils	Grab and multi-increment samples stratified over 0 to 1.8 m (0 to 6 ft) (representing 0 to 15 cm [0 to 6 in.], and deeper intervals).	Grab samples collocated with plant tissue for waste-site specific uptake estimates. Multi-increment samples for estimate of average exposure over sampling area.
I, II, III	Biota tissue sampling	RQ1, RQ3, RQ4, RQ5, RQ6, RQ7, RQ8	Plants, invertebrates caught in pitfall traps, ground-nesting bird eggs, small mammals, lizards	Composite for plant vegetative and reproductive parts separately. For invertebrates, composite of pitfall trap contents. For birds, nonviable eggs of second clutch used. For reptiles, individual animals or tail. For mammals, individual animals.	Initial comparisons of COPECs in biotic tissue made and COPECs in soil made with multi-increment soil samples. Tissue samples of insects, birds (eggs), reptiles, and small mammals provide information for contaminant loading in middle trophic levels and, for upper trophic levels, exposure modeling and comparison to literature information on toxic tissue concentrations. Phase III may involve plant tissue samples collocated with soil grab samples for waste site-specific estimates of exposure and lower trophic-level uptake.

Table 9-1. Central Plateau Ecological Data Quality Objective Sampling Design Summary Table Linking Proposed Measures to Risk Questions. (2 Pages)

Phase[a]	Data Type	Risk Question (Chapter 5.0)	Sample Population	Key Features of Design	Basis for Study Design
III	Toxicity testing	RQ1, RQ3	Waste site and reference site soils	Growth and survival tests for plants (using plant species representative of the Central Plateau) and invertebrates (ASTM E2172-01 nematode bioassay).	Provides site-specific information on toxicity of contaminant mixtures and on contaminant bioavailability for Hanford Site soils.
III	Litter bags	RQ2	Waste site and reference site soils	Assess decomposition rates using a standard methodology.	Provides a measure of effect for soil biota.
III	Field surveys	RQ2, RQ4, RQ5, RQ6	Waste sites and reference sites	Proposed measures subject to field verification. Mark and recapture to estimate abundance. Information on resource injuries collected as part of routine animal handling.	Provides another line of evidence to verify modeling estimates or to serve as sole line of evidence for assessment endpoints (reptiles). Provides information of interest to trustees.
I, II, III	Exposure modeling	RQ4, RQ6, RQ7, RQ8	Waste site and reference site soils and biotic tissues	Use of Hanford Site-specific uptake factors for soil to prey (and soil to plants) reduces uncertainty in the use of non-site-specific literature values.	Exposure modeling especially useful in assessing endpoints for which field measures would not be resource effective.
I, II, III	Reconnais-sance and field verification	All risk questions employ information on habitat type, so this applies universally.	Waste sites and reference sites	All sites will be classified according to vegetation and habitat status. Modified Daubenmire plots will be used to assess cover of dominant plants, bare ground, and cryptogams. Reconnaissance also helps to determine where and when to sample.	Field verification necessary to ground the practicality of proposed measures. For example, nonviable eggs in the second clutch of ground-nesting birds.
I, II, III	Literature reviews	RQ2, RQ4, RQ5, RQ6	Hanford Site-specific literature on the Central Plateau	Local experts will be familiar with proposed measures and will be consulted for relevant published or in-house information.	Existing Hanford Site-specific data on assessment endpoint abundance to support and aid in the interpretation of proposed field efforts.

[a] The Phase III activities noted in this table will be evaluated in the Phase III data quality objectives document.
ASTM E2172-01, *Standard Guide for Conducting Laboratory Soil Toxicity Tests with the Nematode* Caenorhabditis elegans.
COPEC = contaminant of potential ecological concern.

Figure 9-1. Phased Central Plateau Ecological Risk Assessment Emphasizing the Spatial Extent of the Investigations.



As indicated on Figure 9-1, Phase I activities are focused on the 200 East and 200 West Areas in the industrialized Core Zone; Phase II expands consideration of sampling to US Ecology and Office of River Protection sites in the Core Zone and the BC Controlled Area; and Phase III includes habitat outside of the 200 East and 200 West Areas and adjacent to the Core Zone. Phase I and II data collection will be followed by a Phase III DQA, and subsequent investigations will be dependent on the results of the DQA.

An overview of the sampling and analysis options after each investigation phase is described below, and additional details are provided in the SAP.

Phase I. Characterize exposure and ecological effects of COPECs from Central Plateau Core Zone waste sites (potentially impacted locations) and reference area (assumed unimpacted area, also referred to as "control" site), focusing on waste sites with existing soil COPEC concentration data by collecting Tier 1 soil and biota data as follows.

- Collect surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (PCBs, pesticides). Note: 15 cm (6-in.) depth was selected for Phase I to evaluate the importance of near-surface contamination to biota.
- Collect radiological field data for beta and gamma-emitting radionuclides in soils (e.g., burrow spoils, ant nests) and plant material to test the conceptual site model of upward contaminant transport (the conceptual model suggests that the 0 to 15 cm [0 to 6-in.] soil interval is important for exposure, but deeper soil also may be important).
- Collect biological data including body analysis for metals, radionuclides, and organics (PCBs, pesticides) in small mammals, lizards, and insects (these animals are common and should have sufficient mass for analysis of all COPECs).
- Note any abnormalities for the vertebrate animals handled, in the field logbooks (these notes will provide qualitative information of the possible effects of COPECs on biota).
- Perform a literature review of studies relevant to the Hanford Site, and collect exposure parameter data relevant to the Hanford Site terrestrial receptors and exposure pathways.

Phase II. The Phase II DQO/SAP will evaluate characterization needs for ecological effects of COPECs from the BC Controlled Area, tank farms, West Lake, and the US Ecology Site. Tier 1 soil and biota data may include the following.

- Collect surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (PCBs and pesticides).
- Collect 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.
- Collect biological data including body analysis for metals, radionuclides, and organics (PCBs and pesticides) in small mammals, lizards, and insects.

- Note any abnormalities for the animals handled, in the field checklists.

Phase III. Phase III begins with a DQA for Phase I and Phase II data, with the overall objective of testing the following aspects of the conceptual model and defining data needs for Phase III.

- Determine if mean concentrations of COPECs detected in surface soil samples are greater than mean background values (DOE/RL-92-24, Ecology 94-115, and DOE/RL-96-12) or mean concentrations at reference sites and also if these COPECs are those expected from process knowledge and previous site sampling.

- Determine if there is uptake of radionuclides in plants or biological transport through ants or burrowing mammals.

- Determine if COPECs are detected in biota samples (invertebrates, lizards, and small mammals) and if these COPECs are those expected from process knowledge and previous site sampling.

- Determine if biota and surface soil data correlate, suggesting that COPECs are present in surface soil and that the surface soil represents the primary exposure medium for ecological receptors.

- Evaluate the results of a literature review of studies relevant to the Hanford Site and the results of the collected exposure parameter data relevant to the Hanford Site to inform subsequent field data collection activities.

In Phase III, the DQOs may be revised based on the DQA findings, leading to the development of a Phase III SAP. The scope of this SAP is to characterize the ecological effects of COPECs in Central Plateau habitat (outside of the 200 East and 200 West Areas) by collecting Tier 1 soil and biota data as follows.

- Collect surface soil samples to a depth of 15 cm (6 in.) for metals, radionuclides, and organics (PCBs and pesticides) at selected sites.

- Collect biological data including body analysis for metals, radionuclides, and organics (PCBs and pesticides) in small mammals, birds, lizards, and insects.

- Note abnormalities for the animals handled, in the field logbooks.

Phase III characterization also may include the following Tier 2 data collection activities within the Core Zone, dependent on the findings of the DQA.

- Collect representative samples of soil below 15 cm (6 in.) to supplement existing waste site data, if needed, to address data gaps identified through the DQA.

- Collect plant tissue and soil grab samples along the rooting depth. This activity is conditional upon measuring COPEC concentrations greater than plant soil-screening values in Phase I and Phase II soil samples.

- Collect data to evaluate population measures for mammals and lizards if the concentrations measured in biota and soil are greater than literature adverse-effect levels.
- Conduct toxicity tests that are conditional on identifying COPECs for soil biota in Phase I and Phase II soil and biota samples.
- Evaluate the need for field verification of ground- and shrub-nesting bird measures.
- Determine if the density of ground- and shrub-nesting birds is adequate for use in evaluating measures of exposure and effect for middle trophic-level birds.
- Implement the nestbox (as an alternative) to obtain nest success and egg COPEC concentrations if field verification (Tier 2) shows that the density of ground- and shrub-nesting birds is not adequate for field studies
- Note any abnormalities for the animals handled, in the field logbooks.

Phase III also includes developing or revising DQOs for the following potential study design elements.

- Develop DQOs for Central Plateau habitat sampling. A focus of Phase III of the Central Plateau EcoDQO is to assess habitat in nonoperational areas to better understand the status and health of the Central Plateau ecosystem.
- Use the DQO process to evaluate the need for adding other reference sites.
- Develop the DQO to assess potential risks to fossorial mammals from the diffuse carbon tetrachloride plume in the 200 West Area. Carbon tetrachloride was identified as a COPEC based on data reviewed in Phase I. No sampling for carbon tetrachloride is planned for Phase I or Phase II, however, because data collection is focused on the 0 to 15 cm (0 to 6 in.) depth interval; measurement of volatile organics in this interval is meaningless because of barometric pumping and solar heating of the soil.
- Revise the existing DQO for West Lake. The West Lake DQO (Appendix E) will be revised based on an assessment of available and relevant West Lake studies.

9.1 SITE SELECTION PROCESS

9.1.1 Waste Sites

One of the key considerations in the study design is selecting areas for sampling and analysis. This process started with a master list of waste sites that included all of the Central Plateau waste sites listed in the Tri-Party Agreement, Appendix C, as amended to September 1, 2003. A query of a Hanford Site database (e.g., *Waste Information Data System*) was used to create the master list. A systematic site selection process was used to identify the most appropriate waste sites for ecological characterization. This was done by screening out the inappropriate sites from the master list. The first screening step eliminated non-process based Hanford sites because they are

outside the scope of the Central Plateau EcoDQO. Secondly, waste sites classified or reclassified as rejected, proposed rejected, consolidated rejected, or closed out through the TPA Appendix C process were excluded because sites in these categories are no longer considered waste sites. Thirdly, waste sites were excluded if the resident contamination is deeper than 4.6 m (15 ft[4]) below the ground surface (bgs) and therefore not accessible to ecological receptors, or if the potential contaminant pathways to ecological receptors are broken by man-made structural features.

The waste sites that survived these screening steps were grouped into categories that included high, moderate, and low radiological/chemical concentrations. In addition "potential no action or institutional control waste sites" were included as a unique category. This category was important because ecological risk is more likely a decision-driver for sites with very low or nondetectable contaminant concentrations. The site selection process is shown graphically as a flowchart in Figure 9-2. This is complemented by an exhaustive tabulation of the waste sites in Excel[5] files in Appendix B (attached compact disk). These tables may be used to track the development of the representative waste site list from the initial lists of Central Plateau waste sites.

The data obtained through this EcoDQO and the subsequent SAP supplement other characterization activities and will be used for many waste sites in the Central Plateau. Consequently, a representative site approach was implemented. Within each of the four categories, worst-case representative waste sites were selected based on the following:

- Sites with large inventories or volumes of waste
- Sites that received waste from the most contaminated or highly concentrated waste streams for each operation and each grouping
- Sites with potential ecological receptors
- Sites with a minimum thickness of surface stabilization soil
- Sites that had accurate coordinates and could be located in the field
- Sites with data or where data will be collected that potentially could be applicable to this ecological risk assessment activity.

Through this process, 89 candidate waste sites were identified (Figure 9-2). These sites underwent field reconnaissance investigation and evaluation by experts on the Central Plateau ecosystem. The selected sites included those with the greatest potential for complete exposure pathways to ecological receptors (D&D-28419, *Ecological Evaluations of Selected Central Plateau Waste Sites*). Because the potential no action or institutional control waste sites could

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[4] WAC 173-340-7490(4), "Terrestrial Ecological Evaluation Procedures," "Point of Compliance," defines the soil cleanup depth (the standard point of compliance) as extending from the ground surface to 15 ft bgs.

[5] Excel is a trademark of the Microsoft Corporation, Redmond, Washington.

have ecological significance, they were the subject of an additional scoping evaluation that identified the candidate waste sites in that category (D&D-28419, Addendum). Other candidate sites were recommended by the Washington State Department of Ecology, EPA, or U.S. Department of Energy or by public workshop participants.

From the list of representative waste sites, the selection was furthered narrowed by limiting sites to those greater than 500 m^2 in area and with a cover depth of less than 1.8 m (6 ft). (Note: cover depth was presented as a range of values for some sites and, where a range was presented, the minimum cover depth for the site had to be less than 1.8 m [6 ft] to be selected.) Sites that lacked this information also were excluded. Soil contaminant data associated with the candidate waste sites and association of the waste sites with key processes were reviewed, resulting in the list of waste sites considered for investigation in this DQO (Table 9-2). Figure 9-3 shows the locations of these waste sites on the Central Plateau.

9.1.2 Reference Sites

The investigation of candidate reference sites for the Phase I sampling included those waste sites that have been impacted, disturbed, and revegetated with wheatgrass. The reference site should be ecologically similar to the contaminated sites except for the COPEC concentrations. The reference site COPEC concentrations should reflect Hanford Site background levels. Because airborne deposition of COPECs is possible, it is advantageous to locate the reference site upstream of the prevailing (northwest) winds and existing waste management facilities. Other factors to consider in selecting reference sites include dominant plant species and cover, soil type and texture, burn history, and elevation. The reference site should provide a good overall match to these characteristics while meeting the primary requirement of COPEC concentrations at background levels.

Two candidate locations were evaluated for use that previously had been revegetated with crested wheatgrass. One site met the vegetation, cover, and soil requirements and was upwind of most of the Central Plateau waste management sites. However, it was not selected because of its proximity to the T Plant. A second candidate site is a revegetated site located west-northwest of the 218-W-5 Burial Ground. Because it meets the vegetation, cover, and soil requirements and is located upwind of all other Central Plateau waste management sites, it was selected as the reference site for the Phase I field characterization.

Figure 9-2. Waste Site Selection Process. (2 Pages)

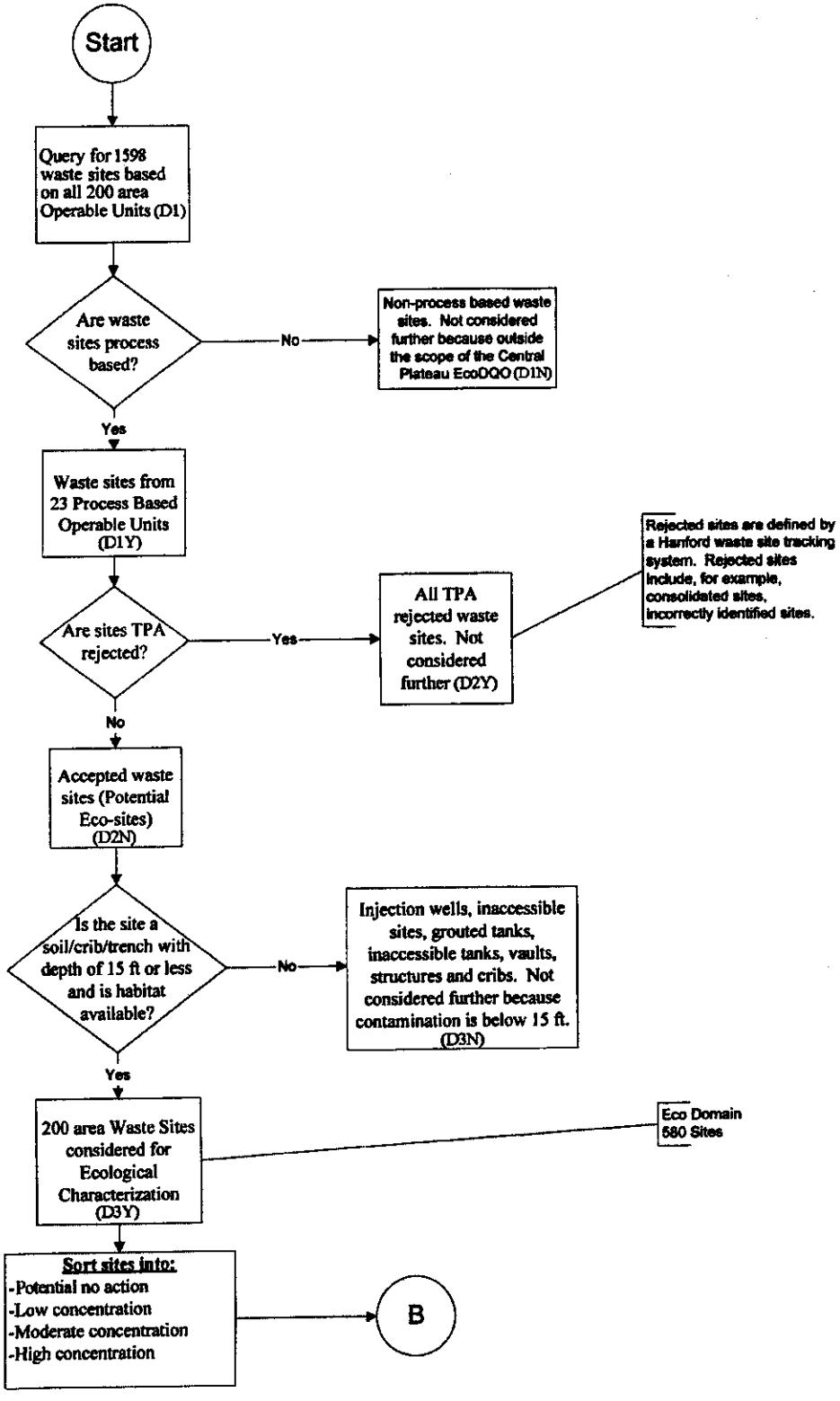


Figure 9-2. Waste Site Selection Process. (2 Pages)

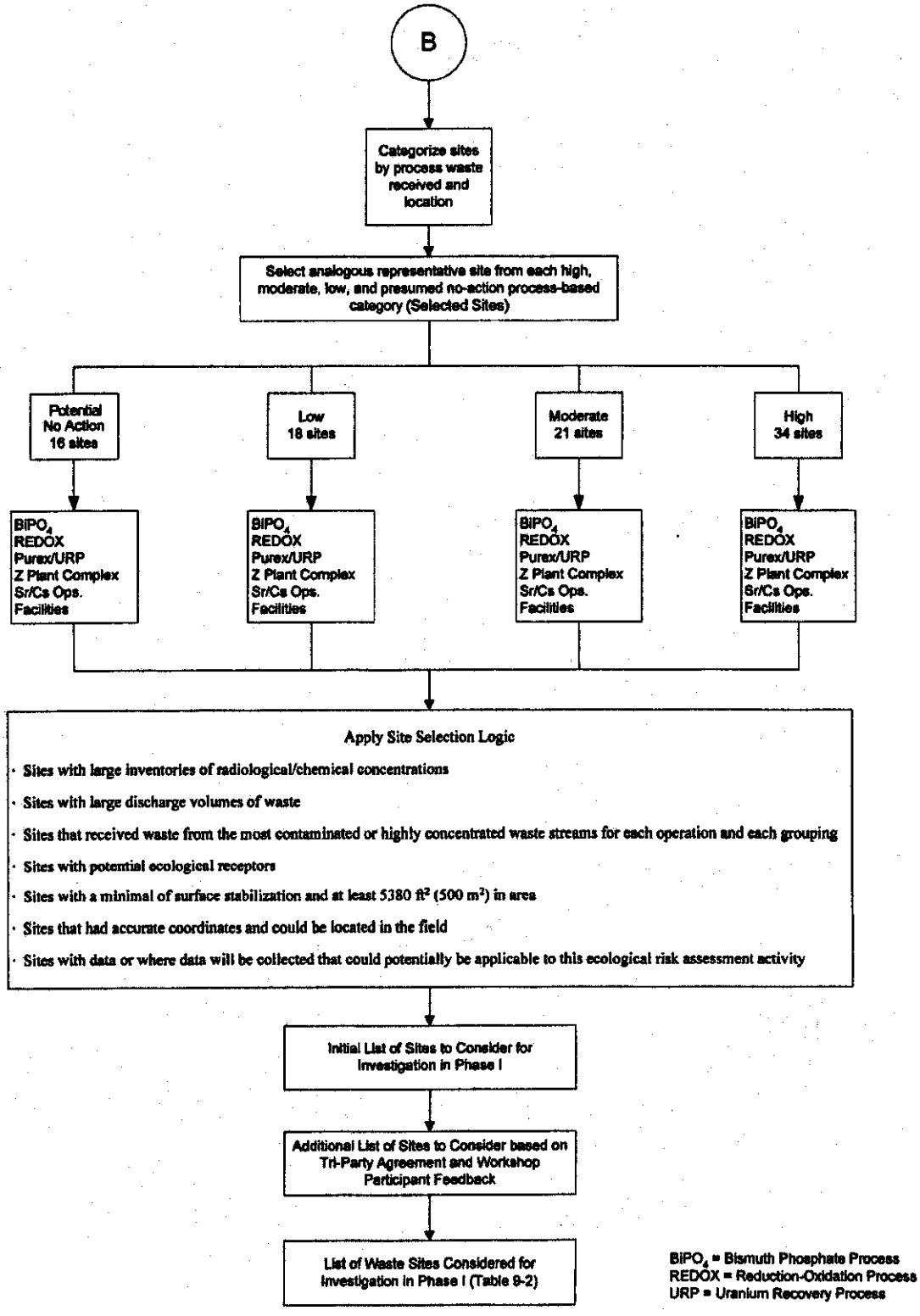


Table 9-2. Candidate Waste Sites to be Considered for the Ecological Data Quality Objective Sampling and Analysis Plan.

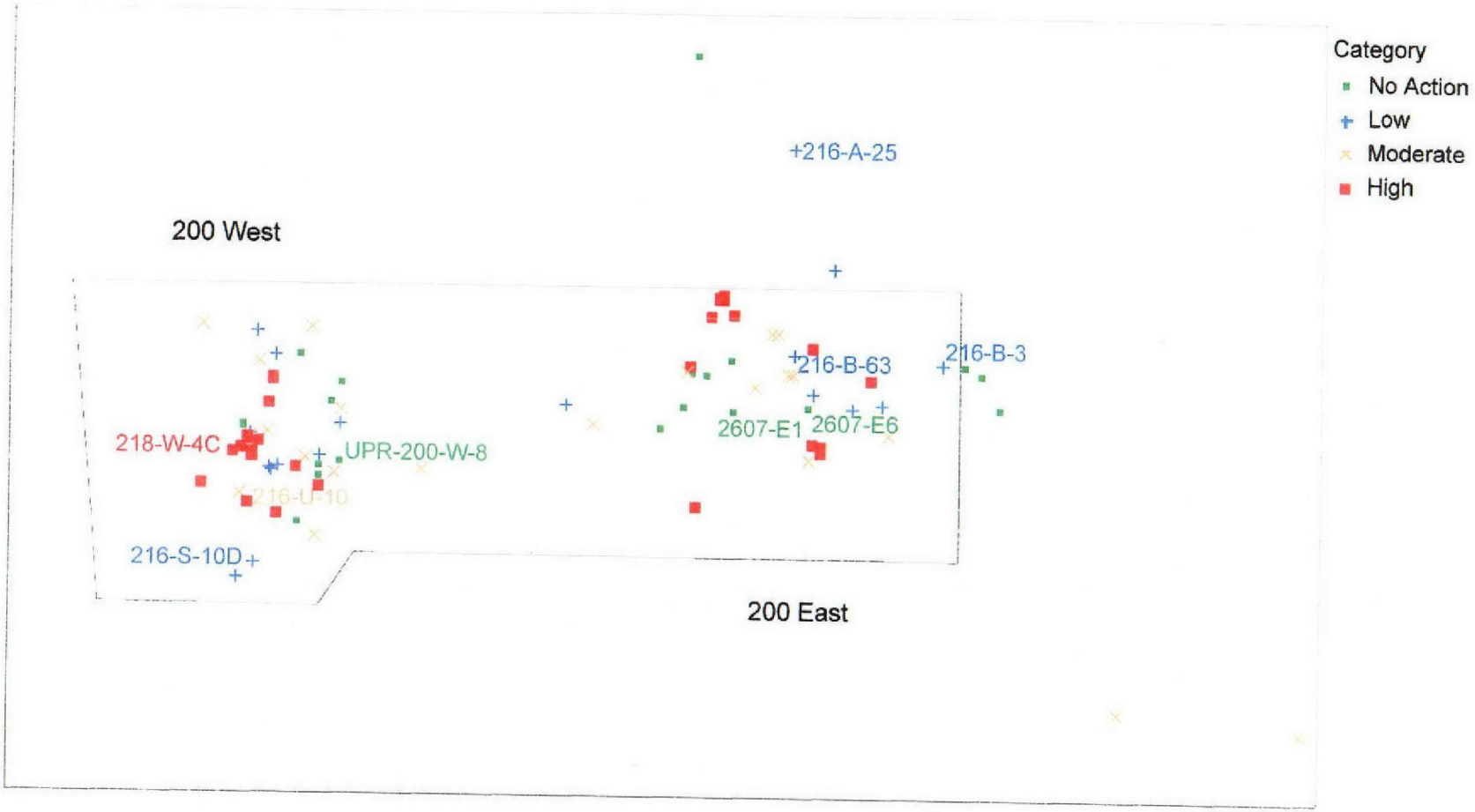
Remedial Action Category[a]	Names	Type	Process/ Operations	Operable Unit	Site Code	Site Area (ft^2)	Site Stabilization Depth	Remediation Type
Potential No-Action	200-W-5, Burial ground/burn pit U Plant burn pit, UPR-200-W-8	Burn pit	U Plant	200-SW-2	UPR-200-W-8	42,500 ft^2 (3,900 m^2)	10 ft (3 m)	Potential No-Action
Potential No-Action	2607-E1	Septic tank (active 1970-1997)	Not available from Hanford Site databases	200-ST-1	2607-E1	Not available from Hanford Site databases	Not available from Hanford Site databases	Potential No-Action
Potential No-Action	2607-E6	Septic tank (active 1953-1997)	Not available from Hanford Site databases	200-ST-1	2607-E6	Not available from Hanford Site databases	Not available from Hanford Site databases	Potential No-Action
Low	216-A-25, Gable Mountain Swamp, 216-A-25 Swamp, Gable Mountain Pond	Pond (active 1958-1987)	PUREX/ URP	200-CW-1	216-A-25	3,732,900 (347,160 m^2)	3-9 ft (0.9-2.7 m)	RTD
Low	216-B-3, B Pond, B-3 Pond, 216-B-3 Main Pond, B Swamp, 216-B-3 Swamp, B Plant Swamp	Pond (active: 1945-1994)	PUREX/ URP	200-CW-1	216-B-3	174,0581 (161,874 m^2)	2-7 ft (edges to center) (0.6 – 2.1 m)	RTD
Low	216-S-10D, 216-S-10D Ditch, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench, Open Ditch to the Chemical Sewer Trench, 216-S-10 Ditch	Ditch (active: 1951-1991)	REDOX	200-CS-1	216-S-10D connected to the 216-S-10P Pond	13,495 (1,255 m^2)	6-10 ft/ 0 ft (1.8 – 3 m)	RTD
Low	216-B-63, B Plant Chemical Sewer, 216-B-63 Trench, 216-B-63 Ditch	Ditch (active 1970- 1992)	Sr/Cs	200-CS-1	216-B-63	5,591 (520 m^2)	9-12 ft (2.7 – 3.7 m)	Barrier (Cap)
Moderate	216-U-10, U Swamp, 216-U-1, 216-U-10 Pond, 231 Swamp	Pond (active: 1944-1985)	PUREX/ URP	200-CW-5	216-U-10	1,305,441 (121,406 m^2)	2-7 ft (0.6-2.1 m)	Barrier (Cap)
High	Dry Waste No. 004C	Burial Ground (1978-present)	Multiple 100 and 200 Area and offsite processes	200-SW-2	218-W-4C	2,500,000 (232,000 m^2)	Active TSD has not been stabilized	Barrier (Cap)

[a]Remediation category based on human health risk, and potential no-action sites will be reviewed and if appropriate selected for characterization.

PUREX = Plutonium-Uranium Extraction (Plant or process). RTD = remove/treat/dispose. URP = Uranium Recovery Process.

REDOX = Reduction-Oxidation (Plant or process). TSD = treatment, storage, and disposal (unit).

Figure 9-3. Map Showing the List of Candidate Waste Sites to be Considered for the Ecological Data Quality Objective Sampling and Analysis Plan.



9.2 GENERAL ASPECTS OF STUDY DESIGN

A general aspect of the study design is that biological activity decreases with depth, and thus the plan is to characterize no more than the first 1.8 m (6 ft) of soil concentrations as a measure of exposure for biota. Based on the decreasing biological activity with depth, representative surface soil samples will be collected from 0 to 15 cm (0 to 6 in.) and deeper if warranted. Subsurface sampling in Phase III may include representative samples from 15 cm to 1.8 m (0.5 to 6 ft). Using the Phase I data, the hypothesis can be tested that there is a correlation between the near-surface soil concentrations and organism concentrations. This comparison would involve exploratory data analysis of soil concentrations from each depth interval and the depth-weighted soil concentrations versus organism concentrations.

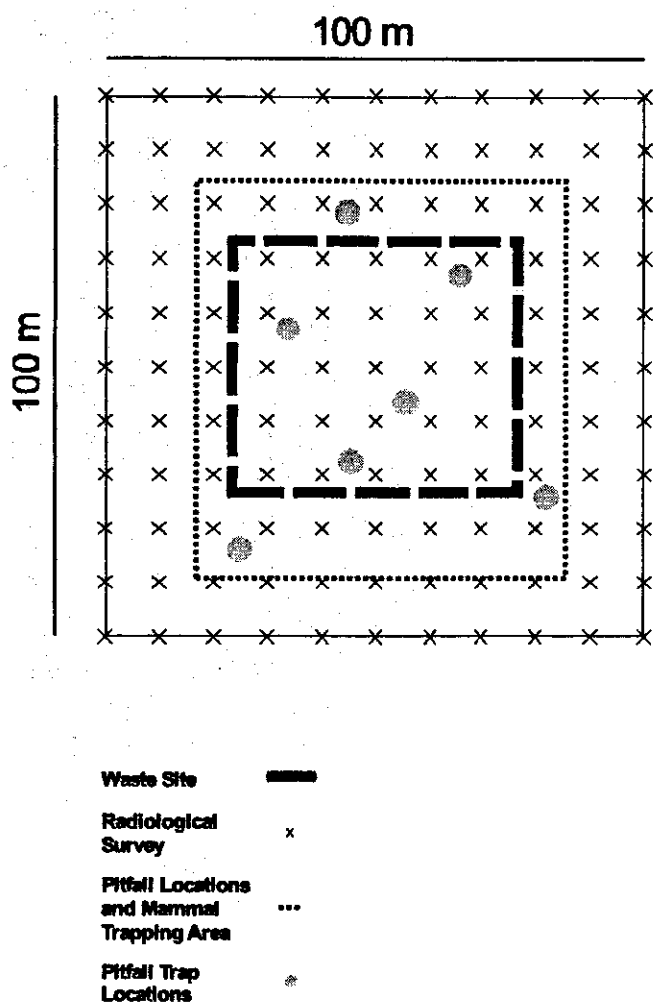
Representative soil concentrations for wildlife measures will be based on collecting multi-increment samples over a 1 ha plot. Collection and analysis of multi-increment samples is appropriate, because the statistical parameter of interest is the mean concentration (Ecology 92-54, *Statistical Guidance for Ecology Site Managers*, pages 28-29) over hectare-size or larger land areas (see Section 8.1). For waste sites that are smaller than 1 ha, sampling will extend into the adjacent habitat. Because animals are mobile, organisms captured from the investigation area may not have been resident in this area. To minimize the chance of capturing transient animals, biota collection will focus on the central portion of the investigation area. Figure 9-4 is a hypothetical schematic illustrating these sampling concepts. The basis for collecting multi-increment samples is that they are more representative of wildlife exposure to individuals and populations (as discussed in Section 8.1). Existing radiological field data will be supplemented (as necessary) with surveys at grid locations for soil and plants and at locations of biological activity (burrowing mammals or ant nests). The target quantitation limits for soil and biota are summarized for the study design COPECs in Table 9-3. The basis for these target quantitation limits is provided in Tables 9-4 to 9-8.

9.3 PHASE I STUDY DESIGN FOR RADIOLOGICAL FIELD DATA COLLECTION

<u>*Overall considerations*</u>: Radiological field data collection for gamma-emitting radionuclides will provide information on the general radioactivity levels across the investigation area and also can help to evaluate biological transport. A 10 m (33-ft) grid will be laid out over the 1 ha investigation area, and soil and plants will be measured at 121 grid points (11 x 11 = 121 points). In addition, locations with biological activity (20 locations with small-mammal burrowing activity and 20 ant nests) will be measured.

Figure 9-4. Schematic Used to Illustrate How Hypothetical Sampling of Waste Sites Smaller than 1 Hectare and Larger than 1 Hectare Might be Implemented.

a. Waste Site Smaller than 1 Hectare (2.47 Acres).



b. Waste Site Larger then 1 Hectare (2.47 Acres).

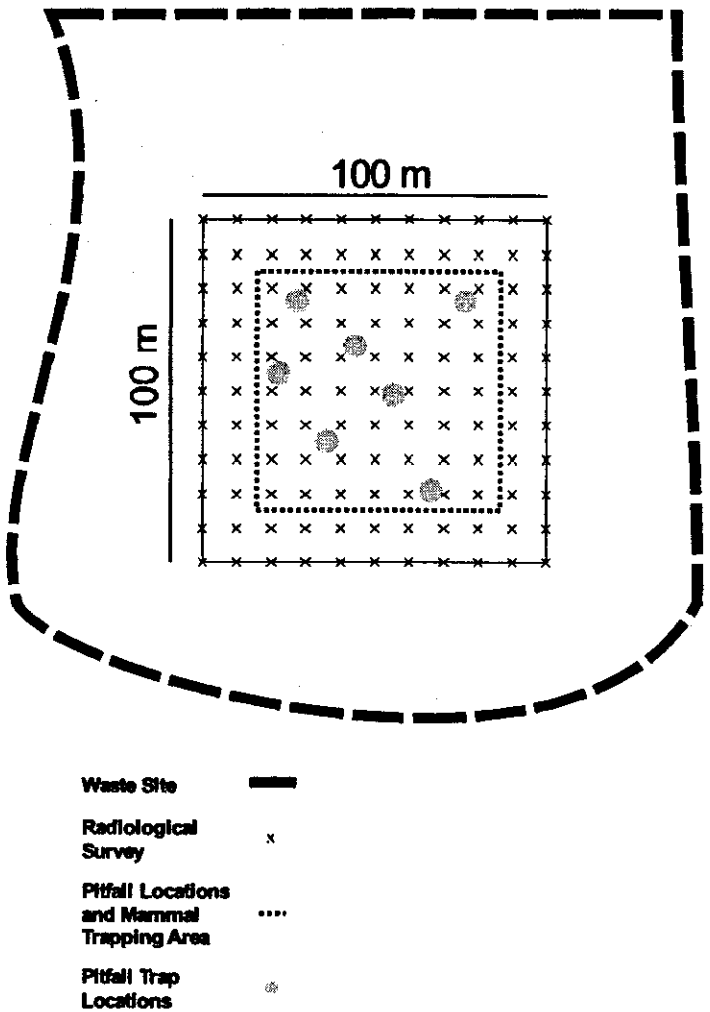


Table 9-3. Synopsis of Target Quantitation Limits for Various Media for Study Design Contaminants of Potential Ecological Concern. (2 Pages)

COPEC or Additional Analytes	Chemical Abstracts Service #	Name/Analytical Technology*	Units	Target Required Quantitation Limits			Precision Soil and Biota	Accuracy Soil and Biota
				Soil	Verte-brates (fresh wt)	Inverte-brates (fresh wt)		
Americium-241	14596-10-2	GEA	pCi/g	3890	15.6	15.6	±30%	70-130[a]
Cobalt-60	10198-40-0	GEA	pCi/g	692	55.4	55.4	±30%	70-130[a]
Cesium-137	10045-97-3	GEA	pCi/g	20.8	2290	2290	±30%	70-130[a]
Plutonium-239/240	Pu-239/240	Plutonium isotopic – AEA	pCi/g	6110	18.3	18.3	±30%	70-130[a]
Radium-226	Ra-226	GEA	pCi/g	50.6	3.0	3.0	±30%	70-130[a]
Radium-228	Ra-228	GEA	pCi/g	43.9	2.6	2.6	±30%	70-130[a]
Strontium-90	Rad-Sr	Total radioactive strontium – GPC	pCi/g	22.5	1710	1710	±30%	70-130[a]
Uranium-238	U-238	Uranium isotopic – AEA (pCi)	pCi/g	1580	5.9	5.9	±30%	70-130[a]
Aroclor-1254	53469-21-9	PCBs – 8082[c]	mg/kg	0.133	0.65	0.2	±30%	70-130[b]
Aroclor-1260	11096-82-5	PCBs – 8082	mg/kg	0.65	19.5	10.2	±30%	70-130[b]
Antimony	7440-36-0	Metals[d]	mg/kg	0.058**	1.27	0.39	±30%	70-130[b]
Arsenic	7440-38-2	Metals[d]	mg/kg	7	2.67	0.83	±30%	70-130[b]
Barium	7440-39-3	Metals[d]	mg/kg	132	668	289	±30%	70-130[b]
Bismuth	7440-69-9	Metals[d]	mg/kg	[e]	[e]	[e]	±30%	70-130[b]
Boron	7440-42-8	Metals[d]	mg/kg	0.5	26.5	13.8	±30%	70-130[b]
Cadmium	7440-43-9	Metals[d]	mg/kg	4	181	95	±30%	70-130[b]
Chromium	7440-47-3	Metals[d]	mg/kg	42	45.4	23.7	±30%	70-130[b]
Copper	7440-50-8	Metals[d]	mg/kg	50	560	293	±30%	70-130[b]
Cyanide	57-12-5	Method 9010B, 9012A, 9013, or 9014	mg/kg	0.31**	0.36	0.19	±30%	70-130[b]
Hexavalent Chromium	18540-29-9	Method 7196A	mg/kg	0.2	N/A	N/A	±30%	70-130[b]
Lead	7439-92-1	Metals[d]	mg/kg	50	102	53.6	±30%	70-130[b]
Mercury	7439-97-6	Metals[d]	mg/kg	0.33	8.18	4.27	±30%	70-130[b]
Molybdenum	7439-98-7	Metals[d]	mg/kg	2	65.4	20.5	±30%	70-130[b]
Nickel	7440-02-0	Metals[d]	mg/kg	30	972	508	±30%	70-130[b]
Selenium	7782-49-2	Metals[d]	mg/kg	0.3	9.09	4.75	±30%	70-130[b]
Silver	7440-22-4	Metals[d]	mg/kg	2	49.4	25.8	±30%	70-130[b]
Thallium	7440-28-0	Metals[d]	mg/kg	0.007**	0.15	0.047	±30%	70-130[b]
Tin	7440-31-5	Metals[d]	mg/kg	13.16**	61.8	32.3	±30%	70-130[b]
Uranium	7440-61-1	Metals[d]	mg/kg	5	129	40.6	±30%	70-130[b]
Vanadium	7440-62-2	Metals[d]	mg/kg	2	10	5.22	±30%	70-130[b]
Zinc	7440-66-6	Metals[d]	mg/kg	86	1190	622	±30%	70-130[b]
Pesticides	N/A	PCBs – 8082	mg/kg	[f]	[f]	[f]	±30%	70-130[b]

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Table 9-3. Synopsis of Target Quantitation Limits for Various Media for Study Design Contaminants of Potential Ecological Concern. (2 Pages)

COPEC or Additional Analytes	Chemical Abstracts Service #	Name/Analytical Technology*	Units	Target Required Quantitation Limits			Precision Soil and Biota	Accuracy Soil and Biota
				Soil	Verte-brates (fresh wt)	Inverte-brates (fresh wt)		

* For 4-digit methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. For Method 200.8, see EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*.

** LANL, 2003, *ECORISK Database*.

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

[b] Accuracy criteria is the minimum for associated batch matrix spike percent recoveries. Laboratories must meet statistically based control if more stringent. 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.

[c] Method also includes Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1262, and Aroclor-1268.

[d] SW-846 Method 6010 or 6020 or EPA Method 200.8 (EPA/600/R-94/111).

[e] No toxicity data on which to base a quantitation limit.

[f] Compound specific.

AEA = alpha energy analysis.
COPEC = contaminant of potential ecological concern.
GEA = gamma energy analysis.
GPC = gas proportional counter.
N/A = not applicable.
PCB = polychlorinated biphenyl.

Table 9-4. Basis for Proposed Radionuclide Target Quantitation Limits in Soil and Biota.

Radionuclide	Terrestrial Animal		
	BCG (pCi/g)	BIV (Concentration in Animal [fresh wt]/ Concentration in Soil)	Concentration in Animal (pCi/g fresh wt)([BCG x BIV)
Am-241	3890	0.004	15.6
Co-60	692	0.08	55.4
Cs-137	20.8	110	2290
Pu-239	6110	0.003	18.3
Ra-226	50.6	0.06	3.04
Ra-228	43.9	0.06	2.63
Sr-90	22.5	75.8	1706
U-238	1580	0.00373	5.89

BCG = biota concentration guideline.
BIV = bioaccumulation factor.

Table 9-5. Basis for Target Quantitation Limits in Killdeer Food (Avian Insectivore Feeding Guild).

Suite	Analyte	TRV (mg-COPEC/ kg-BW/day)	Killdeer Body Weight BW (g) *	Killdeer Food Intake - Fresh Weight I (g/day) **	Proposed Insect Quantitation Limit (mg/kg-fresh wt) (TRV x BW)/I
PCB	Aroclor-1254	0.1	70	14.7	0.47
PCB	Aroclor-1260	2.15	70	14.7	10.2
Metal	Arsenic	5.14	70	14.7	24.4
Metal	Barium	73.5	70	14.7	349
Metal	Boron	2.92	70	14.7	13.8
Metal	Cadmium	20	70	14.7	95
Metal	Chromium	5	70	14.7	23.7
Metal	Copper	61.7	70	14.7	293
Metal	Cyanide	0.04	70	14.7	0.19
Metal	Lead	11.3	70	14.7	53.6
Metal	Mercury	0.9	70	14.7	4.27
Metal	Molybdenum	35.3	70	14.7	167
Metal	Nickel	107	70	14.7	508
Metal	Selenium	1	70	14.7	4.75
Metal	Silver	5.44	70	14.7	25.8
Metal	Tin	6.8	70	14.7	32.3
Metal	Uranium	78	70	14.7	370
Metal	Vanadium	1.1	70	14.7	5.22
Metal	Zinc	131	70	14.7	622

* Purdue and Haines 1977, "Salt Water Tolerance and Water Turnover in the Snowy Plover."

** Allometric relationship for passerines (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*, p. 3-4).

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BW = body weight.
COPEC = contaminant of potential ecological concern.
I = food intake.
PCB = polychlorinated biphenyl.
TRV = toxicity reference value.

Table 9-6. Basis for Target Quantitation Limits in Grasshopper Mouse Food (Mammalian Insectivore Feeding Guild).

Suite	Analyte	TRV (mg-COPEC/kg-BW/day)	Mouse Body Weight BW (g)	Mouse Food Intake - Fresh Weight I (g/day) *	Proposed Insect Quantitation Limit (mg/kg-fresh wt) (TRV x BW)/I
PCB	Aroclor-1254	0.031	26	3.9	0.2
PCB	Aroclor-1260	13.8	26	3.9	91.9
Metal	Antimony	0.06	26	3.9	0.39
Metal	Arsenic	0.126	26	3.9	0.83
Metal	Barium	43.5	26	3.9	289
Metal	Boron	28	26	3.9	186
Metal	Cadmium	15	26	3.9	99.9
Metal	Chromium	35.2	26	3.9	234
Metal	Copper	44	26	3.9	293
Metal	Cyanide	68.7	26	3.9	457
Metal	Lead	20	26	3.9	133
Metal	Mercury	2.86	26	3.9	19
Metal	Molybdenum	3.09	26	3.9	20.5
Metal	Nickel	175.8	26	3.9	1170
Metal	Selenium	0.725	26	3.9	4.83
Metal	Silver	19	26	3.9	126
Metal	Thallium	0.0071	26	3.9	0.047
Metal	Tin	23	26	3.9	153
Metal	Uranium	6.1	26	3.9	40.6
Metal	Vanadium	2.1	26	3.9	13.9
Metal	Zinc	703.3	26	3.9	4680

* Allometric relationship for rodents (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*, p. 3-6).
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BW = body weight.
COPEC = contaminant of potential ecological concern.
I = food intake.
PCB = polychlorinated biphenyl.
TRV = toxicity reference value.

Table 9-7. Basis for Target Quantitation Limits in Red-Tailed Hawk Food (Avian Carnivore Feeding Guild).

Suite	Analyte	TRV (mg-COPEC/kg-BW/day)	Hawk Body Weight BW (kg) *	Hawk Food Intake - Fresh Weight I (kg/day) **	Proposed Mammal Quantitation Limit (mg/kg-fresh wt) (TRV x BW)/I
PCB	Aroclor-1254	0.1	1.2	0.132	0.9
PCB	Aroclor-1260	2.15	1.2	0.132	19.5
Metal	Arsenic	5.14	1.2	0.132	46.7
Metal	Barium	73.5	1.2	0.132	668
Metal	Boron	2.92	1.2	0.132	26.5
Metal	Cadmium	20	1.2	0.132	181
Metal	Chromium	5	1.2	0.132	45.4
Metal	Copper	61.7	1.2	0.132	560
Metal	Cyanide	0.04	1.2	0.132	0.36
Metal	Lead	11.3	1.2	0.132	102
Metal	Mercury	0.9	1.2	0.132	8.18
Metal	Molybdenum	35.3	1.2	0.132	320
Metal	Nickel	107	1.2	0.132	972
Metal	Selenium	1	1.2	0.132	9.09
Metal	Silver	5.44	1.2	0.132	49.4
Metal	Tin	6.8	1.2	0.132	61.8
Metal	Uranium	78	1.2	0.132	709
Metal	Vanadium	1.1	1.2	0.132	10
Metal	Zinc	131	1.2	0.132	1190

* Average of 1224, 1154, and 1235 g from EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*, p. 2-82.
** Adult female in winter (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*, p. 2-82; normalized food intake rate of 0.11 kg/kg/day multiplied by body weight of 1.2 kg).
Aroclor is an expired trademark.
BW = body weight.
I = food intake.
COPEC = contaminant of potential ecological concern.
PCB = polychlorinated biphenyl.
TRV = toxicity reference value.

Table 9-8. Basis for Target Quantitation Limits in Badger Food (Mammalian Carnivore Feeding Guild).

Suite	Analyte	TRV (mg-COPEC/kg-BW/day)	Badger Body Weight BW (kg)	Badger Food Intake - Fresh Weight I (kg/day) *	Proposed Mammal Quantitation Limit (mg/kg-fresh wt) (TRV x BW)/I
PCB	Aroclor-1254	0.031	8.25	0.39	0.65
PCB	Aroclor-1260	13.8	8.25	0.39	292
Metal	Antimony	0.06	8.25	0.39	1.27
Metal	Arsenic	0.126	8.25	0.39	2.67
Metal	Barium	43.5	8.25	0.39	921
Metal	Boron	28	8.25	0.39	593
Metal	Cadmium	15	8.25	0.39	317
Metal	Chromium	35.2	8.25	0.39	745
Metal	Copper	44	8.25	0.39	932
Metal	Cyanide	68.7	8.25	0.39	1450
Metal	Lead	20	8.25	0.39	423
Metal	Mercury	2.86	8.25	0.39	60.6
Metal	Molybdenum	3.09	8.25	0.39	65.4
Metal	Nickel	175.8	8.25	0.39	3720
Metal	Selenium	0.725	8.25	0.39	15.3
Metal	Silver	19	8.25	0.39	402
Metal	Thallium	0.0071	8.25	0.39	0.15
Metal	Tin	23	8.25	0.39	487
Metal	Uranium	6.1	8.25	0.39	129
Metal	Vanadium	2.1	8.25	0.39	44.5
Metal	Zinc	703.3	8.25	0.39	14900

* Allometric relationship for all mammals (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook*, p. 3-6).
Aroclor is an expired trademark.
BW = body weight.
COPEC = contaminant of potential ecological concern.
I = food intake.
PCB = polychlorinated biphenyl.
TRV = toxicity reference value.

9.4 PHASE I STUDY DESIGN FOR PLANT COVER ESTIMATION

Overall considerations: A modified Daubenmire method (Daubenmire 1959, "A Canopy-Coverage Method of Vegetational Analysis") or line transects is proposed to estimate canopy cover of dominant plant species, bare ground, and cryptogam cover. The Daubenmire method typically consists of systematically placing a 20 by 50 cm (7.9- by 19.7-in.) quadrat frame along a tape on permanently located transects. The following vegetation attributes are typically monitored using the Daubenmire method: canopy cover, frequency, and composition by canopy cover. Canopy cover will be visually estimated. It is important that the same investigators collect these data to minimize differences in observer bias.

Methodology: Each investigation area will be divided into 0.25 ha sections. Within each 0.25 ha subarea, 4 to 10 Daubenmire plots will be placed using a systematic sampling array with a random start. Thus, cover information will be recorded at 16 to 40 plots that encompass the entire investigation area. Photographs will be taken at each plot.

9.5 PHASE I STUDY DESIGN FOR SOIL CONCENTRATIONS

Overall considerations: The analytical suites selected for soil contaminant analysis are inclusive of COPECs identified in Table 3-1. The contribution of other radionuclides known to be associated with Hanford Site processes is evaluated in Figures 3-2 and 3-3. Reviewing the sum of the fractions identifies COPECs including Cs-137, Co-60, Sr-90, Pu-239, Ra-226, Am-241, Ra-228, and U-238. Thus, BCGs (Chapter 3.0) will be used as one line of evidence in the assessment of the ecological effects of radionuclides. Radiological doses or other ecological risk evaluations will be calculated based on receptor spatial boundaries (see Section 8.1), using an integrated set that will include new data that supplement existing soil data. The study design also will include pesticides available from EPA Method 8081A (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*) for samples analyzed for PCBs. One of the sites also may be situated near a road with supplemental sampling designed to test the hypothesis that transformer oils (containing PCBs) were used for dust suppression. These data are intended to supplement existing data such as samples collected at waste sites and samples collected in an investigation on the Arc-Loop Roads (PNNL-11651, "Investigation of Potential Polychlorinated Biphenyl (PCB) Contamination on Hanford Site Arc-Loop Roads"). Sampling in PNNL-11651 did not detect PCBs in roadbeds, which suggests that transformer oils were not widely used as dust suppressants.

Analytical suites: The analytical suites include PCBs/pesticides (by Aroclor, EPA Method 8082/8081A in SW-846), metals (including hexavalent chromium and cyanide), and radionuclides. Target quantitation limits for COPECs and additional analytes are listed in Table 9-3.

Sample type: Sample type includes a multi-increment sample collected over 1 ha, collocated with bird/invertebrate/reptile field measurements.

9.6 PHASE I STUDY DESIGN FOR INVERTEBRATE CONCENTRATIONS

Overall considerations: COPEC concentrations in invertebrates are data that are commonly collected to support ERAs (DOE/RL-2002-35, *Evaluation of Risk to Ecological Receptors from DDT at the Horseshoe Landfill*, and Lane et al. 2003, *Sampling and Analysis Instruction for Soil, Vegetation, and Soil Invertebrate Sampling at Gable Mountain Pond, B-Pond, and a 200 West Reference Location*, provide recent examples of sampling design considerations for the Hanford Site; see also Karr and Kimberling 2003, "A Terrestrial Arthropod Index of Biological Integrity for Shrub-Steppe Landscapes"). One of the considerations in sampling invertebrates is whether to separate the collection into taxonomic groups. However, the density of invertebrates at the Hanford Site is not expected to provide sufficient mass for sample analysis by taxonomic groups (Lane et al. 2003; Mitchell et al. 2004, *Soil and Biota Collections at Gable Mountain Pond, B-Pond and Control Site*).

Analytical suites: Analytical suites include PCBs/pesticides (by Aroclor, EPA Method 8082/8081A in SW-846), metals (including cyanide), and radionuclides. Target quantitation limits for COPECs and contaminants of interest are listed in Table 9-3.

Sample type: A composite of invertebrates will be collected in pitfall traps within the 1 ha study plots. Pitfall traps will be located within the inner 7 x 7 m (23 x 23 ft) array to minimize the chance of collecting transient animals and to avoid edge effects. Sorting the samples to order or family levels is not practical and also may cause problems in obtaining sufficient biomass for chemical/radiological analysis.

Sample preparation: Samples will be prepared by homogenizing composites exclusive of external concentrations.

9.7 PHASE I STUDY DESIGN FOR LIZARD CONCENTRATIONS

Overall consideration: The study will collocate lizards with composite soil concentrations within the 1 ha study plots. Lizards will be collected within the inner 7 x 7 m (23 x 23 ft) array to minimize the chance of collecting transient animals and to minimize edge effects. The array will be limited to one habitat type (if at all possible).

Analytical suites: Analytical suites include PCBs/pesticides (by Aroclor; EPA Method 8082/8081A in SW-846), metals (including cyanide), and radionuclides. The target quantitation limits for COPECs and contaminants of interest are listed in Table 9-3. Hexavalent chromium is not a COPEC for wildlife, so concentrations in lizards are not needed.

Sample type: Sample type includes individual animal or tail. Collection of reptile tails is a relatively nonintrusive method to evaluate exposures, and this method has been applied previously to evaluating metal exposure in squamate reptiles (Hopkins et al. 2001, "Nondestructive Indices of Trace Element Exposure in Squamate Reptiles").

Sample preparation: Sample preparation includes homogenizing tissue exclusive of external concentrations.

9.8 PHASE I STUDY DESIGN FOR SMALL MAMMAL CONCENTRATIONS

Overall consideration: Small mammals are collected routinely to evaluate bioaccumulation of COPECs (e.g., Torres and Johnson 2001, "Testing of Metal Bioaccumulation Models with Measured Body Burdens in Mice"). DOE/RL-2002-35 provides a recent example of small-mammal sampling design considerations for the Hanford Site. Animals will be collected within the inner 7 x 7 m (23 x 23 ft) array to minimize the chance of collecting transient animals and to minimize edge effects. The array will be limited to one habitat type (if at all possible).

Analytical suites: Analytical suites include PCBs/pesticides (by Aroclor, EPA Method 8082 / 8081A in SW-846), metals (including cyanide), and radionuclides. Target quantitation limits for COPECs and contaminants of interest are listed in Table 9-3. Hexavalent chromium is not a COPEC for wildlife, so concentrations in mammals are not needed.

Sample type: The sample type is the individual animal.

Sample preparation: Sample preparation includes homogenizing the whole animal exclusive of external concentrations.

9.9 STUDY DESIGN FOR PLANT TOXICITY TEST (TO BE CONSIDERED FOR PHASE III)

Overall considerations: This is a standard toxicity test for soils (Ecology 96-324, *Early Seedling Growth Protocol for Soil Toxicity Screening*). A plant with a readily available and standard seed supply must be selected for the test. For Central Plateau soil, one could select Sandberg's bluegrass (*Poa sanbergii*) for this test. Final selection of a test species will be made in consultation with the toxicity testing laboratory.

Analytical suites: Soil samples submitted for toxicity testing also will be analyzed for standard agricultural parameters (plant nutrients, soil texture, and geochemistry) to help interpret the results of the toxicity test.

Sample type: A large soil sample (roughly 3 L) typically is needed for the test (including five laboratory replicates per sample).

Test endpoints: Test endpoints include emergence count, day 7 post-emergence count, day 7 post-emergence shoot appearance, day 14 post-emergence count, day 14 post-emergence shoot appearance, day 14 post-emergence root appearance, survival, stem height, root length (longest root), shoot mass (wet and dry), root mass (wet and dry), total mass (wet and dry), and total mass (dry) per plant. Differences between test soils, laboratory controls, and reference materials will be evaluated using Dunnett's multiple comparison t-test or the Kruskal-Wallis nonparametric test (depending on whether the data appear to be derived from a normal distribution).

9.10 STUDY DESIGN FOR NEMATODE TEST (TO BE CONSIDERED FOR PHASE III)

Overall considerations: ASTM E2172-01, *Standard Guide for Conducting Laboratory Soil Toxicity Tests with the Nematode Caenorhabditis elegans*, is a standard toxicity test for soils. The test currently is established for only a single species - *Caenorhabditis elegans.*

Analytical suites: Soil samples submitted for toxicity testing also will be analyzed for geochemical parameters (e.g., pH, others suggested in ASTM E2172-01) to help interpret the results of the toxicity tests.

Sample type: Individual field soil samples are needed for each test replicate (a minimum of three [plus laboratory replicates] are required and five replicates are proposed). The soil samples should be checked for the presence/absence of organic material, and the samples must be sieved. Soil samples must be hydrated to a standard level and allowed to equilibrate for 7 days.

Test endpoints: This test measures mortality only, and the test duration is either 24 or 48 hours. This test will be run for 24 hours so that food does not need to be supplied. Differences between test soils, laboratory controls, and reference materials will be evaluated using Dunnett's multiple comparison t-test or the Kruskal-Wallis nonparametric test (depending on whether the data appear to be derived from a normal distribution).

9.11 STUDY DESIGN FOR LITTERBAG DECOMPOSITION TEST (TO BE CONSIDERED FOR PHASE III)

Overall consideration: Toxicant effects on decomposition can be measured in several ways; one of the simplest techniques is the litterbag test, a standard assay for soils (Heath et al. 1964, "Some Methods for Assessing the Activity of Soil Animals in the Breakdown of Leaves," Markwiese et al. 2001, "Toxicity Bioassays for Ecological Risk Assessment in Arid and Semiarid Ecosystems"). Soil properties and microbial activity (one of the key components of the decomposer community) have been shown to vary across an elevational gradient at the Hanford Site (Smith et al. 2002, "Soil Properties and Microbial Activity Across A 500 m Elevation Gradient in A Semi-Arid Environment"). Thus, supporting data on soil properties are recommended to interpret the results of the litterbag tests.

Analytical suites: Soil samples submitted for toxicity testing also will be analyzed for geochemical parameters (e.g., pH) to help interpret the results of the decomposition test.

Methodology: The basic techniques are to enclose preweighed plant litter in a mesh bag, bury it, and after a period of time collect and weigh the bag's contents, comparing the mass loss relative to similarly bagged litter in reference soils (Markwiese et al. 2001). Litterbags of 40 μm mesh size (to exclude invertebrates) are used to assess decomposition from microorganisms only. Preweighed cellulose disks (two disks at 20 x 20 cm [7.9 x 7.9 in.]) will be placed in a bag and at each sampling point; two bags will be placed and covered with several centimeters of soil. Degradation of the cellulose paper disks will be assessed visually by estimating the percentage

disk area remaining after decomposition and by measuring the dry weight of each of the four disks.

Test endpoints: This test measures mass, reduced over time. Differences between test and reference soils will be evaluated using Dunnett's multiple comparison t-test or the Kruskal-Wallis nonparametric test (depending on whether the data appear to be derived from a normal distribution).

9.12 STUDY DESIGN FOR PLANT CONCENTRATIONS (TO BE CONSIDERED FOR PHASE III)

Overall considerations: COPEC concentrations in plants are data that are commonly collected to support ERAs (DOE/RL-2002-35, and Lane et al. 2003, provide recent examples of sampling design considerations for the Hanford Site). One of the considerations in sampling plant tissue is whether to collect and analyze separate samples of root, foliage, and reproductive tissues. One Hanford Site study showed that roots and foliage have similar concentrations of radionuclides (Landeen and Mitchell 1986, "*Radionuclide Uptake By Trees at A Radwaste Pond in Washington State*"). Because some receptors forage on reproductive tissues and others forage on foliage, samples of foliage and reproductive tissues will be collected and analyzed separately. Potential differences between concentrations in the foliage versus the roots will be considered in the uncertainty analysis for this risk assessment.

Analytical suites: Analytical suites will be determined by the DQA of the Phase I/II data.

Sample type: Composite vegetative and reproductive parts are sampled separately.

Sample preparation: Samples will be prepared by homogenizing tissue exclusive of external concentrations.

9.13 STUDY DESIGN FOR SHRUB-STEPPE BIRD (GROUND OR SHRUB NESTING SPECIES) POPULATION SURVEYS (TO BE CONSIDERED FOR PHASE III)

Overall consideration: This data element is subject to field verification to determine if sufficient numbers of nests and eggs can be obtained. Field verification is needed to determine that adequate numbers of nests can be located on the study area (1 ha) and, based on the reported low density of representative birds (less than 1 to 3 birds/ha, see Table 8-1), this may be problematic. Large study areas (36 to 18,000 ha) are common in literature studies of grassland or shrub-steppe birds (Fair et al. 1995, "Effects of Carbaryl Grasshopper Control on Nesting Killdeer in North Dakota"; Martin et al. 2000, "Effects of Two Grasshopper Control Insecticides on Food Resources and Reproductive Success of Two Species of Grassland Songbirds"; Pidgeon et al. 2003, "Landscape-Scale Patterns of Black-Throated Sparrow (*Amphispiza Bilineata*) Abundance and Nest Success"). Thus, an alternative to surveys of shrub-steppe species may have to be considered. One option is to use a nonmigratory species (e.g., starlings).

Survey locations and data collection: The nests of species that primarily forage on invertebrates (e.g., sage sparrow, meadowlark, killdeer) will be marked and revisited to determine the breeding success and the gender ratio of nestlings. Although some investigators have discounted investigator effects on nesting success of arid-zone birds (Lloyd et al. 2000, "Investigator Effects on the Nesting Success of Arid-Zone Birds"), others have suggested that frequent visitation will impact bird counts (Brandt and Rickard 1992, "Effects of Survey Frequency on Bird Density Estimates in the Shrub-Steppe Environment"). Thus, to lessen any impacts, frequency of visits will be based on intervals that minimize disturbance to the adults and nestlings and the proper intervals to determine nest success parameters (roughly 4-7 days). Infertile eggs will be collected from the second clutch (minimum of six per species per study area) for contaminant analysis. Information on eggshell thickness and volume will be recorded.

9.14 STUDY DESIGN FOR EGG CONCENTRATIONS (TO BE CONSIDERED FOR PHASE III)

Overall considerations: COPEC concentrations in eggs are data that are collected to support ERAs (DOE/RL-2002-35 provides recent a example of sampling design considerations for the Hanford Site). Nonviable eggs are selected as a nonintrusive method to assess bioaccumulation and exposure, and the second clutch of migratory species is indicative of local exposures (as opposed to exposures obtained elsewhere during migration). If the second clutch cannot be obtained, then it will be difficult to partition the COPECs measured in eggs to Hanford Site exposures and exposures obtained during migration (see Minh et al. 2002, "Persistent Organochlorine Residues and Their Bioaccumulation Profiles in Resident and Migratory Birds from North Vietnam," for an example of the comparison of migratory and nonmigratory species). Other material such as feathers can be analyzed for contaminants, but similar problems occur for migratory species, because concentrations in feathers reflect blood concentrations at the time of feather formation (Burger and Gochfeld 1995, "Biomonitoring of Heavy Metals in the Pacific Basin Using Avian Feathers") and thus may not reflect Hanford Site exposures. For these reasons, many studies use nonmigratory species (e.g., Gragnaniello et al. 2001, "Sparrows as Possible Heavy-Metal Biomonitors of Polluted Environments"; Chao et al. 2003, "Metal Contamination in Tree Sparrows in Different Locations of Beijing").

Analytical suites: Analytical suites will be determined by the DQA of the Phase I/II data.

Sample type: Sample type will be egg contents without the shell, except if Sr-90 results are needed; then the eggshell will be analyzed.

Sample preparation: Sample preparation will include homogenizing egg contents or eggshell.

9.15 STUDY DESIGN FOR LIZARD POPULATION SURVEYS (TO BE CONSIDERED FOR PHASE III)

Overall considerations: Lizard population surveys routinely are used in ecological studies. But these data are not routinely collected for ERAs, and field verification of the proposed measures

for Hanford Site conditions is important. Based on the reported density of side-blotched lizards from the literature (see Table 8-1), field measures of abundance should be feasible within the 1 ha study plots.

Survey locations and data collection: Marking and re-observation will be performed to determine abundance. Weight and snout-vent length will be determined for animals as they are collected. Information on deformities will be recorded, and samples (tails or adult) will be collected after the animal is documented to have been residence on the study plot.

9.16 STUDY DESIGN FOR SMALL MAMMAL TRAPPING (TO BE CONSIDERED FOR PHASE III)

Overall considerations: Small mammal population studies are commonly used to support ERAs. Capturing individuals in all reproductive classes (juvenile males, nonscrotal males, scrotal males, juvenile females, adult females, pregnant females, lactating females) provides an indication that the population is recruiting new individuals at the site. This information also can be used to evaluate gender ratios, and mark-recapture provides information on animal abundance.

Survey locations and data collection: Small mammals will be trapped within the inner 70 x 70 m portion of the study plot to avoid edge effects. The inner 7 x 7 m array (at 10 m spacing) will be trapped to minimize the chance of collecting transient animals and to minimize edge effects. Trapping arrays will be limited to one habitat type (if at all possible). Trapping will be conducted over 4-5 nights, and the separate trapping events will occur in a 2-4 week interval to document animals resident on the trapping array. Animals captured will be marked with ear tags or equivalent (the pocket mouse has small ears, so alternate marking is needed). Information will be recorded on deformities, and animals will be collected (minimum of 6 per species per set of arrays) for contaminant analysis.

9.17 FIELD RECONNAISSANCE/VERIFICATION

Overall considerations: Field reconnaissance/verification will support all field measures proposed in the study design and will provide a basis for documenting inclusion/exclusion of waste sites selected as ecological study plots and appropriate reference sites.

9.18 LITERATURE REVIEWS

Overall considerations: Literature reviews of relevant ecological data published in the peer reviewed or other literature is useful for putting the results from these proposed studies into context. Literature that provides overall trends for biota in the shrub steppe (e.g., Knick et al. 2003, "Teetering on the Edge or Too Late? Conservation and Research Issues for Avifauna of Sagebrush Habitats"), as well as published studies regarding field measurements of adverse effects for Central Plateau COPECs (e.g., PCB studies in birds by Henning et al. 1997, "Assessment of Effects of PCB-Contaminated Floodplain Soils on Reproductive Success of Insectivorous Songbirds"; Custer et al. 2003, "Exposure and Effects of Chemical

Contaminants on Tree Swallows Nesting Along the Housatonic River, Berkshire County, Massachusetts, USA, 1998-2000") also are useful. However, the studies that provide the most utility and context are those that deal with waste sites (e.g., DOE/RL-2002-35, Mitchell et al. 2004) or annual environmental surveillance reports and other special studies (e.g., Kimberling et al. 2001, "Measuring Human Disturbance Using Terrestrial Invertebrates in the Shrub-Steppe Of Eastern Washington (USA),"; Kimberling and Karr 2002, *A New Approach to Assessing Ecological Health: Developing an Index of Biological Integrity with Insects at Hanford*).

9.19 EXPOSURE MODELING

Overall considerations: Exposure models will be based on site-specific exposure parameters and literature toxicity data. If site-specific exposure data are not available, than data collected in the shrub-steppe will be used. Other exposure data also will be considered as appropriate. Toxicity data will be based on the specific COPECs or on a reasonable surrogate. Where possible, the 95 percent upper confidence limit of the mean will be used, and other statistics may be considered as part of the uncertainty analysis. Spatial averages will be based on appropriate spatial scale for individuals and populations (see Section 8.1).

Data will be evaluated for statistically increased tissue concentrations versus soil concentrations (i.e., transfer factors or more complex bioaccumulation models). Contaminant transfer or bioaccumulation factors are an empirical ratio of contaminants in soil to contaminants in biota, which are used in exposure modeling. Adverse effects are inferred by the ratio of exposure to effects levels (TRVs). It is assumed that the dose received orally for terrestrial wildlife can be described mathematically as:

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

where

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

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

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

TF_{food} is a transfer factor from soil to food (mg/kg food dry weight per mg/kg soil 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 above 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 the same as that used in WAC 173-340-900, Table 749-4, for evaluation of the ecological effects of contaminants on terrestrial wildlife (WAC 173-340-7492). Food ingestion rates and home

ranges for Central Plateau receptors are provided in this document (Tables 8-1; 9-4 to 9-8). Avian and mammalian TRVs for the COPECs being evaluated also are provided in this document. Soil ingestion values will be obtained from the literature for the receptors considered in the Central Plateau or from appropriate surrogate receptors (Beyer et al. 1994, "Estimates of Soil Ingestion by Wildlife"). 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*, Rev. 2 and will be adopted for evaluating uncertainty in this Central Plateau EcoDQO.

10.0 SCIENTIFIC MANAGEMENT DECISION POINT FOR STUDY DESIGN / DATA QUALITY OBJECTIVES

In this document, the study design step of an ERA has been described. Study design represents a synopsis of the information (measures) considered to evaluate whether there are effects of COPECs on the AEs defined in problem formulation. Ultimately, these information needs are satisfied through a SAP that will be developed based on this study design. Concerns over the study design and DQOs (Chapters 7.0 through 9.0) will be addressed before this document is completed and the SAP is drafted.

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APPENDIX A

PARTICIPANT ISSUES AND RESOLUTION

Includes:

December 12, 2003, Participant Interview Issues Matrix

January 29, 2004, Central Plateau EcoDQO Workshop Comments

March 30, 2004, Central Plateau EcoDQO Workshop Comments

May 26-27, 2004, Central Plateau EcoDQO Workshop Comments

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TERMS

ALAD	delta-aminolevulinate acid dehydratase
ARAR	applicable or relevant and appropriate requirement
BCG	biota concentration guide (see DOE-STD-1153-2002)
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DOE	U.S. Department of Energy
DQO	data quality objective
EcoDQO	ecological data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERAGS	ecological risk assessment guidance for Superfund (EPA/540/R-97/006)
ERC	Environmental Restoration Contractor
HAB	Hanford Advisory Board
HEIS	*Hanford Environmental Information System* database
HNRTC	Hanford Natural Resource Trustee Council
IAMIT	Interagency Management Integration Team
LOAEL	lowest observed adverse-effect level
NEPA	*National Environmental Policy Act of 1969*
NOAEL	no observed adverse-effect level

NRDA	natural-resource damage assessment
OU	operable unit
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision
SAP	sampling and analysis plan (DOE/RL-2004-42)
SEPA	State Environmental Policy Act (RCW 43.21C)
SSV	soil screening value
T/E	threatened and (or) endangered
TBC	to be considered
TCE	trichloroethylene
TPH	total petroleum hydrocarbon
TPH-K	total petroleum hydrocarbon-kerosene
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State. Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989a)
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WAC	*Washington Administrative Code*

APPENDIX A

PARTICIPANT ISSUES AND RESOLUTION

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#	Interview Issues	Accept?	Comment Resolution
DQO PROCESS			
1	Provide an open and transparent ecological risk assessment process.	Y	The DQO for this project is based on an open forum for interested HAB and Trustee participants as discussed in the interviews and as shown in the project schedule.
2	The risk assessment should provide the schedule and an organization chart, showing the participants (particularly the experts supporting this evaluation).	Y	These will be addressed in the DQO.
3	Discussions are needed in workshops to achieve agreement regarding sensitive issues. The process will not minimize project scope and purpose.	Y	The DQO process provides for issues discussion with public participants and decision makers before the DQO workshops. The workshops allow for discussion of sensitive issues. The DQO facilitator will forward unresolved issues to the Tri-Party Agency decision makers for resolution.
4	Project needs a large circle for issue resolution outside of the Tri-Party Agreement agency decision-makers.	N	Decision makers have established the issues resolution process as presented in the resolution to Issue #3. If issues are not resolved, public comments would be resolved in RI/FS documents that include OU-specific ecological risk assessments.
5	Provide an overview of the risk assessments that pertain to the Hanford Site and their relationships with the Central Plateau. Include a time-line for completion.	N	Agree that this is needed. This issue has been forwarded to the IAMIT Risk Assessment Group for resolution. The introduction portion of the DQO summary report will identify the relationships of this project with other Hanford Site risk assessment projects. The SAP that follows this DQO will include a risk assessment timeline. Note that because this issue was raised on several projects and in several forums, the Tri-Parties agreed to develop a Hanford Site-wide risk assessment integration document (DOE/RL-2005-37) that would address the concerns in a more comprehensive manner than is possible in individual documents. This is also discussed in Section 1.1 of this summary report.
6	Use a team approach with USFWS for setting standards.	N	Although USFWS has been invited to participate in the DQO process, the Tri-Party Agreement agencies remain as the decision makers. USFWS will have opportunities to influence the decision-making process.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
7	DQO Process			
	a.	For COCs without known toxicity impacts, develop toxicity reference values and potential uncertainties (different genus, life stage, mixtures of COCs).	-	The DQO follows the EPA guidance for an ecological risk assessment, which includes the steps of uncertainty analysis, risk characterization, and risk management. The importance of unknown toxicity reference values will be evaluated during the uncertainty analysis. The DQO will identify those uncertainties during risk characterization. The Tri-Parties will deal with important uncertainties during the risk management activity. Possible approaches to risk management include changes in remedial approaches and development of needed toxicity reference values.
	b.	Integrate 8-step EPA risk assessment methodology with new WAC 173-340-7490 ecological evaluation procedures and include site-specific sampling.	Y	This project will follow EPA's 8-step ecological risk assessment guidance (EPA/540/R-97/006) process as agreed to by the Tri-Party Agency decision makers. The WAC 173-340-7490 ecological evaluation provisions will be integrated with the EPA 8-Step process.
	c.	Define ecological assessment and measurement endpoints.	Y	Assessment and measurement endpoints are defined in the problem formulation (Step 3).
	d.	Establish an independent team of risk assessment experts capitalizing on expertise from the U.S. Geological Survey).	-	The U.S. Geological Survey is being used on this project. Ecology and EPA are considering a variety of non-Hanford Site independent review experts.
	e.	Commit to, and conduct, a comprehensive ecological risk assessment baseline before remedial actions.	Y	It is expected that the terrestrial ecological risk assessment will be completed before most of the remedial actions on the Central Plateau are implemented. A couple of accelerated actions at high-risk waste sites (notably U Plant and 200 Area BC Cribs and Trenches), will be completed by 2006. Nevertheless, these accelerated actions will be protective of the ecosystem because the installed barriers are designed to break the exposure pathways to the ecological receptors.
8	Use a holistic evaluation process.		Y	The process is comprehensive. It is based on the 8-step EPA ecological risk assessment process and relies on screening to focus attention on the major risk drivers and areas with uncertainties. Three spatial scales included in this DQO include waste sites, habitat, and species. Ecology regulates tank farms separately from CERCLA under WAC 173-303 and WAC 173-340 (corrective action). CERCLA and the WAC require protection of human health and the environment. If ecological impacts from tank farms show up at one of the three spatial scales, they would be addressed by the appropriate regulatory authority.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
PROJECT SCOPE				
9		The DQO should define the scope of the risk assessment. It should cover all of the OUs and explain why the scope of the study is Central Plateau-wide.	Y	The scope of this DQO will be well defined in the introduction. In addition to stating what is in the scope, the DQO also will document what is not in scope
10		Scope of investigation		
	a.	Scope should not be limited to terrestrial evaluation, but should address long-term groundwater and river impacts.	N	Agree that long-term groundwater and river impacts must be addressed, but not in this DQO. The scope of this project is limited to the Central Plateau terrestrial ecology. *The groundwater is being addressed by the groundwater project under the DOE Assistant Manager for the Central Plateau. The River Corridor Baseline Risk Assessment will evaluate current river impacts from groundwater.* Refer also to the response to Issue #5. This issue has been forwarded to the IAMIT Risk Assessment Group for resolution.
	b.	Ecological data should be collected to support Trustee NRDA risk assessment.	-	The scope of this DQO is to identify additional ecological data needs to support remedial action decision making. The additional ecological data collected to support remedy decision making may be used to support the DOE NRDA process. Requests to collect data that are outside of this scope would be considered on a case-by-case basis.
	c.	Scope discussion in DQO Summary Report needs to address the linkage to groundwater and other matrix issues beyond the commitment in Issue #5.	Y	Scope discussion must address matrix issues 18, 19, 20, 23, 33b (for point sources in Gable Mountain).
11		Recreational scenario (camping; include children, recreational worker, and unique child dose response)	N	A recreational scenario will be considered for sites outside the Core Zone for human health, but not within the Core Zone. The scope of this project does not include human health. Human health is addressed through RI/FS documents on an OU basis.
12		Should zones outside of the 200 East and 200 West Areas be unrestricted?	-	Ecological exposure will assume that existing land use will continue as documented in DOE/EIS-0222-F. The DOE is evaluating a range of exposure scenarios for human health.
13		Need to prove that remedial actions have been protective: • Biological samples should be collected pre- and post-cleanup • In some instances, some minimum level of long-term biological monitoring should be instituted.	Y	This DQO is focused on supporting pre-remediation decision making. Some additional ecological sampling will be performed. If post-remediation data needs are identified (including long-term bio-monitoring), they will be documented. Post-remediation data will be assessed in a separate DQO process.
14		Areas of ecological concern: • Formerly just the zone between the 200 East and 200 West Areas • Now inside the 200 East and 200 West Areas also is a concern to EPA and Ecology.	Y	The Central Plateau habitat will be evaluated. These areas will be identified as different ecological units and will be addressed accordingly.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#	Interview Issues	Accept?	Comment Resolution
15	Protect high-quality habitat outside of waste sites for rare, threatened, and endangered species. Also because fire reduced best sagebrush habitat. RL is looking at space between 200 East and 200 West Areas as an expansion area, but this is some of the best sagebrush habitat onsite.	Y	Federal and state regulations for protecting threatened and endangered species will be evaluated through the ARAR process. In addition, DOE/RL-96-32 describes how biological resources will be managed on-site. It identifies level 2, 3, and 4 habitats and recommends monitoring for status, impact assessment, and appropriate mitigation through avoidance and minimization. Protecting high-quality habitat will be a priority.
16	How critical is habitat to the north (Gable and B Pond) for rare, threatened, and endangered species?	Y	The DQO will evaluate the significance of this habitat.
17	Want to know what needs to be done in 200 BC Control Area in the interim, protection against further spread, and planned actions.	N	The CERCLA process is being used to evaluate remedial action alternatives in the 200 BC Controlled Area. The cribs and trenches were stabilized after animal intrusion in the 1960s and again in the early 1980s and continue to be monitored. Based on recurring flyovers and other investigations, there is no indication that the contamination in the 200 BC Controlled Area has been moving, but radioactive contamination levels have decreased through radiological decay. The interest in additional information will be forwarded to the BC Cribs and Trenches Project Team.
18	Workshop subjects; be explicit about the sources of fill material for barriers and devaluation of borrow areas (value trade-offs). Identify areas for borrow as low-value, high-value habitat.	N	This is a feasibility study (and NEPA/SEPA) issue that is beyond the scope of this DQO.
19	Size and run-off from barriers; barrier options and how they affect species.	N	This is a feasibility study issue that is beyond the scope of this DQO.
20	Is this scope tied to a regional closure plan, or waste site by waste site?	N	The scope of this DQO is not linked to a regional closure plan, but is being performed in support of the RI/FS process. The scope of this DQO is to determine data requirements needed to support remedial decision making.
21	200 BC Cribs and Trenches and BC Controlled Area have severe direct impact on Eco system.	-	Remediation plans for the 200 Area BC Cribs and Trenches and BC Controlled Area are being developed as an accelerated closure measure under DOE/RL-2002-47. Ecological impact in these areas will be evaluated as part of the accelerated clean-up efforts. The high significance attached to the 200 East Area BC Cribs and Trenches and BC Controlled Area will be considered in this DQO.
22	Maintain or establish habitat for re-introduction of historically present species of concern that are currently absent from the Hanford Site: Sage grouse and Pygmy rabbit.	-	This DQO will evaluate contamination impacts on habitat quality with the goal of promoting biodiversity.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
23		Is habitat value considered in lands identified for new institutional use?	N	Habitat value is part of what is evaluated in the ecological risk assessment process. However, considering lands for institutional use is outside the scope of this DQO. This DQO will not include evaluating data collection needs for "lands identified for new institutional use."
24		What endpoint is expected to be reached? The project should not only be fixing waste sites. There is a need to understand the process as a whole.	-	The scale of this DQO should support a holistic evaluation of the process.
25		Should less money be focused on waste sites and more on improving habitat?	N	These goals are not mutually exclusive. Habitat restoration and risk reduction are primary goals of cleanup.
26		Should this DQO scope include measurement of invasive species in-growth?	Y	Information on the invasive species in-growth as a result of CERCLA actions will be evaluated in the DQO. This may be an important aspect of the long-term health of the ecosystem, and may be considered in long-term monitoring. Management goals are considered in determining assessment endpoints.
NATIVE AMERICAN CONCERNS				
27		Incorporation of evaluation of resources protected by the *Treaty with the Walla Walla, Cayuse and Umatilla 1855* (protectiveness for Native American use and Treaty rights).	-	The Tri-Parties are committed to facilitating consultation and tribal participation as the Tri-Parties determine and evaluate the identified ecological issues associated with CERCLA remedial action decision making. The Tri-Parties have received some information relating to issues a, f, h, i, and j and discussions will continue regarding these issues.
	a.	Need for Native American Treaty Exposure Scenarios	-	Please provide more information on issues b, c, d, e, and g. The Tri-Parties need significantly more information on these issues to fulfill responsibilities for these resources. The Tri-Parties will continue to seek additional input.
	b.	Herb sites		
	c.	Vegetation – food		
	d.	Vegetation –medicine		
	e.	Culturally sensitive areas		
	f.	Long-term effect of radionuclides on Native American lifestyle		
	g.	Evaluate treaty-protected species		
	h.	Native American use categories		
	i.	Protection of Human Health and Ecological receptors now and for future generations		
	j.	Buffer zones are a concern. The zone distinctions may go away and become accessible to Native Americans.		
28		Past treatment of Native Americans and trust issues.	-	The project recognizes that this is a long-standing issue with the Tribal Nations. The Tri-Parties are committed to coordinating with the Tribal Nations, and RL will be diligent in fulfilling its federal trust obligations.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
29		Yakama Nation wants involvement with this study and its development through tribal council involvement.	Y	Appropriate communication will be maintained in accordance with Section 10.10 of the *Tri-Party Agreement Action Plan* (Ecology et al. 1989b), including staff-to-staff communication. RL will try to arrange a briefing for the Yakama Nation Tribal Council, or other briefings as appropriate. Communication with Yakama Nation participants on the Natural Resources Trustee Council also will be maintained.
30		CTUIR wants more involvement in revegetation and restoration process.	-	CTUIR participation is through the Ecological Resources Working Group and the HNRTC representatives. Continued participation is welcomed.
31		Threatened culture.	-	The project understands that this is a long-standing issue with the Tribal Nations and that the Tri-Parties' determinations and evaluations concerning the ecological issues associated with the Central Plateau may impact Tribal Nations' cultures. The Tri-Parties will continue to facilitate consultation and tribal participation as the Tri-Parties evaluate the identified ecological issues associated with CERCLA remedial action decision making. Additional information will be sought so that the agencies can better fulfill responsibilities for resources that support cultural and traditional lifeways.
32		An internal effort is under way to develop a Nez Perce Native American exposure scenario to express policy for the Tribe.	Y	The Tri-Parties have, in the past, requested such input. The project appreciates the Nez Perce Tribe's effort and looks forward to receiving their exposure scenario once it has been completed.
PROJECT ASSUMPTIONS				
33		Assumptions		
	a.	Clearly define the Central Plateau.	Y	This project will clearly define the geographical and representative sampling boundaries of the Central Plateau as it applies to this DQO. Areas that are excluded from the study also will be identified.
	b.	Riparian zone in Central Plateau? A process is needed to eliminate the riparian zone or it becomes a sensitive area.	N	Riparian zones exist along the river. Because the Central Plateau is remote from the Columbia River, it does not include riparian zones. The Powerhouse Ditch and West Lake are wetlands and will be treated accordingly.
	c.	Define the boundary of the assessment and address the entire area within boundary including portions not remediated.	Y	The study area will be based on an ecosystem perspective.
	d.	Describe the ecosystem (or sub-area) boundary.	Y	The project will define the ecosystem including the use of sub-areas.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
	e.	Define groundwater use.	Y	Groundwater use will be clearly defined in terms of exposure pathways to ecological receptors on the Central Plateau.
	f.	Constrain the project to credible events.	Y	This DQO will only consider credible events.
	g.	Evaluate certain sites/areas in ecological risk evaluation: • Liquid waste discharge sites • Leaks along pipelines • Burial ground wastes • "Hot spots" (site should be characterized).	Y	These types of waste sites fit the 200 Area National Priorities List (40 CFR 300, Appendix B) definition in Appendix C of the Tri-Party Agreement and will be evaluated in this project.
	h.	Residual contamination; unused areas (airborne deposits).	Y	This DQO will consider the need to evaluate contamination outside of identified waste sites.
	i.	Overland flows from operational upsets.	Y	Waste sites have been defined based on records of spills, leaks, and soil percolation and are being addressed through the RI/FS process.
	j.	Scope of the project should include pre-contamination, pre-remediation, and post-remediation ecological conditions.	Y	This DQO is focused on supporting pre-remediation decision making. The need for pre-contamination ecological conditions will be evaluated. If post-remediation data needs are identified (including long-term bio-monitoring), they will be documented.
TECHNICAL ISSUES				
34		Global Issues		
	a.	There are concerns over the ability of any agency to effectively plan and control industrial cleanup with long-term stewardship and institutional controls.	-	This issue is beyond the scope of this DQO. Each CERCLA ROD is expected to arrive at a set of institutional controls that would ensure the long-term effectiveness of remedy in the OU or National Priorities List (40 CFR 300, Appendix B). Information collected by this project will be used by the Hanford Long-Term Stewardship Program (DOE/RL-2003-39; HNF-12254). The point of contact is James L. Daily.
	b.	95% UCL not adequate for Native American scenario.	N	The UCL of the mean is the statistical parameter of interest for closeout of waste sites in accordance with EPA and Ecology guidance.
	d.	EPA "hot spot" size not appropriate for Native American uses.		
	c.	Legal recourse for natural resource damages through NRDA.	N	Legal recourse issues are beyond the scope of this DQO.
35		Gather site-specific data to determine cleanup levels protective of eco-receptors.	-	The DQO will use a site-specific weight of evidence and/or credible worst-case analysis as appropriate to determine if the COPEC action levels are protective of ecological receptors.
36		Cleanup to protect the environment via individual standards in the Core Zone using an exposure scenario task force.		
37		The DOE should verify protectiveness of the 0.1 rad/day and 1.0 rad/day exposure rate as "safe levels of radiation exposure for biota."	-	The DOE Technical Standard for Biota Dose Assessment (DOE-STD-1153-2002) is used as a screening level to assess protectiveness at the species

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#	Interview Issues	Accept?	Comment Resolution
			level. This screening test is one of several approaches used in a "weight-of-evidence" evaluation of ecological risk. DOE-STD-1153-2002 will not be used to screen for protectiveness for listed and candidate State and Federal threatened and endangered species. Those are protected (listed species) or evaluated (candidate species) at the individual level.
38[1]	Data gaps in DOE/RL-2001-54 must be addressed in the DQO.		--
	a. More information is required for new-to-science species for an informed decision regarding their need for protection.	Y	New-to-science species associated with the Central Plateau will be considered in this DQO. The information obtained in this DQO may support the process of designating species for protection. NOTE: The designation of protected species is outside of CERCLA.
39	The 100-N Area risk assessment is starting. Most of the focus should be on the River Corridor. There will be an Eco risk assessment for the Corridor. The Central Plateau terrestrial eco risk assessment is diverting attention from the Corridor Assessment.	N	This has been forwarded to the IAMIT Risk Assessment Group for resolution. Risk assessment in the River Corridor and the Central Plateau must proceed with proper attention to both efforts.
ERAGS STEP 3: PROBLEM FORMULATION			
REFINEMENT OF PRELIMINARY CONTAMINANTS OF CONCERN			
40	For ecological protectiveness, use site-specific cleanup criteria for COC elimination, not only WAC 173-340-900 tables.	Y	The DQO will use a site-specific weight of evidence and/or credible worst-case analysis as appropriate to determine if the COPEC action levels are protective of ecological receptors.
41	Regarding radionuclides, clarify that toxicity data are not radionuclide-specific when expressed as dose limits (e.g., 1 rad/d). These dose limits can, however, be translated into radionuclide-specific concentrations (e.g., pCi/L or pCi/g) for a defined exposure scenario, e.g., BCGs (DOE-STD-1153-2002).	Y	This clarification will be provided in the DQO.
42	COPECs lacking toxicity data are not necessarily less toxic than COPECs having toxicity data. This should be handled as an uncertainty.	Y	These will be identified as uncertainties.
43	WAC 173-340-7490 ecological procedures may not include all contaminants.	Y	A master list of potential contaminants is initially compiled from the COPCs within the OUs in the Central Plateau. These then are screened based on the following exclusion criteria:
44	Investigate pesticides, organic/petroleum COCs from support facilities.	Y	

[1]Issue #38 is repeated throughout this matrix table because numerous data gaps were identified in DOE/RL-2001-54 that span a range of topics in the matrix.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
45		Applicability of WAC 173-340-900, Table 749-3 for use in retaining analytes as ecological indicator contaminants.	Y	• Short-lived radionuclides with half-lives less than 3 years • Radionuclides that constitute less than 1% of the fission product inventory and for which historical sampling indicates nondetection • Naturally occurring isotopes that were not created as a result of Hanford Site operations • Constituents with atomic mass numbers greater than 242 that represent less than 1% of the actinide activities • Constituents that would be neutralized and/or decomposed by facility processes • Chemicals in a gaseous state that cannot accumulate in soil media • Chemicals used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to the waste streams except in incidental quantities • Chemicals that are not persistent in the environment because of volatilization, biological degradation or other natural mitigating features • Chemicals that are not persistent in the vadose zone • Constituent concentrations below Hanford Site background • Constituents with calculated reasonable maximum exposure concentrations less than the ecological indicator soil concentrations from WAC 173-340-900, Table 749-3 • If no background concentration or WAC 173-340-900, Table 749-3 value is available for a contaminant that was detected, then the contaminant is eliminated if the calculated reasonable maximum exposure concentration is significantly below a
46		Determine full range of COCs. Existing references may not address all COPCs:	Y	
	a.	Lead	Y	
	b.	Hexavalent chromium	Y	
	c.	Mercury	Y	
	d.	Thorium/thorium oxide	Y	
	e.	U-232, U-233	Y	
	f.	Cadmium	Y	
	g.	Zinc	Y	
	h.	Barium	Y	
	i.	Arsenic	Y	
	j.	PCBs	Y	
	k.	Persistent chlorinated materials formerly used as pesticides	Y	
	l.	Herbicides	Y	
	m.	Rodenticides	Y	
	n.	Fungicides	Y	
	o.	Full suite of reactor isotopes from fuel and tritium target activities	Y	
	p.	The description of excluded COPECs has limitations that should be noted (e.g., high-volatility COPECs may be acutely toxic via inhalation, rapidly degraded COPECs may generate toxic transformation products, low bioaccumulation potential COPECs may be mobile [water soluble] which may increase their distribution and exposure potential, and low bioavailability COPECs may become more bioavailable if environmental conditions change [chemical/physical factors])	Y	
	q.	TCE	Y	
	r.	4-Dinitrophenol	Y	

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
46 cnt	s.	Pentachlorophenol.	Y	Table 749-3 value for a surrogate contaminant (e.g., at Gable Mountain Pond, bis(2-ethylhexyl) phthalate was detected one time out of 42 samples at a concentration of 3.30E-02 mg/kg. Table 749-3 does not have a value for this constituent; however, the Table 749-3 value for a surrogate contaminant, di-n-butyl phthalate, for plants is 200 mg/kg. This value is many orders of magnitude higher than the bis(2-ethylhexyl) phthalate concentration and provides a relative indication of the potential impact associated with the contaminant). If the concentration is similar to the surrogate concentration, then the contaminant will be retained for further evaluation • If no WAC 173-340-900, Table 749-3 value is available for wildlife exposure for a detected contaminant, then that contaminant will be eliminated for areas designated for industrial land use.
47		List known toxicity impacts/mechanisms/effects of COCs to ecological receptors.	Y	Known toxic impacts/mechanisms/effects of COCs will be evaluated in the DQO. A toxicity evaluation is performed twice during EPA's ERA process. Some of this work was performed in DOE-RL-2001-54. It is evaluated again during the problem formulation stage of the baseline ERA.
LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS				
48		Provide a value scale to evaluate deep roots and wide leaves for plants that are valued.	Y	This DQO will consider these exposure pathways. The needed information will be obtained from literature searches.
49		How long must monitoring be performed to determine the health of a system?	-	The answer to this question is not known. Data collection will help understand ecosystem health.
38[2]		Data gaps in DOE/RL-2001-54 must be addressed in DQO.		--
	b.	Little information is available on persistent chemicals, other than radionuclides, in the environment.	Y	This DQO will consider data needs for persistent chemicals.
	c.	Ecotoxicological data (NOAELs and LOAELs) may not be current.	Y	This is a literature search that will be performed in the follow-on ecological risk assessment.

[2]Issue #38 is repeated throughout this matrix table because numerous data gaps were identified in DOE/RL-2001-54 that span a range of topics in the matrix.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#		Interview Issues	Accept?	Comment Resolution
	d.	Some chemicals lack toxicity data. Toxicity studies are single-species toxicity tests.	Y	The DQO follows the EPA guidance for an ecological risk assessment, which includes the steps of uncertainty analysis, risk characterization, and risk management. The importance of unknown toxicity reference values will be evaluated during the uncertainty analysis. The DQO will identify those uncertainties during risk characterization. The Tri-Parties will deal with important uncertainties during the risk management activity. Possible approaches to risk management include changes in remedial approaches and development of needed toxicity reference values.
	e.	Life history information for site-specific species is needed for exposure parameters (food ingestion rate, soil ingestion rate, home range, body weight) and an understanding of how this information relates to the waste areas is important.	Y	Available life history information will be integrated.
CONTAMINANT FATE AND TRANSPORT, ECOSYSTEMS POTENTIALLY AT RISK, AND COMPLETE EXPOSURE PATHWAYS				
50		Use shrub/steppe habitat assessment for uplands.	Y	Terrestrial ecological exposure scenarios will be based on waste site and adjacent native upland habitat types and species.
51		Evaluate pathways for contamination to biota, including surface water ponding as a source of animal drinking water.	Y	All pathways will be evaluated in the DQO.
52		Address potential exposure pathways to ecological receptors (birds, through unsealed structures). Include main facilities and stacks.	Y	Facilities have always been part of the conceptual model to the extent that they are sources for contaminants.
53		Address plant, animal, or insect intrusion into waste sites and facilities (e.g., badgers, ants, gnats, flies, bird nesting materials, snakes, mice, other rodents, and burrowing owls, sagebrush, and Russian Thistle).	Y	Ecological receptors will be evaluated in this DQO.
54		Identify how information about mobile species that reside outside an OU, but which use OU-based resources will be used in making cleanup decisions at the OU.	Y	Study areas will be based on an ecosystem perspective. Ecosystems by nature cross OU boundaries.
55		Evaluate receptors and their abundance:	Y	The DQO will evaluate assessment endpoints. Management goals (e.g., protection of biological diversity and population) are considered in the process of developing assessment endpoints.
	a.	Microbiological receptors		
	b.	Reptiles		
	c.	Amphibians		
	d.	Badgers		
	e.	Gophers		
	f.	Harvester ants		
	g.	Deer, coyotes, and other transients.		

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#	Interview Issues	Accept?	Comment Resolution
56	Evaluate all State and Federally listed T/E and Watch List species:	Y	Please see Chapter 4.0 for a discussion of the species considered when assessment endpoints were established.
	a. Ferruginous hawk, peregrine falcon, loggerhead shrike, and western burrowing owl (Federally listed Species of Concern)		
	b. Hawk (State Threatened species)		
	c. Sage sparrow, sage thrasher, and burrowing owl (State Candidate species)		
	d. Grasshopper sparrow and Swainson's hawk (State Monitor Species)		
	e. Golden eagle, American avocet, Long-billed curlew, Brewer's sparrow, Sage sparrow.		
57	Evaluate *Migratory Bird Treaty Act* (1918) species.	Y	Avian species of concern will be evaluated in this DQO.
58	Characterize ecological receptors from a complete species list (includes native).	Y	The DQO process will determine the appropriate ecological receptors.
59	Show ranges for roving species and mention that it is used to calculate exposure dose.	Y	Where applicable, roving species ranges will be taken into account. Exposure dose calculations will be performed in the ecological risk assessment (not in the DQO) in accordance with EPA guidelines.
60	Consider new-to-science species.	Y	New-to-science species have been considered in developing the assessment endpoints.
61	Use of representative species:	Y	Representative ecological receptors will be identified in this DQO that truly allow assessment of the endpoints. Charismatic species will not be selected.
	a. Resident species for ecological sampling to demonstrate protectiveness		
	b. Darkling beetles		
	c. Harvester ants		
	d. Pocket mice		
	e. Plants with long roots.		
62	Address more than one burrowing species (mice, etc.).	Y	All burrowing species will be considered in this DQO. The best representative species from each group will be selected.
63	Seasonality of small wetland, and determination of its value.	Y	West Lake is a wetland area and will be considered in this DQO to support the ecological risk assessment.
64	Need an understanding of applicability and usability of existing data.	Y	The DQO considers the magnitude and extent of contamination, an activity that requires an understanding of what data can be used and how it will be applied.
65	Consider using soil background values from offsite locations (Columbia Wildlife Refuge) for background values. Give rationale for onsite background values.	Y	Background values have been established for the Hanford Site (DOE/RL-92-24 and DOE/RL-96-12). These studies did include offsite comparisons.

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#	Interview Issues	Accept?	Comment Resolution
66	Review aerial and tractor survey radionuclide results for contamination between waste sites.	Y	This DQO will consider the need to evaluate contamination outside of identified waste sites.
67	Quality of characterization data outside of waste site boundaries.	Y	The location and quantity (the quality of data) will be determined in this DQO.
38[3]	Data gaps in DOE/RL-2001-54 must be addressed in DQO.		--
	f. Geographical data gaps exist for soil sampling data.	Y	The data gaps identified in DOE/RL-2001-54 will be used as inputs for this DQO and resulting ecological risk assessment.
	g. Nonradionuclide data were available for few sites.		
	h. Vegetation Polygon Survey has a large section of land, which has not been recently surveyed (see Figure B-2).		
68	Bioaccumulation of metals, phenols, high-molecular-weight aromatics, chlorinated aromatic hydrocarbons, dioxins, and furans.	Y	The propensity for bioaccumulation will be considered in this DQO.
69	There is "some evidence" (of animals high on the food chain getting low, but detectable radionuclide doses) that implies the need to identify a data gap or uncertainty, and for further evaluation to appear in Section 7.1, Data Gaps.	Y	This was a comment made for DOE/RL-2001-54. The applicability of this issue will be considered in the DQO.
70	What about the genetic effects on insect instability? (Jim Karr of University of Washington) Impacts may exist from radiological and chemical contaminants for insects and other organisms.	Y	All relevant studies will be considered in evaluating the results of the investigations.
71	Jim Karr (University of Washington) is a good expert source for the Hanford Site. He saw missing classes of insects and consequently, other dominant ones. Not just due to waste sites, but also herbicides and pesticides.	Y	The DQO output will help determine additional staffing and consultant needs beyond what DOE already has in place to support this effort.
72	The selection of scales for analysis is important, particularly the areas of contamination, waste sites, foraging ranges, and populations. They must not be too large or too small.	Y	The DQO will consider the scales of measurement.
73	There is a need to tie in analysis with cleanup decisions by local waste site, but there also is a need for the big picture perspective.	Y	The DQO will consider this.
74	Need for a balance of the conservatism in modeling with mean data. The assessment should be reasonable, striving for a measure of central tendency, not the maximum exposure case.	Y	The DQO will consider this. It is noted that statistical assessments work for large data sets, not small data sets. Maximums will be applied to small data sets.
75	There may be a lack of a sufficient ecological community in fringe areas.	Y	The Central Plateau will be considered holistically in this DQO process.

[3]Issue #38 is repeated throughout this matrix table because numerous data gaps were identified in DOE/RL-2001-54 that span a range of topics in the matrix.

Table A-1. December 12, 2003, Participant Interview Issues Matrix. (16 Pages)

#	Interview Issues	Accept?	Comment Resolution
SELECTION OF ASSESSMENT ENDPOINTS			
76	Establish food chain models. a. Establish feeding guilds. b. Establish critical links.	Y	The DQO evaluates the food chain models.
77	Balance between bird and terrestrial populations and how to account for digging.	Y	This DQO will evaluate the significance of what contaminants can adversely affect organisms in direct contact with the contaminated media or if the contaminants accumulate in food chains, resulting in adverse effects in organisms that are not directly exposed.
78	EPA standards are not Hanford Site-specific (relative to species). Show how the project maps to Hanford Site species.	-	This DQO will address Hanford Site-specific exposure models and existing and new site-specific data. NOTE: Ecology standards apply on a state-wide basis.
CONCEPTUAL MODEL AND RISK QUESTIONS			
79	Develop problem statements that respond to data gaps.	Y	The data gaps identified in DOE/RL-2001-54 will be used as inputs to the DQO.
80	A Conceptual Site-Wide Cause/Effect Model was presented to the ERC for the 100 BC Pilot Project. The diagram represents thoughts on conceptual model needs.	Y	The Conceptual Site-Wide Cause/Effect Model presented for the 100 BC Pilot Project was developed further with regard to assessing risks to ecological receptors in the Central Plateau. For example, the conceptual model of contaminated media and biotic exposure pathways associated with Hanford Site facility processes presented in Figure 2-1 of this ecological DQO uses the structure of the Cause/Effect model and develops linkages for contaminant fate and transport in a terrestrial environment.
ERAGS STEP 4: STUDY DESIGN AND DQO PROCESS			
MEASUREMENT ENDPOINTS			
81	Include a summary about the presence of, and potential threats to, sensitive habitats and critical habitats of species protected under the *Endangered Species Act of 1973*. Discuss whether potential threats to sensitive and critical habitats are a recommended endpoint.	Y	First part is covered under Issue #15. The DQO will consider potential threats to sensitive and critical habitats as assessment endpoints.
82	Using data from sites burned by the 24 Command Fire will reflect lower biological diversity and population numbers than un-burned areas. This reduction in diversity and population should be factored into the establishment of remedial goals. Remedial goals should be designed to restore the desired habitat, not a stressed (burned) habitat.	Y	The DQO will evaluate assessment endpoints. Management goals (e.g., protection of biological diversity and population) are considered in the process of developing assessment endpoints. The impacts of fire on the habitat will be taken into account.

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#	Interview Issues	Accept?	Comment Resolution
83	What is the population and how is the project looking at them? • (55% thriving, 45% dying?) • Radioactive contaminated animals and urine? • What else happens? • Sustainable population over time? • Impact to reproductive organs? • Compare inventories; what is there: plants, animals? • Timeline; how fast can the project do this to put in risk assessment? • Ask questions on the generic side; 2 years? Timeline will not allow an adequate job.	Y	The DQO will consider assessment endpoints. Management goals are considered in the process of developing assessment endpoints.
84	What is the management goal for remediation; entity and attribute?	Y	The DQO will consider assessment endpoints. However, it is likely that this question will be answered when the remedial action objectives are developed.
LINES OF EVIDENCE			
Study Design			
85	Identify temporal requirements for species sampling.	Y	Temporal requirements will be addressed in this DQO.
86	Standard ecological sampling for receptors and consistent receptors.	Y	To the extent practicable, a standard sampling plan will be employed.
87	The project should ground truth the environmental modeling with biota data.	Y	The DQO will evaluate ground truthing to support modeling.

Key to Entries in "Accept" Column:

Dash (-) = In some cases, the dash means that clarification is needed. In other cases, the issues were considered to be tangential and may not affect the outcome of the DQO. Nevertheless, they were considered important and answers were provided.

N = No

Y = Yes

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List."
Comprehensive Environmental Response, Compensation, and Liability Act of 1980.
DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement.*
DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes.*
DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*
DOE/RL-96-32, *Hanford Site Biological Resource Management Plan.*
DOE/RL-2001-54, *Central Plateau Ecological Evaluation.*
DOE/RL-2002-47, *Performance Management Plan for the Accelerated Cleanup of the Hanford Site.*
DOE/RL-2003-39, *Hanford Long-Term Stewardship Program and Transition: Preparing for Environmental Management Cleanup Completion.*
DOE/RL-2005-37, *Status of Hanford Site Risk Assessment Integration, FY 2005.*
DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*
Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order.*
Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan.*

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#	Interview Issues	Accept?	Comment Resolution

Endangered Species Act of 1973.
HNF-12254, *Working Draft – Hanford Long-Term Stewardship Program: Integrating Accelerated Site Cleanup Completion with Long-Range Post-Cleanup Planning.*
Migratory Bird Treaty Act (1918).
National Environmental Policy Act of 1969.
RCW 43.21C, "State Government – Executive," "State Environmental Policy," also known as the State Environmental Policy Act.
Treaty with the Walla Walla, Cayuse and Umatilla 1855.
WAC 173-303, "Dangerous Waste Regulations."
WAC 173-340, "Model Toxics Control Act – Cleanup."
WAC-173-340-900, "Tables."
WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures."

ARAR = applicable or relevant and appropriate requirement.
BCG = biota concentration guide (see DOE-STD-1153-2002).
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
COC = contaminant of concern.
COPC = contaminant of potential concern.
COPEC = contaminant of potential ecological concern.
CTUIR = Confederated Tribes of the Umatilla Indian Reservation.
DOE = U.S. Department of Energy.
DQO = data quality objective.
Ecology = Washington State Department of Ecology.
EPA = U.S. Environmental Protection Agency.
ERA = ecological risk assessment.
ERC = Environmental Restoration Contractor.
HAB = Hanford Advisory Board.
HNRTC = Hanford Natural Resource Trustee Council.
IAMIT = Interagency Management Integration Team.
LOAEL = lowest observed adverse-effect level.
NEPA = *National Environmental Policy Act of 1969.*
NOAEL = no observed adverse-effect level.
NRDA = natural-resource damage assessment.
OU = operable unit.
PCB = polychlorinated biphenyl.
RL = U.S. Department of Energy, Richland Operations Office.
ROD = record of decision.
SAP = sampling and analysis plan.
SEPA = *State Environmental Policy Act of 1971.*
T/E = threatened and (or) endangered.
TCE = trichloroethylene.
Tri-Parties = U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State. Department of Ecology.
Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).
USFWS = U.S. Fish and Wildlife Service.
WAC = *Washington Administrative Code.*

Table A-2. January 29, 2004, Central Plateau EcoDQO Workshop Comments. (3 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
DQO PROCESS			
1	Bioaccumulation of COPECs through the food chain should be clearly identified as an additional pathway.	Y	Bioaccumulation is clearly identified in Figure 2-1.
2	A starting point for the COPEC list should be process information from known industrial operations in the 200 Areas.	Y	A comprehensive evaluation of process information on known industrial operations in the 200 Area is used to identify Central Plateau contaminants of concern (Appendix B)
3	It is important to clearly define the spatial scale of this study.	Y	The spatial scale of this ecological risk assessment is addressed in Chapter 8.0.
4	The tank farm human health risk assessment should be a helpful resource.	-	It is unclear how the tank farm human health risk assessment is applicable to this EcoDQO.
5	The project should clarify the relationship between the COPEC list and specific assessment endpoints.	Y	The workbook has been revised to clarify the link between COPECs and assessment endpoints (Chapter 5.0).
6	The Environmental Restoration Disposal Facility risk assessment used the pocket mouse as a limiting receptor.	Y	The pocket mouse is a receptor that represents the herbivorous mammal feeding guild in the EcoDQO.
7	The <5% criterion for screening organic COPECs should apply only to appropriate spatial scales (e.g., the home range of a receptor).	Y	The <5% criterion has been replaced with the requirement that organic chemicals be detected at least twice out of 50 samples to be considered a COPEC (Figure 3-3). Organics with one detect and <50 samples may be COPECs if indicated by process knowledge.
8	BCGs (DOE-STD-1153-2002) are not ARARs and so their use as a COPEC screening tool should be carefully considered.	Y	The project agrees that the BCGs are likely not to identified as ARARs. However, a formal ARAR evaluation has not been conducted and is not part of the baseline risk assessment process (per EPA guidelines). But the BCGs are pertinent to the risk assessment in that they provide useful evaluation systems and numerical values. BCGs will be used as one line of evidence for determining if there are adverse ecological effects of radionuclides.
9	Pesticides and herbicides have been used extensively on the site and should not be dismissed.	Y	Available shallow-zone pesticide and herbicide data were evaluated and are discussed in the Phase I EcoDQO.
10	Be careful about the use of models vs. validated data. There is a need to validate models.	Y	Where practical, modeled risk estimates will be assessed through multiple lines of evidence, including field studies.
11	This project needs to be coordinated with other OU project managers.	Y	Some coordination with OU projects has occurred and additional coordination will happen in the future.
12	The process of finding data sets for COPEC screening needs to continue. An expanded data set will be ready for the next meeting.	Y	An expanded data set was compiled from a comprehensive query of the HEIS database for all OU and Sampling Authorization Form data in the top 15 feet from 1998 to 2003. These data were supplemented with earlier data from 1991 to 1994 (Section 3.2 and Appendix C).
13	This project needs to demonstrate a systematic approach to screening COPECs. Start with a full list and then show the logic thread for working down from that.	Y	A systematic approach starting with contaminants associated with all facility processes, and moving to the identification of contaminants of potential concern, to screening and ultimately to COPEC refinement is presented in the Phase I EcoDQO
14	Keep a biological perspective in mind, not just engineering; e.g., animals can integrate exposure over various sites.	Y	With the exception of tank farms, representative shallow zone soil data have been evaluated. In an effort to incorporate more realism in exposure estimates and because animals integrate exposure irrespective of engineered boundaries, tank farm data will be evaluated for ecological risk potential in Phase II of this EcoDQO.

Table A-2. January 29, 2004, Central Plateau EcoDQO Workshop Comments. (3 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
15	This project needs to articulate the specific goal and scope of this ERA.	Y	The goals of this ERA (EcoDQO) are to identify additional ecological data needs to support remedial action decision making, to provide some data to support trustee information needs, and to provide information to evaluate the health or the condition of the ecosystem across boundaries. The project spatial scale is defined in Chapter 8.0.
16	Keep in mind appropriate time scales – not just the present.	Y	Some lines of evidence (e.g., field measurements) in an ecological risk assessment evaluate current conditions. Future or past conditions can be evaluated with models. Future conditions typically are considered as part of the uncertainty analysis.
17	What about areas that may be transferred to others (e.g., the U.S. Fish and Wildlife Service). Will they accept the transfer based on the proposed level of cleanup?	-	Ecological risks and therefore the need for cleanup are uncertain now.
18	Remember that risk models can run forward and backward, and thus can be used to help shape assessment endpoints.	Y	Prospective and retrospective modeling can be employed to generate hazard estimates, and the project has used models to evaluate quantitation limits for proposed risk measures.
19	Remember that if this project uses a maximum contaminant value for screening, it may not be a legitimate number. On the other hand, keep in mind that "outliers" may in fact be true values. Outlier data analyses and decisions based on these analyses need to be clearly documented.	Y	In all cases, maximum analyte concentrations were used for COPEC refinement. While these values may be outliers, the approach is protective. Outliers will be evaluated as appropriate (e.g., in the consideration of nutrients). Risk characterization in the baseline ecological risk assessment will be based on central tendency estimates of COPECs within a meaningful ecological exposure area.
20	It is important to define geographic boundaries of the study, including the airshed.	Y	Geographic boundaries are identified in Chapter 8.0. Airborne releases are evaluated because they may have contributed to COPEC concentrations in shallow zone soils.
21	Consider alternate future condition scenarios, including long-term future.	Y	See resolution to Comment 16.
22	Soil depth issue – is 15 ft a legitimate cutoff for shallow vs. deep soil?	Y	The depth cutoff of 15 ft is legitimate for soils. The data indicate that the vast majority of biological activity is limited to the top 6 ft with most activity concentrated in the top 1 to 2 ft (Figure 2-3).
23	If micronutrients are to be used for screening inorganics, incorporate a threshold; something that is a nutrient at low levels may be toxic at high levels.	Y	Many metals are nutrients and some of these metals have toxic effects and SSVs. Examples are copper and zinc. Some metals have no SSV and they also are nutrients (calcium, potassium, magnesium, and sodium). Nutrients will be addressed through a qualitative evaluation of statistical outliers (Section 3.2.1).
24	For background comparisons, is this project using Hanford Site surface values or Hanford Site deep values?	Y	For background, the project is using the comprehensive data sets for radionuclides (DOE/RL-96-12) and for inorganic chemicals (DOE/RL-92-24). This information employs data from multiple depths.
25	The project needs an alternate way to screen for radionuclides (not BCGs).	Y	Alternative benchmarks for screening radionuclides are not available. Instead of comparing maximum radionuclide concentrations to the BCG, an appropriate modification for the additive effect of multiple radionuclides was to consider the sum of fractions. See resolution to Comment 8.
26	Add reptiles (snakes or lizards?) to the receptor set.	Y	Insectivorous reptiles (e.g., side-blotched lizard) and carnivorous reptiles (e.g., gopher snake) have been added to the receptor set.

Table A-2. January 29, 2004, Central Plateau EcoDQO Workshop Comments. (3 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
27	Consider disturbed vs. undisturbed areas in choosing plant receptors.	Y	Investigation areas will include waste sites (disturbed) and areas selected to represent "reference" conditions that are distant from waste sites (undisturbed).
28	Create links between levels of the food web when choosing receptors, e.g., does the pocket mouse eat bluegrass?	Y	Links between receptors are established by considering Central Plateau biota from a functional food web basis.
29	How/when does the project confirm that this conceptual model is correct?	Y	The conceptual model will be evaluated through multiple lines of evidence. Corroboration, or lack thereof, among the multiple lines of evidence is performed in ERAGS Step 7, risk characterization.
30	Do not leave herbivores out of the assessment.	Y	Herbivores are explicitly included in the assessment (Table 4-5).
31	Can the project identify alternate attributes for describing entity effects (e.g., the natural-resource damage assessment injury list)?	Y	Information on alternate attributes for describing ecological resource injuries will be collected as part of routine field operations (Chapter 5.0).
32	Provide a bigger list of risk questions to sort through; do not limit us to a pre-screened set of questions.	Y	The set of risk questions has been expanded considerably and shows the decision logic for dropping or for further development of risk questions.
33	How can we distinguish the effects of herbicides at waste sites?	Y	Herbicide data have been evaluated in the Phase I EcoDQO, and waste site effects will be compared to reference locations.
34	There is less coverage at the bottom of the food chain in this proposal.	Y	Coverage of the lower trophic levels has been expanded throughout the revised workbook.
35	We need to see a good logic thread linking all the elements of this problem.	Y	The continuity has been clarified through linking management goals to assessment endpoint entities (Table 4-4), entities to representative ecological receptors (Table 4-5), assessment endpoints to attributes (Tables 5-1 to 5-9), attributes to risk questions (Sections 5.1 to 5.9), and risk questions to proposed measures (Table 7-1).

Key to Entries in "Accept" Column
Dash (-) = unclear how this issue can be resolved in the EcoDQO.
N = No
Y = Yes

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*
DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes.*
DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*
Hanford Environmental Information System, Hanford Site database.

ARAR = applicable or relevant and appropriate requirement.
BCG = biota concentration guide (see DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
DQO = data quality objective.
EcoDQO = ecological data quality objective.
ERA = ecological risk assessment.
ERAGS = EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final).*
HEIS = *Hanford Environmental Information System* database.
OU = operable unit.
SSV = soil screening value.
TBC = to be considered.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
DQO PROCESS			
1	Participants expressed some concern with the approach to refining COPECs based on process knowledge. For example, participants had issue with ruling out phthalates as COPECs based on laboratory contamination. Participant resistance to the issue was diminished when it was clarified that, of the 230 plus phthalate samples for multiple phthalate analytes, few were detected and fewer still exceeded SSVs. Added concern was presented that all pthalates were not common laboratory contaminants. It was noted that di-n-octyl pthlate is used to test high-efficiency particular air filters at the site, and this is noted. There were, however, repeated concerns raised that the COPEC list did not include PAHs or organochlorine compounds.	Y	The data do not indicate that PAHs are risk drivers (see Appendix D); thus analysis of soil or biota for is not warranted. Di-n-octylpthalate only was detected in a single sample at the concentration less than the usual detection limit, and thus is it not identified as a COPEC. Bis(2-ethylhexyl)phthalate was excluded as a COPC because it is a common laboratory and field contaminant (see Appendix B). See response to Comments 3 and 20. Organochlorine pesticides available from EPA Method 8082 in SW-846 will be analyzed in samples analyzed for PCBs.
2	In the COPEC refinement process, participants suggested using additional WAC 173-340 five-part screening criteria (e.g., if a COPEC exceeded the SSV by 2 times). The presenters explained that the maximum concentration was used in all cases, in order to be conservative, and that when the risk assessment data are received, the actual WAC 173-340 statistical assessment and the five-part data assessment will be considered at that time. It also was suggested that less frequently detected analytes be considered with regard to high bioaccumulation potential.	Y	As noted, the actual WAC 173-340 statistical assessment and the five-part data assessment will be considered when the risk assessment data are evaluated for site closeout. The issue of detection frequency applies only to organic chemicals, because detection frequency was not a screening criterion for radionuclides or for inorganic chemicals. None of the infrequently detected (i.e., detected once) COPCs are considered to have high bioaccumulation potential. See the response to Comment 20 for more information on this topic.
3	In the COPEC refinement process, concerns were expressed that fuels and their related constituents such as PAHs are not on the COPEC list. It was noted that kerosene was used in the Hanford Site processes and subsequent data at depths of 0 to 15 ft have not shown positive responses for the kerosene. However, the concern is whether the sites reviewed include the areas where fuels were sprayed on roads, areas around fuel storage tanks, and sites where bioremediation was used to remove oil contamination.	Y	See response to Comment 19. Regarding kerosene, out of 61 samples, TPH-K was detected once. The highest single detect of 440 mg/kg for TPH-K is more than order of magnitude below a comparable WAC 173-340-900, Table 749-3 SSV (between 5,000 and 6,000 mg/kg for gasoline-range and diesel-range organics, respectively). Consequently, kerosene is not a risk driver.
4	Although the radionuclide screening process was revised based on one-tenth of the BCG (DOE-STD-1153-2002) (versus the whole BCG as used previously), the issue of BCGs not being ARARs was raised several times during the meeting. Concerns regarding the basis for BCGs (0.1 rad/d for wildlife and 1 rad/d for plants) were presented in that these dose rates are geared toward population-level impacts and may not be appropriate for screening purposes.	Y	The project agrees that the BCGs are not likely to be identified as ARARs. However, a formal ARARs evaluation has not been conducted and is not part of the baseline risk assessment process (per EPA guidelines). But the BCGs are pertinent to the risk assessment in that they provide useful evaluation systems and numerical values. This point is clarified in the document. The Tri-Parties endorse the use of BCGs as one line of evidence to evaluate ecological effects of radionuclides. BCGs will be used to identify COPECs. BCGs also are used to calculate dose to biota, and the calculated doses are reviewed to determine which radionuclides contribute to dose. The project has calculated the sum of fractions based on maximum concentrations of radionuclides divided by BCGs to be protective of ecological populations and individuals. The project has identified radionuclides as COPECs if they contribute significantly to the sum of fractions. The dose limits are based on no observable reproductive effects in biota and thus are equivalent to NOAELs used for nonradionuclides. Because the dose limits equate to no observable effect levels, they are appropriate for screening populations and the more sensitive individuals in a population.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
5	The issue of PCBs was raised and process knowledge insight (e.g., use of PCBs as dust suppressants and PCBs associated with transformers) was provided. More information is being sought on this topic.	Y	PNNL-11651 tested the hypothesis that PCBs were used as dust suppressants. This information was used to consider if additional sampling near roads was warranted for this project. Although PNNL-11651 did not report the detection of PCBs, additional sampling for PCBs near a road is being considered for one site.
6	The attribute selection criteria were evaluated in terms of best professional judgment and this needs to be clearly stated in the workbook.	Y	Use of best professional judgment is noted in the revised workbook.
7	Participants suggested adding diversity indices to the receptor attributes considered for risk questions and measures of effect.	N	Species diversity is not a direct population-level effect. Consequently, information on this parameter is not amenable to an effects assessment for a particular species. Species diversity also is unlikely to provide definitive data on contaminant impacts considering that the initial focus is on waste sites, and waste sites basically are wheatgrass monocultures. In addition, species diversity may be influenced by a number of noncontaminant stressors (e.g., invasion of non-native species like cheatgrass), which limits the utility of such data in interpreting contaminant effects.
8	Starling nest boxes were proposed as a fall-back measurement/ protocol for the proposed avian middle-trophic-level assessment endpoint.	Y	Starling nest boxes will be employed if other proposed measures (e.g., COPECs in nonviable eggs of ground nesting birds) turn out to be impractical to implement.
9	For body burden analyses of wildlife, it was proposed that wildlife with small home ranges killed on roads be collected and analyzed. There was a concern associated with washing plant/insects before analyses. For PCBs, instead of predicating biota analyses on PCBs in soil, it was suggested that the tiered analytical approach start with biota (e.g., darkling beetles) because biota would be better integrators of PCB contamination. Determining detection limits for PCBs in insect tissue was identified as an action item and consideration was raised for sample preparation (e.g., washing off of exterior dust, depurating gut contents).	Y	The collection of road-killed animals already is a component of routine monitoring and surveillance at the Hanford Site. Relevant data from Hanford Site monitoring programs will be used over the course of the phased investigation. For PCBs, the tiered analytical approach will start with biota (insects, small mammals, and lizards) because, relative to soil, biota would be better integrators of PCB contamination. See response to Comment 16 for washing samples before analyses. Exterior dust will be rinsed off for animals as well, but it is not expected that gut contents will be depurated, because this represents a component of dietary dose.
10	It was noted that the measures are designed to provide multiple lines of evidence that will be evaluated using a weight-of-evidence approach. A preference was stated for more formal analysis of the data that specified Type I and Type II statistical errors.	Y	Multiple lines of evidence are proposed for each of the assessment endpoints. The results from these lines of evidence will be evaluated in an overall weight-of-evidence approach, providing a robust assessment of the potential for contaminant impacts. This type of analysis is preferable to a more rigid framework based on Type I and Type II errors because, relative to a controlled laboratory study, many aspects of the design (e.g., field measures) are not necessarily amenable to a formal statistical analysis of uncertainty.
11	How is the project accounting for upward contaminant migration (e.g., through plant roots)?	Y	Upward migration of contaminants initially will be investigated through radiological surveys. The surveys will target deep-rooted plants and areas where subsurface contamination has a greater potential for having been transported to the surface (e.g., mammal burrow spoils). Further investigation of upward contaminant mobility will be pursued if warranted by the results of the radiological survey.
12	To better understand spatial coverage for soil analytical data, participants requested a graphic showing all samples collected in the 200 Area.	N	Locations of all sample data relevant to ecorisk have been included on spatial plots in the workbook. Although all data would be useful, it is outside the scope of this project to make the appropriate data queries and produce such a map.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
13	For reference site selection, it was suggested that relatively pristine sites with slightly different habitat (relative to waste sites) are preferable to similar-habitat sites within a zone of impact from Hanford Site operations. Consider effects of stack releases over time as would affect reference site selection.	Y	These suggestions will be considered with regard to reference site selection.
14	Considering spatial impacts of Hanford Site contaminants, the issue of effects related to exposure from buildings was raised. The participants wanted to account for buildings in the study design while Fluor Hanford stated a preference toward site selection biased away from the influence of buildings because most of the contaminated structures are being removed and will not be present long-term at the site. To account for buildings and to identify hot spots or to potentially identify unidentified waste sites, participants suggested that the Central Plateau in its entirety be gridded and sampled for small body burdens.	Y	It is not feasible to grid and sample the Central Plateau in its entirety. To enhance project efficiency and to better focus data collected over a 3-year period, the Central Plateau ecological SAP (DOE/RL-2004-42) is based on a phased characterization approach. It is phased in terms of the spatial area being considered; namely, waste sites within the Core Zone and reference area(s) will be evaluated in Phase I; Office of River Protection, US Ecology, the BC Controlled Areas, and West Lake will be evaluated in Phase II; and, non-waste site areas within the Core Zone will be evaluated in Phase III.
15	A participant suggested adding the US Ecology site data to the Central Plateau data. This can be done, provided US Ecology agrees to the use of the data. The soil samples from US Ecology are primarily at depths >15 ft bgs and thus not as useful in this study. However, the soil gas data may be useful.	Y	Applicable data (<15 ft bgs) from the US Ecology site will be used if available. In addition, sampling of the US Ecology site is proposed in Phase II of ecological sampling.
16	Some concern in the sampling approach was noted with regard to washing the plants to remove any residual soil before they are analyzed. It was noted that this process allows better assessment of the true uptake of the plant as opposed to the contamination from dust on the leaves. It also was noted that the current calculations take into account the dust.	N	An assessment of plant uptake in the absence of exterior soil is needed to estimate site-specific uptake. As noted, incidental ingestion of soil is accounted for in wildlife exposure calculations.
17	West Lake screening was proposed for augmentation with freshwater values and the suggestion was to use the lowest of marine or freshwater values. It also was suggested that a comparison be performed for groundwater elevation levels compared to lake water levels to assess whether groundwater would be of concern.	N	West Lake data previously have been screened against freshwater benchmarks (PNL-7662) and, in the current draft of the workbook, against marine benchmarks. Use of either set of benchmarks yielded equivalent COPECs. Current groundwater levels suggest that groundwater does not impact the lake.
18	One suggestion for the SAP was to pick a site with shallow contamination (i.e., stabilized with 3 to 4 ft of clean cover) and a relatively high hazard index or radionuclides above BCGs. It might be helpful to conduct gridded sampling of the soil in a sufficient number of uncomposited samples to obtain a good estimate of the sample statistics, then compare those results to the biota sampling results to see if there is any correlation. This might work for some of the "representative" sites for biological characterization.	Y	Sites with high hazard index and shallow contamination will be selected for Phase I sampling. Grab samples in addition to those already proposed may be collected in areas where COPECs are detected in biota or composites.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
19	COPECs: This is one of the first parts of an ERA and very important because most of the other evaluations are based on this process. My first thoughts on the COPECs for the 200 Area are that there must be many contaminants to consider as being of potential concern. This was an area where for 50 years various chemical processes were being used to purify processed uranium to plutonium. Additionally, normal industrial activities would use petroleum and other products leading to the release of PAHs, PCBs, metals, petroleum compounds, organochlorine pesticides first and newer pesticides/herbicides in the later years, etc. I was very surprised at the short list of COPECs proposed for inorganics, organics, and even radionuclides. I have been thinking why there were not more COPECs seen in the historical sampling and perhaps that is because most of the sampling has been done just in the waste sites rather than in a wide variety of locations. Although many samples have been taken, the purpose of the sampling really was not for screening overall potential contaminants but to document what is in the waste sites. A sampling plan should be devised that looks at a wide variety of locations and constituents and that these data be added to existing data before the screening of COPECs takes place. From experience, PAH, petroleum, volatiles, semivolatiles, and pesticides generally are found at industrial sites and should be found here. The project also needs to explore the use of PCB oil for dust control on roads and develop a sampling methodology to test a hypothesis.	Y	An important general consideration in interpreting the existing waste site characterization data used to develop the list of COPECs is that the majority of the waste sites are now below the ground surface. Sites originally were engineered structures such as trenches, crib, and ponds and they now are covered with some amount of fill. Many structures start deeper than 15 ft and thus were not relevant to developing COPECs and explain why the data have some spatial gaps. To enhance project efficiency and to better focus data collected during a 3-year period, the Central Plateau EcoSAP is based on a phased characterization approach. It is phased in terms of the spatial area being considered and the types of biological data being collected. In Phase I, the project will collect soil and middle-trophic-level biota data for mammals, lizards, and invertebrates for CERCLA waste sites on the Central Plateau. Analytical suites will be based on the COPECs identified with the available data with the addition of pesticides obtained along with PCBs using EPA Method 8082 in SW-846. PNNL-11651 reported the hypothesis that PCBs were used as dust suppressants and this information was used to consider if additional sampling near roads was warranted for this project. Although PCBs were not detected in PNNL-11651, additional sampling for PCBs near a road is being considered for one site. The project agrees that oils (including PAHs and lighter constituents) are often found in industrial sites. However, TPH is not easily a risk driver due to the high ecological soil screening value (WAC Table 749-3 SSVs of 5,000 mg/kg for gasoline range organics and 6,000 mg/kg for diesel range organics). TPH and oil constituents typically are not ecorisk drivers in terrestrial environments and the available data suggest they generally are not present at Central Plateau waste sites. Lighter TPH constituents and other volatile organic analytes would not be expected to persist in surface soils that are the focus of this investigation. Clearly, an exception has been noted in the case of CCl4, which is present in the 200 West Area at concentrations near an ecological screening threshold. A plan to address the diffuse CCl_4 plume has been developed. However, additional sampling of volatile organic analytes in Central Plateau surface soils is not warranted.
	Screening for radionuclides: At this stage of the ERA, the project still should be using conservative approaches to screening out any constituents. In general, the project agrees with most of the screening ideas but using the DOE/EH-0676 to determine biota concentration guidelines is not appropriate without additional safety factors because the RESRAD numbers, as the project understands them, were developed to address population level impacts, which is too coarse for screening purposes.	N	See response to Issue 4.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
20	Additionally, I suggest that we review the existing data and include a COPEC if a level is found that is relatively high even if it does not occur that often.	Y	Detection frequency was used as a selection criterion only in the case of organic chemicals (organics not considered if detected less than twice). Therefore, radionuclides and inorganics are not affected by potentially missing COPECs if a COPC was detected only once. Of the organic chemicals detected once – high boiling hydrocarbons (180 mg/kg), total petroleum hydrocarbons-diesel (31 mg/kg), and TPH-K (440 mg/kg) – an SSV exists only for diesel range organics (DRO). Considering that the WAC 173-340-900, Table 749-3 SSV for DRO is 6,000 mg/kg and the single detect of total petroleum hydrocarbons-diesel is 31 mg/kg, this is unlikely to be a risk driver. The highest single detect of 440 mg/kg for TPH-K is more than an order of magnitude below a comparable WAC 173-340-900, Table 749-3 SSV. Consequently, infrequently detected organics do not appear to be risk drivers.
21	Biological sampling: Most of the historical sampling is soil sampling. Additional biological samples are needed to balance out the data for the ERA. The project should consider small mammal sampling as a way to screen areas in the Central Plateau outside the 200 Areas to determine if any other sites may have been subject to contaminant releases. As discussed at the meeting, a grid using small mammal samples would be an economical way of sampling and I am sure that the trustees would be glad to discuss appropriate grid sample densities. Eventually, the ERA will be identifying/predicting biological effects to populations. It is in all our best interests to clearly define what we mean by a population effect and then design our biological sampling to meet our needs. In this regard, and as discussed at the meeting, a weight-of-evidence approach is a good method of evaluation. To get to a weight of evidence, we need to consider what biological data are appropriate to consider. I suggest that we consider four lines of evidence that can affect survival and reproduction: (1) bioaccumulation, which generally means tissue residue in a variety of indicator species and is important for evaluating contaminant transfer through diets in animals and also if humans use biota for food; (2) toxicity testing, including site-specific data so we understand effect concentrations at this location, including chronic and acute tests for young and adults; (3) population evaluation of the species present on site, are the populations as diverse as to be expected, are there appropriate levels of biomass, are age structures appropriate, etc.; and (4) biomarkers, which test for physiological responses to stressors as an indicator of exposure, examples include the ALAD marker for lead exposure, cholinesterase for pesticide exposure, or rates of deformities. Although having great onsite data for all these lines of evidence would be ideal, this usually is not possible. Hence, the project needs to maximize planning and study design issues so at least some information can be obtained from all the lines of evidence using data from the literature and at least some onsite information. I hope this discussion explains why I was suggesting we collect some population diversity data in addition to the good suggestions that Neptune has for bioaccumulation work.	Y	As indicated in response to the question about COPECs (issue 19) we will collect data in phases. Phase I will include bioaccumulation (line of evidence #1). The plan is to review data from Phase I, revise DQOs, and develop a Phase II SAP. In Phase II, the project considered toxicity testing for plants and invertebrates and certain population measures. The project has not considered line of evidence #4 or biomarkers because biomarkers are good as measures of exposure but not for measures of effect. The project has emphasized data that can be more directly linked to adverse ecological effects (survival, growth, and reproduction) to reflect the state-of-the-science and state-of-the-practice for ecological risk assessments. The project has not selected species diversity measures because the Central Plateau waste sites represent highly managed ecosystems where species diversity is affected by things other than COPECs such as invasion by non-native species. The project also has not selected life-cycle tests for plants and invertebrates or life-cycle tests for animals due to the cost relative to information obtained. However, the selection of the lines of evidence for Phase II should be developed after the Phase I data are available so that all possible measures can be evaluated and appropriate measures can be selected for the COPECs measured in soil and biota.

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
22	Page 3, third paragraph, first sentence: The text characterizes the first "EcoDQO" workshop as a "public meeting." This term has a specific meaning in the context of the Hanford Site, the Tri-Party Agreement, and the Public Involvement Plan. While attended by various agencies, we do not believe this workshop was a public meeting. I suggest that the workbook refer to the January 29 meeting as a workshop.	Y	Public meeting changed to public workshop.
23	Pages 6-8, Section 2.1: Various depths for biological activity are given in the text, e.g., "top 6 ft.," "two meters," "an average depth of 7.5 ft." for harvester ants, and "9.8 ft." for bitterbrush. The text also states, "The Hanford-specific data points to the shallow zone soil (<15 ft bgs) as the primary contaminated media of concern to ecological receptors." In Chapter 9.0, Study Design, the text states the plan is to characterize the first 6 ft. Although this depth may be adequate for the initial design, we recommend it not be arbitrarily applied if field observations indicate target species are located at greater depth. This approach is consistent with the overall environmental investigation goal to quantify the nature and extent of contamination.	N	A phased approach to sampling is proposed. If warranted, initial characterization of surficial (top 1 ft) soils will be augmented with the characterization of deeper soils (to 6 ft bgs). Sampling to depths below 6 ft is not proposed at this time.
24	Page 3, fifth paragraph, sixth sentence: The Nature Conservancy biodiversity inventory (TNC 1999) conducted in the late 1990s is considered one of the most comprehensive data sources to date. We recommend it be cited here and used in developing the SAP. Also, when will this workbook include a list of all the references cited?	Y	TNC 1999 is cited in the text and included among the references. References are provided in Chapter 11.
25	Page 10, first paragraph, first sentence: The text notes four radionuclides exceed the soil BCG for terrestrial animals, but Table 3 only lists three.	Y	See response to Comment 4. Table 3-1 has been revised to include all radionuclide COPECs.
26	Page 11, second paragraph, second sentence: It is good to see persistent, bioaccumulative, and toxic chemicals recognized to be of special concern. Washington is one of the few states in the country to have an articulated strategy for addressing these substances. Persistent, bioaccumulative, and toxic chemicals were a line item in the governor's budget. We recommend the workbook acknowledge the state strategy and list the website.	Y	The workbook will be amended to include an acknowledgement of Washington State's program through the following link: http://www.ecy.wa.gov/biblio/0003054.html
27	Page 15, Table 3-1: Chloroform is missing from the list of organics yet is mentioned in the text. Chloroform is a significant contaminant in Hanford Site soils. Ra-226 should be included in the table because its maximum concentration is five times the BCG.	Y	Chloroform soil gas data were screened and in no cases was the maximum concentration greater than the SSV. Ra-226 is a COPEC (see response to Comment 4).
28	Page 20, first paragraph, second sentence: We disagree that the best representative insectivorous bird should be the killdeer as suggested. First, "the killdeer is a transient species that receives only seasonal exposure to Hanford waste-site contaminants." Second, another species such as the sage sparrow is present in greater numbers and offers increased sampling opportunities. Third, it makes sense to collect data on shrub-steppe obligate species because they are at higher risk. Fourth, data on the sage sparrow could provide useful information for a natural resource damage assessment.	Y	Representative receptors for middle trophic-level birds are presented and include the sage sparrow. The killdeer is not necessarily a more representative insectivore than the sage sparrow and the text has been modified accordingly. As noted in the document, given the dietary overlap among middle trophic-level birds, it would be an artificial distinction to focus on a specific trophic category, much less a particular species.
29	Page 21, Table 4-5, AE6: A representative avian species needs to be listed.	N	This was a typographic error in the table. The assessment endpoint entity for AE6 should have been herbivorous, omnivorous, or insectivorous *mammals* (emphasis added).

Table A-3. March 30, 2004, Central Plateau EcoDQO Workshop Comments. (7 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO)
30	Page 23, Tables 5-1 to 5-3: Expense is listed as justification for running or not running certain tests, but this subjective criterion is inadequately explained. Please provide additional information in the text or explain it at the next meeting.	Y	The relative expense of a line of evidence (attribute) was compared to the data that the line of evidence would yield. This comparison involved an informal cost-benefit analysis based on best professional judgment.
31	Page 41, second paragraph: Appendix B was not available at the time of this review. It lists the sites considered and the list of representative waste sites. It is not known therefore, what sites are excluded from the study design because they did not meet the criteria, or because information was lacking. Given the uncertainties in the amount and nature of inventory of waste disposed at the Hanford Site, there is concern that sites will be missed. It is important that this ERA be fully integrated with operable unit investigations to take advantage of the most recent information. It also is important that the lack of complete information be factored into the uncertainty analysis. It is highly recommended that reference site sampling be sufficiently robust to provide adequate information to assess potential natural resource damages.	Y	The wastes sites lists are provided in a compact disc attached to this EcoDQO. The Appendix B folder in the disc contains the exhaustive tabulation of the waste sites (in an Excel file) that were used in the site selection process in this ecological DQO. EcoDQO Section 9.1 describes the site selection process. Recommendations obtained during the DQO process were factored into waste site and reference site selections. The sampling design used for the reference sites was the same as that applied to the CERCLA waste sites.

Key to Entries in "Accept" Column:
N = No
Y = Yes

DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation.*
DOE/RL-2004-42, 2005, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase I.*
DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*
PNNL-11651, *Investigation of Potential Polychlorinated Biphenyl (PCB) Contamination on Hanford Site Arc-Loop Roads.*
PNL-7662, *An Evaluation of the Chemical, Radiological, and Ecological Conditions of West Lake on the Hanford Site.*
SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*
TNC, 1999, *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999.*
WAC 173-340, "Model Toxics Control Act – Cleanup."
WAC-173-340-900, "Tables."

ALAD = delta-aminolevulinate acid dehydratase.
ARAR = applicable or relevant and appropriate requirement.
BCG = biota concentration guide (see DOE-STD-1153-2002).
bgs = below ground surface.
COPC = contaminant of potential concern.
COPEC = contaminant of potential ecological concern.
DQO = data quality objective.
EPA = U.S. Environmental Protection Agency.
ERA = ecological risk assessment.
NOAEL = no observed adverse-effect level.
PAH = polyaromatic hydrocarbon.
PCB = polychlorinated biphenyl.
PCH = polycyclic aromatic hydrocarbon.
RESRAD = RESidual RADioactivity (dose model).
SAP = sampling and analysis plan.
SSV = soil screening value.
TBC = to be considered.
TPH = total petroleum hydrocarbon.
TPH-K = total petroleum hydrocarbon-kerosene.
Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order.*
WAC = *Washington Administrative Code.*

Table A-4. May 26-27, 2004, Central Plateau EcoDQO Workshop Comments. (4 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO or SAP)
DQO PROCESS			
1	The question was raised of whether VOC samples in soil were collected randomly or were specifically targeted for VOC contamination.	Y	Waste sites are screened based on contaminants of potential concern, and if VOCs are believed to be of concern they are targeted for sampling at such sites.
2	Will participants have an opportunity to comment on site selection process (asked using PCB site as an example)?	Y	The final site selection process outlined in the SAP (DOE/RL-2004-42) will be open to review by the Tri-Parties.
3	It was unclear to some participants if radiological dose accounted for concentration in organs (Tc-99 accumulates in thyroid) in ecological exposure.	Y	Specific organ-uptake factors are not employed in BCG calculations (DOE-STD-1153-2002). The intent behind BCGs is to convert whole-body exposure into uptake; the focus is on energy deposited, and effects involve reproduction because reproductive effects are typically most sensitive. While BCGs do not account for radiosensitive organs, they are extremely conservative (e.g., infinitely small for external dose, infinitely large for internal dose).
4	The conceptual model refers to the biological uptake model and it was asked if it also targets vadose zone transport.	Y	Vadose zone transport is assessed to the extent revealed by measuring upward transport through radiation in burrow spoils, ant mounds and plants. All data collected will be available in the remedial investigation/feasibility study work plan and open to review.
5	The SAP may not capture effects that are important to stakeholders; the ecological assessment must incorporate all effects to assess resource damages. For example, COPECs could have effects such as changes on individual enzyme levels as revealed through biomarkers.	N	The Washington State Department of Ecology noted that remedial project managers are not obligated to measure damage assessments but will, however, accommodate them to the extent practicable.
6	Concerns were raised about the sampling depths proposed in the SAP.	Y	Samples will be collected from sites with the highest probability of surface contamination. The sampling depth planned for Phases I and II was noted again as 6 ft, and sampling will focus initially on the first foot, represented by 0-6-in. and 6-12-in. increments. One foot was selected because of a high concentration of biological activity over this depth, and this also represents surface exposure pathways. One foot represents a practical limit, because deeper samples would require U.S. Department of Energy excavation permits. Notes will be taken on sample cores to assess potential anomalies. Samples deeper than 1 foot will be collected if warranted through the data quality assessment of Phase I and Tier 1 data. The inconsistency in sampling depths among sites was brought up; e.g., shallow zone soil is sampled to a depth of 15 ft. In response, it was noted that existing shallow zone data (0-15 ft) will be supplemented with the proposed data. Further, based on review of information from the scientific literature, about 95% of the biological activity occurs in the top 6 ft.

Table A-4. May 26-27, 2004, Central Plateau EcoDQO Workshop Comments. (4 Pages)

#		Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO or SAP)
7		The detection levels were considered to be too high for some analytes and the question was posed of how are detection levels were set.	Y	Detection levels are based on the capacity of the instrument available and the sample mass obtained, not on what the laboratory can obtain. Normally we have target laboratory levels, and an understanding of typical contract laboratories' detection limits shows how easily we can meet or beat the target levels. The target required quantitation limits are presented to assess whether the selected method will be adequate. Laboratory methods typically can reach detection limits up to three orders of magnitude lower than target required quantitation limits.
8		Concerns were raised about holding times and sample preservation.	Y	Standard protocols are followed for holding times and sample preservation.
9		It was noted that for many sites, active work was aimed at preventing establishment of deep-rooted plants and the question was posed, "How can you find contaminants in biota when biota are absent?"	Y	Information will be gained from the remedial investigation work on deeper soils; it also is being collected through the EcoDQO, which is complimentary to the remedial investigation data. The focus of the site screening process is on sites having biota and also having a high probability of surface contamination.
10		Organic COPEC issues		
	a	There was a concern that organic COPECs were eliminated prematurely.	N	The organic COPECs identified are the appropriate organic chemical risk drivers. Hundreds of organic data points were collected and reviewed, and field data collection efforts over the years indicate that total petroleum hydrocarbons are not present in soils. Also, discolored soils have been targeted and sampled and were not shown to have any total petroleum hydrocarbons.
	b	What is being done with VOCs?	Y	With regard to VOCs, carbon tetrachloride will be sampled as part of soil vapor. The SAP (DOE/RL-2004-42) will reflect the reconnaissance work necessary to assess this pathway and also will indicate that soil vapors will be evaluated as part of the potential deeper soil characterization considered in Phase III.
	c	Concerning PCBs, weathering would limit utility of typical Aroclor analyses, and congeners should be the focus.	Y	PCB sampling will be performed in a tiered approach; i.e., if an Aroclor was suggested as a detect in the results, it would trigger congener analysis.
11		Sampling subset of sites (analogous sites) is appropriate only as long as the other sites are truly analogous (maintained in a similar way).	Y	Maintaining the comparability of sites (e.g., vegetation removal) is a corollary of the Hanford Site mission: the goal is to maintain the waste site in the current condition indefinitely or at least until remediation.
12		Spraying of sites was noted as an impact and also recognized as a tradeoff in management goals.	Y	Information on where and when chemicals are applied is made available to the state every year. This information will be made available to participants.
13		Proposed rejected sites should be considered for sampling, and a correction should be made to SAP Figure 1-3 (DOE/RL-2004-42) to reflect this change.	Y	If a proposed rejected site is rejected by the Tri-Parties, then it can be considered for assessment or sampling in Phase III.
14		Questions were raised as to the basis for sampling within the investigation area.	Y	The idea behind composites is to represent the average within the entire area. A 10 m grid was applied across the investigation area to characterize the gamma field. The reason for selecting one sample per row is for stratified random sampling, to maximize coverage of the hectare. For small sites, consider requiring half of the composite from inside the site and half from outside, although, lacking existing composites data, one cannot come up with optimum data on variability within composited material.

Table A-4. May 26-27, 2004, Central Plateau EcoDQO Workshop Comments. (4 Pages)

#		Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO or SAP)
15		The best way to have an adaptive sampling plan is get all the data and do a power analysis.	Y	This can be achieved through radiological survey data from which structured sampling can be based: basically, a double sampling approach by using radiological surveys. Gamma surveys via sodium iodide detector were suggested as optimal because they have good sensitivity for some of the radionuclide COPECs and can be employed to adapt sampling based on survey.
16	a	Questions were raised about selection of the hectare as the investigation area.	Y	1 ha was selected based on the home range of Central Plateau receptors. Animals with the highest site fidelity were selected from among assessment endpoints to make a correlation between soil and biota; highly mobile animals were not selected. This will be emphasized in the SAP (DOE/RL-2004-42). Further, it is worth emphasizing that the contingency of designing the 1 ha site is not necessarily based on a square; it can be modified to waste site geometry and is biased towards sites with the least amount of fill.
	b	20% of coverage of the total waste site should be performed via radiological survey to select the 1 ha sample area. The survey grid needs to be designed to capture 20% of the site.	Y	In addition to doing stratified random sampling, the radiological survey will help by providing information for selecting the 1 ha within large sites. The focus is on selecting the most heavily contaminated location within each site.
	c	Is it reasonable to survey based on radionuclides only?	Y	The radiological survey serves as an adequate surrogate for other (metal and organic) COPECs, given the propensity for plant uptake of gamma emitters (e.g., Cs-137) over something like hydrophobic PCBs.
17		How was it determined to look at <5% of waste sites? Need to see the number of sites that fall out at each step of site screening (it was then pointed out that this information was included in the EcoDQO appendices).	Y	Screening did not start out with a cap on the sites to be investigated. Sites were screened based on a thin cover over the top and were sorted by contamination level, yielding a (still large) set of sites. Field reconnaissance served to further eliminate sites (e.g., denuded sites), yielding the current list. The purpose of the EcoDQO is not to characterize sites, but to use the SAP (DOE/RL-2004-42) to assess the exposure and effects for Central Plateau biota. With the sites chosen, the SAP is capturing a major percentage of the total Hanford Site waste site area.
18		A concern was posed for reference sites, specifically, "don't you want to get away from places where aerial deposition could have occurred?"	N	Two sites are out of the path of prevailing winds and the project is trying to match vegetation and soil as much as possible. Hanford Site background also can be used.
19		In references to SAP Figure 2-1, a question was asked, "what if uptake is occurring at levels less than predicted but above zero (i.e., diamond-shape box of "COPEC uptake greater or equal to uptake predicted from *Washington Administrative Code* toxicity reference value"). The "no" decision leading from this conclusion needs to be clarified from "COPECs are not bioavailable" to "COPECs are not bioaccumulating at levels of concern" and the statement "end assessment of Central Plateau waste sites" should be removed.	Y	Changes will be made to SAP Figure 2-1.
20		In reference to SAP Figure 2-2, "COPECs in lizards" diamond-shape box should be clarified to ask if COPECs in lizards are at levels greater than reference site.	Y	Changes will be made to SAP Figure 2-2.

Table A-4. May 26-27, 2004, Central Plateau EcoDQO Workshop Comments. (4 Pages)

#	Meeting Issues	Accept?	Comment Resolution (All references are to Central Plateau EcoDQO or SAP)
21	It was requested that a cross site transfer line be added (high site) and this suggestion was evaluated.	Y	The "Cross-site Transfer Line" is really two different lines. The old one that leaked and has always been a "bad player" for biotic uptake. That line is denuded and sprayed with non-selective herbicides. The new line (600-269), which has never leaked, has some sections of good wheatgrass growth that would be comparable to our other sites and would provide a better fit than the 218-E-111 line. Both of these sites are designated in the "moderate" category. Because the new line has never leaked and the old line has no vegetation, neither of these sites is appropriate for ecological sampling.
22	The exploratory data analysis aspect of the data quality assessment needs to be clarified in the SAP.	Y	This will be clarified in the SAP (DOE/RL-2004-42).
23	An executive summary needs to be added to the SAP.	Y	An executive summary will be added to the SAP.

Aroclor is an expired trademark.

DOE/RL-2004-42, 2005, *Central Plateau Terrestrial Ecological Sampling and Analysis Plan - Phase I.*

DOE-STD-1153-2002, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.

BCG = biota concentration guide (see DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
EcoDQO = ecological data quality objective.
PCB = polychlorinated biphenyl.
SAP = sampling and analysis plan (DOE/RL-2004-42).
Tri-Parties = Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy.
VOC = volatile organic compound.

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WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC-173-340-900, "Tables," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

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APPENDIX B

CENTRAL PLATEAU CONTAMINANTS OF POTENTIAL CONCERN

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TERMS

AMSCO	Allen Maintenance Supply Company, Inc.
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
DQO	data quality objective
OU	operable unit
PFP	Plutonium Finishing Plant
PRF	Plutonium Reclamation Facility
PUREX	Plutonium-Uranium Extraction Plant or process
RECUPLEX	Recovery of Uranium and Plutonium by Extraction Plant or process
REDOX	Reduction-Oxidation Plant or process
RG	rubber glove (line)
RMA	remote mechanical "A" (line)
RMC	remote mechanical "C" (line)
TBP	tributyl phosphate
URP	Uranium Recovery Process
WESF	225-B Waste Encapsulation and Storage Facility

APPENDIX B

CENTRAL PLATEAU CONTAMINANTS OF POTENTIAL CONCERN

This appendix presents the logic used to select sites for potential characterization and the logic used to select a list of Central Plateau contaminants of potential concern (COPC) that serve as one of the inputs to the selection of contaminants of potential ecological concern (COPEC). The term COPC is used in the context of the preliminary contaminant screening. The term COPEC specifically refers to the logic and output presented in Chapter 3.0 of the main document.

B1.0 DEVELOPMENT OF CONTAMINANTS OF POTENTIAL CONCERN

A list of constituents was developed based on process and waste site knowledge using all Central Plateau process-based operable unit (OU) remedial investigation/feasibility study DQO documents including CP-13196, *Remedial Investigation Data Quality Objective Summary Report – 200-IS-1 and 200-ST-1 Operable Units*. The initial list was screened for characteristics that would result in minimal ecological risk from specific contaminants, such as minimal use or having undergone numerous half-lives of radioactive decay. Similarly, many of the contaminants possess qualities that render them unlikely to present a risk to ecological receptors beyond the waste site boundaries. Substances resulting from Central Plateau waste streams that had high volatility, rapid environmental degradation relative to the age of the waste site, low potential for bioaccumulation, and low bioavailability likely would not represent important ecological risks and were excluded. Conversely, contaminants with properties of high persistence, slow degradation, high bioavailability, and high potential for bioaccumulation could pose ecological risks, and were retained as COPCs. The development of the COPC list is illustrated in Figure B-1. The list of COPCs produced from this evaluation is further screened using the logic in Chapter 3.0 of the main document.

For the purposes of the main document, both the Central Plateau constituents (Table B-1) and the constituents listed in WAC 173-340-900, "Tables," Table 749-3 (Table B-2) are considered as the starting point for development of the COPECs list.

Some contaminants routinely are excluded from consideration as contaminants of concern for Hanford Site assessments (documents such as CP-13196). These substances are listed in Figure B-1, box D4Y, and include the following:

- Short-lived radionuclides having undergone more than eight half-life disintegrations (indicating that a maximum of only 0.07 percent of the initial concentration is present)
- Radionuclides that constitute less than 1 percent of the fission product inventory and for which historical sampling indicates nondetection
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Constituents with atomic mass numbers greater than 242 that represent less than 1 percent of the actinide activities

- Progeny radionuclides that build insignificant activities within 50 years and/or for which parent/progeny relationships exist that permit progeny estimation
- Constituents that would be neutralized and/or decomposed by facility processes
- Chemicals in a gaseous state that cannot accumulate in soil media
- Chemicals used in minor quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or elevated concentrations
- Chemicals that are not persistent in the environment because of volatilization, biological/physical/chemical degradation, or other natural mitigating features
- Chemicals that are not persistent in the vadose zone because of high mobility or as evidenced by previous confirmatory sampling/analysis activities.

Radionuclide constituents known or suspected to be present in the 200 Areas, that survived the exclusion evaluation are listed in Figure B-1, box D4N.

Nonradionuclide constituents that are not identified in WAC 173-340-900, Table 749-3, have been or will be evaluated as COPCs in the Central Plateau through the OU-specific DQO processes. Once the remedial investigation data are available, detected constituents will be evaluated for potential ecological risks in accordance with this document and the U.S. Environmental Protection Agency guidance.

B2.0 HANFORD SITE CENTRAL PLATEAU CHEMICAL PROCESSES

The following sections illustrate the five main Hanford Site processes for chemical separation and waste treatment operations conducted in the Central Plateau.

Bismuth Phosphate Process. The bismuth phosphate process was an inorganic, step-wise, precipitation process that separated plutonium from uranium and fission products. This process occurred in the 221-B and 221-T Canyon Buildings and used sodium hydroxide to remove aluminum cladding and concentrated nitric acid to dissolve the fuel rods. Bismuth phosphate and bismuth oxynitrate were used to support precipitation of plutonium, while hydrogen peroxide, sodium dichromate, ferrous hydroxide, and ferrous ammonium sulfates were used to change the plutonium valence during the oxidation reactions. Phosphoric, sulfuric, and nitric acids were added to dissolve the precipitants formed. The bismuth phosphate process preferentially attracted plutonium from the solution and, as a precipitate, was physically separated by centrifuging.

The second part of the bismuth phosphate process included the lanthanum fluoride process. It was performed in the 224-B and 224-T Concentration Facilities and further purified the dilute plutonium solution created in the last step of the bismuth phosphate process. The dilute plutonium nitrate supernatant was oxidized with sodium metabismuthate. Phosphoric acid was added to precipitate impurities, and the resulting solution was treated with oxalic and

hydrofluoric acids and lanthanum salt. As a result, lanthanum fluoride and plutonium fluorides were co-precipitated. Next, the lanthanum and plutonium fluoride solids were converted to hydroxides by the addition of a hot potassium hydroxide solution. The hydroxides were washed with water, dissolved in nitric acid, and heated to form a concentrated plutonium nitrate solution. This solution was sent to the isolation building (231-Z Plutonium Isolation Plant) for further purification treatments and evaporation. A concentrated plutonium nitrate paste was the final product. For every batch (760 L [200 gal]) of dilute, unpurified plutonium solution entering the 224-B and 224-T Concentration Facilities, an estimated 30 L (8 gal) of purified concentrated weapons-grade plutonium was produced (HW-10475, *Hanford Engineer Works Technical Manual (T/B Plants)*).

Uranium Recovery Process U/UO_3 Plant and Scavenging Operations and PUREX Process. The Uranium Recovery Process (URP) was implemented at U Plant to recover the spent uranium from the metal waste and first-cycle waste streams generated in T and B Plants for reuse in weapons-grade plutonium production. The URP was performed in three phases. The first phase included the removal of bismuth/phosphate waste (metal waste, first-cycle supernatants, and cell 5 and 6 drainage) from the T, TX, TY, B, BX, and BY Tank Farms and preparation of the sludge/slurry solution, using nitric acid to dissolve the uranium metal and jet it into the plant. The second phase consisted of the separation of the uranium from remaining plutonium, fission products, and nonradiological constituents by a solvent extraction process. The counter-current solvent extraction process used tributyl phosphate (TBP) in a normal paraffin hydrocarbon diluent such as AMSCO[1] or kerosene to bond with the uranium. Sulfamic acid and ferrous ammonia sulfate were used to ensure that the correct valence state was obtained. The separated uranyl nitrate hexahydrate was sent to the 224-U (Concentration Facility) Building or the UO_3 Plant where it was calcined or heated to 400 °F to drive off nitrate, resulting in UO_3. The UO_3 powder was removed from the vessels, packaged, and shipped offsite to Oak Ridge, Tennessee, where it was converted to uranium metal; then it was sent back to the 300 Area at the Hanford Site to be reincorporated into the uranium fuel rod production (HW-19140, *Uranium Recovery Technical Manual*).

In 1953, tests to further treat URP aqueous waste streams generated at the T, U, and B Plants during the bismuth/phosphate campaign proved successful. The "scavenging" process separated the long-lived fission products (including Sr-90 and Cs-137) from the waste solutions by precipitation. The order of operations often was modified throughout the duration of the scavenging process. After URP processing, TBP column wastes were sent to a neutralization tank at the U Plant, where the pH was adjusted to 9 ± 1. Chemicals used to scavenge fission products included potassium and sodium derivatives of the metal/ferrocyanide complex ion. The most notable and widely used metals (used to assist precipitation) were iron, nickel, and cobalt. Calcium nitrate and/or strontium nitrate often were added to enhance the precipitation of Sr-90. Phosphate ions also were added to aid the soil retention of Sr-90. After the TBP waste had been scavenged, it was returned to the B, BX, BY, T, TX, and TY Tank Farms to allow the solids (containing the fission products and scavenging chemicals) to settle. The waste was sampled

[1] AMSCO is the trade name of a kerosene-based solvent, and is a trademark of Allen Maintenance Supply Company, Inc., Allentown, Pennsylvania.

from the tanks at various depths and analyzed before the liquid effluent was sent to cribs and/or trenches (pending the concentrations of Cs-137 and Sr-90) or was rerouted to other nearby tanks, where settling continued. The U/UO_3 and scavenging operations process samples were analyzed at the 222-U or 222-S Laboratories.

The Plutonium-Uranium Extraction (PUREX) process was an advanced solvent extraction process that replaced the Reduction-Oxidation (REDOX) process. PUREX used a recyclable salting agent, nitric acid (which greatly lessened costs and the amount of waste generated), and TBP in a normal paraffin hydrocarbon diluent such as AMSCO or kerosene solution as a solvent, just like the URP process. The main purpose of the PUREX facility (202-A Canyon Building) was to extract, purify, and concentrate plutonium, uranium, and neptunium contained in irradiated uranium fuel rods discharged from Hanford Site reactors. Fuel decladding was performed with a boiling sodium hydroxide/sodium nitrate solution or a boiling solution of ammonium fluoride and ammonium nitrate. Feed dissolution used concentrated nitric acid and ammonium nitrate nonahydrate. The prepared feed entered the pulsing, counter-current solvent extraction column, where TBP in a normal paraffin hydrocarbon diluent was fed to the bottom of the column and the aqueous phase (sodium nitrite/nitric acid salting agent solution) was fed to the column from the top. Dilute nitric acid, ferrous sulfamate, and sulfamic acid descended from the top of the second column to remove uranium and neptunium from plutonium. Chemical separation processes were based on conducting multiple purification operations on the resulting aqueous nitrate solution containing each of the separated products. The driving forces for the separations consisted of varying partition coefficients between aqueous and organic phases, controlled by valence state changes of the element of interest (DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report*). The solvent and salting agent (nitric acid) were recovered, treated, and recycled back into the process operations. An analytical laboratory also was housed within the 202-A (A Plant Canyon) Building.

REDOX. The REDOX process, used until 1967, was a solvent-extraction process that extracted plutonium and uranium from dissolved fuel rods into a methyl isobutyl ketone (or hexone) solvent. The solvent-extraction process was based on the preferential distribution of uranyl nitrate and the nitrates of plutonium between an aqueous phase and an immiscible organic phase (DOE/RL-91-60, *S Plant Source Aggregate Area Management Study Report*). The REDOX process included fuel decladding with boiling sodium hydroxide/sodium nitrate solution or a boiling solution of ammonium fluoride and ammonium nitrate. Feed dissolution using concentrated nitric acid and plutonium oxidation was completed simultaneously with potassium permanganate and sodium dichromate. The prepared feed entered the packed counter-current solvent extraction column, where acidified hexone was fed to the bottom of the column and the aqueous phase (ammonium nitrate nonahydrate scrub solution or salting agent) was fed to the column from the top. The aqueous solubility of the uranium and plutonium nitrates was reduced by increasing the nitrate concentration in the aqueous phase. The uranium and plutonium were extracted into the organic phase and routed to the second extraction column, while the fission products remained in the aqueous phase. Uranium and plutonium (present in the organic phase) were chemically separated in the second extraction column using ferrous sulfamate solution containing ammonium nitrate nonahydrate to reduce the plutonium to the +III valence state. Further purification cycles of uranium and plutonium were conducted during operations using the same chemical constituents. The solvent was recovered and recycled back into the process after sampling and analysis. Waste generated in the 202-S REDOX or Canyon Building also was

treated and routed to cribs after sampling and analysis. Radioactive and radioactive mixed liquid wastes from the laboratory were treated in the 219-S Waste Handling Facility.

Waste Recovery/Fractionation/WESF. From 1961 (Hot Semiworks) and 1963 to 1966 (B Plant), strontium, cerium, and rare earths were recovered using an acid-side, oxalate-precipitation process. The waste recovery/fractionation process included a thermal evaporation to concentrate process wastewaters before disposal. This system was used to concentrate low-level radioactive waste once the cesium and strontium waste fractionation process was shut down in 1984. Double-shell tank waste was received at the 221-B Canyon Building (B Plant) to be processed through the low-level waste concentrator from 1968 to 1986. Other sources of low-level waste included miscellaneous sumps and drains in WESF, which diverted decontamination waste solutions generated in the 225-B Waste Encapsulation and Storage Facility (WESF) process cells. Another contributor was a liquid collection system located beneath the 40 cells in the 221-B Building that collected cell drainage from decontamination work and water washdowns in the processing section of the 221-B Canyon Building. The concentrator also processed wastes produced by the cleanout process vessels at the 221-B Canyon Building and WESF from 1968 to 1986 (DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*). The strontium recovery process was performed via solvent extraction using a complexant di-2-ethyl-hexyl phosphoric acid to extract strontium from acid solutions of waste fuels.

The Z Plant Complex (231-Z and 234-5Z). At the Z Plant Complex, the recovered, purified plutonium was refined to one of several forms, depending on the era and available process. At the start of Hanford Site operations (1945 to 1949), plutonium was refined in the 231-Z Plutonium Isolation Plant Building, where it was converted to a nitrate paste before being shipped off site. In 1949, the 231-Z Plutonium Isolation Plant Building was converted into a plutonium metallurgy laboratory (Materials Engineering Laboratory) and operated in this capacity from the 1950s until the 1970s. The research included tensile strength, stress testing, coating, and other material science properties of plutonium and plutonium alloys. Beginning in the 1960s, the U.S. Atomic Energy Commission's Division of Military Application began the design, development, and fabrication of experimental weapons that supported the weapons testing program at the Nevada Test Site. Other projects including state-of-the-art sampling methods for plutonium buttons, new coating processes, and development work in reactor fuels containing plutonium and other alpha-emitting materials also were completed at the 231-Z Materials Engineering Laboratory Building in the late 1960s and early 1970s. In 1975, the experimental work performed by the Division of Military Application was phased out (HNF-EP-0924, *History and Stabilization of the Plutonium Finishing Plant (PFP) Complex, Hanford Site*). Shortly thereafter, however, a more elaborate plant, the 234-5Z Plutonium Finishing Plant (PFP), was constructed with the capability to convert plutonium into metal, nitrate, or oxide forms. A number of process lines in the 234-5Z Building were used between 1949 and 1989. Initially, batch inorganic chemical steps were used to refine and convert plutonium to the desired form. Later, elaborate mechanical extraction processes were developed. The PFP was used to fabricate plutonium into weapons shapes and reprocessing scrap plutonium, using solvent extraction techniques based on TBP mixed with carbon tetrachloride (Recovery of Uranium and Plutonium by Extraction or RECUPLEX process). Processes at the Z Plant Complex that generated the primary waste streams into the 200-PW-1 OU waste sites included

the following. (It should be noted that 200-PW-1 waste sites did not receive any waste from the 231-Z Building and its operations.)

- Plutonium finishing: Conducted at the PFP or the 234-5Z Building, these processes operated continuously from 1949 to 1973, and intermittently between 1985 and 1988. Waste generated by these processes included hydroiodic, hydrofluoric, hydrochloric, nitric, and sulfuric acids in addition to oxalate, potassium permanganate, magnesium oxide, lanthanum, gallium, polychlorinated biphenyls, acetone, lard oil, and various other oils and solvents used for plutonium metal machining.

- Rubber glove (RG) line: Operation was then transferred to the newly constructed 234-5 Building in 1949 and operated until 1953, when it was abandoned for remote mechanical operations. Waste generated by this process included hydrofluoric, sulfuric, and nitric acids, as well as peroxide, plutonium, and other transuranic metals.

- Remote mechanical "A" line: The remote mechanical "A" (RMA) line was constructed in 1949 and began operations in 1953. The RMA line operated until it was upgraded to remote mechanical C (RMC) line operations. The process was the same as the RG line chemically; however, the plutonium was handled by remote mechanical means. Thus, the RMA produced the same waste as the RG line.

- Remote Mechanical "C" line: The RMC line was constructed in 1957 and began operations in 1960. The RMC line operated until 1973 and again from 1985 to 1989. The process was the same as the RG and RMA lines chemically; however, the plutonium was handled remotely by mechanical means, with additional mechanical upgrades to increase the safety of the operators. Thus, the RMC produced the same waste as the RG and RMA lines.

- Plutonium metal fabrication: Weapons-grade plutonium metal was cut and milled into weapons shapes for quick assembly into nuclear weapons in the late 1950s. Waste generated by this process included mixed lard and carbon tetrachloride, as well as other volatile organics used as cutting fluids.

- RECUPLEX: This plutonium recovery process operated inside the 234-5Z Building from 1951 to 1962, at which time it was terminated after a criticality event (uncontrolled nuclear reaction) within the PFP. Waste generated by this process included hydroiodic, hydrofluoric, sulfuric, and nitric acids, plus silver, carbon tetrachloride and TBP, plutonium, and other transuranic metals.

- Americium recovery: An americium recovery process operated in the 242-Z Waste Treatment Facility Building between 1964 and 1976. It was shut down in 1976 after an explosion occurred in one of the recovery units. Waste generated by this process included hydrochloric, hydrofluoric, phosphoric, and nitric acids, as well as dibutyl butyl phosphonate, carbon tetrachloride and TBP, plutonium, and other transuranic metals.

- Plutonium Reclamation Facility: In 1964, a replacement scrap solution recovery facility, the Plutonium Reclamation Facility (PRF), was brought on line in the 236-Z Building. The PRF operated from 1964 to 1979 and from 1984 to 1987. Waste generated by this

process included hydrofluoric, phosphoric, and nitric acids, along with silver, hydroxyl amines, dibutyl butyl phosphonate, carbon tetrachloride and TBP, uranium, plutonium, and other transuranic metals.

The Critical Mass Laboratory (209-E Building) conducted criticality experiments from 1960 to 1983 using plutonium nitrate and enriched uranium solutions. Criticality research also was conducted with solid nuclear materials and fuels such as plutonium blocks, uranium blocks and slabs, and fuel assemblies from the Fast Flux Test Facility and other reactors (DOE/RL-92-18, *Semiworks Plant Source Aggregate Area Management Study Report*).

B3.0 CENTRAL PLATEAU FACILITY WASTES

A number of other facilities in the Central Plateau have contributed to the collective Central Plateau facility waste groupings. Some of these waste sources are as follows:

- Decontamination efforts
- Solid wastes in burial grounds from offsite sources
- Laundry waste effluents
- Powerhouse solid debris and effluents
- 200-CW-3 waste sites or 200 Area North operational discharges
- Central Plateau shops, dumps, chemical landfill wastes.

Two types of decontamination operations were conducted in the 200 West Area. These included decontamination and refurbishment of highly contaminated process equipment and the decontamination of heavy equipment and vehicles. Where known, decontamination wastes from process equipment were grouped with their respective chemical process/waste handling operation. Typical decontamination efforts involved chemical and water flushes, but techniques other than water and chemical flushes also were used. Sand blasting and ultrasonic cleaning were used when considered suitable.

Over the course of equipment decontamination and refurbishment operations at the various facilities, numerous chemical compounds including phosphate-based soaps and complexants were used. Tables in WHC-EP-0172, *Inventory of Chemicals Used at Hanford Site Production Plants and Support Operations (1944-1980)*, provide a listing of compounds that were used at either the 221-T or the U Plant over the period from 1961 through 1980. Decontamination wastes from the 221-T Plant were routed through tanks and ultimately to the 216-T-27 and 216-T-28 Cribs. Decontamination wastes from the 221-U Plant were routed to the 216-U-4A and 216-U-4B French Drains.

Contamination of heavy equipment, railcars, and vehicles usually consisted of particles of fission products (e.g., ruthenium, zirconium, niobium, iodine). These particles were drawn into the radiator and other engine components and became attached to oily surfaces of the engine compartment. To continue use of this equipment, a decontamination facility was established at the 269-W Garage. Removal of contamination was accomplished using commercial cleaners

(Actresol, Kerful Cleaner, Aeso Wash[2]) and a steam jet spray on the radiators, engines, and undercarriages. Painted automobile surfaces and all interior surfaces and materials were hand cleaned using mild detergents such as Calgon.[2] Sometimes external surfaces required more stringent methods, such as aggressive chemicals like Kleeno Bowl and other harsh acids and caustics, and occasional sandblasting (HW-63110, *Decontamination*).

These decontamination operations initially were performed outdoors in open pit areas such as the 216-U-13 Trench (1952 to 1956) and the 216-T-13 Trench (1954 to 1988). These sites had limited facilities for handling steam and water. Provisions for waste collection, drainage, and disposal were considered unsatisfactory. Cold and inclement weather further complicated the work. In 1964, a new decontamination facility, the 2706-T Building (originally known as 2706-W), was completed. This facility provided improved steam, high-pressure water, and chemical cleaning capabilities for all of the site's railroad equipment and heavy and light duty automotive equipment. Means for adding chemicals to the steam spray or high-pressure water were made available. Adequate waste collection, drainage, and disposal facilities were provided. Commercial chemicals were tested for their application to this decontamination work. Among the waste sites used for disposal of decontamination wastes from the 2706-T Building were the 216-T-33 Crib in the 200-MW-1 OU and the 216-T-27 and 216-T-28 Cribs in the 200-LW-1 OU. After the pipeline to the 216-T-33 Crib plugged in February 1963, waste was routed to the 216-T-28 Crib. The 216-T-27 and 216-T-28 Cribs were active from February 1960 to December 1966.

B4.0 EXCLUSIONS AND CONTAMINANTS OF POTENTIAL CONCERN

Table B-3 lists the constituents that were excluded, with supporting rationale and references. The constituents that survived the exclusion process are identified as contaminants of potential concern and are shown in Table B-4.

B5.0 REFERENCES

CP-13196, 2002, *Remedial Investigation Data Quality Objective Summary Report – 200-IS-1 and 200-ST-1 Operable Units*, Draft A, Fluor Hanford, Inc., Richland, Washington.

DOE/RL-91-60, 1992, *S Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-92-04, 1993, *PUREX Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-92-05, 1993, *B Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[2] Trademarks and registered trademarks are the property of their respective owners. All product names mentioned are listed for contaminant potential only; such listing does not imply ownership and does not constitute endorsement.

DOE/RL-92-18, 1993, *Semiworks Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

HNF-EP-0924, 1997, *History and Stabilization of the Plutonium Finishing Plant (PFP) Complex, Hanford Site*, Fluor Daniel Hanford, Inc., Richland, Washington.

HW-10475, 1944, *Hanford Engineer Works Technical Manual (T/B Plants)*, Parts A, B, and C, General Electric Company, Richland, Washington.

HW-19140, 1951, *Uranium Recovery Technical Manual*, General Electric Company, Richland, Washington.

HW-63110, 1960, *Decontamination*, General Electric Company, Richland, Washington.

WAC-173-340-900, "Tables," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WHC-EP-0172, 1990, *Inventory of Chemicals Used at Hanford Site Production Plants and Support Operations (1944-1980)*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Figure B-1. Contaminants of Potential Concern Evaluation Process.

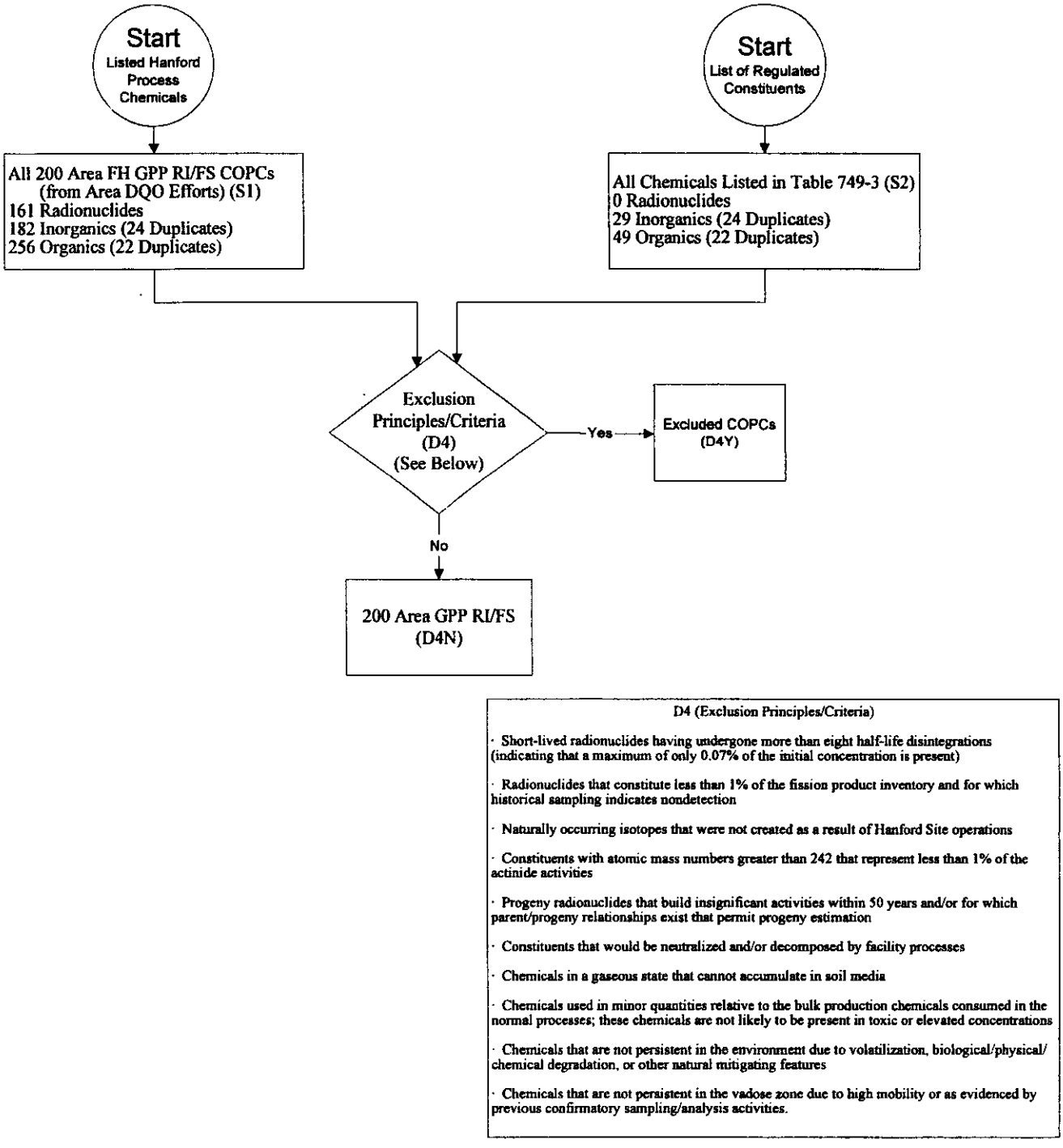

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Radionuclides			
1	Actinium-225	46	Francium-221
2	Actinium-227	47	Francium-223
3	Aluminum-28	48	Gadolinium-152
4	Americium-241	49	Gadolinium-153
5	Americium-242	50	Germanium-68
6	Americium-242m	51	Gold-195
7	Americium-243	52	Hydrogen-3 (tritium)
8	Antimony-122	53	Iodine-123
9	Antimony-123	54	Iodine-125
10	Antimony-124	55	Iodine-129
11	Antimony-125	56	Iodine-131
12	Antimony-126	57	Iron-55
13	Antimony-126m	58	Iron-59
14	Barium-133	59	Krypton-85
15	Barium-135m	60	Lanthanum-140
16	Barium-137	61	Lead-209
17	Barium-137m	62	Lead-210
18	Barium-140	63	Lead-211
19	Beryllium-10	64	Lead-212
20	Bismuth-210	65	Lead-214
21	Bismuth-213	66	Manganese-54
22	Bismuth-214	67	Molybdenum-93
23	Cadmium-109	68	Neodymium-147
24	Cadmium-113m	69	Neptunium-237
25	Carbon-14	70	Neptunium-239
26	Cerium-141	71	Nickel-59
27	Cerium-144	72	Nickel-63
28	Cesium-134	73	Niobium-93m
29	Cesium-135	74	Niobium-94
30	Cesium-137	75	Niobium-95
31	Cesium-141	76	Niobium-96
32	Cesium-144	77	Niobium-98
33	Chlorine-36	78	Palladium-107
34	Chromium-51	79	Phosphorus-32
35	Cobalt-57	80	Plutonium-238
36	Cobalt-58	81	Plutonium-239/240
37	Cobalt-60	82	Plutonium-241
38	Curium-242	83	Plutonium-242
39	Curium-243	84	Polonium-210
40	Curium-244	85	Polonium-211
41	Curium-245	86	Polonium-212
42	Ensteinium-254	87	Polonium-213
43	Europium-152	88	Polonium-214
44	Europium-154	89	Polonium-215

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Radionuclides (cont)			
45	Europium-155	90	Polonium-216
91	Polonium-218	127	Tellurium-127
92	Potassium-40	128	Tellurium-129
93	Praseodymium-143	129	Tellurium-129m
94	Praseodymium-144	130	Thallium-204
95	Promethium-143	131	Thallium-207
96	Promethium-147	132	Thallium-208
97	Protactinium-231	133	Thallium-209
98	Protactinium-233	134	Thorium-227
99	Protactinium-234	135	Thorium-228
100	Radium-223	136	Thorium-229
101	Radium-224	137	Thorium-230
102	Radium-226	138	Thorium-231
103	Radium-228	139	Thorium-232
104	Radon-219	140	Thorium-233
105	Radon-220	141	Thorium-234
106	Radon-222	142	Thulium-170
107	Rhenium-187	143	Tin-113
108	Rhodium-106	144	Tin-123
109	Ruthenium-103	145	Tin-123m
110	Ruthenium-106	146	Tin-125
111	Samarium-147	147	Tin-126
112	Samarium-149	148	Uranium-232
113	Samarium-151	149	Uranium-233
114	Selenium-75	150	Uranium-234
115	Selenium-79	151	Uranium-235
116	Silver-108	152	Uranium-236
117	Silver-110m	153	Uranium-237
118	Sodium-22	154	Uranium-238
119	Strontium-85	155	Vanadium-49
120	Strontium-89	156	Yttrium-88
121	Strontium-90	157	Yttrium-90
122	Sulfer-35	158	Yttrium-91
123	Tantalum-182	159	Zinc-65
124	Technetium-99	160	Zirconium-93
125	Tellurium-121	161	Zirconium-95
126	Tellurium-125m		

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Inorganics			
162	Aluminum	207	Chromium Nitrate
163	Aluminum Nitrate (Mono Basic)	208	Chromous Sulfate
164	Aluminum Nitrate (Nonahydrate)	209	Clayton Kerful Cleaner
165	Aluminum Sulfate	210	Clorox
166	Ammonia/Ammonium	211	Cobalt
167	Ammonium Chloride	212	Cobalt Sulfate
168	Ammonium Fluoride	213	Copper
169	Ammonium Hydroxide	214	Cyanide
170	Ammonium Nitrate	215	Dichromate
171	Ammonium Silicofluoride	216	Ferric Ammonium Sulfate
172	Ammonium Sulfate	217	Ferric Nitrate
173	Ammonium Sulfite	218	Ferric Sulfate
174	Antimony	219	Ferrous Ammonium Sulfate
175	Arsenic	220	Ferrous Sulfamate
176	Barium	221	Ferrous Sulfate
177	Barium Nitrate	222	Fluorine (as fluoride)
178	Beryllium	223	Gallium
179	Bismuth	224	Gallium Oxide
180	Boron	225	Germanium
181	Borate(s)	226	Gold
182	Boric Acid	227	Hafnium
183	Borox (Boric Acid)	228	Hydrobromic Acid
184	Bromine	229	Hydrochloric Acid
185	Cadmium	230	Hydrofluoric Acid
186	Cadmium Nitrate	231	Hydrogen
187	Calcium	232	Hydrogen Fluoride
188	Calcium Carbonate	233	Hydrogen Peroxide
189	Calcium Chloride	234	Hydroiodic Acid
190	Calcium Nitrate	235	Hydroxide
191	Carbon	236	Indium
192	Carbon Dioxide	237	Iodine
193	Carbon Disulfide	238	Iron
194	Carbonate(axb)	239	Kleen-o-bowl
195	Cerium	240	Lanthanum
196	Ceric Ammonium Nitrate	241	Lanthanum Fluoride
197	Ceric Fluoride	242	Lanthanum Hydroxide
198	Ceric Iodate	243	Lanthanum Nitrate
199	Ceric Nitrate	244	Lanthanum-Neodynium Nitrate
200	Ceric Sulfate	245	Lead
201	Cesium	246	Lead Nitrate
202	Cesium Chloride	247	Lithium
203	Chloride	248	Magnesium
204	Chloroplatinic Acid	249	Magnesium Carbonate
205	Chromium	250	Magnesium Nitrate

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Inorganics (cont)			
206	Chromium (VI)	251	Magnesium Oxide
252	Magnesium Silicate (Mistron)	296	Silicon
253	Manganese	297	Silver
254	Mercury (inorganic)	298	Silver Nitrate
255	Mercuric Nitrate	299	Silver Oxide
256	Mercuric Thiocyanate	300	Sodium
257	Molybdenum	301	Sodium Acetate
258	Neodymium	302	Sodium Bismuthate
259	Nickel	303	Sodium Bisulfate
260	Nickel Nitrate	304	Sodium Bromate
261	Nickel Sulfate	305	Sodium Carbonate
262	Nitrate/Nitrite	306	Sodium Dichromate
263	Nitric Acid	307	Sodium Ferrocyanide
264	Nitrogen	308	Sodium Fluoride
265	Oakite LSD	309	Sodium Hydroxide
266	Osmium	310	Sodium Nitrate
267	Oxides	311	Sodium Nitrite
268	Oxygen	312	Sodium Oxalate
269	Ozone	313	Sodium Persulfate
270	Perchlorate	314	Sodium Phosphate
271	Periodic Acid	315	Sodium Sulfate
272	Permanganate	316	Sodium Thiosulfate
273	Phosphorus	317	Spic-n-Span
274	Phosphate	318	Strontium
275	Phosphoric Acid	319	Strontium Fluoride
276	Phosphorous Pentoxide	320	Strontium Nitrate
277	Phosphotungstic Acid	321	Sulfamates
278	Platinum	322	Sulfamic Acid
279	Plutonium	323	Sulfate/Sulfite
280	Potassium	324	Sulfonate
281	Potassium Acetate	325	Sulfuric Acid
282	Potassium Bicarbonate	326	Tantalum
283	Potassium Carbonate	327	Tellurium
284	Potassium Dichromate	328	Tin
285	Potassium Ferrocyanide	329	Titanium
286	Potassium Fluoride	330	Titanium Chloride
287	Potassium Hydroxide	331	Tungsten
288	Potassium Iodate	332	Turco 4306 B, C, and D
289	Potassium Oxalate	333	Turco 4502D
290	Potassium Permanganate	334	Turco 4512 A
291	Potassium Persulfate	335	Uranium (chemical toxicity)
292	Rhodium	336	Vanadium
293	Ruthenium	337	Yttrium

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Inorganics (cont)			
294	Sani-Flush	338	Zeolite AW-500 (IX Resin)
295	Selenium	339	Zinc
340	Zinc Amalgam		
341	Zirconium		
342	Zirconyl Nitrate		
343	Zirconyl Phosphate		
Organics			
344	1,1-dichloroethane (DCA)	383	Acenaphthylene
345	1,1-dichloroethene	384	Acetic Acid
346	1,1-dimethylhydrazine	385	Acetic Acid Ethyl Ester
347	1,1,1-trichloroethane (TCA)	386	Acetic acid n-butyl-ester
348	1,1,2-trichloroethane	387	Acetone
349	1,1,2,2-tetrachloroethane	388	Acetonitrile
350	1,2-dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	389	Acetophenone
351	1,2-dichlorobenzene	390	Acrolein
352	1,2-dichloroethane (DCA)	391	Acrylonitrile
353	1,2,2-trichloro-1,1,2-trifluoroethane	392	Aldrin
354	1,2,4-trichlorobenzene	393	Alizarin Yellow
355	1,3-butadiene	394	alpha-BHC
356	1,3-dichlorobenzene	395	Ammonium Oxalate
357	1,4-dinitrobenzene	396	Ammonium Perfluorooctanoate
358	1,4-dioxane	397	AMSCO
359	1-chloroethene (Vinyl Chloride)	398	Anthracene
360	1-methylpropyl Alcohol (2-butanol)	399	Anti-Foam 60 (GE)
361	2,4-dinitrophenol	400	Arsenzao III
362	2,4-dinitrotoluene	401	Benzene
363	2,4,5-trichlorophenol	402	Benzene hexachloride
364	2,6-bis(tert-butyl)-4-methylphenol	403	Benzo(a)anthracene
365	2-butanone (Methyl Ethyl Ketone/MEK)	404	Benzo(a)pyrene
366	2-butenaldehyde (2-butenal)	405	Benzo(b)fluoranthene
367	2-heptanone	406	Benzo(ghi)perylene
368	2-hexanone	407	Benzo(k)fluoranthene
369	2-methyl-2-propanol	408	Benzyl Alcohol
370	2-methyl-2-propenenitrile	409	beta-BHC [Lindane]
371	2-methylphenol (o-cresol)	410	Biphenyl
372	2-pentanone	411	Bromocresol Purple
373	2-propenoic acid	412	Bromomethane
374	2-sec-butyl-4,6-dinitrophenol (dinoseb)	413	Bromonaphthalene
375	3-chloropropene	414	Butane
376	3-heptanone	415	Butanol
377	3-methyl-2-butanone	416	Carbazole
378	3-pentanone	417	Carbon Tetrachloride
379	4-heptanone	418	Chlordane
380	4-methylphenol (p-cresol)	419	Chlorobenzene

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Organics (cont)			
381	5-methyl-2-hexanone	420	Chlorodifluoromethane (Freon 22)
382	Acenaphthene	421	Chloroethane
422	Chloroform	464	Heptachlor
423	Chloromethane	465	Hexachlorobenzene
424	Chrysene	466	Hexachlorobutadiene
425	Cis-1,2-dichloroethylene	467	Hexachloroethane
426	Cis-1,3-dichloropropene	468	Hexachloronaphthalene
427	Citric Acid	469	Hexafluoroacetone
428	Cyclohexane	470	Hexanal
429	Cyclohexanone	471	Hydrazine
430	Cycleohexene	472	Hydroxyacetic Acid
431	Cyclopentane	473	Hydroxylamine Hydrochloride
432	DDT/DDD/DDE (total)	474	Hydroxylamine Nitrate (HN)
433	Decane	475	Hydroxyquinoline
434	Di-(2-ethylhexyl) Phosphoric Acid	476	Hyflo-Super-Cel
435	Diacetone Alcohol	477	Immunol 1468-2
436	Dibenz[a,h]anthracene	478	Ionac A-580/Permutit [SKA] (IX Resin)
437	Dibenzofuran	479	Isodrin
438	Dibutyl Butyl Phosphonate (DBBP)	480	Isopropyl Alcohol
439	Dibutyl Phosphate (DBP)	481	Jasco Paint Stripper
440	Dichlorodifluoromethane	482	Kelite 25E
441	Dichlorofluoromethane (Freon 21)	483	Keraff
442	Dichloromethane (Methylene Chloride)	484	Kerosene
443	Dieldrin	485	Lard Oil
444	Diethylphthalate	486	Mandelic Acid
445	Di-n-butylphthalate	487	Methanol
446	Diversy Chemical 159	488	Methyl Isobutyl Ketone (MIBK/Hexone)
447	Dodecane	489	Methyl Isocyanate
448	Dow Anti-Foam B	490	Methyl Lactic Acid
449	Dowex 21 K/Amberlite XE-270 (IX Resin)	491	Methylcyclohexane
450	Duolite ARC-359 (IX Resin)	492	Methylhydrazine
451	Endrin	493	Mineral Oil
452	Ethanol	494	Miscellaneous Commercial Products
453	Ethyl Benzene	495	Molybdate-Citrate Reagent
454	Ethyl Ether	496	Mono-2-ethylhexyl Phosphoric Acid
455	Ethylene Dibromide	497	Monobutyl Phosphate (MBP)
456	Ethylene Glycol	498	m-xylene
457	Ethylene-diamine Tetraacetic Acid (EDTA)	499	Naphthalene
458	Fluoranthene	500	Naphthylamine
459	Formaldehyde	501	n-butyl Benzene
460	Formic Acid	502	n-heptane

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Organics (cont)			
461	gamma-BHC (Lindane)	503	n-hexane
462	Glycerol	504	Nitrilotriacetic Acid (NTA)
463	Greases	505	Nitrobenzene
506	n,n-diphenylamine	549	Super Gel Hyflo
507	n-nitroso-n,n-dimethylamine	550	Tartaric Acid
508	n-nonane	551	Tetrabromoethane
509	n-octane	552	Tetrachloroethylene (PCE)
510	Normal Paraffin Hydrocarbons	553	Tetrachloronaphthalene
511	n-pentane	554	Tetradecane
512	n-propionaldehyde	555	Tetrahydrofuran
513	n-propyl Alcohol (1-propanol)	556	Tetraphenyl Boron
514	Oakite Clear Guard	557	Thenyltrifluoroacetone
515	Oakite Rust Stripper	558	Thymolphthalein
516	Oakite Swiff	559	Tide
517	Octachloronaphthalene	560	Toluene
518	o-phenanthroline	561	Total Organic Carbon
519	Orvus K	562	Toxaphene
520	Oxalic Acid	563	Trans-1,2-dichloroethylene
521	Oxirane (Ethylene Oxide)	564	Trans-1,3-dichloropropene
522	o-xylene	565	Tributyl Phosphate (TBP)
523	Pace-S-Teen	566	Trichloroethylene (TCE)
524	Pentachloronaphthalene	567	Trichlorofluoromethane
525	Pentachlorophenol	568	Triethylamine
526	Pentasodium Diethylene Triamine Penta Acetate (DTPA)	569	Tri-iso-octylamine
527	Penvert 192	570	Tri-n-dodecylamine
528	Peroklean	571	Tri-n-octylamine
529	Phenanthrene	572	Tris (hydroxymethyl) Amino Methane
530	Phenol	573	Trisodium hydroxyethyl Ethylene-diamine triacetate (HEDTA)
531	Phosphotungstic Acid (PTA)	574	Trisodium Nitrilo Triacetate (NTA)
532	Picric Acid	575	Turco (Fabricfilm)
533	p-nitrochlorobenzene	576	Turco 2822
534	Polychlorinated Biphenyls (PCB)	577	Turco 2844
535	Propionitrile	578	Turco 4358-4A
536	p-xylene	579	Turco 4501 A
537	Pyrene	580	Turco 4518
538	Pyridine	581	Turco 4521
539	Saf-tee Solvent F.O. 128	582	Turco 4605-8
540	s-diphenyl Carbazide	583	Turco 4669
541	Shell E-2342	584	Turco 4715
542	Shell Spray Base	585	Turco 4738 (Thin)
543	Sodium Gluconate	586	Turco Alkaline (Rust Remover)
544	Sodium Tartrate	587	Turco Deseal Zit 2
545	Soltrol-170	588	Turco EPO Strip

Table B-1. Central Plateau Process Contaminants. (8 Pages)

Number	Constituent	Number	Constituent
Organics (cont)			
546	Spartan DC 13	589	Turco EPO Strip NP
547	Sugar	590	Turco Plaudit
548	Sulfonic Acid (chloro)	591	Turco T-5561
592	Turco T-5589	596	Wyandotte Kelvar
593	Urea	597	Wyandotte MF
594	West Lode Degreaser	598	Wyandotte P1075
595	Wyandotte 1112	599	Xylene

[a] Trademarks and registered trademarks are the property of their respective owners. All product names mentioned are listed for contaminant potential only; such listing does not imply ownership and does not constitute endorsement.

Table B-2. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3). (4 Pages)

Hazardous Substance[a,b]	Plants[c]	Soil Biota[d]	Wildlife[e]
METALS[f]:			
Aluminum (soluble salts)	50	[b]	
Antimony	5	[b]	
Arsenic III	[b]	[b]	7
Arsenic V	10	60	132
Barium	500	[b]	102
Beryllium	10	[b]	
Boron	0.5	[b]	
Bromine	10	[b]	
Cadmium	4	20	14
Chromium (total)	42[g]	42[g]	67
Cobalt	20	[b]	
Copper	100	50	217
Fluorine	200	[b]	
Iodine	4	[b]	
Lead	50	500	118
Lithium	35[g]	[b]	
Manganese	1,100[g]	[b]	1,500
Mercury, inorganic	0.3	0.1	5.5
Mercury, organic	[b]	[b]	0.4
Molybdenum	2	[b]	7
Nickel	30	200	980
Selenium	1	70	0.3
Silver	2	[b]	
Technetium	0.2	[b]	

Table B-2. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3). (4 Pages)

Hazardous Substance[a,b]	Plants[c]	Soil Biota[d]	Wildlife[e]
Thallium	1	b	
Tin	50	b	
Uranium	5	b	
Vanadium	2	b	
Zinc	86[g]	b	
PESTICIDES:			
Aldrin	b	b	0.1
Benzene hexachloride (including lindane)	b	b	6
Chlordane	b	1	2.7
DDT/DDD/DDE (total)	b	b	0.75
Dieldrin	b	b	0.07
Endrin	b	b	0.2
Hexachlorobenzene	b	b	17
Heptachlor/heptachlor epoxide (total)	b	b	0.4
Pentachlorophenol	3	6	4.5
OTHER CHLORINATED ORGANICS:			
1,2,3,4-tetrachlorobenzene	b	10	
1,2,3-trichlorobenzene	b	20	
1,2,4-trichlorobenzene	b	20	
1,2-dichloropropane	b	700	
1,4-dichlorobenzene	b	20	
2,3,4,5-tetrachlorophenol	b	20	
2,3,5,6-tetrachloroaniline	20	20	
2,4,5-trichloroaniline	20	20	
2,4,5-trichlorophenol	4	9	
2,4,6-trichlorophenol	b	10	
2,4-dichloroaniline	b	100	
3,4-dichloroaniline	b	20	
3,4-dichlorophenol	20	20	
3-chloroaniline	20	30	
3-chlorophenol	7	10	
Chlorinated Dibenzofurans (total)	b	b	2.00 E-06
Chloroacetamide	b	2	
Chlorobenzene	b	40	
Dioxins	b	b	2.00 E-06

Table B-2. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3). (4 Pages)

Hazardous Substance[a,b]	Plants[c]	Soil Biota[d]	Wildlife[e]
Hexachlorocyclopentadiene	10	b	
Polychlorinated biphenyl mixtures (total)	40	b	0.65
Pentachloroaniline	b	100	
Pentachlorobenzene	b	20	
OTHER NONCHLORINATED ORGANICS:			
2,4-dinitrophenol	20	b	
4-nitrophenol	b	7	
Acenaphthene	20	b	
Benzo(a)pyrene	b	b	12
Biphenyl	60	b	
Diethylphthalate	100	b	
Dimethylphthalate	b	200	
Di-n-butyl phthalate	200	b	
Fluorene	b	30	
Furan	600	b	
Nitrobenzene	b	40	
n-nitrosodiphenylamine	b	20	
Phenol	70	30	
Styrene	300	b	
Toluene	200	b	
PETROLEUM:			
Gasoline Range Organics	b	100	5,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics	b	200	6,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.

a Caution on misusing ecological indicator concentrations: Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under WAC 173-340-7493. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table. The table is not intended for purposes such as evaluating sludges or wastes.

This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

Table B-2. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3). (4 Pages)

Hazardous Substance[a,b]	Plants[c]	Soil Biota[d]	Wildlife[e]

b For hazardous substances where a value is not provided, plant and soil biota indicator concentrations will be based on a literature survey conducted in accordance with WAC 173-340-7493(4), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Literature Surveys," and calculated using methods described in the publications listed below in footnotes c and d. Methods to be used for developing wildlife indicator concentrations are described in WAC 173-340-900, Tables 749-4 and 749-5.

c Based on benchmarks published in ES/ER/TM-85/R3, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision.*

d Based on benchmarks published in ES/ER/TM-126/R2, *Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.*

e Calculated using the exposure model provided in WAC 173-340-900, Table 749-4, and chemical-specific values provided in WAC 173-340-900, Table 749-5. Where both avian and mammalian values are available, the wildlife value is the lower of the two.

f For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated-anaerobic and unsaturated-aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

g Benchmark replaced by Washington State natural background concentration (Ecology 94-115, 1994, *Natural Background Soil Metals Concentrations in Washington State*).

Note: These values represent soil concentrations that are expected to be protective at any waste site and are provided for use in eliminating hazardous substances from further consideration under WAC 173-340-7493 (2)(a)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "The Chemicals of Ecological Concern." Where these values are exceeded, various options are provided for demonstrating that the hazardous substance does not pose a threat to ecological receptors at a site, or for developing site-specific remedial standards for eliminating threats to ecological receptors. See WAC 173-340-7493 (1)(b)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Purpose," WAC 173-340-7493 (2)(a)(ii), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "Exposure Pathways," and WAC 173-340-7493(3), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Selection of Appropriate Terrestrial Ecological Evaluation Methods."

Ecology 94-115, 1994, *Natural Background Soil Metals Concentrations in Washington State*, Toxics Cleanup Program, Washington State Department of Ecology, Olympia, Washington.

ES/ER/TM-85/R3, 1997, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee.

ES/ER/TM-126/R2, 1997, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee.

WAC 173-340-900, "Tables," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7493(1)(b)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Purpose," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7493(2)(a)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "The Chemicals of Ecological Concern," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7493(2)(a)(ii), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "Exposure Pathways," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7493(3), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Selection of Appropriate Terrestrial Ecological Evaluation Methods," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7493(4), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Literature Surveys," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides		
Actinium-225	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 10 d)	Parrington et al. 1996
Actinium-227	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-235 parent.	
Aluminum-28	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 12.75 d)	Parrington et al. 1996
Americium-242	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Americium-242m	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Americium-243	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Antimony-122	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.72 d)	Parrington et al. 1996
Antimony-123	Naturally occurring isotope.	Parrington et al. 1996
Antimony-124	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 60.2 d)	Parrington et al. 1996
Antimony-126	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 12.4 d)	Parrington et al. 1996
Antimony-126m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 11 s)	Parrington et al. 1996
Barium-133	Is a Ba-132 neutron activation product. However, Ba-132 is present at 0.101% of the natural barium isotopes. Ba-133 can also be produced from proton bombardment of Cs-133. However, bombardment was not done at Hanford. ORIGEN2 modeling of high burn-up N-reactor fuels (highest yields) shows no yield for this isotope.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Barium-135m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.2 d)	Parrington et al. 1996
Barium-137	Naturally occurring isotope.	Parrington et al. 1996
Barium-137m	Short-lived daughter of Cs-137 (which is a final COPEC).	Parrington et al. 1996
Barium-140	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 12.75 d)	Parrington et al. 1996
Beryllium-10	It is the product of neutron activation of Be-9. The only presence would be from the beryllium braze used to close the ends of Zircalloy clad fuel. ORIGEN2 modeling of high burn-up N-reactor fuels (highest yields) shows production at approximately 1 μCi per metric ton of uranium fuel. This calculates to approximately 1 pCi of Be-10 per gram of fuel. Chemical processing of the fuel would dilute this concentration further.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Bismuth-210	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-238 parent.	RadDecay Version 3, Parrington et al. 1996
Bismuth-213	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 45.6 m)	Parrington et al. 1996
Bismuth-214	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 19.9 m)	Parrington et al. 1996
Cadmium-109	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 462 d)	Parrington et al. 1996
Cadmium-113m	Less than 1% of cesium-137 activity. Insignificant contribution to dose.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Cerium-141	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 32.5 d)	Parrington et al. 1996
Cerium-144	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 284.6 d)	Parrington et al. 1996
Cesium-135	Constituent generated at less than 5.0 E-05 times Cs-137 activity.	Parrington et al. 1996
Cesium-141	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 24.9 s)	Parrington et al. 1996
Cesium-144	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.01 s)	Parrington et al. 1996
Chlorine-36	ORIGEN2 modeling of high burn-up N-reactor fuels (highest yields) shows no yield for this isotope.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Chromium-51	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 27.7 d)	Parrington et al. 1996
Cobalt-57	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 271.8 d)	Parrington et al. 1996
Cobalt-58	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 70.88 d)	Parrington et al. 1996
Curium-242	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Curium-243	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Curium-244	Constituent with atomic mass number greater than or equal to 242 that represents less than 1% of the actinide activity. May be reported via americium isotopic analysis.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Curium-245	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Ensteinium-254	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 276 d)	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Francium-221	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 4.8 m)	Parrington et al. 1996
Francium-223	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 21.8 m)	Parrington et al. 1996
Gadolinium-152	Naturally occurring isotope.	Parrington et al. 1996
Gadolinium-153	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 241.6 d)	Parrington et al. 1996
Germanium-68	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 270.8 d)	Parrington et al. 1996
Gold-195	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 186.12 d)	Parrington et al. 1996
Iodine-123	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 13.2 h)	Parrington et al. 1996
Iodine-125	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 59.4 d)	Parrington et al. 1996
Iodine-129	Constituent generated at less than 5.0 E-05 times Cs-37 activity, historical tank and vadose sampling indicates nondetection; highly mobile constituent found mainly in groundwater.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Iodine-131	Volatile gas emission; short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 8 d)	Parrington et al. 1996, Rickard and McShane 1984
Iron-55	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.73 y)	Parrington et al. 1996
Iron-59	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 44.51 d)	Parrington et al. 1996
Krypton-85	Gas.	
Lanthanum-140	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.678 d)	Parrington et al. 1996
Lead-209	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 3.25 h)	Parrington et al. 1996
Lead-210	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-238 parent.	RadDecay Version 3, Parrington et al. 1996
Lead-211	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 36.1 m)	Parrington et al. 1996
Lead-212	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 10.64 h)	Parrington et al. 1996
Lead-214	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 27 m)	Parrington et al. 1996
Manganese-54	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 312.1 d)	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Molybdenum-93	The product of neutron activation of Mo-92, but Mo-92 is present at 14.84% of the natural molybdenum isotopes and has a low neutron cross section. ORIGEN2 modeling of high burn-up N-reactor fuels (highest yields) shows yields of less than 50 pCi/g and processing should have diluted this isotope further.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Neodymium-147	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 10.98 d)	Parrington et al. 1996
Neptunium-239	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.355 d)	Parrington et al. 1996
Nickel-59	Activity will be <5% of Ni-63 activity and may be estimated from that isotope.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Niobium-93m	Constituent generated at less than 5.0 E-05 times Cs-137 activity.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Niobium-94	ORIGEN2 modeling of high burn-up N-reactor fuels (highest yields) shows yields less than 10 pCi/g and chemical processing should have diluted this isotope further.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Niobium-95	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 34.97 d)	Parrington et al. 1996
Niobium-96	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 23.4 h)	Parrington et al. 1996
Niobium-98	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 51 m)	Parrington et al. 1996
Palladium-107	Constituent generated at less than 5.0 E-05 times Cs-137 activity.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Phosphorus-32	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 14.28 d)	Parrington et al. 1996
Plutonium-241	Not detected by normal plutonium analysis; can infer from americium/plutonium results.	Parrington et al. 1996
Plutonium-242	Constituent with atomic mass number greater than or equal to 242 that represents < 1% of the actinide activity.	Based on ORIGEN2 modeling of Hanford Site reactor production (ORNL-5621)
Polonium-210	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 138.38 d)	Parrington et al. 1996
Polonium-211	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 25.2 s)	Parrington et al. 1996
Polonium-212	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 45 s)	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Polonium-213	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 4 μs)	Parrington et al. 1996
Polonium-214	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 163.7 μs)	Parrington et al. 1996
Polonium-215	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.87 μs)	Parrington et al. 1996
Polonium-216	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 0.145 μs)	Parrington et al. 1996
Polonium-218	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 3.1 m)	Parrington et al. 1996
Potassium-40	Naturally occurring isotope.	Parrington et al. 1996
Praseodymium-143	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 13.57 d)	Parrington et al. 1996
Praseodymium-144	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 17.28 m)	Parrington et al. 1996
Promethium-143	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 265 d)	Parrington et al. 1996
Promethium-147	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 13.4 m)	Parrington et al. 1996
Protactinium-231	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-235 parent.	
Protactinium-233	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 27 d)	Parrington et al. 1996
Protactinium-234	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 6.69 h)	Parrington et al. 1996
Radium-223	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 11.44 d)	Parrington et al. 1996
Radium-224	Thorium-232 decay daughter value can be calculated from Th-232/Ra-228 if present.	Parrington et al. 1996, RadDecay Version 3
Radon-219	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 3.96 s)	Parrington et al. 1996
Radon-220	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 55.6 s)	Parrington et al. 1996
Radon-222	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 3.82 d)	Parrington et al. 1996
Rhenium-187	Naturally occurring isotope.	Parrington et al. 1996
Rhodium-106	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.18 h)	Parrington et al. 1996
Ruthenium-103	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 39.27 d)	Parrington et al. 1996
Ruthenium-106	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.02 y)	Parrington et al. 1996
Samarium-147	Naturally occurring isotope.	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Samarium-149	Stable.	Parrington et al. 1996
Samarium-151	Less than 1% of Cs-137 activity. Insignificant contribution to dose.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Selenium-75	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 119.78 d)	Parrington et al. 1996
Selenium-79	Constituent generated at less than 5.0 E-05 times Cs-137 activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Silver-108	Less than 10% of Ag-108m decays through Ag-108. ORIGEN2 shows yields less than 2 pCi/g for high burn-up N-reactor fuels and chemical processing should have diluted this isotope further.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Silver-110m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 249.8 d)	Parrington et al. 1996
Sodium-22	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.60 y)	Parrington et al. 1996
Strontium-85	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 64.84 d)	Parrington et al. 1996
Strontium-89	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 50.52 d)	Parrington et al. 1996
Sulfer-35	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 87.2 d)	Parrington et al. 1996
Tantalum-182	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 114.43 d)	Parrington et al. 1996
Tellurium-121	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 154 d)	Parrington et al. 1996
Tellurium-125m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 58 d)	Parrington et al. 1996
Tellurium-127	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 109 d)	Parrington et al. 1996
Tellurium-129	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 33.6 d)	Parrington et al. 1996
Tellurium-129m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.16 h)	Parrington et al. 1996
Thallium-204	ORIGEN2 shows no yield for this isotope.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Thallium-207	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 4.77 m)	Parrington et al. 1996
Thallium-208	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 3.05 m)	Parrington et al. 1996
Thallium-209	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 2.16 m)	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Radionuclides (cont)		
Thorium-227	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 18.72 d)	Parrington et al. 1996
Thorium-228	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.91 y)	Parrington et al. 1996
Thorium-229	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-233 parent.	RadDecay Version 3, Parrington et al. 1996
Thorium-230	Progeny radionuclide that builds insignificant activities within 50 years and can be estimated from U-238 parent.	RadDecay Version 3, Parrington et al. 1996
Thorium-231	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 1.06 d)	Parrington et al. 1996
Thorium-233	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 22.3 m)	Parrington et al. 1996
Thorium-234	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 24.1 d)	Parrington et al. 1996
Thallium-170	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 128.6 d)	Parrington et al. 1996
Tin-113	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 115.1 d)	Parrington et al. 1996
Tin-123	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 129.2 d)	Parrington et al. 1996
Tin-123m	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 40.1 m)	Parrington et al. 1996
Tin-125	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 9.63 d)	Parrington et al. 1996
Tin-126	Constituent generated at less than 5.0 E-05 times Cs-137 activity (GEA will be reported if detected).	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Uranium-232	<2.0 E-03 times U-238 activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Uranium-233	Measurement cannot resolve U-234 + U-233 isotopes, reported as U-234.	
Uranium-236	Measurement cannot resolve U-235 + U-236 isotopes, reported as U-235.	Parrington et al. 1996
Uranium-237	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 6.75 d)	Parrington et al. 1996
Vanadium-49	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 337 d)	Parrington et al. 1996
Yttrium-88	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 106.65 d)	Parrington et al. 1996
Yttrium-90	Short-lived daughter of Sr-90 (which is a final COPEC).	Parrington et al. 1996
Yttrium-91	Short-lived radionuclide (half-life <3 years). ($t_{1/2}$= 58.5 d)	Parrington et al. 1996
Zinc-65	Short-lived radionuclide (half-life <3 years).	Parrington et al. 1996

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
	($t_{1/2}$= 243.8 d)	
Radionuclides (cont)		
Zirconium-93	Constituent generated at less than 5.0 E-05 times Cs-137 activity.	Based on ORIGEN2 modeling of Hanford reactor production (ORNL-5621)
Zirconium-95	Short-lived radionuclide (half-life <3 years).	Parrington et al. 1996
	($t_{1/2}$= 64.02 d)	
Inorganics		
Aluminum Nitrate (Mono Basic)	Contains aluminum and nitrate, which have been previously identified as COCs.	
Aluminum Nitrate Nonahydrate		
Aluminum Sulfate	Contains aluminum and sulfate, which have been previously identified as COCs.	
Ammonium Chloride	Contains aluminum and chloride, which have been previously identified as COCs.	
Ammonium Fluoride	Contains aluminum and fluoride, which have been previously identified as COCs.	
Ammonium Hydroxide	Contains ammonium, which has been previously identified as a COC, and hydroxide, which has been previously excluded.	
Ammonium Nitrate	Contains ammonium and nitrate, which have been previously identified as COCs.	
Ammonium Silicofluoride	Contains ammonium and fluoride, which have been previously identified as COCs, and silicon, which has been previously excluded.	
Ammonium Sulfate	Contains ammonium and sulfate, which have been previously identified as COCs.	
Ammonium Sulfite	Contains ammonium and sulfite, which have been previously identified as COCs.	
Barium Nitrate	Contains barium and nitrate, which have been previously identified as COCs.	
Boron	This substance was not used routinely or significantly during Hanford Site Central Plateau Operations.	
Borate(s)	Material used in very low or trace quantities at Hanford.	
Boric Acid	Contains boron, which has been previously excluded; acid determined by pH.	
Borox (Boric Acid)	Product name for boric acid, which has been previously excluded.	
Bromine	This substance was not used routinely or significantly during Hanford Site Central Plateau Operations.	
Cadmium Nitrate	Contains cadmium and nitrate, which has been previously identified as COCs.	
Calcium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Calcium Carbonate	Contains calcium, which has been previously excluded; contains carbonate, which degrades to carbon dioxide which has been previously excluded.	
Calcium Chloride	Contains calcium, which has been previously excluded, and chloride, which has been previously identified as a COC.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Calcium Nitrate	Contains calcium, which has been previously excluded, and nitrate, which has been previously identified as a COC.	
Carbon	Inorganic carbon used at the Hanford site is only found as a gas. Total organic carbon will be measured.	
Carbon Dioxide	Gas.	
Carbon Disulfide	Gas.	
Carbonate (axb)	This inorganic substance is unlikely to be present in toxic concentrations. Screened for potential effect on pH.	
Cerium	Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Ceric Ammonium Nitrate	Contains cerium, which has been previously excluded, and ammonium and nitrate, which has been previously identified as a COC.	
Ceric Fluoride	Contains cerium, which has been previously excluded, and fluoride, which has been previously identified as a COC.	
Ceric Iodate	Contains cerium, which has been previously excluded, and iodine, which has been previously identified as a COC.	
Ceric Nitrate	Contains cerium, which has been previously excluded, and nitrate, which has been previously identified as a COC.	
Ceric Sulfate	Contains cerium, which has been previously excluded, and sulfate, which has been previously identified as a COC.	
Cesium	Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Cesium Chloride	Contains cesium, which has been previously excluded, and chloride, which has been previously identified as a COC.	
Chloroplatinic Acid	Contains platinum, which has been previously excluded; chlorine detected by anion analysis.	
Chromium Nitrate	Contains chromium and nitrate, which have been previously identified as COCs.	
Chromous Sulfate	Contains chromium and sulfate, which have been previously identified as COCs.	
Clayton Kerful Cleaner	Product name for sodium hydroxide, which has been previously excluded. pH will be assessed separately.	
Clorox	Commercial product, sodium hypochlorite; sodium has been previously excluded and chloride which has been previously identified as a COC.	
Cobalt Sulfate	Contains cobalt, which is excluded, and sulfate, which has been previously identified as a COC.	
Dichromate	Contains chromium, which has been previously identified as a COC.	
Ferric Ammonium Sulfate	Contains iron, which has been previously excluded, and ammonium and sulfate, which have been previously identified as COCs.	
Ferric Nitrate	Contains iron, which has been previously excluded, and nitrate, which has been previously identified as a COC.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Ferric Sulfate	Contains iron, which has been previously excluded, and sulfate, which has been previously identified as a COC.	
Ferrous Ammonium Sulfate	Contains iron, which has been previously excluded, and ammonium and sulfate, which have been previously identified as COCs.	
Ferrous Sulfamate	Contains iron, which has been previously excluded; and sulfamate which degrades to sulfate and ammonium which have been previously identified as COCs.	
Ferrous Sulfate	Contains iron, which has been previously excluded, and sulfate, which has been previously identified as a COC.	
Gallium	Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Gallium Oxide	Contains gallium, which has been excluded.	
Germanium	Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Gold	Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Hafnium	This inorganic substance is unlikely to be present in toxic or high concentrations owing to minimal use in Hanford Site Central Plateau processes.	
Hydrobromic Acid	Contains bromine, which has been previously identified as a COC; acid determined by pH.	
Hydrochloric Acid	Contains chlorine, which has been previously identified as a COC; acid determined by pH.	
Hydrofluoric Acid	Contains fluorine, which has been previously identified as a COC; acid determined by pH.	
Hydrogen	Gas.	
Hydrogen Fluoride	Contains fluorine, which has been previously identified as a COC; acid determined by pH.	
Hydrogen Peroxide	Degrades to water.	
Hydroiodic Acid	Contains iodine, which has been previously identified as a COC; acid determined by pH.	
Hydroxide	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Indium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Iron	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Kleen-o-bowl	Product name for ammonium chloride and hydrochloric acid, which have been previously identified as COCs.	
Lanthanum	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Lanthanum Fluoride	Contains lanthanum, which has been previously excluded; and fluoride which has been previously identified as a COC.	
Lanthanum Hydroxide	Contains lanthanum and hydroxide, which have been previously excluded.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Lanthanum Nitrate	Contains lanthanum, which has been previously excluded; and nitrate which has been previously identified as a COC.	
Lanthanum-Neodynium Nitrate	Contains lanthanum and neodymium, which have been previously excluded; and nitrate which has been previously identified as a COC.	
Lead Nitrate	Contains lead and nitrate, which have been previously identified as COCs.	
Magnesium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Magnesium Carbonate	Contains magnesium and carbonate, which have been previously excluded.	
Magnesium Nitrate	Contains magnesium, which has been previously excluded; and nitrate which has been previously identified as a COC.	
Magnesium Oxide	Contains magnesium and oxide, which has been previously excluded.	
Magnesium Silicate (Mistron)	Contains magnesium and silicon, which have been previously excluded.	
Mercury (organic)	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Mercuric Nitrate	Contains mercury and nitrate, which have been previously identified as a COC.	
Mercuric Thiocyanate	Contains mercury and cyanide, which have been previously identified as a COC.	
Neodynium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Nickel Nitrate	Contains nickel and nitrate, which have been previously identified as COCs.	
Nickel Sulfate	Contains nickel and sulfate, which have been previously identified as COCs.	
Nitric Acid	Contains nitrate, which is included as a COC; acid assessment through pH analysis.	
Nitrogen	Gas.	
Oakite LSD	Product name for sodium hydroxide; which have been previously excluded.	
Osmium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Oxides	Anion form which typically has minimal effect on potential toxicity of total compounds. Reactive oxides will have degraded to hydroxide (excluded) or oxygen a gas (also excluded).	
Oxygen	Gas.	
Ozone	Gas.	
Perchlorate	Has degraded to chlorine, which is a previously identified COC; and oxygen which has previously been excluded.	
Periodic Acid	Contains iodine, which has been previously identified as a COC; acids assessed through pH analysis.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Permanganate	Contains potassium and oxygen, which have been previously excluded; and manganese which has been previously identified as a COC.	
Phosphorus	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2	
Phosphoric Acid	Contains phosphate, which has been previously identified as a COC; acid assessment through pH analysis.	
Phosphorous Pentoxide	Contains phosphorous, which has been previously identified as a COC; and oxide which has been previously excluded.	
Phosphotungstic Acid	Contains phosphate which is a final COC and tungsten which has been previously excluded.	
Platinum	Material used in low or trace quantities at Hanford, typically as metallic components. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Plutonium	Will be identified via radionuclide analysis.	
Potassium	Material used in low quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Potassium Acetate	Contains potassium and acetate, which have been previously excluded.	
Potassium Bicarbonate	Contains potassium and carbonate, which have been previously excluded.	
Potassium Carbonate	Contains potassium and carbonate, which have been previously excluded.	
Potassium Dichromate	Contains potassium which has been previously excluded and dichromate which has been previously identified as a final COC.	
Potassium Ferrocyanide	Contains potassium and iron which have been previously excluded and cyanide which has been previously identified as a final COC.	
Potassium Fluoride	Contains potassium which has been previously excluded and fluoride which has been previously identified as a final COC.	
Potassium Hydroxide	Contains potassium and hydroxide which have been previously excluded.	
Potassium Iodate	Contains potassium which has been previously excluded and iodine which has been previously identified as a final COC.	
Potassium Oxalate	Contains potassium and oxalate, which have been previously excluded.	
Potassium Permanganate	Contains potassium and oxygen which have been previously excluded, and manganese which has been previously identified as a final COC.	
Potassium Persulfate	Contains potassium which has been previously excluded, and sulfate which has been previously identified as a final COC.	
Rhodium	This inorganic substance is unlikely to be present in toxic or high concentrations owing to minimal use in Hanford Site Central Plateau processes.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Ruthenium	Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables.	
Sani-Flush	Commercial chemical. Generates sulfuric acid (sulfate) on contact with water. Sulfate has been previously identified as a COC.	
Silicon	No cleanup levels established in Ecology 94-145, Section 3.1 tables. No known discharge of respirable silica (potentially hazardous form) to the included sites.	
Silver Nitrate	Contains silver and nitrate which have been previously identified as COCs.	
Silver Oxide	Contains silver which has been previously identified as a COC, and oxide which has been previously excluded.	
Sodium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. Routine analyte reported by ICP analysis.	
Sodium Acetate	Contains sodium and acetate, which have been previously excluded.	
Sodium Bismuthate	Contains sodium, bismuth, and oxygen which have been previously excluded.	
Sodium Bisulfate	Contains sodium which has been previously excluded, and sulfate which has been previously identified as a COC.	
Sodium Bromate	Contains sodium, boron, and oxygen which have been previously excluded.	
Sodium Carbonate	Contains sodium and carbonate, which have been previously excluded.	
Sodium Dichromate	Contains sodium which has been previously excluded, and chromium which has been previously identified as a COC.	
Sodium Ferrocyanide	Contains sodium and iron which have been previously excluded, and cyanide which has been previously identified as a COC.	
Sodium Fluoride	Contains sodium which has been previously excluded, and fluoride which has been previously identified as a COC.	
Sodium Hydroxide	Contains sodium and hydroxide, which have been previously excluded.	
Sodium Nitrate	Contains sodium which has been previously excluded, and nitrate which has been previously identified as a COC.	
Sodium Nitrite	Contains sodium which has been previously excluded, and nitrite which has been previously identified as a COC.	
Sodium Oxalate	Contains sodium and oxalate, which have been previously excluded.	
Sodium Persulfate	Contains sodium, which has been previously excluded; contains persulfate, which degrades to sulfate and has been previously identified as a COC.	
Sodium Phosphate	Contains sodium which has been previously excluded, and phosphate which has been previously identified as a COC.	
Sodium Sulfate	Contains sodium, which has been previously excluded; and sulfate which has been previously identified as a COC.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Sodium Thiosulfate	Contains sodium, which has been previously excluded; contains thiosulfate, which degrades to sulfate and has been previously identified as a COC.	
Spic-n-Span	Commercial product, cleaning agent, no standard analytical method in place for its analysis. Contains ammonia which has been previously identified as a COC.	
Strontium Fluoride	Contains strontium and fluoride which have been previously identified as COCs.	
Strontium Nitrate	Contains strontium and nitrate which have been previously identified as COCs.	
Sulfamates	Degrades to sulfates which has been previously identified as a COC.	
Sulfamic Acid	Degrades to sulfate and ammonia, which have been previously identified as COCs.	
Sulfonate	Degrades to sulfate, which has been previously identified as a COC.	
Sulfuric Acid	Chemical has degraded to sulfate, which has been previously identified as a COC.	
Tantalum	Material used in low or trace quantities at Hanford, typically as metallic components. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Technetium	Only radioactive technetium was disposed of from Hanford Site Central Plateau Operations. Chemical technetium was never introduced. Will be identified via radionuclide analysis.	
Tellurium	Material used in low or trace quantities at Hanford, typically as metallic components. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Thallium	Only radioactive Thallium was disposed of from Hanford Site Central Plateau Operations. Chemical thallium was never introduced. Will be identified via radionuclide analysis.	
Titanium	Material used in low or trace quantities at Hanford, typically as metallic components. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Titanium Chloride	Chemical contains titanium, which has been previously excluded, and chlorine which has been previously identified as a COC.	
Tungsten	Material used in low or trace quantities at Hanford, typically as metallic components. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Turco 4306 B, C, and D	Product name for sodium sulfate compounds. Sodium has been previously excluded and sulfate has been previously identified as a COC.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Inorganics (cont)		
Turco 4502D	Product name for potassium hydroxide, dichromate, and permanganate compounds. Potassium and hydroxide have been previously excluded and chromium and manganese have previously been identified as COCs.	
Turco 4512 A	Product name for phosphoric compounds, which have already been identified as COCs.	
Yttrium	This inorganic substance is unlikely to be present in toxic or high concentrations owing to minimal use in Hanford Site Central Plateau processes.	
Zeolite AW-500 (IX Resin)	Commercial product that contains aluminum, silicon, and hydroxide which have previously been excluded.	
Zinc Amalgam	Contains zinc which has been previously excluded and mercury which has been previously identified as a COC.	
Zirconium	Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Zirconyl Nitrate	Chemical contains zirconium, which has been previously excluded, and nitrate which has been previously identified as a COC.	
Zirconyl Phosphate	Contains zirconium which has been previously excluded and phosphate which has been previously identified as a COC.	
Organics		
1,1-dimethylhydrazine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. Reactive material with minimal lifetime in Hanford Site environment. No direct standard analytical technique available.	
1,2-dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	Gas above 48 degrees C.	
1,2-dichloropropane	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
1,2,2-trichloro-1,1,2-trifluoroethane	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
1,2,3,4-tetrachlorobenzene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
1,2,3-trichlorobenzene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
1,2,4-trichlorobenzene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
1,3-butadiene	Gas.	
1,4-dichlorobenzene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
1,4-dinitrobenzene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
1,4-dioxane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
1-chloroethene (vinyl chloride)	Gas.	
1-methylpropyl Alcohol (2-butanol)	Butanol has been previously identified as a COC.	
2,3,4,5-tetrachlorophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
2,3,5,6-tetrachloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
2,4-dichloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
2,4-dinitrophenol	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
2,4,5-trichloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in v	
2,4,5-trichlorophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
2,4,6-trichlorophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
2,6-bis(tert-butyl)-4-methylphenol	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
2-butenaldehyde (2-butenal)	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
2-heptanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
2-methyl-2-propanol	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
2-methyl-2-propenenitrile	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
2-pentanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
2-propenoic acid	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
2-sec-butyl-4,6-dinitrophenol (dinoseb)	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
3,4-dichloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
3,4-dichlorophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
3-chloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
3-chlorophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
3-chloropropene	Gas above 45 degrees C.	
3-heptanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
3-methyl-2-butanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
3-pentanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
4-heptanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
4-nitrophenol	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
5-methyl-2-hexanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Acenaphthene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Acenaphthylene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Acetic Acid	Available as food-grade chemical (for example, vinegar). Potential pH effects will be determined. Has dissolved into a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexing agents. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Acetic acid ethyl ester	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Acetic acid n-butyl-ester	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Acetone	Very soluble in water; likely to have migrated or vaporized if exposed; reasonably biodegradable. Not likely to be present in toxic and/or flammable concentrations.	
Acetonitrile	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Acetophenone	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Acrolein	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Acrylonitrile	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Aldrin	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Alizarin Yellow	Laboratory indicator. Typically used in drop quantities as <1% solutions. No analytical technology or toxicity issues identified.	
Alpha-BHC	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Ammonium Oxalate	Contains ammonium, which has been previously identified as a COC, and oxalate, which has been previously excluded.	
Ammonium Perfluorooctanoate	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. No direct standard analytical technique available.	
AMSCO	Commercial product containing normal paraffin hydrocarbon, which has been previously identified as a COC.	
Anthracene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Anti-Foam 60 (GE)	Commercial product, no standard analytical method in place for its analysis.	
Arsenzao III	Commercial product, no standard analytical method in place for its analysis.	
Benzene hexachloride (including lindane)	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Benzo(a)anthracene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Benzo(a)pyrene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Benzo(b)fluoranthene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Benzo(ghi)perylene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Benzo(k)fluoranthene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Benzyl Alcohol	Available as food grade material. Minimal use of this compound at Hanford. The WAC 173-340-745 direct exposure limit is 24,000 mg/kg. Semivolatile analysis could report presence as TIC.	
Beta-BHC [Lindane]	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Biphenyl	If present, will be identified in polychlorinated biphenyls (PCB), which previously were identified as a COC.	
Bromocresol Purple	Laboratory indicator. Typically used in drop quantities as <1% solutions. No analytical technology or toxicity issues identified.	
Bromomethane	Gas.	
Bromonaphthalene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Butane	Gas.	
Carbazole	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Chlordane	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Chlorinated Dibenzofurans (total)	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Chloroacetamide	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Chlorodifluoromethane (Freon 22)	Gas.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Chloroethane	Gas.	
Chloromethane	Gas.	
Chrysene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Cis-1,3-dichloropropene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Citric Acid	Available as food-grade material. Potential pH effects will be determined. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Cyclohexane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Cyclohexanone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Cyclohexene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Cyclopentane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
DDT/DDD/DDE (total)	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Decane	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
Di-(2-ethylhexyl) Phosphoric Acid	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Degradation products include phosphate (final COC). Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Diacetone Alcohol	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Dibenz[a,h]anthracene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Dibenzofuran	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Dibutyl Butyl Phosphonate (DBBP)	DBBP was widely used as a solvent during the PRF americium recovery operations. Will degrade to phosphate and butanol (final COCs). Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical procedure available.	
Dibutyl Phosphate (DBP)	This compound is a degradation product of TBP and is unlikely to be present in toxic or high concentrations. Will degrade to phosphate and butanol (final COCs). Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Dichlorodifluoromethane	Gas.	
Dichlorofluoromethane (Freon 21)	Gas.	
Dieldrin	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Diethylphthalate	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Dimethylphthalate	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Di-n-butyl phthalate	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Dioxins	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Diversy Chemical 159	Commercial product, no standard analytical method in place for its analysis.	
Dodecane	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Dow Anti-Foam B	Commercial product that contains silicon, which has been previously excluded.	
Dowex 21 K/Amberlite XE-270 (IX Resin)	Commercial product in which no standard analytical method in place for its analysis.	
Duolite ARC-359 (IX Resin)	Commercial product that contains sulfate and phenol which have been previously identified as COCs. No standard analytical method in place for its analysis.	
Endrin	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Ethanol	Material used in low quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. Available as food-grade material; not likely to be present in flammable concentrations.	
Ethyl Ether	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. Compound could be measured as VOA TIC.	
Ethylene Dibromide	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Ethylene Glycol	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Ethylene-diamine tetra acetic acid (EDTA)	Available as food-grade material. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. No direct standard analytical technique available.	
Fluoranthene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Fluorene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Formaldehyde	Very soluble in water; likely to have migrated or vaporized if exposed; reasonably biodegradable. Available as food-grade material; not likely to be present in toxic and/or flammable concentrations.	
Formic acid	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Used in minimal quantities at Hanford. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. No direct standard analytical technique available.	
Furans	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
gamma-BHC (Lindane)	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Glycerol	Available as food-grade material. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	
Greases	Can be measured as normal paraffin hydrocarbon which has been previously identified as a COC or can be measured as a semivolatile TIC.	
Heptachlor/Heptachlor Epoxide (total)	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Hexachlorobenzene	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Hexachlorobutadiene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Hexachloroethane	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Hexachlorocyclopentadiene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Hexachloronaphthalene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Hexafluoroacetone	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Hexanal	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Hydrazine	Extremely reactive, soluble, and very likely to have degraded and not be present within waste stream.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Hydroxyacetic Acid	Available as food-grade material. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Hydroxylamine Hydrochloride	Hydroxylamine was used during the PRF processes. Extremely reactive; very likely to have degraded to water, nitrogen, and ammonium hydroxide and not be present within waste stream. No direct standard analytical technique available. Chloride has been previously identified as a COC.	
Hydroxylamine Nitrate (HN)	Hydroxylamine was used during the PRF processes. Extremely reactive; very likely to have degraded to water, nitrogen, and ammonium hydroxide and not be present within waste stream. No direct standard analytical technique available. Nitrate has been previously identified as a COC.	
Hydroxyquinoline	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Hyflo-Super-Cel	Commercial product, solid, no standard analytical method in place for its analysis.	
Immunol 1468-2	Commercial product, no standard analytical method in place for its analysis.	
Ionac A-580/Permutit [SKA] (IX Resin)	Commercial product which is a solid with active methyl groups. The active methyl groups will react or degrade during production operations, leaving a non-reactive or regulated plastic. No standard analytical method in place for its analysis.	
Isodrin	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Isopropyl Alcohol	Extremely soluble, and very likely to have degraded and not be present within waste stream. Material used in low or trace quantities at Hanford.	
Jasco Paint Stripper	Commercial product that most likely contains methanol, methylene chloride, and/or caustics such as sodium hydroxide owing to time period used.	
Kelite 25E	Commercial product, no standard analytical method in place for its analysis.	
Keraff	Commercial product, no standard analytical method in place for its analysis.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Kerosene	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
Lard Oil	This is a food-grade chemical with no applicable regulatory action levels. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Mandelic Acid	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Methanol	Extremely soluble, and very likely to have degraded and not be present within waste stream.	
Methyl Isocyanate	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Methyl Lactic Acid	Has decomposed to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Methylcyclohexane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Methylhydrazine	Used in minimal quantities at Hanford. Reactive material with minimal lifetime in Hanford environment. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. No direct standard analytical technique available.	
Mineral Oil	Commercial product, no standard analytical method in place for its analysis.	
Miscellaneous Commercial Products	Commercial product, no standard analytical method in place for its analysis.	
Molybdate-Citrate Reagent	Constituents analyzed as molybdenum and citrate which has been previously excluded. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No direct standard analytical technique available.	
Mono-2-ethylhexyl Phosphoric Acid	Degradation product of Di-2-ethyl hexyl phosphoric acid. Degradation products include phosphate (final COC). Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. No direct standard analytical technique available.	
Monobutyl Phosphate (MBP)	This compound is a degradation product of TBP. Will degrade to phosphate and butanol, which have been previously identified as COCs. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
m-xylene	Measured as total Xylene (EPA Method 8260, SW-846).	
Naphthylamine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
n-heptane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
n-hexane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Nitrilotriacetic Acid (NTA)	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Nitrobenzene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
n,n-diphenylamine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
n-nitrosodiphenylamine	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
n-nitroso-n,n-dimethylamine	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
n-nonane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
n-octane	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
n-pentane	Gas above 36 degrees C.	
n-propionaldehyde	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
n-propyl Alcohol (1-propanol)	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Oakite Clear Guard	Commercial product, no standard analytical method in place for its analysis.	
Oakite Rust Stripper	Commercial product, no standard analytical method in place for its analysis.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Oakite Swiff	This commercial chemical is trichloroethane, which has been previously identified as a COC.	
Octachloronaphthalene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
o-phenanthroline	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Orvus K	Commercial product, no standard analytical method in place for its analysis.	
Oxalic Acid	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Oxirane (Ethylene Oxide)	Gas.	
o-xylene	Measured as total Xylene (EPA Method 8260, SW-846).	
Pace-S-Teen	Commercial product, no standard analytical method in place for its analysis.	
Pentachloroaniline	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Pentachlorobenzene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Pentachloronaphthalene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Pentachlorophenol	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Pentasodium Diethylene Triamine Penta Acetate (DTPA)	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Penvert 192	Commercial product, no standard analytical method in place for its analysis.	
Peroklean	Commercial product, no standard analytical method in place for its analysis.	
Phenanthrene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Phosphotungstic Acid (PTA)	Will degrade to phosphate and butanol, which have been previously identified as COCs, and tungsten, which has been previously excluded. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Picric Acid	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
p-nitrochlorobenzene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Propionitrile	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
p-xylene	Measured as total Xylene (EPA Method 8260, SW-846).	
Pyrene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Pyridine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Saf-tee Solvent F.O. 128	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
s-diphenyl Carbazide	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Shell E-2342	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
Shell Spray Base	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
Sodium Gluconate	Available as food-grade material. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Sodium Tartrate	Available as food-grade material. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Soltrol-170	Contains normal paraffin hydrocarbon, which has been previously identified as a COC.	
Spartan DC 13	Commercial product, no standard analytical method in place for its analysis.	
Sugar	This is a food-grade chemical. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Sulfonic Acid (chloro)	This chemical has degraded to sulfate and chlorine, which have been previously identified as COCs.	
Styrene	No identified use in Hanford Site Central Plateau processing to retain this constituent listed in WAC 173-340-900, "Tables," Table 749-3; and WAC 173-340-7493 (2)(a)(i).	
Super Gel Hyflo	A chromatography medium (insoluble solid) that was used in determining if samples collected from various steps of the bismuth-phosphate process had successfully reacted, separated, etc. This substance is unlikely to be present in toxic concentrations.	
Tartaric Acid	Available as food-grade material. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Tetrabromoethane	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Tetrachloronaphthalene	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Tetradecane	Will be measured as a normal paraffin hydrocarbon, which has been previously identified as a COC.	
Tetrahydrofuran	Extremely soluble, and very likely to have degraded and not be present within waste stream. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. Presence could be reported as a TIC from volatile organic analysis.	
Tetraphenyl Boron	Boron and phenyl constituents of this chemical have been previously listed.	
Thenyltrifluoroacetone	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Material used in low or trace quantities at Hanford. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Thymolphthalein	Laboratory indicator. Typically used in drop quantities as <1% solutions. No analytical or toxicity issues identified.	
Tide	This commercial chemical is sodium silicate, soap, and organic complexants, no standard analytical method in place for its analysis.	
Toxaphene	Pesticide (EPA Method 8081, SW-846). Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Trans-1,3-dichloropropene	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Tributyl Phosphate (TBP)	Will degrade to phosphate and butanol, which have been previously identified as COCs. Not a Washington State toxic and not an underlying hazardous constituent as defined in 40 CFR 268.2. No direct standard analytical technique available.	
Trichlorofluoromethane	Gas above 24 degrees C.	
Triethylamine	No identified use in Hanford Site Central Plateau processing. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. VOA/SVOA (via GCMS) of soils from high-organic inventory tank farms (T,TX,TY WMA) reported nondetection for this and similar compounds. Not on routine analytical calibration lists. GCMS TIC searches could be used to screen for potential presence.	
Tri-iso-octylamine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Tri-n-dodecylamine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	
Tri-n-octylamine	Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Tris (hydroxymethyl) Amino Methane	Very soluble. Available and used as pharmaceutical-grade material. Minimal potential for presence in toxic level quantities. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Trisodium Hydroxyethyl Ethylene-Diamine Triacetate (HEDTA)	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Based on evaluation of the sources identified in CP-13196, Table 1-4, chemicals are used in minute quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals have no suspected introduction to waste streams except in incidental quantities. No direct standard analytical technique available.	
Trisodium nitrilo triacetate (NTA)	Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexants. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No direct standard analytical technique available.	
Turco (Fabricfilm)	Commercial chemical compound containing toluene, butanol, and isopropanol, which have been previously identified as COCs.	
Turco 2822	Commercial chemical compound containing methylene chloride and acetic acid, which have been previously identified as COCs.	
Turco 2844	Commercial product, no standard analytical method in place for its analysis.	
Turco 4358-4A	Commercial product, no standard analytical method in place for its analysis.	
Turco 4501 A	Commercial product which contains potassium hydroxide and hydroxydiamine compounds which have been previously excluded.	
Turco 4518	Commercial chemical compound containing benzene, sulfonate, and sodium, which have been previously identified as COCs.	
Turco 4521	Commercial chemical compound containing benzene, sulfonate, and sodium, which have been previously identified as COCs.	
Turco 4605-8	Commercial product, no standard analytical method in place for its analysis.	
Turco 4669	Commercial product, no standard analytical method in place for its analysis.	
Turco 4715	Commercial product, no standard analytical method in place for its analysis.	
Turco 4738 (Thin)	Commercial product, no standard analytical method in place for its analysis.	

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]
Organics (cont)		
Turco Alkaline (Rust Remover)	Commercial chemical compound containing sodium hydroxide and kerosene, which have been previously identified as COCs.	
Turco Deseal Zit 2	Commercial chemical compound containing methylene chloride and acetic acid, which have been previously identified as COCs.	
Turco EPO Strip	Commercial product, no standard analytical method in place for its analysis.	
Turco EPO Strip NP	Commercial product, no standard analytical method in place for its analysis.	
Turco Plaudit	Commercial product, no standard analytical method in place for its analysis.	
Turco T-5561	Commercial chemical compound containing ethanol and mineral oil, which have been previously identified as COCs.	
Turco T-5589	Commercial chemical compound containing isopropanol and ammonium hydroxide, which have been previously identified as COCs.	
Urea	This is a constituent of some fertilizers. This compound will degrade to nitrogen, nitrate, and ammonia. Material used in low or trace quantities at Hanford. No cleanup levels established in Ecology 94-145, Section 3.1 tables. No standard analytical method in place for its analysis.	
West Lode Degreaser	Commercial chemical compound containing aromatic compounds such as benzene and phenol, which have been previously identified as COCs	
Wyandotte 1112	Commercial product, no standard analytical method in place for its analysis.	
Wyandotte Kelvar	Commercial product, no standard analytical method in place for its analysis.	
Wyandotte MF	Commercial product, no standard analytical method in place for its analysis.	
Wyandotte P1075	Commercial product, no standard analytical method in place for its analysis.	

Trademarks and registered trademarks are the property of their respective owners. All product names mentioned are listed for contaminant potential only; such listing does not imply ownership and does not constitute endorsement.

40 CFR 268.2, "Land Disposal Restrictions," "Definitions Applicable to this Part," Title 40, *Code of Federal Regulations*, Part 268.2, as amended.

CP-13196, 2002, *Remedial Investigation Data Quality Objective Summary Report – 200-IS-1 and 200-ST-1 Operable Units*, Draft A, Fluor Hanford, Inc., Richland, Washington.

Ecology 94-145, 2001, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*, Washington State Department of Ecology, Olympia, Washington.

ORNL-5621, 1980, *ORIGEN2-A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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RadDecay, 1981, *RadDecay Software for Windows* (RadDecay.exe), Grove Engineering, Rockville, Maryland.

RadDecay is a registered trademark of Areva Radiation Software Products, Lynchburg, Virginia.

Table B-3. Excluded Contaminants. (42 Pages)

Contaminant	Description	Reference [a]

Rickard, W. H. and M. C. McShane, 1984, "Iodine in Terrestrial Wildlife on the U.S. Department of Energy's Hanford Site in South Central Washington," *Environ. Monitor. Assess.*, 4:379-388.

SW-846, 1999, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, as amended*, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

COC = contaminant of concern.
COPEC = contaminant of potential ecological concern.
EPA = U.S. Environmental Protection Agency.
GCMS = gas chromatograph/mass spectrometer.
GEA = gamma energy analysis.
ICP = inductively coupled plasma.
PRF = Plutonium Reclamation Facility.
SVOA = semivolatile organic analyte.
TBP = tri butyl phosphate.
TIC = tentatively identified compound.
VOA = volatile organic analyte.
WMA = Waste Management Area.

Table B-4. Central Plateau Contaminants of Potential Concern. (5 Pages)

Contaminant	Chemical Process	Reference
Radionuclides		
Americium-241	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133; ES/ER/TM-33/R2
Antimony-125	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	Parrington et al. 1996
Carbon-14	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Cesium-134	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	Parrington et al. 1996
Cesium-137	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; WHC-SD-WM-ER-133; ES/ER/TM-33/R2
Cobalt-60	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; WHC-SD-WM-ER-133; WHC-MR-0270; ES/ER/TM-33/R2
Europium-152	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; HNF-1744
Europium-154	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; HNF-1744
Europium-155	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; WHC-SD-WM-ER-133
Hydrogen-3 (tritium)	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Neptunium-237	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Nickel-63	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Plutonium-238	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C
Plutonium-239/240	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; ES/ER/TM-33/R2

Table B-4. Central Plateau Contaminants of Potential Concern. (5 Pages)

Contaminant	Chemical Process	Reference
Radionuclides (cont)		
Radium-226	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133; RadDecay Version 3
Radium-228	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	LA-UR-96-3860; WHC-SD-WM-ER-133; RadDecay Version 3
Strontium-90	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	ES/ER/TM-33/R2
Technetium-99	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; WHC-MR-0270; ES/ER/TM-33/R2
Thorium-232	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; HNF-1744
Uranium-234	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; ES/ER/TM-33/R2
Uranium-235	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C
Uranium-238	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex, Sr/Cs Operations	HW-10475, Sections A, B, and C; ES/ER/TM-33/R2
Metals		
Aluminum	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Sections A, B, and C, HW-18700; HW-31000-DEL; ISO-100, DOE/RL-91-52
Antimony	REDOX	HW-18700
Arsenic, Total all valence states	Z Plant Complex	FH-0002791
Arsenic (III)	N/A-included in total	WAC 173-340-900, Table 749-3
Arsenic (V)	N/A-included in total	WAC 173-340-900, Table 749-3
Barium	REDOX, Sr/Cs Operations	HW-18700; ISO-100
Beryllium	REDOX, PUREX/URP	HW-18700; HW-31000-DEL;
Bismuth	Bismuth phosphate, Sr/Cs Operations	HW-10475
Cadmium	Bismuth phosphate	HW-10475, Section A,
Chromium	Bismuth phosphate, Sr/Cs Operations	HW-10475, Section C; WHC-MR-0132; ISO-100
Chromium (VI)	Bismuth phosphate, Sr/Cs Operations	HW-10475, Section C; WHC-MR-0132; ISO-100
Cobalt	Scavenging Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Copper	Bismuth phosphate, REDOX, Sr/Cs Operations	HW-10475, Section A, HW-18700; ISO-100
Lead	Bismuth phosphate, Sr/Cs Operations	HW-10475, Sections A, B, and C, ISO-100
Lithium	Z Plant Complex	DOE/RL-91-52
Manganese	Bismuth phosphate, REDOX, PUREX/URP, Z Plant Complex	HW-10475, Sections A, B, and C, HW-18700; HW-31000-DEL; DOE/RL-91-52
Mercury (inorganic)	Bismuth phosphate, REDOX, PUREX/URP	LA-UR-96-3860; HW-10475, Sections A, B, and C, HW-18700; HW-31000-DEL
Molybdenum	Bismuth phosphate	HW-10475, Sections A, B, and C
Nickel	Bismuth phosphate	LA-UR-96-3860; WHC-SD-WM-ER-133
Selenium	Z Plant Complex	FH-0002791

Table B-4. Central Plateau Contaminants of Potential Concern. (5 Pages)

Contaminant	Chemical Process	Reference
Metals (cont)		
Silver	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Strontium	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Tin	Bismuth phosphate, REDOX, PUREX/URP	HW-10475, Section C; HW-18700; HW-31000-DEL
Uranium	Bismuth phosphate, REDOX, PUREX/URP	HW-10475, Section C; HW-18700; HW-31000-DEL
Vanadium	Bismuth phosphate	HW-10475, Sections A, B, and C
Zinc	Bismuth phosphate	HW-10475, Sections A, B, and C
General Inorganics		
Ammonia/Ammonium	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100
Chloride	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Cyanide	Scavenging Operations	LA-UR-96-3860; WHC-SD-WM-ER-133
Fluoride	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, WHC-SD-WM-ER-133; CCN 092732
Iodine	Z Plant Complex	DOE/RL-91-52
Nitrate/Nitrite	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Phosphate	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Sulfate/Sulfite	Bismuth phosphate, REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-10475, Section C; HW-18700; HW-31000-DEL; ISO-100, FH-0002791
Organics		
1,1-dichloroethane (DCA)	Z Plant Complex	WHC-SD-EN-TI-248
1,1-dichloroethene	Z Plant Complex	WHC-SD-EN-TI-248
1,1,1-trichloroethane (TCA)	Z Plant Complex	WHC-SD-EN-TI-248
1,1,2-trichloroethane	Z Plant Complex	WHC-SD-EN-TI-248
1,1,2,2-tetrachloroethane	Z Plant Complex	WHC-SD-EN-TI-248
1,2-dichlorobenzene	Z Plant Complex	WHC-SD-EN-TI-248
1,2-dichloroethane (DCA)	Z Plant Complex	WHC-SD-EN-TI-248
1,3-dichlorobenzene	Z Plant Complex	WHC-SD-EN-TI-248
2,4-dinitrotoluene	Z Plant Complex	WHC-SD-EN-TI-248
2-butanone (Methyl Ethyl Ketone/MEK)	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248

Table B-4. Central Plateau Contaminants of Potential Concern. (5 Pages)

Contaminant	Chemical Process	Reference
Organics (cont)		
2-hexanone	Z Plant Complex	WHC-SD-EN-TI-248
2-methylphenol (o-cresol)	Misc equipment oils and lubricants	CP-13196
4-methylphenol (p-cresol)	Misc equipment oils and lubricants	CP-13196
Benzene	Z Plant Complex	WHC-SD-EN-TI-248
Butanol	PUREX/URP	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19
Carbon Tetrachloride	Z Plant Complex	WHC-SD-EN-TI-248
Chlorobenzene	Z Plant Complex	WHC-SD-EN-TI-248
Chloroform	Z Plant Complex	WHC-SD-EN-TI-248
Cis-1,2-dichloroethylene	Z Plant Complex	WHC-SD-EN-TI-248
Dichloromethane (Methylene Chloride)	Z Plant Complex	WHC-SD-EN-TI-248
Ethyl Benzene	Z Plant Complex	WHC-SD-EN-TI-248
Methyl Isobutyl Ketone (MIBK/Hexone)	REDOX, Z Plant Complex	HW-18700; WHC-SD-EN-TI-248
Naphthalene	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248
n-butyl Benzene	Z Plant Complex	WHC-SD-EN-TI-248
Tetrachloroethylene (PCE)	Z Plant Complex	WHC-SD-EN-TI-248
Toluene	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248
Total Organic Carbon	REDOX, PUREX/URP, Sr/Cs Operations, Z Plant Complex	HW-18700; HW-31000-DEL; ISO-100, DOE/RL-91-52
Trans-1,2-dichloroethylene	Z Plant Complex	WHC-SD-EN-TI-248
Trichloroethylene (TCE)	Z Plant Complex	WHC-SD-EN-TI-248
Xylene	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248
Semivolatile Organics		
Normal paraffin hydrocarbons	PUREX/URP, Sr/Cs Operations	WHC-SD-WM-ER-133; HW-31000-DEL; ISO-100
Phenol	Z Plant Complex	WHC-SD-EN-TI-248
Polychlorinated Biphenyls (PCB)	Bismuth phosphate, Z Plant Complex	HW-10475, Sections A, B, and C; CCN 092732
Petroleum		
Gasoline Range Organics	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248
Diesel Range Organics	PUREX/URP, Z Plant Complex	WHC-EP-0342, Addendum 14; Addendum 12; Addendum 19; WHC-SD-EN-TI-248

Table B-4. Central Plateau Contaminants of Potential Concern. (5 Pages)

Contaminant	Chemical Process	Reference

CCN 092730, 2001, "Discussion Notes with PFP Personnel," (ERC Team Interoffice Memorandum to 200-PW-1 Project File from M. Y. Mandis), Bechtel Hanford, Inc., Richland, Washington, October 22.

CP-13196, 2002, *Remedial Investigation Data Quality Objective Summary Report – 200-IS-1 and 200-ST-1 Operable Units*, Draft A, Fluor Hanford, Inc., Richland, Washington.

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HNF-1744, 1999, *Radionuclide Inventories of Liquid Waste Disposal Sites on the Hanford Site*, Fluor Daniel Hanford, Inc., Richland, Washington.

HW-10475, 1944, *Hanford Engineer Works Technical Manual (T/B Plants)*, Parts A, B, and C, General Electric Company, Richland, Washington.

HW-18700-DEL, 1951, *REDOX Technical Manual*, General Electric Company, Richland, Washington.

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LA-UR-96-3860, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.

Parrington, Josef R., Harold D. Knox, Susan L. Breneman, Edward M. Baum, and Frank Feiner, 1996, *Nuclides and Isotopes: Chart of the Nuclides*, 15th ed., General Electric Co. and Knolls Atomic Power Laboratory, Inc., Schenectady, New York.

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WHC-EP-0342, 1990, Addendum 14, *PUREX Plant Ammonia Scrubber Condensate Stream-Specific Report*, Westinghouse Hanford Company, Richland, Washington.

WHC-EP-0342, 1990, Addendum 19, *UO_3 Plant Process Condensate Stream-Specific Report*, Westinghouse Hanford Company, Richland, Washington.

WHC-MR-0132, 1990, *A History of the 200 Area Tank Farms*, Westinghouse Hanford Company, Richland, Washington.

WHC-MR-0270, 1991, *200-BP-5 Operable Unit Technical Baseline Report*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-248, 1994, *Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-ER-133, 1991, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*, Westinghouse Hanford Company, Richland, Washington.

N/A = not applicable.
PUREX = Plutonium-Uranium Extraction (Plant or process).
REDOX = Reduction-Oxidation (Plant or process).
URP = Uranium Recovery Process.

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APPENDIX C

DATA EVALUATED IN CONTAMINANTS-OF-POTENTIAL-ECOLOGICAL-CONCERN REFINEMENT

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CONTENTS

Files on Compact Disk

File: 01-NoDups.data.R5.xls

File: 02-COPEC_pivot table_R4_rev.xls

File: 03-Soil Vapor from 5 ft 1997

File: 04-Soil Vapor from 5 ft 1998

File: 05-Soil Vapor from 5-15 ft 1998

File: 06-Soil Vapor from 5 ft 1999

File: 07-Soil Vapor from 5-15 ft 1999

File: 08-Soil Vapor from 10-15 ft 2000-2002

File: 09-Soil Vapor August 18-23, 2003

File: 10-Soil Vapor from 15 ft, Summary 1996-2003

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APPENDIX C

DATA EVALUATED IN CONTAMINANTS-OF-POTENTIAL-ECOLOGICAL-CONCERN REFINEMENT

INTRODUCTION

The data for Appendix C are contained in the accompanying compact disk (CD). This CD contains soil data that were evaluated for the purpose of identifying contaminants of potential ecological concern (COPEC) for Central Plateau waste sites. The soil data evaluated are provided in two formats; both file formats contain the same basic information.

The initial combined data set from the *Hanford Environmental Information System* database with all relevant fields for each sample result but no duplicate results is "NoDups.data.R5.xls".

A more compact version of these data is provided in a pivot table format in "COPEC_pivot table_R4_rev.xls". The pivot table format makes it easier to review results for all analytes for a particular sample by reading along a row. By reading up and down the columns of the pivot table format one can review the results for an analyte.

The CD also contains eight files of soil vapor sample results that were collected between the ground surface and 15 ft bgs. These results were evaluated for the purpose of identifying COPECs for the inhalation pathway. The data include the soil vapor monitoring surveys from 1997, 1998, and 1999.

- The 1997 data are published in BHI-01105, *Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, November 1996 Through July 1997*, Rev. 0.
- The 1998 and 1999 data are published in BHI-00720, *Performance Evaluation Report for Soil Vapor Extraction Operations at the Carbon Tetrachloride Site, February 1992 - September 2001*, Rev. 6.

The first phase of the remedial investigation for the carbon tetrachloride vadose zone vapor plume was conducted in 2002:

- CP-13514, *200-PW-1 Operable Unit Report on Step I Sampling and Analysis of the Dispersed Carbon Tetrachloride Vadose Zone Plume*, Rev. 0.

Numerous samples were collected from 15 ft or less. Note that the 2002 "vent riser" samples were collected from within engineered trenches rather than in the vadose zone. Soil vapor samples also were collected from the vadose zone in the vicinity of the Plutonium Finishing Plant in 2003. The 2003 soil vapor data down to approximately 15 ft depth also are included.

REFERENCES

BHI-00720, 2002, *Performance Evaluation Report for Soil Vapor Extraction Operations at the Carbon Tetrachloride Site, February 1992 – September 2001*, Rev. 6, Bechtel Hanford, Inc., Richland, Washington.

BHI-01105, 1997, *Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

CP-13514, 2003, *200-PW-1 Operable Unit Report on Step I Sampling and Analysis of the Dispersed Carbon Tetrachloride Vadose Zone Plume*, Fluor Hanford, Inc., Richland, Washington.

Hanford Environmental Information System, Hanford Site database.

APPENDIX D

CONTAMINANTS-OF-POTENTIAL-ECOLOGICAL-CONCERN REFINEMENT

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TABLES

Table D-1. Key to the Terminology in Table D-2. (2 Pages) D-1

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages) D-3

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages) D-19

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APPENDIX D

CONTAMINANTS-OF-POTENTIAL-ECOLOGICAL-CONCERN REFINEMENT

Table D-1 provides a key to the terminology found in Table D-2. Table D-2 provides the refinement of contaminants of potential ecological concern.

Table D-1. Key to the Terminology in Table D-2. (2 Pages)

Column	Definition
Analyte	Specific chemical
COPEC Designation Justification	COPEC means kept on list or justification to remove as COPEC
Method Class	Analytical category: GENCHEM = general chemistry GENORG = general organic chemical HERB = herbicide [a] METALMULT = metal from analysis for multiple metals PEST/PCB = pesticide or polychlorinated biphenyl [a] RAD = radionuclide SVOA = semivolatile organic analyte [b] VOA = volatile organic analyte [b]
Samples	Number of samples collected
# NDs	Number of nondetect samples (minimum, median, maximum)
Detects	Number of detected samples (median)
Max Detect	Maximum detected value
Units	Unit of concentration measured in soil (mg/kg or pCi/g)
Top Depth (ft) of Max Detect	Top interval marking where the maximum detected concentration was collected
Bottom Depth (ft) of Max Detect	Bottom interval marking where the maximum detected concentration was collected
Mean Site	Sitewide average of all detected values
BV	Background concentration
# Detects >BV	Number of detected values above background concentrations
# ND >BV	Number of nondetected values above background concentrations
Plant	Plant soil-screening value
# D >Plant	Number of detected values above soil-screening value for plants
Biota	Soil biota soil-screening value
# D >Biota	Number of detected values above soil-screening value for soil biota
Shrew	Wildlife soil-screening value based on shrew (mammalian insectivore)
# D >Shrew	Number of detected values above soil-screening value for shrew
Vole	Wildlife soil-screening value based on vole (mammalian herbivore)

Table D-1. Key to the Terminology in Table D-2. (2 Pages)

Column	Definition
# D >Vole	Number of detected values above soil-screening value for vole
Robin	Wildlife soil-screening value based on robin (avian insectivore)
# D >Robin	Number of detected values above soil-screening value for robin
BCG Plant	Biota concentration guideline (pCi/g) for plants (see DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*)
# D >BCG Plant	Number of detected values above biota concentration guideline for plants
BCG Wildlife	Biota concentration guideline (pCi/g) for wildlife
# D >BCG Wildlife	Number of detected values above biota concentration guideline for wildlife
FD >BV	Frequency of detected values exceeding background out of all samples
FD >SSV	Frequency of detected values exceeding soil-screening values or biota concentration guidelines out of all samples
FD	Detection frequency

Highlighted rows signify contaminants of potential ecological concern.

[a] The sample size for each of the 19 sampled **pesticides** (PEST/PCB) was typically 57 samples, and only two chemicals were detected at least twice. Dichlorodiphenyltrichloroethane (DDT) had 3 detected values, and heptaclor was detected 2 times; neither chemical exceeded the available soil-screening values. The data on **herbicides** was more limited. There were no detected herbicides, but the sample size was typically 4 or 5 samples.

[b] No **semivolatile** contaminants of concern exceed soil-screening values, nor do **volatile** contaminants of concern exceed soil-screening values. Some volatile contaminants of concern do not have soil-screening values. Volatile chemicals are not expected to persist on the Central Plateau and, for the unique situations where volatiles may persist (e.g., the large volumes of carbon tetrachloride used on site and contaminating subsurface aquifers), a qualitative evaluation will be performed.

Table D-3 presents the screening of the non-COPCs to assure that none of these constituents should be added back to the COPEC list. The column headers are the same as Table D-2. Table D-4 provides the final list of COPECs.

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Radionuclides																																		
Americium-241	COPEC	RAD	408	337	-0.49	5.60 E-02	8.50 E+02	71	0.395	649	pCi/g	7.5	10	7.89 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	21600	0	3.89 E+03	0	NA	0	0.17402
Antimony-125	Not significant contributor to dose based on SOF	RAD	23	22	-0.023	8.90 E-02	9.00 E+02	1	1.67	1.67	pCi/g	4	5	3.93 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34100	0	3.52 E+03	0	NA	0	0.04348
Carbon-14	Not significant contributor to dose based on SOF	RAD	28	26	-1.8	5.83 E-01	9.51 E+01	2	9.25	12.2	pCi/g	1	1	4.52 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.90 E+07	0	NA	0	0.07143
Cesium-134	Not significant contributor to dose based on SOF	RAD	120	119	-0.0062	4.00 E-02	1.00 E+02	1	0.05	0.05	pCi/g	0	0	8.93 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1000	0	1.13 E+01	0	NA	0	0.00833
Cesium-137	COPEC	RAD	310	95	0.008	2.70 E-02	2.80 E-01	215	1.67	529000	pCi/g	12.5	15	2.83 E+03	1.05	123	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1090	7	2.08 E+01	40	0.396774	0.129032	0.69355
Cobalt-60	COPEC	RAD	310	301	-0.008	3.00 E-02	8.90 E+01	9	0.1	1700	pCi/g	12.5	15	5.85 E+00	0.00842	9	292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	13900	0	6.92 E+02	1	0.029032	0.003226	0.02903
Europium-152	Not significant contributor to dose based on SOF	RAD	249	248	-0.37	7.60 E-02	8.50 E+02	1	1.1	1.1	pCi/g	4.4	5.4	5.23 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7340	0	1.52 E+03	0	NA	0	0.00402
Europium-154	Not significant contributor to dose based on SOF	RAD	249	232	-0.0547	9.60 E-02	2.80 E+02	17	0.538	3.37	pCi/g	14	15	1.48 E+00	0.0334	17	223	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12400	0	1.29 E+03	0	0.068273	0	0.06827
Europium-155	Not significant contributor to dose based on SOF	RAD	249	244	0.0093	9.05 E-02	5.80 E+02	5	0.602	2.04	pCi/g	12	13	3.30 E+00	0.0539	5	211	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	151000	0	1.58 E+04	0	0.02008	0	0.02008
Hydrogen-3 (tritium)	Not significant contributor to dose based on SOF	RAD	26	18	-0.753	-7.00 E-03	4.70 E+00	8	5.6695	44	pCi/g	3	5.5	3.10 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1660000	0	1.74 E+05	0	NA	0	0.30769
Neptunium-237	Not significant contributor to dose based on SOF	RAD	112	103	-0.543	4.00 E-03	3.61 E+00	9	0.05003333	0.28	pCi/g	6.5	6.5	6.10 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2700	0	1.90 E+03	0	NA	0	0.08036
Nickel-63	Not significant contributor to dose based on SOF	RAD	19	17	-45.4	0.00 E+00	1.01 E+00	2	1137.5	2110	pCi/g	12.5	15	1.17 E+02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.20 E+07	0	NA	0	0.10526
Plutonium-238	Not significant contributor to dose based on SOF	RAD	270	229	-0.376	7.67 E-03	7.81 E+00	41	0.06	39.2	pCi/g	10	12.5	5.27 E-01	0.00378	41	131	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110000	0	5.40 E+03	0	0.151852	0	0.15185
Plutonium-239/240	COPEC	RAD	270	194	-0.059	1.00 E-02	3.48 E-01	76	0.245	2230	pCi/g	10	12.5	1.96 E+01	0.0248	59	27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12700	0	6.11 E+03	0	0.218519	0	0.28148
Radium-226	COPEC	RAD	304	39	0.043	6.00 E-01	4.10 E+02	265	0.606	15.2	pCi/g	0	0	2.71 E+00	0.815	63	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	246	0	5.06 E+01	0	0.207237	0	0.87171
Radium-228	COPEC	RAD	218	17	0.09	3.00 E-01	4.70 E+02	201	0.735	2.6	pCi/g	6.5	6.5	3.31 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	261	0	4.39 E+01	0	NA	0	0.92202
Strontium-90	COPEC	RAD	309	124	-11	3.00 E-02	5.00 E-01	185	0.829	974000	pCi/g	12.5	15	3.22 E+03	0.178	165	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2230	3	2.25 E+01	19	0.533981	0.061489	0.59871
Technetium-99	Not significant contributor to dose based on SOF	RAD	116	82	-28.2	6.50 E-01	7.00 E+01	34	1	8.8	pCi/g	6.5	6.5	2.93 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9610	0	4.49 E+03	0	NA	0	0.2931
Thorium-232	Not significant contributor to dose based on SOF	RAD	404	46	-9.48	2.83 E-01	4.70 E+02	358	0.5935	5.969	pCi/g	9.5	10.5	2.00 E+00	1.32	4	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4440	0	1.51 E+03	0	0.009901	0	0.88614
Uranium-233/234	Not significant contributor to dose based on SOF	RAD	39	5	0.676	2.45 E+00	3.17 E+01	34	0.6295	85	pCi/g	6.5	6.5	4.02 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52200	0	4.83 E+03	0	NA	0	0.87179
Uranium-234	Not significant contributor to dose based on SOF	RAD	16	1	0.0545	5.45 E-02	5.45 E-02	15	0.84	5.17	pCi/g	8	9	1.04 E+00	1.1	4	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	51600	0	5.13 E+03	0	0.25	0	0.9375
Uranium-235	Not significant contributor to dose based on SOF	RAD	250	229	-0.109	1.20 E-01	7.40 E+02	21	0.0415	0.439	pCi/g	4	5	4.54 E+00	0.109	4	126	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	27400	0	2.77 E+03	0	0.016	0	0.084
Uranium-238	COPEC	RAD	256	209	-0.656	3.50 E+00	1.00 E+04	47	0.652	88	pCi/g	6.5	6.5	5.14 E+01	1.06	8	206	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15800	0	1.58 E+03	0	0.03125	0	0.18359

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Metals																																		
Aluminum	Considered nontoxic to terrestrial wildlife, BPJ	METALMULT	94	0	NA	NA	NA	94	4.52 E+03	14300	mg/kg	6.5	6.5	5.15 E+03	13000	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.010638	NA	1
Antimony	COPEC	METALMULT	192	163	0.16	0.26	11.1	29	3.00 E-01	13.5	mg/kg	9	10	2.47 E+00	NA	NA	NA	5.00 E+00	2	78	0	0.05772	29	0.846262	29	NA	NA	NA	NA	NA	NA	NA	0.151042	0.15104
Arsenic	COPEC	METALMULT	280	2	2.42	10.86	19.3	278	2.70 E+00	33.8	mg/kg	5.5	6.5	3.62 E+00	20	1	0	1.00 E+01	10	60	0	7.118644	22	42.91045	0	1.50 E+02	0	NA	NA	NA	NA	0.003571	0.078571	0.99286
Barium	COPEC	METALMULT	282	0	NA	NA	NA	282	7.25 E+01	331	mg/kg	6.5	6.5	7.38 E+01	144	1	0	5.00 E+02	0	330	1	508.7719	0	603.8078	19	1.22 E+03	0	NA	NA	NA	NA	0.003546	0.067376	1
Beryllium	No detects above background	METALMULT	276	14	0.01	0.295	2.97	262	3.20 E-01	1.2	mg/kg	9	10	3.69 E-01	1.62	0	1	1.00 E+01	0	40	0	0.509861	40	47.9638	0	NA	NA	NA	NA	NA	NA	0	0.144928	0.94928
Bismuth	COPEC	METALMULT	24	14	0.29	0.58	9.7	10	1.38 E+00	233	mg/kg	12.5	15	1.51 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.41667
Boron	COPEC	METALMULT	24	2	0.58	2.835	5.09	22	1.50 E+00	23.8	mg/kg	7.5	10	3.24 E+00	NA	NA	NA	NA	NA	NA	NA	26.93603	0	85.8764	0	5.65 E+00	3	NA	NA	NA	NA	NA	0.125	0.91667
Cadmium	COPEC	METALMULT	291	141	0.02	0.04	1.3	150	1.95 E-01	28	mg/kg	4	5	7.57 E-01	0.81	36	23	4.00 E+00	8	20	1	14.43001	4	288.4615	0	7.87 E+01	0	NA	NA	NA	NA	0.123711	0.027491	0.51546
Chromium	COPEC	METALMULT	291	5	0.56	4.7	6.8	286	8.00 E+00	815	mg/kg	0	1.5	1.24 E+01	21.4	13	0	4.20 E+01	3	42	3	306.7538	1	2884.287	2	6.73 E+01	3	NA	NA	NA	NA	0.044674	0.010309	0.98282
Chromium (VI)	COPEC	METALSING	196	175	0.08	0.42	11.7	21	1.09 E+00	14.1	mg/kg	1.5	3	7.06 E-01	NA	NA	NA	3.50 E-01	20	0.2	21	28.58388	0	319.6102	1	5.12 E+01	0	NA	NA	NA	NA	NA	0.107143	0.10714
Cobalt	No detects above background	METALMULT	81	6	7.1	8.7	10.3	75	7.80 E+00	13.2	mg/kg	9	10	8.23 E+00	16.9	0	0	2.00 E+01	0	NA	NA	7.022607	50	514.0845	0	1.47 E+01	0	NA	NA	NA	NA	0	0.617284	0.92593
Copper	COPEC	METALMULT	289	5	4.95	15.5	16	284	1.36 E+01	244	mg/kg	0	1.5	1.69 E+01	24.1	18	0	1.00 E+02	3	50	8	217.284	1	2366.197	0	5.31 E+02	0	NA	NA	NA	NA	0.062284	0.027682	0.9827
Lead	COPEC	METALMULT	289	3	1.26	11.9	19.3	286	4.40 E+00	582.5	mg/kg	8	9	1.23 E+01	11.7	30	2	5.00 E+01	9	500	1	125.1956	5	2132.083	0	1.18 E+02	5	NA	NA	NA	NA	0.103806	0.031142	0.98962
Manganese	No detects above SSV	METALMULT	100	0	NA	NA	NA	100	2.67 E+02	641	mg/kg	12.5	15	2.85 E+02	550	1	0	1.10 E+03	0	NA	NA	8946.237	0	5504.905	0	1.10 E+04	0	NA	NA	NA	NA	0.01	0	1
Mercury	COPEC	METALSING	278	211	0	0.02	0.99	67	1.00 E-01	9.1	mg/kg	8	9	1.71 E-01	0.6	13	1	3.00 E-01	17	0.1	32	9.485904	0	62.64168	0	5.50 E+00	1	NA	NA	NA	NA	0.046763	0.115108	0.24101
Molybdenum	COPEC	METALMULT	23	6	0.11	0.775	9.7	17	5.30 E-01	3.2	mg/kg	4	5	1.40 E+00	NA	NA	NA	2.00 E+00	1	NA	NA	27.46667	0	7.238154	0	4.82 E+02	0	NA	NA	NA	NA	NA	0.043478	0.73913
Nickel	COPEC	METALMULT	285	1	3.76	3.76	3.76	284	8.90 E+00	131	mg/kg	6.5	6.5	9.55 E+00	21	3	0	3.00 E+01	2	200	0	976.6667	0	5919.401	0	1.01 E+03	0	NA	NA	NA	NA	0.010526	0.007018	0.99649
Selenium	COPEC	METALMULT	306	220	0.15	0.38	19.3	86	5.80 E-01	4.7	mg/kg	11	13.5	5.26 E-01	NA	NA	NA	1.00 E+00	8	70	0	0.306295	78	55.29027	0	8.68 E-01	18	NA	NA	NA	NA	NA	0.254902	0.28105
Silver	COPEC	METALMULT	289	231	0.01	0.1	2.12	58	1.15 E+00	42	mg/kg	4	5	1.11 E+00	1.33	27	37	2.00 E+00	16	NA	NA	18.27802	4	141.8969	0	1.05 E+01	4	NA	NA	NA	NA	0.093426	0.055363	0.20069
Thallium	COPEC	METALMULT	200	110	0.29	0.42	1.6	90	7.05 E-01	1.7	mg/kg	14	15	6.03 E-01	NA	NA	NA	1.00 E+00	14	NA	NA	0.00683	90	0.775109	90	NA	NA	NA	NA	NA	NA	NA	0.45	0.45
Tin	COPEC	METALMULT	4	4	3.5	3.95	9.7	0	NA	NA	mg/kg	NA	NA	5.28 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

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Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Metals (cont)																																		
Uranium	COPEC	METALMULT	74	51	0.3	0.54	8	23	1.70 E+00	270	mg/kg	6.5	6.5	4.70 E+00	NA	NA	NA	5.00 E+00	1	NA	NA	5.868206	1	576.6958	1	1.51 E+02	1	NA	NA	NA	NA	NA	0.013514	0.31081
Uranium	Identified as a COPEC as a metal based on mass, contribution of uranium isotopes to SOF was evaluated	RAD	170	0	NA	NA	NA	170	0.60225	56.9	mg/kg	12.5	15	1.29 E+00	NA	NA	NA	5	4	NA	NA	5.868206	4	576.6958	0	150.97 84	0	NA	NA	NA	NA	NA	0.023529	1
Vanadium	COPEC	METALMULT	277	1	23.3	23.3	23.3	276	5.14 E+01	101	mg/kg	12.5	15	4.95 E+01	93.9	2	0	2.00 E+00	276	NA	NA	2.020202	276	218.0119	276	2.13 E+00	276	NA	NA	NA	NA	0.00722	0.99639	0.99639
Zinc	COPEC	METALMULT	277	2	20.1	21	21.9	275	4.50 E+01	645	mg/kg	6.5	6.5	5.19 E+01	72.1	25	0	8.60 E+01	19	200	5	973.7625	0	14207.53	0	3.59 E+02	2	NA	NA	NA	NA	0.090253	0.068592	0.99278
General Inorganics																																		
Ammonia	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	185	148	0.146	1.7	28.3	37	5.35 E+00	91.9	mg/kg	14	15	5.54 E+00	15.1	13	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07027	NA	0.2
Ammonium ion	Considered nontoxic to terrestrial wildlife, BPJ	METALMULT	2	1	0.258	0.258	0.258	1	2.85 E-01	0.285	mg/kg	11	13.5	2.72 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.5
Chloride	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	180	19	0.11	1.3	1.33	161	4.00 E+00	226	mg/kg	4	5	9.34 E+00	182	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005556	NA	0.89444
Cyanide	COPEC	GENCHEM	297	292	0.13	0.53	1.33	5	4.50 E-01	4.09333	mg/kg	8	9	6.24 E-01	NA	NA	NA	NA	NA	NA	NA	299.3464	0	212.7594	0	3.10 E-01	4	NA	NA	NA	NA	NA	0.013468	0.01684
Fluoride	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	183	150	0.4	2.6	19.2	33	2.06 E+00	7.4	mg/kg	14.5	15.5	2.43 E+00	3.7	5	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.027322	NA	0.18033
Nitrate	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	205	19	0.4	1.2	2.5	186	3.02 E+01	927	mg/kg	4	5	6.03 E+01	93.4	41	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2	NA	0.90732
Nitrite	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	176	170	0.069	1.3	9.62	6	1.26 E+00	1.741	mg/kg	9.5	10.5	1.40 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03409
Nitrogen in nitrite and nitrate	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	198	10	0.038	0.2035	2.49	188	8.35 E+00	230	mg/kg	5	6	1.67 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.94949
Phosphate	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	199	120	0.37	1.3	9.6	79	2.40 E+00	19	mg/kg	12.5	15	2.06 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.39698
Sulfate	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	216	4	1.28	3.145	63.8	212	2.82 E+01	3640	mg/kg	14	15	1.44 E+02	469	14	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.064815	NA	0.98148
Sulfide	Considered nontoxic to terrestrial wildlife, BPJ	GENCHEM	161	115	0.63	21.1	61.2	46	4.20 E+00	59	mg/kg	5	6	1.62 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.28571
Organics																																		
Benzene	No detects above SSV	VOA	229	224	0.0019	0.005	0.017	5	5.00 E-03	0.008	mg/kg	5	6	5.69 E-03	NA	NA	NA	NA	NA	NA	NA	71.00337	0	26.86369	0	NA	NA	NA	NA	NA	NA	NA	0	0.02183
4-(2,4-Dichlorophenoxy)-butanoic acid	No detects and <50 samples; eliminated as COPEC because ~~not one of the herbicides~~ currently used at waste sites; characterization of soils for ~~herbicides will continue at~~ waste sites, facilities, and tank farms	HERB	4	4	0.17	0.17	0.18	0	NA	NA	mg/kg	NA	NA	1.73 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1-Butanol	Less than 2 detects and <50 samples; detection limits are below SSV of surrogate, 2-butanone	VOA	3	3	0.1	0.22	0.24	0	NA	NA	mg/kg	NA	NA	1.87 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2-Butanone (same as Methyl Ethyl Ketone)	No detects above SSV	VOA	229	210	0.0019	0.01	0.024	19	6.00 E-03	0.11333	mg/kg	8	9	1.09 E-02	NA	NA	NA	NA	NA	NA	NA	5662.67	0	471.462	0	NA	NA	NA	NA	NA	NA	NA	0	0.08297

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Organics (cont)																																		
2-secButyl-4,6-dinitrophenol(DNBP)	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	4	4	0.017	0.017	0.018	0	NA	NA	mg/kg	NA	NA	1.73 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Carbon tetrachloride*	No detects above SSV	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.68 E-03	NA	NA	NA	NA	NA	NA	NA	15.06591	0	41.98289	0	NA	NA	NA	NA	NA	NA	NA	0	0.00873
Chlorobenzene	No detects above SSV	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.70 E-03	NA	NA	NA	NA	NA	40	0	148.9758	0	115.7854	0	NA	NA	NA	NA	NA	NA	NA	0	0.00873
Chloroform	>2 detects, no SSV, below SSV of surrogate, tetrachloroethene	VOA	229	226	0.0019	0.005	0.011	3	5.00 E-03	0.005	mg/kg	3	6	5.64 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0131
Dalapon	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	4	4	0.17	0.17	0.18	0	NA	NA	mg/kg	NA	NA	1.73 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dicamba	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	4	4	0.069	0.069	0.07	0	NA	NA	mg/kg	NA	NA	6.93 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1,2-Dichlorobenzene	Less than 2 detects	VOA	234	234	0.2493	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1,3-Dichlorobenzene	Less than 2 detects	VOA	234	234	0.2483	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1,1-Dichloroethane	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.70 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
1,2-Dichloroethane	>2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	226	0.0019	0.005	0.017	3	5.00 E-03	0.013	mg/kg	4	5	5.72 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0131
1,1-Dichloroethene	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
1,2-Dichloroethene (Total)	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
2,4-Dichlorophenoxy-acetic acid	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	5	5	0.035	0.035	0.036	0	NA	NA	mg/kg	NA	NA	3.52 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Organics (cont)																																		
Dichloroprop	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	4	4	0.17	0.17	0.18	0	NA	NA	mg/kg	NA	NA	1.73 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2,4-Dinitrotoluene	Less than 2 detects	VOA	235	235	0.069	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.00 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Ethylbenzene	2 detects, no SSV, below SSV of surrogate, benzene	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
2-Hexanone (same as 4-methyl-2-pentanone)	>2 detects, no SSV, below SSV of surrogate, 2-butanone	VOA	229	227	0.0019	0.01	0.024	2	1.00 E-02	0.01	mg/kg	3	6	1.08 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
4-Methyl-2-Pentanone (same as 2-hexanone)	>2 detects, no SSV, below SSV of surrogate, 2-butanone	VOA	229	226	0.0019	0.01	0.024	3	1.00 E-02	0.01	mg/kg	3	6	1.07 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0131
2-Methylphenol (cresol, o-)	Less than 2 detects	VOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
3+4 Methylphenol (cresol, m+p)	No detects and <50 samples (typically reported as 4-Methylphenol (cresol, p-) that has no detects in 233 samples	VOA	1	1	0.12	0.12	0.12	0	NA	NA	mg/kg	NA	NA	1.20 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
4-Methylphenol- (cresol, p-)	Less than 2 detects	VOA	233	233	0.2547	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Naphthalene	Less than 2 detects	VOA/SVOA	234	234	0.259	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
1,1,2,2-Tetrachloroethane	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Tetrachloroethene	No detects above SSV	VOA	229	224	0.0019	0.005	0.017	5	5.00 E-03	0.006	mg/kg	4	5	5.67 E-03	NA	NA	NA	1.00 E+01	0	NA	NA	5.079365	0	3.281109	0	NA	NA	NA	NA	NA	NA	NA	NA	0	0.02183
Toluene	No detects above SSV	VOA	229	207	0.0019	0.005	0.011	22	2.50 E-03	0.017	mg/kg	6.5	6.5	5.45 E-03	NA	NA	NA	NA	NA	NA	NA	65.28562	0	45.72635	0	NA	NA	NA	NA	NA	NA	NA	NA	0	0.09607
1,1,1-Trichloroethane	>2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	226	0.0019	0.005	0.017	3	5.00 E-03	0.005	mg/kg	3	6	5.66 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0131
1,1,2-Trichloroethane	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Trichloroethene	2 detects, no SSV, below SSV of surrogate, methylene chloride	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.70 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
2-(2,4,5-Trichlorophenoxy) propionic acid	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	5	5	0.017	0.017	0.018	0	NA	NA	mg/kg	NA	NA	1.74 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Organics (cont)																																		
2,4,5-Trichlorophenoxy-acetic acid	No detects and <50 samples; eliminated as COPEC because not one of the herbicides currently used at waste sites; characterization of soils for herbicides will continue at waste sites, facilities, and tank farms	HERB	5	5	0.017	0.017	0.018	0	NA	NA	mg/kg	NA	NA	1.74 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Xylenes (total)	No detects above SSV	VOA	229	225	0.0019	0.005	0.017	4	3.50 E-03	0.005	mg/kg	3	6	5.68 E-03	NA	NA	NA	NA	NA	NA	NA	5.017921	0	5.441824	0	4.86 E+02	0	NA	NA	NA	NA	NA	0	0.01747
Semivolatile Organics																																		
Aroclor-1016	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	227	227	0.0189	0.036	56.3	0	NA	NA	mg/kg	NA	NA	3.81 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1221	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	227	227	0.033	0.072	344	0	NA	NA	mg/kg	NA	NA	1.74 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1232	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	227	227	0.0189	0.036	317	0	NA	NA	mg/kg	NA	NA	1.53 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1242	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	227	227	0.0189	0.036	179	0	NA	NA	mg/kg	NA	NA	9.21 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1248	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	227	227	0.0189	0.036	18.3	0	NA	NA	mg/kg	NA	NA	2.13 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1254	COPEC	PEST/PCB	227	217	0.0207	0.036	7.4	10	7.20 E-01	52	mg/kg	7.5	10	4.55 E-01	NA	NA	NA	1.60 E+02	0	NA	NA	0.398175	5	15.95404	1	1.33 E+01	6	NA	NA	NA	NA	NA	0.026432	0.04405
Aroclor-1260	COPEC	PEST/PCB	229	217	0.0207	0.036	2.6	12	8.05 E-01	77.6	mg/kg	7.5	10	6.92 E-01	NA	NA	NA	NA	NA	NA	NA	8.993157	3	378.388	0	2.85 E+00	4	NA	NA	NA	NA	NA	0.017467	0.0524
Aroclor-1262	Less than 2 detects, additional analyte to be measured with PCBs	PEST/PCB	2	2	0.034	0.042	0.05	0	NA	NA	mg/kg	NA	NA	4.20 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Aroclor-1268	Less than 2 detects, not routinely part of EPA method 8082	PEST/PCB	2	2	0.034	0.042	0.05	0	NA	NA	mg/kg	NA	NA	4.20 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Petroleum																																		
High boiling hydrocarbons	Less than 2 detects	GENORG	8	7	0.026	0.028	34	1	1.80 E+02	180	mg/kg	8	9	3.33 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.125
Kerosene	Less than 2 detects	GENORG	11	11	5	5	10	0	NA	NA	mg/kg	NA	NA	5.91 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Total petroleum hydrocarbon- diesel range	Less than 2 detects	GENORG	163	162	2.5	4.7	132	1	3.10 E+01	31	mg/kg	0	1.5	9.35 E+00	NA	NA	NA	NA	NA	200	0	6000	0	6000	0	6000	0	NA	NA	NA	NA	NA	0	0.00613
Total petroleum hydrocarbon - gasoline range	Less than 2 detects	GENORG	4	4	0.03	0.045	0.25	0	NA	NA	mg/kg	NA	NA	9.25 E-02	NA	NA	NA	NA	NA	100	0	5000	0	5000	0	5000	0	NA	NA	NA	NA	NA	0	0
Total petroleum hydrocarbon - kerosene range	Less than 2 detects	GENORG	61	60	3.9	12.5	33	1	4.40 E+02	440	mg/kg	4	6.5	2.02 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01639
Total petroleum hydrocarbon - motor oil (high boiling)	No soil screening value but highest detect almost 10X less than comparable wildlife SSV	GENORG	22	15	0.0146	45	1100	7	3.90 E+01	760	mg/kg	4	5	1.24 E+02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.31818

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Pesticides																																		
Aldrin	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.61 E-02	NA	NA	NA	NA	NA	NA	NA	2.039434	0	166.2543	0	1.12 E-01	0	NA	NA	NA	NA	NA	0	0
Alpha-BHC	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.61 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
alpha-Chlordane	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	56	0.0017	0.16	0.83	1	1.60 E-01	0.16	mg/kg	3	6	1.59 E-01	NA	NA	NA	2.20 E+00	0	1	0	2.718543	0	735.5917	0	5.52 E+00	0	NA	NA	NA	NA	NA	0	0.01754
beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	Less than 2 detects	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.61 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Delta-BHC	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.61 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dichlorodiphenyldichloroethane (DDD)	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dichlorodiphenyldichloroethylene (DDE)	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dichlorodiphenyltrichloroethane (DDT)	3 detects, all < SSV, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	54	0.0033	0.032	0.17	3	1.10 E-02	0.034	mg/kg	3	6	2.79 E-02	NA	NA	NA	3.70 E+00	0	NA	NA	0.447792	0	116.8122	0	2.06 E-01	0	NA	NA	NA	NA	NA	0	0.05263
Dieldrin	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	1.00 E+01	0	NA	NA	0.067854	0	19.95891	0	1.40 E+00	0	NA	NA	NA	NA	NA	0	0
Endosulfan I	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.64 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Endosulfan II	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Endosulfan sulfate	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Endrin	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0033	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.94 E-02	NA	NA	NA	3.40 E-03	0	NA	NA	1.343155	0	42.07348	0	2.44 E-01	0	NA	NA	NA	NA	NA	0	0
Endrin aldehyde	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	6	6	0.0033	0.0034	0.0056	0	NA	NA	mg/kg	NA	NA	3.78 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Endrin ketone	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	56	56	0.0034	0.032	0.17	0	NA	NA	mg/kg	NA	NA	2.99 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Gamma-BHC (Lindane)	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	56	0.0017	0.016	0.083	1	1.70 E-02	0.017	mg/kg	3	6	1.61 E-02	NA	NA	NA	1.00 E-01	0	NA	NA	0.006148	1	0.05749	0	6.31 E+00	0	NA	NA	NA	NA	NA	0.017544	0.01754

Table D-2. Screening of Contaminants of Potential Concern for Contaminants of Potential Ecological Concern Identification. (8 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Pesticides (cont)																																		
gamma-Chlordane	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.16	0.83	0	NA	NA	mg/kg	NA	NA	1.59 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Heptachlor	2 detects, all < SSV, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	55	0.0017	0.016	0.083	2	1.65 E-02	0.017	mg/kg	3	6	1.61 E-02	NA	NA	NA	4.00 E-01	0	NA	NA	1.1628	0	132.8863	0	4.02 E-01	0	NA	NA	NA	NA	NA	0	0.03509
Heptachlor epoxide	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0017	0.016	0.083	0	NA	NA	mg/kg	NA	NA	1.61 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Isodrin	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	1	1	0.0033	0.0033	0.003 3	0	NA	NA	mg/kg	NA	NA	3.30 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Kepone	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	1	1	0.017	0.017	0.017	0	NA	NA	mg/kg	NA	NA	1.70 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Methoxychlor	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.0016	0.16	0.83	0	NA	NA	mg/kg	NA	NA	1.61 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Toxaphene	Less than 2 detects, additional analyte to be measured with chlorinated pesticides	PEST/PCB	57	57	0.15	0.32	1.7	0	NA	NA	mg/kg	NA	NA	3.10 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Highlighted rows signify contaminants of potential ecological concern.

* Note: Carbon tetrachloride was kept as a COPEC based on its presence in groundwater at Hanford and the potential for its existence in soil gas as a result of the groundwater.

Aroclor is an expired trademark.

BPJ = best professional judgment.
COPC = contaminant of potential concern.
COPEC = contaminant of potential ecological concern.
EPA = U.S. Environmental Protection Agency.
NA = not available.
PCB = polychlorinated biphenyl.
SOF = sum of fractions.
SSV = soil-screening value.
VOA/SVOA = constituents that may be determined either by volatile or semivolatile methods

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Radionuclides (cont)																																		
Ruthenium-103	Not a COPC	RAD	98	97	0	3.00 E-01	9.00 E+00	1	0.3	0.3	pCi/g	0	0	6.31 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0102
Ruthenium-106	Not a COPC	RAD	103	102	- 0.0945	3.00 E-01	3.00 E+01	1	0.4	0.4	pCi/g	0	0	9.18 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00971
Selenium-79	Not a COPC	RAD	15	13	-23.7	-4.42 E-01	8.10 E+01	2	1.4335	2	pCi/g	6.5	6.5	3.40 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.13333
Sodium-22	Not a COPC	RAD	28	28	- 0.0079	4.90 E-02	9.00 E-01	0	NA	NA	pCi/g	NA	NA	9.76 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8900	0	NA	NA	NA	0	0
Thallium-208	Not a COPC	RAD	1	0	NA	NA	NA	1	0.136	0.136	pCi/g	9	11.5	1.36 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Thorium-228	Not a COPC	RAD	489	64	-0.171	2.96 E-01	3.70 E+02	425	0.6155	9.35	pCi/g	2.5	5	1.79 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	810	0	NA	NA	NA	0	0.86912
Thorium-230	Not a COPC	RAD	190	37	-22.1	1.69 E-01	3.22 E+00	153	0.523	7.6	pCi/g	10	12.5	4.46 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	27000	0	NA	NA	NA	0	0.80526
Thorium-234	Not a COPC	RAD	27	27	0.25	6.00 E-01	8.00 E+00	0	NA	NA	pCi/g	NA	NA	8.94 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Tin-113	Not a COPC	RAD	12	12	- 0.0022	1.00 E-01	6.00 E+00	0	NA	NA	pCi/g	NA	NA	7.91 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Tin-126	Not a COPC	RAD	17	17	0.035	8.80 E-02	3.70 E+02	0	NA	NA	pCi/g	NA	NA	2.19 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Zinc-65	Not a COPC	RAD	87	86	0.0091	9.00 E-02	1.00 E+00	1	0.1	0.1	pCi/g	0	0	1.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	25000	0	4.13 E+02	0	NA	0	0.01149
Zirconium-95	Not a COPC	RAD	86	85	0.0041	1.00 E-01	1.00 E+00	1	0.1	0.1	pCi/g	0	0	1.29 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11400	0	1.17 E+03	0	NA	0	0.01163
Metals																																		
Calcium	Micronutrient	METALMULT	94	0	NA	NA	NA	94	6.86 E+03	57000	mg/kg	6.5	6.5	7.76 E+03	19700	2	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.021277	NA	1
Iron	Micronutrient	METALMULT	94	0	NA	NA	NA	94	1.45 E+04	37900	mg/kg	12.5	15	1.66 E+04	35000	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.010638	NA	1
Magnesium	Micronutrient	METALMULT	95	0	NA	NA	NA	95	3.43 E+03	8240	mg/kg	6.5	6.5	3.71 E+03	7620	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.010526	NA	1
Potassium	Micronutrient	METALMULT	94	4	466	950	1000	90	9.75 E+02	11600	mg/kg	3.2	5.7	1.15 E+03	2440	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.010638	NA	0.95745
Sodium	Micronutrient	METALMULT	94	6	104.8	132.5	586	88	1.97 E+02	898	mg/kg	12.5	15	2.38 E+02	878	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.010638	NA	0.93617
Titanium	No detects above background	METALMULT	12	0	NA	NA	NA	12	1.46 E+03	2420	mg/kg	9	10	1.57 E+03	2950	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	1
General Inorganics																																		
Bromide	Not a COPC	GENCHEM	2	2	1	1.625	2.25	0	NA	NA	mg/kg	NA	NA	1.63 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Free cyanide	Not a COPC	GENCHEM	3	2	0.05	0.05	0.05	1	2.00 E+00	2	mg/kg	3	6	7.00 E-01	NA	NA	NA	NA	NA	NA	NA	299.3464	0	212.7594	0	3.10 E-01	1	NA	NA	NA	NA	NA	0.333333	0.33333
Hydrazine	Not a COPC	GENCHEM	24	23	0.91	1.1	1.5	1	1.94 E+00	1.94286	mg/kg	7	8	1.12 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04167

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Organics																																		
Acetone	Not a COPC	VOA	229	141	0.0019	0.011	0.046	88	6.67 E-03	0.19	mg/kg	6.5	6.5	1.37 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.38428
Bromodichloro-methane	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.70 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Bromoform	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Bromomethane	Not a COPC	VOA	229	227	0.0019	0.01	0.017	2	1.00 E-02	0.01	mg/kg	3	6	1.05 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Carbon disulfide	Not a COPC	VOA	229	225	0.0019	0.005	0.011	4	5.00 E-03	0.007	mg/kg	6.5	6.5	5.65 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01747
Chloroethane	Not a COPC	VOA	229	227	0.0019	0.01	0.017	2	1.00 E-02	0.01	mg/kg	3	6	1.05 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Chloromethane	Not a COPC	VOA	229	225	0.0019	0.01	0.017	4	8.00 E-03	0.01	mg/kg	3	6	1.04 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01747
Cyclohexanone	Less than 2 detects, not a COPC	VOA	3	3	0.05	0.05633 33	0.06	0	NA	NA	mg/kg	NA	NA	5.54 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dibromochloro-methane	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
1,2-Dichloropropane	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.70 E-03	NA	NA	NA	NA	NA	700	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0.00873
cis-1,3-Dichloropropene	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
trans-1,3-Dichloropropene	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
1-Propanol	Less than 2 detects, not a COPC	VOA	158	158	3	5.5	34.33 333	0	NA	NA	mg/kg	NA	NA	1.11 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Diethyl ether	Less than 2 detects, not a COPC	VOA	2	2	0.011	0.0115	0.012	0	NA	NA	mg/kg	NA	NA	1.15 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Ethanol	Less than 2 detects, not a COPC	VOA	158	158	3	5.5	30	0	NA	NA	mg/kg	NA	NA	1.08 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Ethylene glycol	Less than 2 detects, not a COPC	VOA	1	1	5	5	5	0	NA	NA	mg/kg	NA	NA	5.00 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Hexane	Less than 2 detects, not a COPC	VOA	1	0	NA	NA	NA	1	1.04 E-02	0.01039	mg/kg	4	6	1.04 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Isobutyl alcohol	Not a COPC	VOA	3	0	NA	NA	NA	3	1.10 E+02	110	mg/kg	2.5	3.5	1.10 E+02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Methanol	Less than 2 detects, not a COPC	VOA	2	2	28	29	30	0	NA	NA	mg/kg	NA	NA	2.90 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Methylene chloride	Not a COPC	VOA	229	66	0.0019	0.008	0.03	163	1.00 E-02	0.078	mg/kg	4	5	1.16 E-02	NA	NA	NA	1.60 E+03	0	NA	NA	17.44966	0	2.74519	0	NA	NA	NA	NA	NA	NA	NA	0	0.71179
Styrene	Not a COPC	VOA	229	227	0.0019	0.005	0.017	2	5.00 E-03	0.005	mg/kg	3	6	5.71 E-03	NA	NA	NA	3.00 E+02	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0.00873
Tetrahydrofuran	Less than 2 detects, not a COPC	VOA	1	1	0.0031	0.0031	0.003 1	0	NA	NA	mg/kg	NA	NA	3.10 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Trichloromonofluoro methane	Less than 2 detects, not a COPC	VOA	3	3	0.006	0.006	0.006	0	NA	NA	mg/kg	NA	NA	6.00 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Organics (cont)																																		
1,2,4-Trimethylbenzene	Less than 2 detects, not a COPC	VOA	3	3	0.0041	0.006	0.006	0	NA	NA	mg/kg	NA	NA	5.38 E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Vinyl acetate	Not a COPC	VOA	53	51	0.01	0.01	0.013	2	1.00 E-02	0.01	mg/kg	3	6	1.02 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03774
Vinyl chloride	Not a COPC	VOA	229	227	0.0019	0.01	0.017	2	1.00 E-02	0.01	mg/kg	3	6	1.04 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00873
Semivolatile Organics																																		
Acenaphthene	Not a COPC	SVOA	235	232	0.069	0.35	5.6	3	6.10 E-02	0.26533	mg/kg	5	6	3.96 E-01	NA	NA	NA	2.00 E+01	0	NA	NA	154.0154	0	338.1969	0	NA	NA	NA	NA	NA	NA	NA	0	0.01277
Acenaphthylene	No detects above SSV, not a COPC	SVOA	234	234	0.083	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Anthracene	No detects above SSV, not a COPC	SVOA	234	232	0.07	0.35	5.6	2	2.06 E-01	0.26267	mg/kg	5	6	3.99 E-01	NA	NA	NA	NA	NA	NA	NA	204.8131	0	820.1427	0	NA	NA	NA	NA	NA	NA	NA	0	0.00855
Benzo(a)anthracene	No detects above SSV, not a COPC	SVOA	234	227	0.07	0.35	5.6	7	6.40 E-02	0.55	mg/kg	0	1.5	3.85 E-01	NA	NA	NA	NA	NA	NA	NA	3.777778	0	3.480041	0	NA	NA	NA	NA	NA	NA	NA	0	0.02991
Benzo(a)pyrene	No detects above SSV, not a COPC	SVOA	234	227	0.07	0.35	5.6	7	9.03 E-02	0.6	mg/kg	0	1.5	3.85 E-01	NA	NA	NA	NA	NA	NA	NA	11.75309	0	80.07039	0	NA	NA	NA	NA	NA	NA	NA	0	0.02991
Benzo(b)fluoranthene	No detects above SSV, not a COPC	SVOA	234	227	0.07	0.35	5.6	7	9.47 E-02	0.53	mg/kg	0	1.5	3.85 E-01	NA	NA	NA	NA	NA	NA	NA	40.40404	0	116.6283	0	NA	NA	NA	NA	NA	NA	NA	0	0.02991
Benzo(ghi)perylene	No detects above SSV, not a COPC	SVOA	234	229	0.07	0.35	5.6	5	7.47 E-02	0.66	mg/kg	0	1.5	3.97 E-01	NA	NA	NA	NA	NA	NA	NA	11.55235	0	289.7734	0	NA	NA	NA	NA	NA	NA	NA	0	0.02137
Benzo(k)fluoranthene	No detects above SSV, not a COPC	SVOA	234	229	0.07	0.35	5.6	5	1.07 E-01	0.45	mg/kg	0	1.5	3.97 E-01	NA	NA	NA	NA	NA	NA	NA	64	0	209.9309	0	NA	NA	NA	NA	NA	NA	NA	0	0.02137
Benzoic acid	No detects above SSV	SVOA	51	47	1.6	1.7	1.9	4	6.35 E-02	0.07	mg/kg	9	11.5	1.60 E+00	NA	NA	NA	NA	NA	NA	NA	11.11111	0	3.243462	0	NA	NA	NA	NA	NA	NA	NA	0	0.07843
Benzyl alcohol	Less than 2 detects, not a COPC	SVOA	51	51	0.33	0.34	0.38	0	NA	NA	mg/kg	NA	NA	3.45 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Bis(2-chloro-1-methylethyl)ether	Less than 2 detects, not a COPC	SVOA	230	230	0.2597	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.04 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Bis(2-Chloroethoxy)-methane	Less than 2 detects, not a COPC	SVOA	234	234	0.12	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Bis(2-chloroethyl)-ether	Less than 2 detects, not a COPC	SVOA	234	234	0.255	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Bis(2-chloroisopropyl)	Less than 2 detects, not a COPC	SVOA	4	4	0.34	0.34	0.35	0	NA	NA	mg/kg	NA	NA	3.43 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Bis(2-ethylhexyl) phthalate	Not a COPC	SVOA	234	175	0.075	0.35	5.6	59	5.70 E-02	6.2	mg/kg	4	5	3.56 E-01	NA	NA	NA	NA	NA	NA	NA	27.38496	0	1024.98	0	3.24 E+00	1	NA	NA	NA	NA	NA	0.004274	0.25214
4-Bromophenyl phenyl-ether	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2,6-di-tert-Butyl-p-benzoquinon	Less than 2 detects, not a COPC	SVOA	1	0	NA	NA	NA	1	1.20 E-02	0.01202	mg/kg	6	8	1.20 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Butylbenzylphthalate	Not a COPC	SVOA	234	225	0.07	0.35	5.6	9	2.90 E-01	1.8	mg/kg	6	8	3.97 E-01	NA	NA	NA	NA	NA	NA	NA	315.4762	0	1654.527	0	NA	NA	NA	NA	NA	NA	NA	0	0.03846
Carbazole	Not a COPC	SVOA	183	181	0.083	0.35	5.6	2	1.78 E-01	0.25933	mg/kg	5	6	4.13 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01093
4-Chloro-3-methylphenol	Less than 2 detects, not a COPC	SVOA	235	234	0.069	0.35	5.6	1	2.70 E-02	0.027	mg/kg	10	12.5	3.99 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00426
4-Chloroaniline	Less than 2 detects, not a COPC	SVOA	234	234	0.097	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Semivolatile Organics (cont)																																		
2-Chloronaphthalene	Less than 2 detects, not a COPC	SVOA	234	231	0.07	0.35	5.6	3	6.50 E-02	0.074	mg/kg	3	6	4.04 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01282
2-Chlorophenol	Less than 2 detects, not a COPC	SVOA	235	234	0.15	0.35	5.6	1	3.10 E-02	0.031	mg/kg	10	12.5	4.00 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00426
4-Chlorophenyl phenyl-ether	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Chrysene	Not a COPC	SVOA	234	225	0.07	0.35	5.6	9	6.20 E-02	0.68	mg/kg	0	1.5	3.84 E-01	NA	NA	NA	NA	NA	NA	NA	2.905983	0	3.480041	0	NA	NA	NA	NA	NA	NA	NA	0	0.03846
Decane	Less than 2 detects, not a COPC	SVOA	1	1	0.25	0.25	0.25	0	NA	NA	mg/kg	NA	NA	2.50 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Diacetone alcohol	Not a COPC	SVOA	3	0	NA	NA	NA	3	6.50 E+01	76	mg/kg	10	12.5	4.70 E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Dibenz[a,h]-anthracene	Not a COPC	SVOA	234	232	0.07	0.35	5.6	2	1.77 E-01	0.244	mg/kg	8	9	3.99 E-01	NA	NA	NA	NA	NA	NA	NA	13.43434	0	53.25752	0	NA	NA	NA	NA	NA	NA	NA	0	0.00855
Dibenzofuran	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	6.10 E+00	0	NA	NA	NA	NA	NA	NA	1.93 E-06	0	NA	NA	NA	NA	NA	0	0
1,4-Dichlorobenzene	Less than 2 detects, not a COPC	SVOA	235	234	0.2473	0.35	5.6	1	2.00 E-02	0.02	mg/kg	10	12.5	4.01 E-01	NA	NA	NA	NA	NA	20	0	5.817336	0	7.857311	0	NA	NA	NA	NA	NA	NA	NA	0	0.00426
3,3'-Dichlorobenzidine	Less than 2 detects, not a COPC	SVOA	234	234	0.083	0.36	5.6	0	NA	NA	mg/kg	NA	NA	5.14 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2,4-Dichlorophenol	Less than 2 detects, not a COPC	SVOA	234	234	0.083	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Diethylphthalate	Not a COPC	SVOA	235	224	0.27	0.35	5.6	11	6.60 E-02	0.36	mg/kg	11	13.5	3.91 E-01	NA	NA	NA	1.00 E+02	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0.04681
2,4-Dimethylphenol	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Dimethyl phthalate	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	200	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
Di-n-butylphthalate	Not a COPC	SVOA	234	194	0.062	0.35	5.6	40	1.20 E-01	3.3	mg/kg	0	2.5	4.66 E-01	NA	NA	NA	2.00 E+02	0	NA	NA	2731.906	0	11557.2	0	5.51 E-01	15	NA	NA	NA	NA	NA	0.064103	0.17094
Di-n-octylphthalate	Less than 2 detects, not a COPC	SVOA	234	233	0.07	0.35	5.6	1	2.30 E-02	0.023	mg/kg	12.5	15	4.00 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00427
4,6-Dinitro-2-methylphenol	Less than 2 detects, not a COPC	SVOA	234	234	0.5997	0.9	14	0	NA	NA	mg/kg	NA	NA	1.22 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2,4-Dinitrophenol	Less than 2 detects, not a COPC	SVOA	234	234	0.6093	0.9	14	0	NA	NA	mg/kg	NA	NA	1.22 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2,6-Dinitrotoluene	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Fluoranthene	Not a COPC	SVOA	234	226	0.07	0.35	5.6	8	1.58 E-01	1.5	mg/kg	0	1.5	3.91 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03419
Fluorene	Not a COPC	SVOA	234	232	0.07	0.35	5.6	2	1.60 E-01	0.26	mg/kg	5	6	3.98 E-01	NA	NA	NA	NA	NA	30	0	265.8161	0	771.9147	0	NA	NA	NA	NA	NA	NA	NA	0	0.00855
Hexachlorobenzene	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Hexachlorobutadiene	Less than 2 detects, not a COPC	SVOA	234	234	0.259	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Hexachlorocyclo-pentadiene	Less than 2 detects, not a COPC	SVOA	234	234	0.2447	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.41 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-3. Screening of Noncontaminants of Potential Concern with Empirical Data for Contaminant of Potential Ecological Concern Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Semivolatile Organics(cont)																																		
Hexachloroethane	Less than 2 detects, not a COPC	SVOA	234	234	0.247	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Hexadecanoic acid (9CI)	Less than 2 detects, not a COPC	SVOA	2	0	NA	NA	NA	2	2.20 E-01	0.25	mg/kg	3	5.5	2.20 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Indeno(1,2,3-cd)pyrene	No detects above SSV	SVOA	234	229	0.07	0.35	5.6	5	6.67 E-02	0.4	mg/kg	0	1.5	3.96 E-01	NA	NA	NA	NA	NA	NA	NA	64	0	281.217	0	NA	NA	NA	NA	NA	NA	NA	0	0.02137
Isophorone	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Mesityl oxide	Less than 2 detects, not a COPC	SVOA	1	0	NA	NA	NA	1	3.90 E-01	0.39	mg/kg	9	11.5	3.90 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
2-Methylnaphthalene	Less than 2 detects, not a COPC	SVOA	234	234	0.19	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
N-Butyl benzenesulfonamide	Less than 2 detects, not a COPC	SVOA	1	0	NA	NA	NA	1	4.40 E+00	4.4	mg/kg	9	11.5	4.40 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Nitrobenzene	Less than 2 detects, not a COPC	SVOA	234	234	0.2573	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.03 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2-Nitroaniline	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.9	14	0	NA	NA	mg/kg	NA	NA	1.21 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
3-Nitroaniline	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.9	14	0	NA	NA	mg/kg	NA	NA	1.21 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
4-Nitroaniline	Less than 2 detects, not a COPC	SVOA	234	234	0.26	0.9	14	0	NA	NA	mg/kg	NA	NA	1.21 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
2-Nitrophenol	Less than 2 detects, not a COPC	SVOA	235	235	0.18	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.01 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
4-Nitrophenol	No detects above SSV	SVOA	234	232	0.6147	0.9	14	2	1.70 E+00	1.7	mg/kg	2	4.5	1.22 E+00	NA	NA	NA	NA	NA	7	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0.00855
N-Nitrosodi-n-dipropylamine	Less than 2 detects, not a COPC	SVOA	235	235	0.069	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.00 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
N-Nitrosodiphenylamine	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Octathiocane	Less than 2 detects, not a COPC	SVOA	1	1	0.0204	0.02038	0.02038	0	NA	NA	mg/kg	NA	NA	2.04 E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Pentachlorophenol	No detects above SSV	SVOA	235	232	0.31	0.9	910.3	3	1.50 E-01	0.15	mg/kg	3	5.5	5.06 E+00	NA	NA	NA	3.00 E+00	0	6	0	4.508547	0	187.9226	0	5.68 E+00	0	NA	NA	NA	NA	NA	0	0.01277
17-Pentatriacontene	Less than 2 detects, not a COPC	SVOA	1	0	NA	NA	NA	1	1.90 E-01	0.19	mg/kg	3	5.5	1.90 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
Phenanthrene	No detects above SSV	SVOA	234	227	0.07	0.35	5.6	7	1.50 E-01	0.93	mg/kg	0	1.5	3.88 E-01	NA	NA	NA	NA	NA	NA	NA	10.52739	0	42.15534	0	NA	NA	NA	NA	NA	NA	NA	0	0.02991
Phenol	Not a COPC	SVOA	235	228	0.1	0.35	5.6	7	2.80 E-02	0.12	mg/kg	9	11.5	3.89 E-01	NA	NA	NA	7.00 E+01	0	30	0	174.2919	0	34.47483	0	NA	NA	NA	NA	NA	NA	NA	0	0.02979
Pyrene	No detects above SSV	SVOA	235	225	0.069	0.35	5.6	10	9.55 E-02	1.6	mg/kg	0	1.5	3.87 E-01	NA	NA	NA	NA	NA	NA	NA	14.43001	0	97.15026	0	NA	NA	NA	NA	NA	NA	NA	0	0.04255
Tributyl phosphate	Not a COPC	SVOA	73	71	0.069	0.35	0.77	2	4.27 E-01	0.54321	mg/kg	4	6.5	3.77 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0274
1,2,4-Trichlorobenzene	Less than 2 detects, not a COPC	SVOA	235	235	0.258	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.02 E-01	NA	NA	NA	NA	NA	20	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
2,4,5-Trichlorophenol	Less than 2 detects, not a COPC	SVOA	234	234	0.076	0.89	14	0	NA	NA	mg/kg	NA	NA	1.16 E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Table D-3. Screening of Non-COPCs with Empirical Data for COPEC Identification. (7 Pages)

Analyte	COPEC Designation Justification	Method Class	Samples	# NDs	Min ND	Median ND	Max ND	Detects	Median Detect	Max Detect	Units	Top Depth (ft) of Max Detect	Bottom Depth (ft) of Max Detect	Mean Site	BV	# Detects >BV	# ND >BV	Plant	#D> Plant	Biota	#D> Biota	Shrew	#D> Shrew	Vole	#D> Vole	Robin	#D> Robin	BCG Plant	#D>BCG Plant	BCG Wild-life	#D> BCG Wild-life	FD>BV	FD>SSV	FD
Semivolatile Organics (cont)																																		
2,4,6-Trichlorophenol	Less than 2 detects, not a COPC	SVOA	234	234	0.07	0.35	5.6	0	NA	NA	mg/kg	NA	NA	4.08 E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Highlighted rows signify contaminants of potential ecological concern.

Aroclor is an expired trademark.

4-digit EPA Methods are found in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, as amended.*

BPJ = best professional judgment.
COPC = contaminant of potential concern.
COPEC = contaminant of potential ecological concern.
EPA = U.S. Environmental Protection Agency.
NA = not available.
PCB = polychlorinated biphenyl.
SOF = sum of fractions.
SSV = soil-screening value.

Table D-4. Contaminants of Potential Ecological Concern and Additional Analytes for the Central Plateau.

Radioactive Constituents		
Americium-241	Plutonium-239/240	Strontium-90
Cesium-137	Radium-226	Uranium-238
Cobalt-60	Radium-228	
Chemical Constituents – Metals		
Antimony	Chromium (VI)	Selenium
Arsenic	Copper	Silver
Barium	Cyanide	Thallium
Bismuth	Lead	Tin
Boron	Mercury	Uranium
Cadmium	Molybdenum	Vanadium
Chromium	Nickel	Zinc
Chemical Constituents - Organics		
Aroclor-1254[a]	Aroclor-1260	Carbon tetrachloride
Pesticides[b]		

[a] Aroclor is an expired trademark.

[b] Pesticides are included in the study design as additional analytes, because they can be analyzed by EPA Method 8082/8081A (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, as amended,* for little additional cost.

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APPENDIX E

WEST LAKE ECOLOGICAL RISK ASSESSMENT GUIDANCE FOR COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT OF 1980, STEPS 1 THROUGH 4

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TERMS

AE	assessment endpoint
ARAR	applicable or relevant and appropriate requirement
AUF	area-use factors
BCG	biota concentration guide
CCC	criteria continuous concentration
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
DL	detection limit
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERAGS	EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*
HQ	hazard quotient
MCL	maximum contaminant load
NA	not available/not applicable
No.	number
NOAA	National Oceanic and Atmospheric Administration
SAP	sampling and analysis plan
SQRT	Screening Quick Reference Tables
SSV	soil screening value
SVOC	semivolatile organic compound
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
VOC	volatile organic compound

APPENDIX E

WEST LAKE ECOLOGICAL RISK ASSESSMENT GUIDANCE FOR COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT OF 1980, STEPS 1 THROUGH 4

E1.0 INTRODUCTION

A screening-level ecological risk assessment was conducted for analytes measured in sediment, surface water, and surface soil in and adjacent to West Lake, which is located to the north of the 200 East Area on the Hanford Site. A screening-level ecological risk assessment is needed for West Lake because relevant data were not included in DOE/RL-2001-54, *Central Plateau Ecological Evaluation*. In addition, West Lake represents a unique ecological entity for the Central Plateau in that it is primarily an aquatic environment. This appendix on West Lake follows EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)* (ERAGS). Steps 1 and 2 of the 8-step U.S. Environmental Protection Agency (EPA) *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) guidance encompass the screening portion of the ecological risk assessment (ERA). Step 1 of the ERAGS process is the screening-level problem formulation and ecological effects evaluation, which encompasses the description of the environmental setting, fate and transport mechanisms, identification of complete exposure pathways, and the selection of screening levels for media of concern. Step 2 of the ERAGS process is the screening-level exposure and risk calculations, where conservative exposure estimates are compared to the chemical-specific screening levels selected in Step 1 for each media of concern. The conceptual model refinement for West Lake encompasses Step 3 of the EPA guidance, which allows for the refinement of the contaminants of potential ecological concern (COPEC) by applying more site-specific information to the exposure assessment. The purpose of this screening assessment was to identify any data gaps in our knowledge of current conditions of West Lake and whether additional investigation is needed.

E2.0 SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

This section presents information on the environmental setting of West Lake, environmental fate and transport mechanisms, and complete ecological exposure pathways. It also identifies appropriate screening values for potentially contaminated media at West Lake.

E2.1 ENVIRONMENTAL SETTING

West Lake is a saline and alkaline lake located southwest of Gable Mountain on the Hanford Site. Historically West Lake was an intermittent pond that appeared in response to seasonal fluctuations in the water table (PNL-7662, *An Evaluation of the Chemical, Radiological, and Ecological Conditions of West Lake on the Hanford Site*). Discharges of large amounts of wastewater associated with the start up of the Plutonium-Uranium Extraction Plant in 1957 resulted in a rise of the water table and indirectly contributed to West Lake's expansion. Contaminated effluent discharges to liquid waste sites ceased in 1995 (DOE/RL-2001-54). Currently, the water table is approximately 1.5 m below the bottom of West Lake, and no recharge of lake waters from groundwater is occurring. Water levels in West Lake have fluctuated greatly over the years. PNL-7662 cites a 1978 report (PNL-2499, *Comparative Ecology of Nuclear Waste Ponds and Streams on the Hanford Site*) that shows West Lake encompassing 19.2 acres. In 2003, the lake covered less than 5 acres (DOE/RL-2001-54). An aerial photograph showing lake levels in 1989, when the lake was still connected to the water table, is shown in Figure E-1. A photo of West Lake from Gable Mountain taken in 2003 is shown in Figure E-2. Surveys of West Lake and its adjacent wetlands in 1997 concluded that native plant communities were substantially degraded and that much of the lake was infested with weedy species, primarily smotherweed (*Bassica hysoppifolia*). Wetland vegetation was limited to scattered patches of cattails (*Typha* spp.) and bulrushes (*Scirpus* spp.) (DOE/RL-2001-54). PNL-7662 reports that a 1976 investigation of West Lake observed an abundance of annelid and oligochaete worms and a variety of aquatic insects. No fish have been observed in West Lake.

Figure E-1. Aerial Photograph of West Lake in 1989.

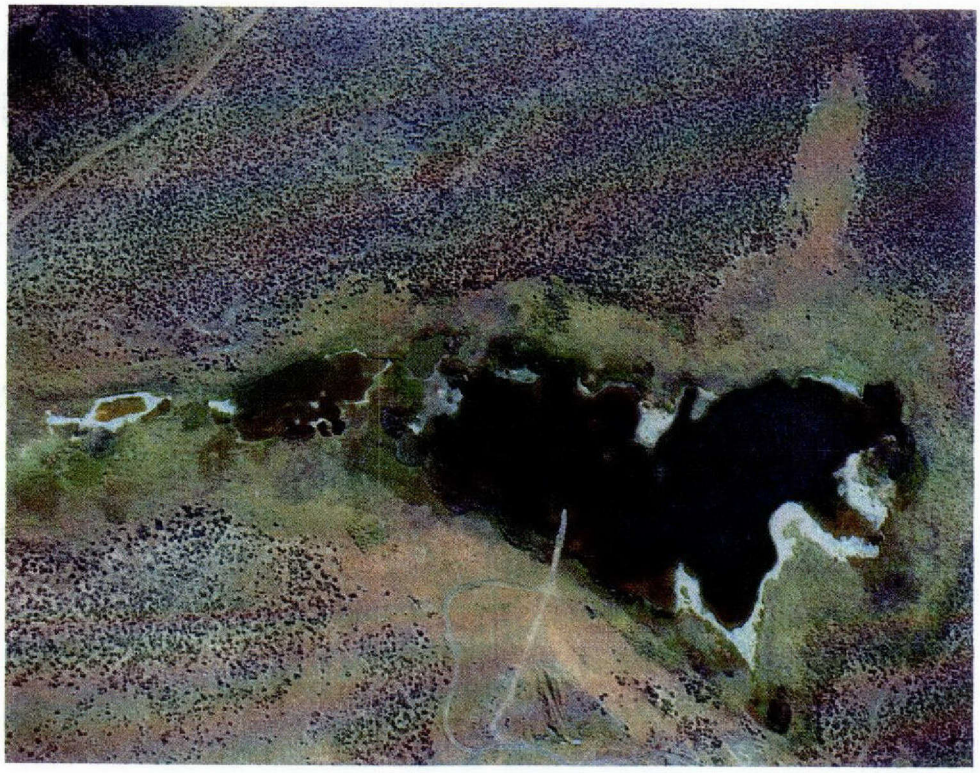


Figure E-2. Photograph of West Lake taken from Gable Mountain in 2003.

In August 1989, sediment and surface water samples were collected from West Lake, and surface soil samples were collected from a transect just to the north of West Lake and another transect just to the south of West Lake (hereafter referred to as North Transect and South Transect). Both transects were located within the zone of salt-influenced vegetation surrounding the lake. Sediment and soil samples were analyzed for radionuclides; surface water samples were analyzed for radionuclides, trace metals, and select organic constituents. Radionuclides also were analyzed in vegetation samples collected around the lake and in eggshells of American coots (*Fulica americana*) that were breeding on West Lake. Results from the 1989 sampling were published in PNL-7662. Additional surface water samples for radiological analysis have been collected yearly since 1990, and 10 additional sediment samples were collected for radiological analysis between June 2000 and October 2003. As of 2002, collection of water samples has been deemed impractical because of the limited availability of sample volume.

Based on the measured water quality parameters (e.g., total dissolved solids, conductivity, sodium, potassium, magnesium, and chloride), PNL-7662 concluded that West Lake was a more saline environment than other saline lakes in eastern Washington. West Lake is likely to become increasingly saline over time now that it is cut off from the water table; constituents dissolved in runoff will concentrate in the lake as the water evaporates. All of the sediment, surface water, and soil samples collected from 1989 to 2003 were used in this screening assessment.

E2.2 CONTAMINANT FATE AND TRANSPORT

2.2.1 Impacted Media

The data quality objectives (DQO) summary report main document identifies shallow soils as the primary impacted media of interest for ecological receptors over most of the Hanford Site. Because of the unique ecological conditions presented by West Lake, three additional media (surface water, sediment, and salt deposits) in addition to surface soils are being evaluated as part of the ecological screening assessment of West Lake. There is no evidence that direct releases of contaminants have occurred to any of the four media at West Lake, but rather these represent secondarily contaminated media from the historical groundwater discharges that formed West Lake. Data from groundwater monitoring wells suggest that groundwater in the West Lake area also has been impacted by operations at the Hanford Site, but groundwater is not being evaluated as part of this screening assessment because of the lack of ecological exposure pathways to groundwater (see Section 2.1 of the main text).

2.2.2 Groundwater and Surface Water Transport

The primary source of chemical constituents observed in West Lake surface water and sediment is presumed to be historical fuel reprocessing activities in the 200 Areas on the Hanford Site. Discharge of wastewater from those activities resulted in a rise of the water table and the expansion of West Lake. Water table maps of the West Lake area show that unconfined groundwater passing West Lake flows from the 200 East Area north through the gap between Gable Butte and Gable Mountain (PNL-7662). The presence of tritium and technetium-99 in groundwater monitoring wells in the vicinity of West Lake provide evidence that 200 Area activities have impacted groundwater and likely are the source of chemical constituents in West Lake surface water and sediment. All contaminated wastewater discharges to the 200 Areas holding ponds ceased in 1995, so it is assumed that the 200 Areas are not a continuing source of chemical constituents to groundwater and West Lake. Because West Lake is no longer connected to the regional aquifer system, water levels will continue to drop if evaporation rates are greater than input from precipitation runoff. As the lake level declines, chemical constituents in surface water likely are deposited in newly exposed surface soils and salt deposits. Because West Lake is a closed system with no outlet, surface water is not a mechanism for contaminants to be transported offsite.

2.2.3 Airborne Transport

Airborne entrainment of dust particles or fine salt particles is the primary mechanism for contaminants at West Lake and adjacent areas to be transported offsite. Surface soils and salt deposits that are newly exposed by declining water levels are particularly susceptible to windborne transport because of the lack of vegetation or other suitable cover to hold the soil in place.

E2.3 COMPLETE EXPOSURE PATHWAYS

Completed exposure pathways for West Lake and its immediate environs are dermal contact with contaminants in sediment, surface water, and soil; ingestion of surface water; root uptake of contaminants by terrestrial and aquatic plants; incidental ingestion of sediment and soil; inhalation of entrained particles; ingestion of contaminated salt deposits; and dietary exposure to contaminants in foodstuffs (food chain uptake).

Dermal contact with sediments and water is most important for aquatic organisms that live immersed in water and sediment (i.e., aquatic invertebrates). Indeed, for these organisms it is difficult to differentiate exposures from various pathways because the organism is immersed in or in direct contact with the media of concern. Dermal contact with sediment and surface water is a complete exposure pathway for wildlife, especially wading birds and swimming birds, but as with dermal contact of wildlife with shallow soil, fur and feathers serve as an effective barrier to make these exposure pathways of less relative importance than ingestion pathways (see Section 2.1 of the main text).

Ingestion of surface water is likely not a significant pathway for terrestrial wildlife because the salinity of West Lake eliminates it as a routine drinking water source for most terrestrial animals. However, many aquatic birds, including American coots, which have nested on West Lake in the past, have glands in their bills that allow excess salt to be filtered out of drinking water and excreted through the bill or nostril. This allows the bird to drink water that is much higher in salt content than can be tolerated by other wildlife. For these species, ingestion of surface water is a complete exposure pathway.

Root uptake is the primary exposure pathway for both aquatic and terrestrial plant species at the Hanford Site. As noted in Section 2.1, the native plant community at West Lake is substantially degraded, with much of the area covered by weedy species and only scattered areas of emergent wetland vegetation. The species that do occur tend to be salt tolerant and thus can colonize soils exposed by falling water levels, potentially becoming exposed to contaminants in those soils.

While there is a potentially complete exposure pathway via inhalation of particulates, as discussed in the main document, inhalation of particulates is a minor exposure pathway for terrestrial receptors when compared to the ingestion pathways. Available data and knowledge of site activities do not suggest the presence of volatile chemicals. However, tritium has been measured so inhalation of vapors is a complete exposure pathway at least for tritium.

Incidental ingestion of contaminated media and food chain ingestion of contaminated foodstuffs are likely to be the most important exposure pathways for wildlife at West Lake. During low water periods, terrestrial mammals would be expected to use dry areas of the lakebed for foraging, and burrowing mammals could colonize the area as well. Incidental ingestion of sediment and surface water is likely in animals feeding on aquatic plants or invertebrates in West Lake. Ingestion of prey from the lake is expected to be limited to invertivores, because no fish occur in West Lake.

A unique exposure pathway for West Lake is the ingestion of salt deposits by wildlife. Many mammals use salt licks for nutritional purposes, and the mineral deposits concentrated by evaporation of West Lake water could be considered an attractive resource to area wildlife for

this reason. Intake of salt in this manner is very difficult to quantify, and therefore this exposure pathway will be evaluated in a qualitative manner in the screening assessment.

E2.4 SELECTION OF SCREENING LEVELS

Protective screening values for radionuclides were obtained as radionuclide-specific biota concentration guidelines (BCG) (DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota*). The BCGs are not applicable or relevant and appropriate (ARAR) regulations but are "to-be-considered" values used for ecological screening. The BCGs were developed by a consortium of the U.S. Department of Energy (DOE), the EPA, and the U.S. Nuclear Regulatory Commission (DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation, User's Guide, Version 1*). These BCGs are based on prescribed dose limits that can be translated into radionuclide-specific concentrations (e.g., pCi/g) for a defined exposure scenario (DOE/EH-0676). Before development of the BCGs, no single set of screening criteria was agreed upon or applied consistently across different regions of the country. The intent of the consortium was to provide screening criteria for radionuclides that could be applied in a consistent manner across multiple contaminated sites. BCGs are intended to protect populations of ecological receptors.

Ecological screening values for chemical constituents in West Lake surface water were obtained from the Screening Quick Reference Tables (SQRT) developed by the National Oceanic and Atmospheric Administration (NOAA) (Buchman 1999, *Screening Quick Reference Tables*). A hierarchy was established to choose surface water screening values from SQRT. Chronic toxicity screening values for marine waters were chosen over acute toxicity screening values or freshwater screening values. Chronic criteria are more conservative than acute criteria, because chronic effects generally occur at lower concentrations than acute affects. Marine criteria are more appropriate than freshwater criteria because of the high salinity of West Lake. PNL-7662 previously screened the metals data using freshwater ambient water-quality criteria for wildlife. Of the detected metals in West Lake for which both freshwater and marine water chronic screening values are available (arsenic, chromium, copper, mercury, and zinc), marine values are more conservative for three metals (arsenic, copper, and zinc), whereas freshwater screening values are more conservative for the remaining two metals (chromium and mercury). PNL-7662 identified all five of these metals as COPECs.

Nonradionuclide screening values were chosen from SQRT in the following hierarchy:

1. Chronic marine criteria continuous concentrations (CCC)
2. Acute marine CCC
3. Chronic freshwater CCC
4. Acute freshwater CCC
5. Maximum contaminant load (MCL) values for groundwater.

E3.0 SCREENING-LEVEL EXPOSURE ESTIMATION AND RISK CHARACTERIZATION

E3.1 EXPOSURE ESTIMATES

Screening-level risk assessments use protective assumptions to identify the potential for adverse ecological effects and to identify COPECs. In the West Lake ecological screening assessment, maximum concentrations of each analyte in each medium are used to represent the ecological exposure. Hazard quotients (HQ) are calculated by dividing the maximum concentration by the BCG. The hazard index is the sum of hazard quotients for a medium. Use of maximum observed concentrations is a conservative assumption scenario representing the worst-case exposure scenario. Use of maximum concentrations is also more protective of individual ecological receptors, which generally have smaller exposure areas than populations of individuals.

E3.2 SCREENING RESULTS

In the initial screening, maximum radionuclide concentrations in sediment, surface water, and soil were compared to conservative screening values for each medium. Radionuclides with maximum concentrations exceeding their respective screening values were carried forward to the ERAGS COPEC-refinement step (Step 3). If a BCG was not available for a radionuclide in a given medium and the radionuclide was detected in that medium, then that radionuclide also was carried forward for further evaluation in screening refinement.

Nonradionuclides with maximum concentrations exceeding their respective screening values were carried forward as COPECs. Detected constituents without ecological screening values also were identified as COPECs. Constituents that were not detected but that had detection limits exceeding ecological screening values were identified as potential data gaps.

3.2.1 Radionuclides in West Lake Sediment

Screening results for radionuclides in West Lake sediment are presented in Table E-1. Four radionuclides (K-40, Pb-212, Pb-214, and Ru-106) were retained following initial screening because they were detected in one or more samples and no BCGs were available for comparison. These four constituents, highlighted in Table E-1, are evaluated further in COPEC refinement and the uncertainty discussion. Eight radionuclides (Cs-137, Eu-154, Eu-155, Tc-99, U-234, U-235, U-238, and Zr-95) were detected in at least one sediment sample, but at concentrations less than the BCG, and were eliminated from further consideration as sediment COPECs. Six radionuclides (Sb-125, Be-7, Co-60, Cs-134, Eu-152, and Sr-90) were not detected in any sediment samples and had maximum detection limits less than their respective BCGs (Sb-125, Co-60, Cs-134, Eu-152, Sr-90), or did not have BCGs (Be-7). These six radionuclides also were eliminated from further consideration as sediment COPECs.

Table E-1. Screening Results for Radionuclides in West Lake Sediment.

Radionuclide	Maximum Concentra-tion (pCi/g)	90th Percentile Soil Back-ground (pCi/g)	BCG for Aquatic Sediment (pCi/g)	Maximum/ BCG Ratio	Suspect Sediment COPEC?	Justification
Antimony-125	[0.0419]	--	7030	<0.0001	No	Less than BCG
Beryllium-7	[0.25]	--	NA	NA	No	Not detected, no BCG
Cobalt-60	[0.015]	0.00842	1460	<0.0001	No	Less than BCG
Cesium-134	[0.0613]	--	1480	<0.0001	No	Max DL less than BCG
Cesium-137	2.45	1.05	3120	0.0008	No	Less than BCG
Europium-152	[0.0413]	--	3040	<0.0001	No	Max DL less than BCG
Europium-154	0.082	0.0334	2570	<0.0001	No	Less than BCG
Europium-155	0.085	0.0539	31600	<0.0001	No	Less than BCG
Lead-212	0.859	--	NA	NA	Yes	Detected, no background or BCG
Lead-214	0.743	--	NA	NA	Yes	Detected, no background or BCG
Potassium-40	21.9	16.6	NA	NA	Yes	Detected above background, no BCG
Ruthenium-106	0.166	--	NA	NA	Yes	Detected, no background or BCG
Strontium-90	[1.57]	0.178	582	0.0027	No	Max DL less than BCG
Technetium-99	0.956	--	42200	<0.0001	No	Less than BCG
Tritium	0.001	--	374000	<0.0001	No	Less than BCG
Uranium-234	9.1	1.1	5270	0.0017	No	Less than BCG
Uranium-235	0.86	0.109	4730	0.0002	No	Less than BCG
Uranium-238	8.53	1.06	2490	0.0034	No	Less than BCG
Zirconium-95	0.031	--	2330	<0.0001	No	Less than BCG
Hazard Index [sum of maximum/BCG] = 0.009						

DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota.*
[ ] - signifies that values shown are non-detections.
BCG = biota concentration guidelines (DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
DL = detection limit.
NA = not available/ not applicable.

3.2.2 Radionuclides in West Lake Salt Deposits

Two salt deposit samples collected from the dry portion of the lakebed in 1989 showed levels of U-234 approximately five times higher than the maximum observed in sediment and concentrations of U-238 approximately 3 times the sediment maximum. Screened solely against sediment or soil BCGs, these concentrations are still well below levels of concern. However, it is prudent to consider the potential for these deposits to be attractive resources, where wildlife would purposely and preferentially ingest these deposits by use as a salt-lick. Soil and sediment BCGs for terrestrial animals are based mainly on food chain ingestion of radionuclides, and incidental ingestion of abiotic media. Salt deposits around West Lake may be attractive to

wildlife as a salt-lick, leading to purposeful and preferential ingestion of the salt by terrestrial wildlife. In this case, sediment and soil BCGs may not be conservative enough, because they do not take into account preferential ingestion of abiotic media. This represents an uncertainty in the risk screening. This uncertainty is likely minimal at West Lake, however, because maximum HQs for all isotopes are uranium isotopes are less than 1 (U-234 HQ=0.035, U-235 HQ=0.0001, U-238 HQ=0.082).

3.2.3 Radionuclides in West Lake Surface Water

Screening of West Lake surface water samples is presented in Table E-2. Two radionuclides (U-234 and U-238) were detected in West Lake surface water at concentrations exceeding their respective BCGs. Uranium-234 and U-238 had HQs of 14 and 21, respectively, accounting for 98 percent of the total hazard index summed across all radionuclides for which an HQ could be calculated. These uranium isotopes, highlighted in Table E-2, are retained for further evaluation in COPEC refinement. Uranium isotopes are listed on the Central Plateau list of contaminants of potential concern (COPC) based on facility processes (see Appendix B), so the potential exists for concentrations of these constituents in West Lake water to be related to operations at the Hanford Site. Two radionuclides (Be-7 and K-40) were detected in at least one surface water sample and had no BCGs for comparison, and these two constituents, highlighted in Table E-2, were retained for further evaluation in COPEC refinement. Twelve radionuclides (Sb-125, Co-60, Ce-144, Cs-134, Cs-137, Eu-154, Eu-155, Sr-90, Tc-99, H-3, U-235, and Zr-95) were detected in at least one surface water sample but at concentrations less than their respective BCGs and, therefore, are eliminated from further consideration as potential COPECs. Ruthenium-106 was not detected in any surface water samples and is not evaluated further.

Table E-2. Screening Results for Radionuclides in West Lake Surface Water. (2 Pages)

Radionuclide	Maximum Concentration (pCi/L)	Surface Water BCG	Maximum/ BCG Ratio	Suspect Surface Water COPEC?	Justification
Antimony-125	46.1	367000	0.0001	No	Less than BCG
Beryllium-7	52.1[a]	--	NA	Yes	Detected, no BCG
Cobalt-60	14.8	3760	0.0039	No	Less than BCG
Cerium-144	11.2	1600	0.0070	No	Less than BCG
Cesium-134	1.6[b]	21.1	0.076	No	Less than BCG
Cesium-137	31.3	42.6	0.734	No	Less than BCG
Europium-154	28.6	21600	0.0013	No	Less than BCG
Europium-155	96.5	264000	0.0004	No	Less than BCG
Potassium-40	3970	--	NA	Yes	Detected, no BCG
Ruthenium-106	[206]	--	NA	No	Not detected
Strontium-90	26.2	278	0.094	No	Less than BCG
Technetium-99	1400	667000	0.0021	No	Less than BCG
Tritium	1300	2.65E+08	<0.0001	No	Less than BCG

Table E-2. Screening Results for Radionuclides in West Lake Surface Water. (2 Pages)

Radionuclide	Maximum Concentration (pCi/L)	Surface Water BCG	Maximum/ BCG Ratio	Suspect Surface Water COPEC?	Justification
Uranium-234	2860	202	14.2	Yes	Exceeds BCG
Uranium-235	132	217	0.61	No	Less than BCG
Uranium-238	4590	223	20.6	Yes	Exceeds BCG
Zirconium-95	20	7330	0.0022	No	Less than BCG
Hazard Index [sum of maximum/BCG] = 36					

[a]Represents maximum detected concentration. Maximum nondetected sample result is 337.
[b]Represents only detected concentration. Maximum nondetected sample result is 9.39.
DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota..*
[ ] - signifies that values shown are non-detections.
BCG = biota concentration guidelines (DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
NA = not available/not applicable.

3.2.4 Radionuclides in West Lake Soil

Five radionuclides were identified as COPECs in soils along the North Transect, located to the north of West Lake, but within the zone of salt influenced vegetation. Cesium-137, highlighted in Table E-3, was identified as a COPEC and was carried forward to screening refinement because the maximum detected concentration of 57.4 pCi/g exceeds the BCG for soil (20.8 pCi/g). The maximum concentration of Cs-137 was located at the southernmost sampling location of the North Transect and greatly exceeded the next highest concentration observed in the North Transect (1.34 pCi/g). The other four radionuclides identified as COPECs in North Transect soils (Pb-212, Pb-214, K-40, Ru-106), highlighted in Table E-3, were carried forward because they were detected in at least one sample, and no BCGs are available for screening. Europium-155, Sr-90, U-235, and U-238 all were detected in at least one sample, but maximum concentrations were less than their respective BCGs. These radionuclides were eliminated from further evaluation as COPECs in North Transect soils. Cesium-134, Co-60, Eu-154, and Zr-95 were eliminated as a COPECs because they were not detected in North Transect soils. North Transect soil screening is presented in Table E-3.

Table E-3. Screening of Radionuclides in Soil Along the North Transect. (2 Pages)

Radionuclide	Maximum Concentration (pCi/g)	90th Percentile Soil Background (pCi/g)	Soil BCG	Maximum/ BCG Ratio	Suspect Soil COPEC?	Justification
Cobalt-60	[0.013]	0.00842	700	<0.0001	No	Not detected, DL less than BCG
Cesium-134	[-0.003]	--	11.3	not calc.	No	Not detected, DL less than BCG
Cesium-137	57.4	1.05	20.8	2.76	Yes	Exceeds background and BCG

Table E-3. Screening of Radionuclides in Soil Along the North Transect. (2 Pages)

Radionuclide	Maximum Concentration (pCi/g)	90th Percentile Soil Background (pCi/g)	Soil BCG	Maximum/ BCG Ratio	Suspect Soil COPEC?	Justification
Europium-154	[0.052]	0.0334	1300	<0.0001	No	Not detected, DL less than BCG
Europium-155	0.12	0.0539	2000	<0.0001	No	Less than BCG/10
Lead-212	0.713	--	--	--	Yes	Detected, no background, no BCG
Lead-214	0.62	--	--	--	Yes	Detected, no background, no BCG
Potassium-40	18.3	16.6	--	--	Yes	Detected, above background, no BCG
Ruthenium-106	0.155	--	--	--	Yes	Detected, no background, no BCG
Strontium-90	0.35	0.178	22.5	0.016	No	Less than BCG
Uranium-235	8.2	0.109	2770	0.003	No	Less than BCG
Uranium-238	1.91	1.06	1580	0.0012	No	Less than BCG/10
Zirconium-95	[0.013]	--	1170	<0.0001	No	Not detected, DL less than BCG
Hazard Index [sum of maximum/BCG] = 2.8						

DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota..*
[ ] - signifies that values shown are non-detections.
BCG = biota concentration guidelines (DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
DL = detection limit.

Four radionuclides were identified as COPECs in South Transect soils. Lead-212, Pb-214, and K-40, highlighted in Table E-4, were carried forward because they were detected in at least one sample, and no BCGs are available for screening. Cesium-134, Cs-137, Eu-154, Eu-155, Sr-90, U-235, U-238, and Zr-95 all were detected in at least one sample of South Transect soil but at concentrations less than their respective BCGs; therefore, all were eliminated from further evaluation as COPECs in South Transect soils. Cobalt-60, Ru-106, and Zr-95 were eliminated as COPECs because they were not detected in samples of South Transect soil. South Transect soil screening is presented in Table E-4.

Table E-4. Screening of Radionuclides in Soil Along the South Transect. (2 Pages)

Radionuclide	Maximum Concentration (pCi/g)	90th Percentile Soil Background (pCi/g)	Soil BCG	Maximum/ BCG Ratio	Suspect Soil COPEC?	Justification
Cobalt-60	[0.023]	0.00842	700	<0.0001	No	Not detected, DL less than BCG
Cesium-134	0.044	--	11.3	0.0039	No	Not detected, DL less than BCG
Cesium-137	1.52	1.05	20.8	0.073	No	Less than BCG

Table E-4. Screening of Radionuclides in Soil Along the South Transect. (2 Pages)

Radionuclide	Maximum Concentration (pCi/g)	90th Percentile Soil Background (pCi/g)	Soil BCG	Maximum/ BCG Ratio	Suspect Soil COPEC?	Justification
Europium-154	0.1	0.0334	1300	<0.0001	No	Less than BCG
Europium-155	0.075	0.0539	2000	<0.0001	No	Less than BCG
Lead-212	0.818	--	--	--	Yes	Detected, no background, no BCG
Lead-214	0.684	--	--	--	Yes	Detected, no background, no BCG
Potassium-40	16.9	16.6	--		Yes	Detected, above background, no BCG
Ruthenium-106	[0.092]	--	--	--	No	Not detected
Strontium-90	0.671	0.178	22.5	0.0030	No	Less than BCG
Uranium-235	0.122	0.109	2770	<0.0001	No	Less than BCG
Uranium-238	1.91	1.06	1580	0.0012	No	Less than BCG
Zr-95	[0.013]	--	1170	<0.0001	No	Not detected, DL less than BCG
Hazard Index [sum of maximum/BCG] = 0.11						

DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota..*
[ ] - signifies that values shown are non-detections.
BCG = biota concentration guidelines (BCG) (DOE-STD-1153-2002).
COPEC = contaminant of potential ecological concern.
DL = detection limit.

3.2.5 Nonradionuclides in West Lake Surface Water

Trace metals and organic constituents were analyzed in at least one unfiltered surface water sample in 1989. PNL-7662 noted that arsenic, chromium, copper, and zinc exceeded EPA criteria for acute toxicity to freshwater organisms but stated "the levels are probably not toxic to organisms found in West Lake because of the lake's high salt content and alkaline state." The NOAA SQRTs (Buchman 1999) include screening criteria for chemical constituents in marine water. Marine water criteria are probably a better choice for screening West Lake surface water because of the high salinity of the lake. A comparison of marine water screening criteria to maximum detected trace metal concentrations is presented in Table E-5. Arsenic, chromium, copper, manganese, and zinc, highlighted in Table E-5, were detected at concentrations above screening values. In addition, cyanide and silver, highlighted in Table E-5, had detection limits exceeding marine screening values by an order of magnitude, and the detection limit for nickel (10 µg/L) was slightly above the screening value of 8.2 µg/L. Boron, molybdenum, silicon, and strontium, highlighted in Table E-5, were detected in surface water samples and do not have available surface water screening values. The twelve inorganic compounds highlighted in Table E-5 are retained as suspected COPECs for further evaluation in the next phase of surface water sampling, because current data are not sufficient to allow for further refinement of the inorganic nonradionuclide COPEC list.

Organic compounds analyzed included 59 volatile organic compounds (VOC) and semivolatile organic compounds (SVOC), 30 pesticides/herbicides, 7 Aroclors, and 7 thiourea compounds. Of this list, only hexachlorophene was detected. However, screening could not be conducted because detection limits for the organic compounds were universally above screening limits, often by several orders of magnitude. Based on the list of potential COPCs related to processes in the 200 East Area, organic constituents are not expected to be COPECs and no further evaluation of possible organic constituents in West Lake is recommended.

Table E-5. Screening of Metals Concentrations in West Lake Surface Water. (2 Pages)

Analyte	Concentration (µg/L)	Screening Value from NOAA SQRT	Source	Suspect COPEC	Rationale
Aluminum	[150]	--	--	No	Not detected
Antimony	[100]	--	--	No	Not detected
Arsenic	900	36	Chronic Marine CCC	Yes	Exceeds Screening Value
Barium	141	2000	Groundwater MCL	No	Less than screening value
Beryllium	[5]	5.3	Freshwater CCC	No	Less than screening value
Boron	6156	--	--	Yes	Detected, no screening value
Cadmium	[2]	9.3	Chronic Marine CCC	No	Not detected
Chromium	131	50	Chronic Marine CCC	Yes	Exceeds Screening Value
Cobalt	[20]	--	--	No	Not detected
Copper	30	3.1	Chronic Marine CCC	Yes	Exceeds Screening Value
Cyanide	[10]	1	Chronic Marine CCC	Yes	Detection Limit exceeds screening value
Iron	323	--	--	No	Detected, no screening value
Lead	[5]	8.1	Chronic Marine CCC	No	Not detected
Lithium	[10]	--	--	No	Not detected
Manganese	10749	50	Groundwater MCL	Yes	Exceeds Screening Value
Mercury	0.3	0.94	Chronic Marine CCC	No	Less than screening value
Molybdenum	2236	--	--	Yes	Detected, no screening value
Nickel	[10]	8.2	Chronic Marine CCC	Yes	Detection Limit exceeds screening value
Selenium	[5]	71	Chronic Marine CCC	No	Not detected
Silicon	4522	--	--	Yes	Detected, no screening value
Silver	[10]	0.95	Acute Marine CCC	Yes	Detection Limit exceeds screening value
Strontium	626	--	--	Yes	Detected, no screening value
Thallium	[5]	2130	Acute Marine CCC	No	Not detected
Tin	[30]	--	--	No	Not detected

Table E-5. Screening of Metals Concentrations in West Lake Surface Water. (2 Pages)

Analyte	Concentration (µg/L)	Screening Value from NOAA SQRT	Source	Suspect COPEC	Rationale
Titanium	[60]	--	--	No	Not detected
Vanadium	[5]	--	--	No	Not detected
Zinc	119	81	Chronic Marine CCC	Yes	Exceeds Screening Value

DOE-STD-1153-2002, *A Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota.*
[ ] - signifies that values shown are non-detections.
CCC = criteria continuous concentration.
COPEC = contaminant of potential ecological concern.
MCL = maximum contaminant level.
NOAA = National Oceanic and Atmospheric Administration.
SQRT = Screening Quick Reference Tables.

E4.0 REFINEMENT OF CONTAMINANT FATE AND TRANSPORT INFORMATION

Three radionuclides (K-40, Pb-212, and Pb-214) were identified as COPECs in South Transect soils in the initial screening. The same three radionuclides, along with Ru-106 and Cs-137, were identified as soil COPECs in North Transect soils. Only Cs-137 is a radionuclide on the COPC list (see Appendix B) and warrants further evaluation, but concentrations of Cs-137 in West Lake soils are much lower than those reported in the Central Plateau (see the main document and Appendix G). Because soils in these areas are functionally and ecologically similar to other Central Plateau soils, specific evaluation of West Lake soils and the terrestrial community associated with them is not required.

Because West Lake surface water and sediment represent unique media and exposure conditions on the Central Plateau, COPECs in these media will be further evaluated through COPEC refinement.

E5.0 REFINEMENT OF CONTAMINANT OF POTENTIAL ECOLOGICAL CONCERNS

Two criteria were used in the COPEC refinement to focus the list of COPECs. Radionuclide concentrations in sediment and soil were compared to soil background concentrations developed for the Central Plateau of the Hanford Site. Radionuclide concentrations that appeared to represent regional background conditions were dropped from further evaluation as COPECs. No regional background concentrations for lake waters have been developed; but because radionuclides such as Pb-212, Pb-214, and K-40 are universally present in soils and waters, professional judgment was used in a qualitative evaluation of these constituents with respect to background. The second COPEC refinement criterion was an evaluation of the detection

frequency of individual radionuclides. If a radionuclide was detected in less than 5 percent of the samples, detected concentrations were evaluated spatially to determine if they were potentially indicative of a hotspot or localized release. If they were not indicative of such, they were eliminated from further consideration as COPECs.

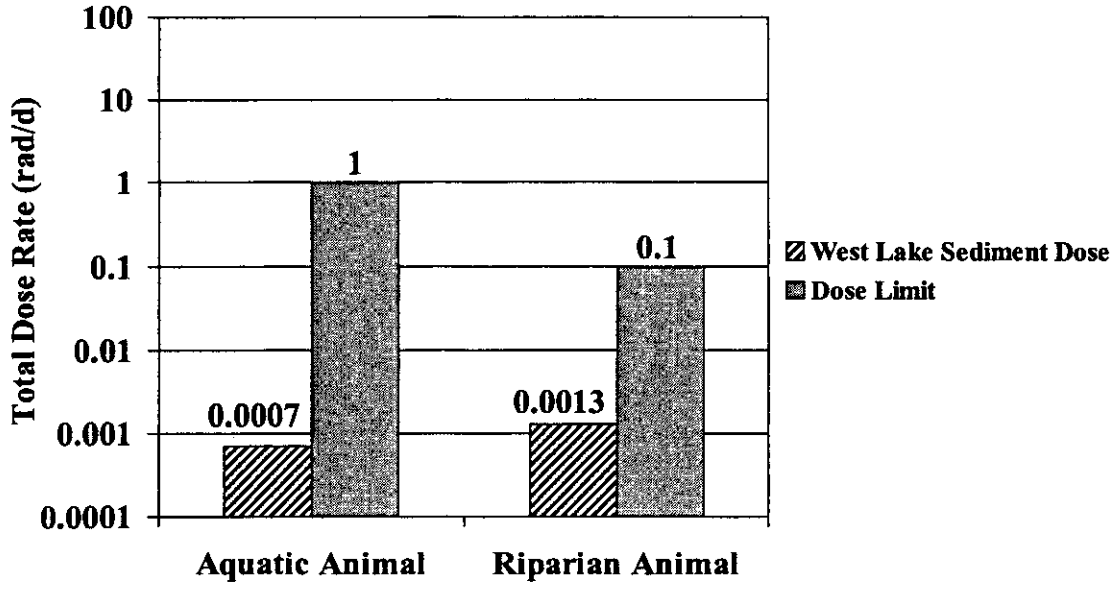
As mentioned in Section E3.2.5, data currently available for inorganic nonradionuclide compounds in surface water are not sufficient to allow for further refinement, so the 12 inorganic compounds identified as suspected COPECs in the screening will be further evaluated in the next phase of data collection.

E5.1 WEST LAKE SEDIMENT

Four radionuclides were carried forward to screening refinement from the initial screening. All were carried forward solely because they were detected in at least one sample and no BCGs were available to screen against. Ruthenium-106 was detected in 1 of 19 samples. Although this exceeds the 5 percent rule generally used to evaluate frequency of detected samples for certain analyte classes (see Section 3.2 of the main document), Ru-106 was not detected in any other surface water, soil, or vegetation samples, has a 1-yr half-life, and thus will not be further evaluated as a COPEC. Lead-212 and Pb-214 both were detected in all nine samples that were analyzed for lead. Concentrations of both are fairly uniform across the sampling locations, with relative difference of ~50 percent between minimum and maximum concentrations of each. Lead-212 and Pb-214 are part of the uranium decay chain, and hence natural background concentrations of these isotopes exist. Because concentrations of radioactive lead isotopes are relatively low and relatively uniform across sampling locations, they likely represent natural background conditions. Background concentrations of K-40 in soils at the Hanford Site have been derived, with a concentration of 16.6 pCi/g representing the 90th percentile upper confidence limit of background concentrations. The 19 sediment samples collected from West Lake had K-40 concentrations ranging from 13.8 to 21.9 pCi/g, with 11 of the 19 samples exceeding, albeit slightly, the 16.6 pCi/g concentration representing soil background at the Hanford Site. This can be explained by the saline nature of the lake. Potassium-40 occurs naturally with stable potassium, making up approximately 0.012 percent of total potassium in the environment. Because West Lake is a saline lake, total potassium concentrations are expected to be more concentrated in the lake sediments than in surrounding soils. Therefore, it follows that K-40 concentrations are also proportionately higher in saline systems than in freshwater or terrestrial systems, and the slightly higher concentrations of K-40 found in West Lake likely represent background conditions. Because of the low frequency of detect of Ru-106, and the fact that Pb-212, Pb-214, and K-40 likely represent local background conditions and are not on the list of potential process-oriented COPCs, these constituents will not be evaluated further as sediment COPECs.

The total dose to aquatic animals from radionuclides in West Lake sediment is estimated to be 0.0007 rad/day, substantially less than the aquatic animal dose limit of 1.0 rad/day. The total dose to riparian animals from radionuclides in West Lake sediment is 0.0013 rad/day. The dose limit for riparian animals is 0.1 rad/day. A comparison of total sediment dose to the different receptor types is presented in Figure E-3.

Figure E-3. Total West Lake Sediment Dose Rate by Receptor Type.



E5.2 WEST LAKE SURFACE WATER

Four radionuclides (Be-7, K-40, U-234, and U-238) were identified as surface water COPECs following initial screening. Beryllium-7 and K-40 were identified as COPECs because no BCGs were available to screen against. Beryllium-7 was only detected in 2 of 44 surface water samples. Using the frequency-of-detect rule that constituents detected in less than 5 percent of samples can be eliminated as COPECs provided that the detected concentration(s) are not indicative of a localized "hotspot." In addition, Be-7 has an extremely short half-life of 53 days and can be eliminated from further consideration as a COPEC. Potassium-40 is a naturally occurring isotope, and concentrations in salt water are expected to be higher than concentrations in freshwater because of higher naturally occurring potassium levels. However, K-40 concentrations in surface water samples were much more variable than concentrations observed in sediment, ranging from 33.4 pCi/L to 3970 pCi/L. Notes accompanying the data indicate that the sample containing the highest K-40 concentration also contained very high salt content, which may explain the high levels of K-40 noted in that sample. West Lake surface water samples collected during and after 2002 have higher concentrations of radionuclides than the water samples collected before 2002. This is because the water volume in West Lake decreased significantly over a period of several years, concentrating the suspended and dissolved solids. At times, the remaining water volume has resembled mud more than water. Therefore, the post-2001 samples were analyzed as if they were solids instead of liquids and are not representative of pure surface water concentrations. This likely greatly overestimates water concentrations of radionuclide COPECs. Even so, given that sediment and soil concentrations from West Lake are indicative of background conditions in the area, it is also likely that K-40 concentrations in water represent normal background conditions for a saline lake. For this reason, and because of

potassium's role as an essential nutrient in the environment, K-40 is eliminated from further consideration as a surface water COPEC in West Lake.

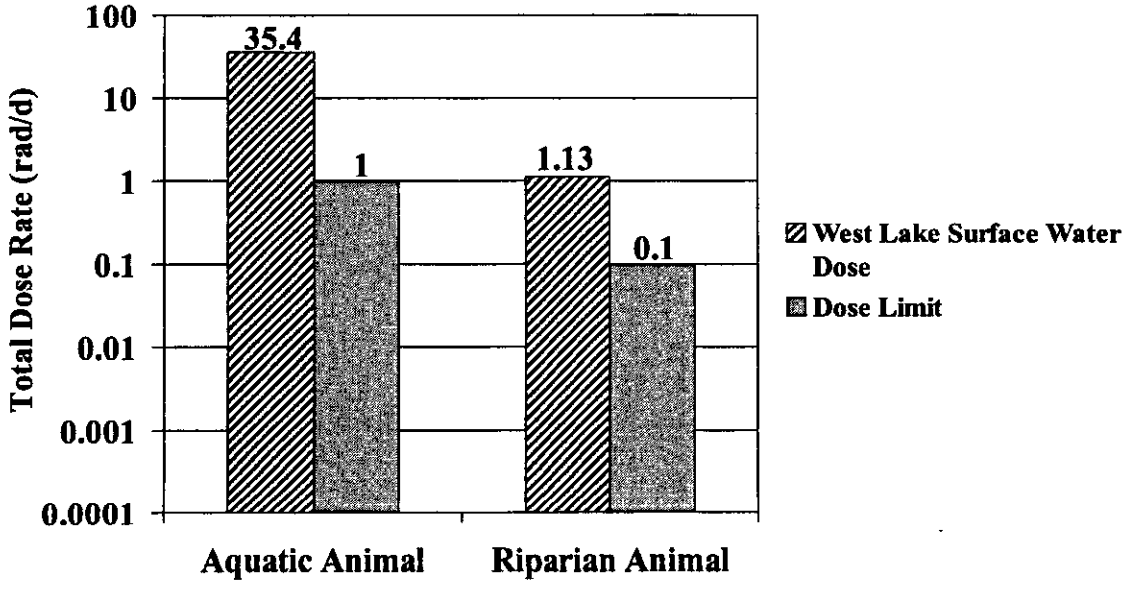
Uranium-234 and U-238 had maximum concentrations exceeding the BCG, with HQs of 14.2 and 20.6, respectively. Uranium-234 concentrations exceeded the BCG in 25 of 54 samples, and U-238 concentrations exceeded its BCG in 24 of 54 samples. All post-1989 samples contain much higher concentrations of uranium isotopes than observed in samples collected in 1989. As mentioned above, this is because of the high concentrations of suspended and dissolved solids in the post-1989 samples. The 1989 concentrations of U-234 and U-238 did not exceed the BCGs. Uranium-234 and U-238 cannot be eliminated as surface water COPECs based on frequency of detect, or by comparing to background conditions. Although surface water background conditions for the Hanford Site have not been documented, mean concentrations of uranium isotopes in West Lake water in the 1989 samples, which were less confounded by suspended particulate matter than later samples, were over 700 times higher than concentration measured in the Columbia River at Priest Rapids Dam. The lack of water background data and BCGs for a number of naturally occurring radionuclides such as Pb-212, Pb-214, and K-40 represents an uncertainty in this screening assessment. Assessment of these radionuclides was based on professional judgment and review of the concentrations detected across the three abiotic media, and in the case of K-40, background concentration in soils at the Hanford Site. Although there is some uncertainty in eliminating these constituents as COPECs, there is no evidence pointing to non-natural sources of these constituents in West Lake.

Two uranium isotopes (U-234 and U-238) in West Lake surface water warrant further investigation following comparison to background conditions and the frequency of detect evaluation. The limiting organisms upon which the three uranium water BCG values are based are aquatic animals. In West Lake these are represented by aquatic invertebrates. Evidence that aquatic invertebrates are being exposed to radionuclides in West Lake is provided by limited analysis of biotic tissue conducted by PNL-7662. The highest uranium concentrations in animals at West Lake were detected in larvae of aquatic ephydrid flies, which contained U-234 and U-238 concentrations of 0.59 and 0.55 pCi/g, respectively (based on a single composite sample). Although uranium and cesium isotopes were identified as surface-water COPECs, neither showed up in coot eggshells collected from nests at West Lake.

The dose limit for aquatic animals based on the Biota Dose Assessment Committee guidance (DOE/EH-0676) is 1 rad/day. Total dose to aquatic animals from all radionuclides in West Lake surface water is 35.4 rad/day. U-234 accounts for 40.1 percent of the total dose (14.2 rad/day), U-238 is responsible for 58.2 percent of the total dose (20.6 rad/day), and U-235 is responsible for 1.7 percent of the total dose (0.6 rad/day). All other radionuclides in West Lake water contribute a combined dose of less than 0.05 rad/day to aquatic animals. The dose limit for riparian animals based on the Biota Dose Assessment Committee guidance is 0.1 rad/day. The total dose to riparian animals from radionuclides in West Lake water is 1.13 rad/day, with U-234 responsible for 0.42 rad/day, U-238 accounting for 0.61 rad/day, and Cs-137 accounting for 0.073 rad/day. A comparison of total water doses to each of the limiting receptor types is presented in Figure E-4. Riparian animals are represented by mammals such as raccoon, mink, and muskrat. Dose to this category of receptors is primarily through ingestion of contaminated media and foodstuffs. Because no fish are present in West Lake and biota are limited to

invertebrate fauna, foraging opportunities for riparian animals likely are limited. Because of this, risk to riparian animals from radionuclides in West Lake likely are overestimated.

Figure E-4. West Lake Water Dose Rate by Receptor Type.



A summary of media-specific radionuclide COPECs remaining after screening and refinement is presented in Table E-6. Refinement of the list of nonradionuclide COPECs in West Lake water is not practical because of the very limited data set and the lack of regional background values for surface waters at the Hanford Site. It is worth noting that concentrations of trace metals in unfiltered West Lake water samples were compared to marine water screening values that are based on filtered water samples. This results in an overestimation of risk to organisms such as aquatic invertebrates that receive the bulk of their exposure from dissolved compounds in the water in which they live. Unfiltered water samples are appropriate for assessing doses to terrestrial and riparian wildlife that may use the lake as a source of drinking water, because they will be ingesting suspended particulate matter as well as water. However, the increased salinity of the lake makes it an undesirable source of drinking water for riparian animals. The limited trace metals data were collected 15 years ago, and how well that data represent current conditions is unknown. Current, filtered water samples would reduce the uncertainties associated with both of these factors. Available data for organic chemical constituents were inadequate for ecological screening purposes because of unacceptably high detection limits. However, operational history of sites that may have affected West Lake does not suggest that VOCs, SVOCs, pesticides, polychlorinated biphenyls, or thiourea compounds are of concern.

Uranium-234 and U-238, highlighted in Table E-6, were retained for further evaluation as COPECs.

Table E-6. Summary of Contaminant of Potential Ecological Concern Refinement for Radionuclides in Sediment and Surface Water.

COPEC	Was the constituent detected in <5% of samples?	Do constituent concentrations appear to represent regional background?	Retain as COPEC?
Sediment			
Lead-212	No	Yes	No
Lead-214	No	Yes	No
Potassium-40	No	Yes	No
Ruthenium-106	No[a]	Unknown	No
Surface Water			
Beryllium-7	Yes[b]	Unknown	No
Potassium-40	No	Yes	No
Uranium-234	No	No	Yes
Uranium-238	No	No	Yes

[a]Ru-106 was detected in one soil sample and one sediment sample at low concentrations. When summed across media, Ru-106 was detected in only 2 of 78 samples. It is therefore eliminated as a COPEC based on the infrequency of detects across media, short half-life, and the low concentrations observed.

[b]Be-7 was detected in 2 of 44 surface water samples and was not detected in any sediment samples. It is therefore eliminated as a COPEC, based on the infrequency of detects across media.

COPEC = contaminant of potential ecological concern.

E5.3 CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN REFINEMENT SYNOPSIS

- Radionuclide COPECs in surface water are U-234 and U-238.
- Internal dose dominates for the key radionuclides and is based on protective assumptions about diet and biological uptake of these radionuclides.
- Nonradionuclide COPECs in surface water are boron, chromium, copper, cyanide, manganese, molybdenum, nickel, silicon, silver, strontium, and zinc.
- Historical data show arsenic, chromium, copper, manganese, and zinc detected at concentrations above screening values. Cyanide, silver, and nickel had detection limits exceeding screening values. Boron, molybdenum, silicon, and strontium were detected in surface water samples and do not have screening values.
- Only limited historical data were available to evaluate inorganic constituents in water and are insufficient to conduct COPEC refinement of inorganics in surface water. There is no information about bioavailability of these constituents in West Lake.
- Data on inorganic chemicals in sediment and soil are completely lacking.

- Detection limits for available organics data are not adequate for ecological screening, but organic constituents are not expected based on knowledge of site operations.
- No COPECs were identified in sediment following COPEC screening and refinement.

E6.0 ASSESSMENT ENDPOINTS

As stated in the main document, assessment endpoints are specific ecological values to be protected and are a combination of an entity at risk and an attribute of entity at risk. 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 the main document). Because West Lake represents a unique habitat relative to the Central Plateau, the specific entities at risk may be different from those on the Central Plateau. However, because the COPECs in West Lake water are radionuclides and metals, the attributes at risk will be similar. For example, metal COPECs that may affect native plants by causing seedling mortality in terrestrial settings have similar modes of action in aquatic or riparian settings.

Based on water table elevations measured in wells adjacent to West Lake, the lake has been cut off from the water table since 1990. The water table currently is approximately 1.5 m below the lake bottom. Before 1957, West Lake existed as a small riparian area with intermittent springs that flowed as a result of seasonal fluctuations in the water table. Since releases of wastewater ceased in 1995, it is unlikely that a permanent connection between the lake and water table will be reestablished, although periodic connections may occur because of seasonal water table fluctuations (i.e. pre-1957 conditions). PNL-7662 reported the area of West Lake as 19.8 acres in 1989. By 2003, the area of West Lake had declined to less than 5 acres (DOE/RL-2001-54), and without groundwater recharge, the lake may continue to shrink. Whether West Lake will be reduced to its pre-1957 level is not known at this time. Specific aquatic assessment endpoints for West Lake are identified in Section 6.3. The specific endpoints proposed in this section include a mix of open water and riparian receptors and assume that the lake will continue to have areas of open surface water. If the lake returns to its pre-1957 condition (riparian springs), terrestrial receptors and exposure scenarios will be more relevant for the dry lake bed, and riparian receptors will be more relevant for areas surrounding the springs.

E6.1 MANAGEMENT GOALS

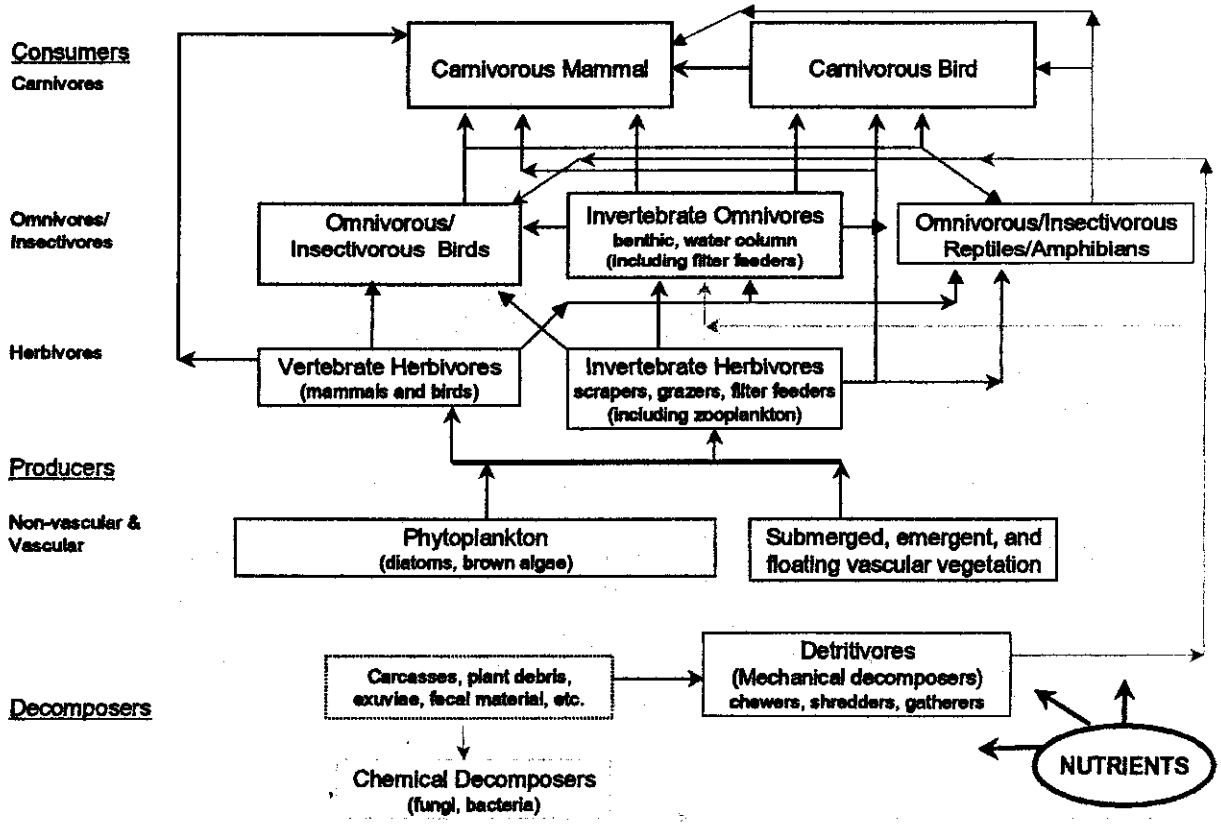
Management goals for West Lake are similar to those for terrestrial areas of the Central Plateau. Management goals include considering impacts to special status species, considering if contaminants are adversely impacting plants and invertebrates, and minimizing contaminant loading (or bioaccumulation) into West Lake biota. Special status species include migratory bird species, although no state or federal listed species have been specifically identified at West Lake. The primary ERA goal for CERCLA is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota (EPA 1999, *Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites* [Memorandum], OSWER Directive 9285.7-28P). This is of particular

importance because West Lake represents a unique habitat for the Central Plateau, and therefore unique communities are expected. These management goals are integrated with the results of the physical model (contaminated media) and COPEC refinement to develop assessment endpoints. The entities selected as assessment endpoints are based on an understanding of ecological interactions among West Lake plants, sediment, water biota, and wildlife as described in the next section.

E6.2 BIOLOGICAL TROPHIC-LEVEL LINKAGES

Ingestion (dietary and incidental sediment and surface water ingestion) and direct contact are the important exposure pathways for COPECs in West Lake. These pathways are efficiently represented by a functional food web, showing general classes of organisms sharing common characteristics. For example, ecological systems comprise many feeding relationships. Some organisms prey on plants (herbivores), plants and animals, including invertebrates (omnivores), or just on animals (carnivores). A generalized West Lake food web is presented in Figure E-5. Emergent vascular vegetation includes both aquatic and riparian vegetation such as cattails and bulrushes. Strictly aquatic species are likely limited to the producer level and the lower-trophic levels. Because West Lake is a relatively small, isolated aquatic habitat, it is unlikely to support populations of carnivorous mammals with strictly aquatic habitats. Top-level carnivorous birds and mammals at West Lake are likely terrestrial species such as badger and red-tailed hawk that are opportunistic feeders.

Figure E-5. Aquatic/Wetland Ecological Food Web Represented by Simplified Feeding Guilds.



E6.3 WEST LAKE ASSESSMENT ENDPOINTS

The Central Plateau ecological evaluation (DOE/RL-2001-54) suggests representative ecological receptors for terrestrial areas of the Central Plateau, but does not suggest specific aquatic receptors. Based on biota collected, observed, or expected at West Lake, the following representative receptors are proposed for West Lake assessment endpoints:

- Plants – DOE/RL-2001-54 describes the vegetative community at West Lake as "significantly degraded." Primary productivity of the lake is periphyton, an attached colony comprised of diatoms and brown algae. The shores and marshy areas of the lake are dominated by smotherweed (*Bassica hysoppifolia*) and bulrushes (*Scirpus* spp.). Maintenance of primary productivity is necessary to support viable benthic and aquatic invertebrate communities. Emergent aquatic/wetland plants such as cattails and bulrushes are proposed as representative plant receptors for West Lake.

- Invertebrates – A variety of aquatic invertebrates have been recorded in West Lake. A number of different freshwater insects, annelids, and oligochaetes were recorded in the late 1970's. However, because the lake no longer experiences recharge from groundwater and evaporation has shrunk the area of the lake, rising salinities may have created conditions that are not suitable for many freshwater invertebrates. Invertebrate surveys should be conducted to identify current invertebrate communities and current lake salinities. Representative invertebrate receptors will be used as surrogates for the invertebrate herbivore, invertebrate omnivore, and detritivore functional groups.

- Vertebrate herbivores – It is unknown whether herbivorous aquatic mammals inhabit West Lake. Aquatic mammals that are more likely to occur, such as mink or muskrat, are omnivorous in nature. Even then, the small size, isolated nature, and lack of fish community make it unlikely that West Lake supports populations of these animals. Therefore, mammalian herbivores are not proposed as an assessment endpoint for West Lake. It is likely that terrestrial mammalian herbivores, such as pocket mice, forage along the shore and in the salt-influenced zone around the lake, but impacts on terrestrial receptors are being evaluated as part of the terrestrial investigation in the main document. A number of herbivorous bird species could use West Lake and surrounding wetland areas. Mallard ducks, though generally considered omnivores, primarily are herbivorous during the critical breeding season. Terrestrial birds such as song sparrows and red-winged blackbirds use wetland areas for foraging and nesting, especially if extensive areas of emergent vegetation are present. For this reason, the song sparrow is proposed as a representative for herbivorous birds at West Lake.

- Omnivorous mammals – It is unknown whether omnivorous aquatic mammals inhabit West Lake. While populations of mink or muskrat are possible, the small size, isolated nature, and lack of fish community make it unlikely that West Lake supports populations of these animals. Additional observations and surveys are needed to determine if omnivorous aquatic mammals are a potential endpoint at risk in West Lake.

- Omnivorous birds – Omnivorous birds that have been collected at West Lake include American coots, which have nested at West Lake, and green-winged teal. Both of these

bird species feed on aquatic plant material and benthic invertebrates, and both have salt glands that allow them to drink saline waters. For these reasons, the green-winged teal is proposed as a representative for omnivorous birds at West Lake.

- Insectivorous birds – Invertebrate feeding shorebirds that have been recorded at West Lake include American avocet and killdeer. Both of these species feed on benthic invertebrates around the lake margins and in shallow water. Killdeer also is proposed as the insectivorous bird representative for terrestrial habitats on the Central Plateau. For this reason, killdeer is proposed as the representative aquatic insectivorous bird.

- Insectivorous reptiles/amphibians – It is not known if current conditions in West Lake provide suitable habitat for amphibians because of the saline and alkaline nature of the lake. Additional biotic surveys are needed to determine if these ecological receptors are present or if suitable habitat currently exists for amphibians.

- Carnivorous mammals and carnivorous birds – Carnivorous aquatic mammal and carnivorous aquatic bird populations are resource limited at West Lake because of the small size and isolated nature of West Lake, and the lack of a fish prey base. Terrestrial carnivores such as badgers and hawks may opportunistically feed at West Lake, but because of their infrequent exposure, and relatively low bioaccumulation potential of the COPECs at West Lake, these animals are better evaluated through terrestrial pathways.

Selection of representative avian herbivores, omnivores, and insectivores is limited by animal abundance and exposure potential. All three of the chosen avian assessment endpoint representatives are migratory, and site exposure will vary seasonally. In addition, considerable dietary overlap exists among these middle-trophic levels because all species are, to some degree, opportunists. For example, although the song sparrow is generally classified as a granivore (Sutherland et al. 2000, "Scaling of Natal Dispersal Distances in Terrestrial Birds and Mammals"), some studies have reported that animal matter may make up more than 30 percent of the birds' diet at certain times of the year (EPA/600/R-93/187a, *Wildlife Exposure Factors Handbook, Office of Health and Environmental Assessment*). Therefore it would be an artificial distinction to focus on a specific category given the dietary overlap. For West Lake, herbivorous, omnivorous, and insectivorous birds will be considered together for developing risk questions to evaluate impacts on middle-trophic-level species.

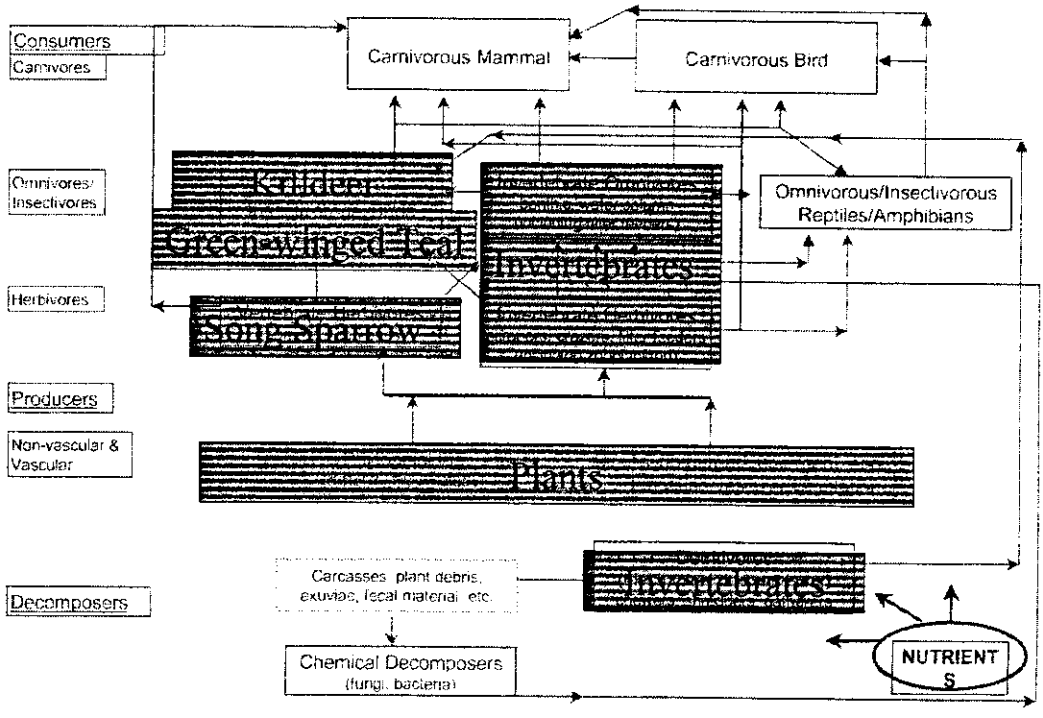
The role of the assessment endpoint representatives in addressing management goals is presented in Table E-7. A summary of the assessment endpoint representatives and the functional guilds they represent is presented in Figure E-6.

Table E-7. Management Goals Addressed by West Lake Assessment Endpoint Entities.

Management Goals	Plants	Macroinvertebrates	Herbivorous, Omnivorous, Insectivorous Birds
	AE1	AE2	AE3
Assess impacts on plants and invertebrates	+	+	-
Assess impacts on special status species	-	-	+
Minimize contaminant loading into biota	+	+	+
Protect populations of ecological receptors	+	+	+

(+) Management goal is addressed through endpoint
(-) Management goal is not addressed through endpoint
AE = assessment endpoint.

Figure E-6. Representative Receptors for West Lake Aquatic Feeding Guilds.



E7.0 CONCEPTUAL MODEL AND RISK QUESTIONS

The conceptual model summarizes the problem formulation results in terms of cause and effect relationships that link stressors to endpoint receptors. The COPEC screening and refinement identified three radionuclides and several metals in West Lake surface water as potentially posing the greatest risk to aquatic biota. Because metals accumulate more in invertebrates than in upper-trophic levels, invertebrates and invertebrate-feeding birds and amphibians are most at risk from metals in West Lake surface water. No radionuclide COPECs were identified in West Lake sediments, and no analyses for metals or organic constituents have been conducted on West Lake sediments.

Additional data are needed regarding the current and likely future conditions in West Lake to assess risk to ecological receptors from surface water COPECs. This section identifies risk questions for West Lake to help identify the types of data needed. Risk questions are presented as corollaries of COPEC refinement (including the toxicity evaluation) and assessment endpoints. Consistent with the terrestrial resource injury attributes discussed in Chapter 5.0 of the main document, injuries to aquatic macroinvertebrates and plants simply involve toxicity; whereas for upper-trophic-level biological resources, injuries involve impairment to reproduction, growth, or survival.

The following section describes the link between the conceptual model and COPEC refinement and selection of assessment endpoint attributes for development into risk questions.

E7.1 ASSESSMENT ENDPOINT ONE (AE1): PLANTS

Conceptual Model and COPEC Refinement: Aquatic and wetland plants are readily exposed to COPECs in surface water. Dissolved metals in surface water are readily taken up by plants. The plant attributes selected for development into risk questions are shown in Table E-8.

Table E-8. Plant Attributes Selected for Development into Risk Questions.

Code	Attribute	Select	Justification
AE1A	Survival	Yes	Direct correlation to population-level effects
AE1B	Growth	Yes	Direct correlation to population-level effects
AE1C	Reproduction	No	Not cost or time effective to measure, because these are multigenerational tests.
AE1D	Presence/ absence	No	Not resource effective to measure (confounding effects may contribute to presence/absence, limiting data interpretability)
AE1E	Species diversity	No	Not a direct population-level effect. Diversity may be impacted by confounding factors (high salinity/alkalinity, invasive species)
AE1F	Primary productivity	No	Not a direct population-level effect, may be effected by other

Plant Risk Question:

RQ1 Do COPECs in surface water decrease aquatic plant survival or growth?

E7.2 ASSESSMENT ENDPOINT TWO (AE2): AQUATIC MACROINVERTEBRATES

Conceptual Model and COPEC Refinement: Surface water has greatest exposure potential because organisms are immersed. Macroinvertebrates are fairly resistant to adverse effects of ionizing radiation (DOE-STD-1153-2002) and site risks likely are manifested as metal chemical toxicity. This assessment endpoint also is used to evaluate tissue burdens of COPECs in aquatic invertebrates, thus addressing the management goal concerned with contaminant loading in Central Plateau biota. The aquatic macroinvertebrates selected for development into risk questions are shown in Table E-9.

Table E-9. Aquatic Macroinvertebrate Attributes Selected for Development Into Risk Questions.

Code	Attribute	Select	Justification
AE3A	Survival	Yes	Direct correlation to population-level effects
AE3B	Growth	Yes	Direct correlation to population-level effects
AE3C	Reproduction	Yes	Direct correlation to population level effects. Standardized methodologies available for aquatic macroinvertebrates. Selection of test organism dependent on physico-chemical properties of the test water (salinity, pH).
AE3D	Species diversity	No	Not a population-level effect because this does not readily translate into effects on a given species population
AE3E	Secondary productivity	No	Not a direct population-level effect because this does not readily translate into effects on a given species population

Aquatic Macroinvertebrate Risk Question:

RQ2 Do COPECs in West Lake surface water affect aquatic macroinvertebrate survival, growth, or reproduction?

E7.3 ASSESSMENT ENDPOINT THREE (AE3): HERBIVOROUS, INSECTIVOROUS, OR OMNIVOROUS BIRDS

Conceptual Model and COPEC Refinement: Ingestion of contaminated water and foodstuffs represents the most significant exposure route. Inorganics have a greater propensity to accumulate in invertebrates than in plants. Consequently, insectivorous birds should be at greater risk than herbivorous or omnivorous birds. This avian assessment endpoint also is used to evaluate bioaccumulation of COPECs in upper-trophic levels, thus addressing the management goal concerned with contaminant loading in Central Plateau biota. The herbivorous, insectivorous, or omnivorous bird attributes selected for development into risk questions are shown in Table E-10.

Table E-10. Herbivorous, Insectivorous, or Omnivorous Bird Attributes Selected for Development into Risk Questions.

Code	Attribute	Select	Justification
AE4A	Survival	Yes	Direct correlation to population-level effects
AE4B	Growth	Yes	Direct correlation to population-level effects
AE4C	Reproduction	Yes	Direct correlation to population-level effects
AE4D	Balanced sex ratios	No	Most insectivorous and omnivorous aquatic birds at West Lake are migratory or transient. Sex ratio is expected to vary seasonally (males migrate earlier than females, who migrate earlier than juveniles)
AE4E	Abundance	No	Because of small area of suitable habitat, abundance is more likely resource limited rather than stressor limited
AE4F	Physical abnormalities	No	Not a population-level effect. However, abnormalities noted as component of routine field data collection efforts
AE4G	Fledgling success	No	Field information on fledgling success will be collected if possible and evaluated for reproductive effects
AE4H	Species diversity	No	Not a population-level effect because this does not readily translate into effects on a given species population
AE4I	Persistence	No	Not resource effective because of the time involved in following a species population over a long enough time frame to adequately quantify the perseverance of a species
AE4J	Biomass	No	Not a direct measure of impacts on populations; also evaluating this attribute requires capturing and handling birds, therefore it was decided that this would an undesirable and unnecessary perturbing effect and other less intrusive attributes can be measured

Herbivorous, Insectivorous, or Omnivorous Bird Risk Question:

RQ3 Do COPECs in West Lake surface water and food decrease herbivorous, insectivorous, or omnivorous bird survival, growth, or reproduction?

E7.4 CONCEPTUAL MODEL AND RISK QUESTIONS SYNOPSIS

The draft risk questions are an outcome of COPEC refinement and consideration of assessment endpoints likely to be adversely impacted by COPECs in West Lake surface water. The attributes considered for each assessment endpoint are very similar to the attributes considered for the same terrestrial feeding guilds, but the attributes selected for evaluation were sometimes different. As with the terrestrial endpoint selection, the draft risk questions are presented from an ERA remedial investigation perspective and from a resource injury perspective; the remedial investigation -specific questions are generally comprehensive of resource injury concerns. The draft risk questions represent the conceptual model of how contaminant stressors are most likely

to impact the West Lake ecosystem. Before evaluating risk to any of the selected endpoints, additional reconnaissance of West Lake conditions are needed so that current and future conditions can be adequately addressed as part of risk investigations.

E8.0 MEASURES

The framework for ecological measures is derived from EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*. Data collection efforts will address measures of effect, measures of ecosystem and receptor characteristics, and measures of exposure. Data may include field, laboratory, and model data. The measures that address risk questions for Hanford Site-specific assessment endpoints are presented in Table E-11. These measures will provide multiple lines of evidence to assess the adverse effects from site COPECs. The following section links assessment endpoint risk questions to appropriate ecological measures to address the question (Table E-12).

Table E-11. Proposed Measures of Exposure, Effect, and Ecosystem/Receptor Characteristics.

Code	Measure
Measures of Exposure	
M1	COPEC concentration in filtered water samples
M2	COPEC concentration in biota tissue
Measures of Effect	
M3	Laboratory toxicity testing
M4	Modeled extrapolation of COPEC concentration in water and biological tissue (food items) to literature-derived adverse effect level for diet (wildlife only)
M5	Comparison of COPEC concentration in tissue to literature-derived adverse effect level for assessment endpoint tissue concentration (wildlife only)
M6	Field study of potential for adverse effects (conditional on field verification efforts)
Measures of ecosystem/receptor characteristics	
M7	Habitat types

COPEC = contaminant of potential ecological concern.

Table E-12. Proposed Measures to Assess Adverse Effects in Central Plateau Assessment Endpoints.

Risk Question	Assessment Endpoint Attributes	M1: COPEC in Water	M2: COPEC in Biota	M3: Toxicity Testing	M4: Compare Modeled COPEC Exposure to SSV	M5: Tissue concentration Effects	M7: Habitat Type
Plants (AE1)							
RQ1	Survival, growth	-	+	+	-	-	+
Aquatic Invertebrates (AE2)							
RQ2	Survival, growth	+	+	+	-	-	+
*Herbivorous, Insectivorous and Omnivorous Birds (AE3)**							
RQ3	Survival, growth, reproduction	+	+	-	+	+	+

Key: "+" measure is applicable; "-" measure is not applicable

*COPEC concentrations in biota are based on nonviable eggs. Modeled exposure estimate based on COPEC concentrations in plants and/or aquatic invertebrates. Observation of fledglings in nest will provide information on reproduction (fledgling success) and observation of physical abnormalities proposed as a component of routine field work but conditional on field verification efforts.

COPEC = contaminant of potential ecological concern.
SSV = soil-screening value.

These measures are intended to collect additional data to support the ecological screening assessment and add site specificity to initial risk assumptions. The degree of conservatism in the screening assessment is reduced with increased ecological realism provided in this stage of an ERA (Fairbrother 2003, "Lines of Evidence in Wildlife Risk Assessments"). For example, initial assumptions of 100 percent bioavailability will be reassessed with direct measures of concentrations of contaminants in wildlife diet items (plants and macroinvertebrates) and in wildlife tissue concentrations. This measure eliminates the imprecision inherent in literature-derived trophic transfer factors (e.g., WAC 173-340-900, "Tables," Table 749-5) and also directly assesses variations in site-specific bioavailability (Fairbrother 2003).

E9.0 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS

ERAGS and the DQO process offer two complementary approaches to developing sampling and analysis plans. The DQO process is general and can be applied to any environmental problems. DQO Steps 1 and 2 ("state the problem" and "identify the decision") were considered in ERAGS Step 3 or problem formulation. The parts of the DQO process that complement ERAGS study design include DQO Steps 3 through 6, which include "identify the inputs to the decision" (or ERAGS measures), "define the study boundaries," "develop a decision rule," and "limits on

decision errors." DQO Step 7 is to develop and optimize the design for collecting data is started during ERAGS study design and is completed during ERAGS field verification (Step 5).

E9.1 BOUNDARIES

Relevant ecological spatial boundaries are areas encompassed by individuals and populations and the depth of biological activity. Information on receptors considered representative of the wildlife assessment endpoints is summarized in Table E-13 and includes information on home range, dispersal distance, minimum critical patch size, population density, and assessment population area.

Home range is defined in terms of how individuals use the environment for breeding or feeding. Population density information is an important consideration when selecting species to evaluate measures of effect and exposure. Small, lower-trophic-level aquatic and wetland species (e.g., invertebrates) are predicted to be more abundant per hectare than larger upper-trophic-level species (e.g., badger, osprey). Home range is used to calculate area-use factors (AUF) for individual ecological receptors where AUFs are the ratio of the contaminated site area to the receptor's home range (EPA 2003, *Draft Guidance for Developing Ecological Soil Screening Levels*, OSWER Directive 9285.7-55).

Table E-13. Receptor Information for Wildlife Species Considered as Representatives for West Lake Assessment Endpoints.

Guild	Class	Scientific name	Common name	Body Weight (g) (male, female)	Home Range (ha)	Median dispersal distance (km) (male, female)	Maximum dispersal distance (km) (male, female)	Minimum critical patch size (ha)	Population density (No./ha)	Assess Population Area (ha)
Herbivore	Bird	*Melospiza melodia*	Song Sparrow	21	0.04[a]	0.2 (m) 0.2 (f)	13.2 (m) 1.3 (f)	NA	22[b]	1.6
Omnivore	Bird	*Anas crecca*	Green-winged Teal	322 (m) 308 (f)	NA	NA	3.8[c]	NA	0.008	4536[d]
Insectivore	Bird	*Charadrius vociferous*	Killdeer	70	1	11.8	596 (m) 146 (f)	NA	0.9	40

[a]Winter home ranges average greater than 1 ha, because song sparrows are not territorial in winter. Because song sparrows are migratory, most exposure at West Lake would be during breeding season, so breeding territory size from Granholm (1990) is used here.

[b]Based on maximum number of pairs per hectare in California salt marsh fringe vegetation published in the *Cal/Ecotox Database* (http://www.oehha.ca.gov/cal_ecotox/species_reports.htm).

[c]Based on reported dispersal distance for Wood Duck (*Aix sponsa*), a slightly larger omnivorous dabbling duck that breeds on ponds and sheltered lakes.

[d]Based on the maximum reported dispersal distance.

Granholm, S., 1990, "Song Sparrow, Melospiza melodia."

NA = not available.
No. = number

While effects on individuals need to be considered (especially for protected species) in an ecological risk assessment, the primary ecological risk management goal for CERCLA is the protection and maintenance of healthy populations of ecological receptors (EPA 1999). Consequently, information on the area that populations encompass is needed to assess population-level impacts. Specifically, population AUFs can be used to calculate COPEC exposure estimates for populations of ecological receptors. For aquatic invertebrates and amphibians at West Lake, the population area is defined as the area of the lake. The rationale for this is that because West Lake is a unique habitat isolated from other aquatic ecosystems, gene flow between West Lake and other aquatic systems is likely very limited for animals with short dispersal distances. Dispersal distance provides a measure of the distance that animals may travel from their place of birth and, therefore, is an indicator of gene flow – an important consideration in defining a biological population.

Wildlife assessment population boundaries can be based on a receptor's dispersal distance (Ryti et al. 2004, "Preliminary Remediation Goals for Terrestrial Wildlife"). Dispersal distance information for birds is available from Sutherland et al. (2000). However, calculation of a population AUF based solely on home range or dispersal distance information may underestimate exposure of aquatic wildlife to West Lake COPECs. Birds such as green-winged teal have dispersal distances measured in kilometers; but if West Lake is the only suitable habitat within the dispersal area, exposure will be weighted much more heavily toward West Lake than would otherwise be predicted. The total area encompassed by West Lake has varied over the years from its current size of ~2 ha to over 8 ha in size in the 1970s and 1980s. West Lake averages less than 1 m deep, and it is assumed that ecological exposures occur across its entire depth. Because West Lake is shallow and encompasses a small area, and because aquatic and riparian wildlife exposure could be weighted heavily toward the lake because of its status as a unique habitat, the entire lake will be treated as a single 2 ha exposure area for wildlife. A smaller spatial scale may be needed for aquatic invertebrates and plants.

E9.2 SPATIAL DISTRIBUTION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Because West Lake is a closed system no longer subject to flushing by groundwater and not connected to point sources of contaminant releases, it is reasonable to assume that COPECs in surface water are distributed relatively homogenously across the lake by the mixing of surface waters. Past sampling also has operated under this assumption, and surface water samples collected periodically from 1990 to 2001 have been limited to a single sample per sampling event. Because the lake represents a single exposure area, multiincrement samples representing an areawide exposure are appropriate. Sediment concentrations may be less homogeneous because they are less subject to mixing processes than surface water, but potential heterogeneity of sediment is not important because no COPECs remained after screening and refinement of sediment data. Water samples should be collected from different areas across the lake to ensure that concentrations are representative of relevant ecological exposure areas.

E9.3 DECISION RULES

The following decision rules have been developed to determine if COPECs in surface water adversely affect the assessment endpoints. The decision rules are stated generically for a receptor – with receptors replaced by the relevant measure species for each assessment endpoint. All of the decision rules are based on a design with a reference site. Suitable reference sites should be identified during reconnaissance.

1. Are concentrations in surface water greater than literature – no adverse effect levels or toxicity reference values for the **receptor**? (NOTE: This is directed particularly toward metals, because available data are insufficient to conduct COPEC refinement of these analytes.)

2. Does survival or growth of **receptor** decrease from the reference site surface water? (AE1, AE2)

3. Do **receptor** reproductive rates decrease from the reference site for the same habitat type? (AE1, [as determined in laboratory bioassays])

4. Do COPEC concentrations in **receptor** increase from the reference site (greater than published levels associated with toxicity)? (AE1, AE2)

5. Do COPEC concentrations in **receptor** diet increase from the reference site (greater than toxicity reference values)? (AE3)

Risks will be characterized based on the answers to these decision rules, and the answers to decision rules 2 through 6 either will refute or confirm the answer to question 1 (screening-level risk characterization). For the avian wildlife receptors (AE3), risks will be characterized through a single decision rule. Inferences on ecological effects on invertebrates and amphibians are based on differences in field measures of abundance and laboratory measures of survival, growth (invertebrates only), and reproduction. Because animal abundance fluctuates greatly, less credence will be afforded differences based on abundance compared to the laboratory measures of acute and chronic toxicity. Field measures and laboratory measures will be given greater weight than measures depending on toxicity data in the literature.

E10.0 STUDY DESIGN

This section presents the proposed study design for West Lake and shows the key features of the study design and how the various data types (measures) relate to risk questions. All 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. Of particular importance is documentation of current surface water quality parameters such as salinity, pH, and total dissolved and suspended solids, and verification of current site habitat types. Because of the uncertainty associated with current site conditions (water quality and habitat), a phased approach is recommended for further investigation of West Lake. The first phase focuses on surface water

chemistry, water quality, and field surveys to assess habitat and current biotic conditions (e.g., do amphibians occur or is West Lake too saline and/or alkaline to support amphibian populations). Data to be collected in the initial phase are presented in Table E-14. If results of the first phase of the investigation verify the screening results and show that conditions are suitable to support the assessment endpoints and receptors identified in Sections 7 and 8, a second investigation phase will be developed and implemented. If results of the first phase of the investigation do not verify the screening results or show that site conditions are not appropriate to support the identified aquatic and riparian receptors (for reasons other than stress from COPECs), then the need to proceed to the second phase will be reevaluated.

A general aspect of the study design is that ecological exposure occurs at all lake depths. Water samples should be collected just above the sediment substrate because COPECs moving in and out of equilibrium with sediment may cause COPEC concentrations to be higher. Unfiltered water samples should be analyzed for water quality parameters, particularly salinity, pH, alkalinity, total suspended solids, and total dissolved solids. Analyses for radionuclide and inorganic COPECs should be conducted on filtered water samples because filtered water better represents the bioavailable portion of the contaminant concentrations.

Representative water concentrations for wildlife measures will be based on collecting multiincrement samples across the entire lake. Collection and analysis of multiincrement samples are appropriate because the statistical parameter of interest is the mean concentration (see pages 28 and 29 in Ecology 92-54, *Statistical Guidance for Ecology Site Managers*) over the exposure area (i.e., the lake). The basis for collecting multiincrement samples is that this is more representative of wildlife exposure to individuals and populations. Existing radiological surveys will be supplemented (as necessary) at plant sampling locations to help select across a range of radionuclide concentrations. Existing radionuclide data will be supplemented to support Tier 2 BCG calculation (estimating the aquatic animal and riparian animal lumped parameter or bioaccumulation factor). Collected water and biota samples will be analyzed for the radionuclide and inorganic COPECs to better understand potential risk from these constituents.

Table E-14. West Lake Initial Sampling Design Summary Table Linking Proposed Measures to Risk Questions.

Data Type	Assessment Endpoint and Attribute	Measures	Sample Population	Key Features of Design	Basis for Study Design
Reconnaissance and field verification	Herbivorous, insectivorous, and omnivorous bird; amphibian; and macroinvertebrate attributes based on field measures.	Basis for comparing all field-related measures in future phases of the SAP.	West Lake and reference sites.	Ascertain if current site physical conditions and habitat support populations of the identified assessment endpoints.	Determine if identified assessment endpoints for Phase 2 are appropriate for current West Lake conditions. Select appropriate toxicity test organisms for site conditions.
Literature reviews	All assessment endpoints and attributes for which information can be gathered.	All proposed measures may benefit from this information.	Specific literature relevant for regional conditions.	Local experts will be familiarized with proposed measures and consulted for relevant published or in-house information.	Existing region-specific data on assessment endpoint abundance to support and aid in the interpretation of proposed field efforts.
Radiological surveys	Information used to guide sampling and test conceptual model of contaminant transport.	Radioactive COPECs in soil	West Lake soil.	Used to indicate whether additional soil sampling is justified.	Supports evaluation of radionuclides in soil and assessment of whether additional soil data are needed.
Surface water sampling	Herbivorous, insectivorous, and omnivorous bird, amphibian, and macroinvertebrate attributes of survival, growth, and reproduction.	Radionuclides and inorganic chemicals in filtered and unfiltered surface water.	West Lake surface water.	Filtered and unfiltered water samples representing water just overlying sediment substrate collected in multiple increments. Unfiltered: measure geochemical parameters (salinity, TOC, TSS, TDS, pH, etc.). Filtered: measure COPECs.	Water samples collocated with plant tissue, and invertebrate tissue for West Lake specific uptake estimates
Biota tissues	Macroinvertebrate attributes of survival, growth, and reproduction	Radionuclides and inorganic chemicals in black fly (adult or larvae) tissues.	Black flies	Used to calculate ingestion of COPECs for West Lake insectivores (e.g., pallid bats)	Invertebrate samples likely will need to be composited to achieve sufficient mass for analyses.

Table E-14. West Lake Initial Sampling Design Summary Table Linking Proposed Measures to Risk Questions.

Data Type	Assessment Endpoint and Attribute	Measures	Sample Population	Key Features of Design	Basis for Study Design
Sediment sampling	Herbivorous, insectivorous, and omnivorous bird, amphibian, and macroinvertebrate attributes of survival, growth, and reproduction.	Radionuclides, inorganic chemicals and semivolatile organic compounds in sediment	West Lake sediment.	Sediments collected in a multi-increment sampling design.	Sampling for metals fills a data gap for inorganic chemicals in sediments. Sampling of semivolatile organic compounds tests the conceptual model that organic chemicals are not expected, based on process knowledge.

COPEC = contaminant of potential ecological concern.
SAP = sampling and analysis plan.
TOC = total organic carbon.
TDS = total dissolved solids.
TSS = total suspended solids.

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APPENDIX F

PERCENT OF BURROW VOLUME PER DEPTH INTERVAL AND PERCENT OF ROOT MASS VERSUS DEPTH

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APPENDIX F

PERCENT OF BURROW VOLUME PER DEPTH INTERVAL AND PERCENT OF ROOT MASS VERSUS DEPTH

F1.0 INTRODUCTION

Data in this appendix were compiled from the open scientific literature on burrowing and rooting depths for arid-adapted plant and animal species. These data were extracted from a comprehensive literature review provided in Hooten et al., 2001, *A Literature Review of Biotic Components, Processes, and Characteristics Central to Biotic Transport Modeling of Soils at the Nevada Test Site*; see also Figure 2-3 in the main document.

Table F-1. Characteristic Burrowing Parameters for Potentially Deep-Burrowing Desert Mammals. (2 Pages)

Species	Max Burrow Depth (cm)	Burrow Depth Distributions (cm)	Percent Burrow by Depth (% per cm ± s.e.)	References
		Range Mean ± s.d.	Depth % Burrow ± s.d.	
"Several species" of pocket gophers	--	--	0–50 85 51–100 15 >100 0	Kennedy et al. 1985
"Several species" of pocket mice and kangaroo rats	--	--	0–50 50 51–100 40 101–150 5 151–200 5 >201 0	Kennedy et al. 1985
Townsend's ground squirrel, *Spermophilus townsendii*	From reference [1] 150 (approx.)	From reference [1]: "Shallow burrow system" 14–55 29 ± 12 "Deep burrow system" 121–138 128 ± 9 Overall: 14–138 46 ± 38	n = 20, reference [2] 0–10 12.8 ± 1.1 11–20 37.4 ± 27.8 21–30 27.7 ± 23.5 31–40 7.5 ± 9.4 41–50 3.1 ± 6.7 51–60 0.8 ± 2.3 61–70 0.5 ± 1.3 71–80 0.4 ± 1.1 81–90 0.3 ± 0.7 91–100 0.4 ± 1.1 101–110 0.8 ± 2.0 111–120 1.2 ± 3.0 121–130 6.9 ± 18.2 131–140 0.3 ± 1.5	[1] Reynolds and Wakkinen 1987 [2] Reynolds and Laundré 1988, Table 2. Percent distribution from undisturbed sites.

Table F-1. Characteristic Burrowing Parameters for Potentially Deep-Burrowing Desert Mammals. (2 Pages)

Species	Max Burrow Depth (cm)	Burrow Depth Distributions (cm)		Percent Burrow by Depth (% per cm ± s.e.)		References
		Range	Mean ± s.d.	Depth	% Burrow ± s.d.	
Townsend's ground squirrel, *S. townsendii* (continued)	--	--		n = 10, reference [2]		[2] Reynolds and Laundré 1988, Table 2. Percent distribution from disturbed sites.
				0–10	11.0 ± 16.0	
				11–20	28.3 ± 31.2	
				21–30	15.7 ± 16.1	
				31–40	7.0 ± 10.0	
				41–50	5.6 ± 7.9	
				51–60	7.7 ± 8.2	
				61–70	5.2 ± 5.5	
				71–80	3.8 ± 7.5	
				81–90	3.9 ± 7.8	
				91–100	5.3 ± 10.8	
				101–110	2.7 ± 8.6	
				111–120	3.0 ± 9.6	
				121–130	0.6 ± 1.9	
				131–140	zero	
"Several species" of ground squirrels	--	--		0–50	50	Kennedy et al. 1985
				51–100	30	
				101–150	15	
				151–200	5	
				>200	0	

Kennedy et al., 1985, "Biotic Transport of Radionuclide Wastes from a Low-Level Radioactive Waste Site."
Reynolds and Laundré, 1988, "Vertical Distribution of Soil Removed by Four Species of Burrowing Rodents in Disturbed and Undisturbed Soils."
Reynolds and Wakkinen, 1987, "Characteristics of the Burrows of Four Species of Rodents in Undisturbed Soils in Southeastern Idaho."

s.d. = standard deviation.
s.e. = standard error.

Table F-2. Relative Root Distribution with Depth for Desert Shrub Species. (3 Pages)

Species	Reported Root Distribution[a] Depth (cm)	RPD ± s.e.[b]		Number of Observations	Author
Ambrosia dumosa [white bursage]	0–10	27.7	±8.8	8	Winkel et al. 1995[c]
	10–20	35.6	±11.6		
	20–30	16.8	±9.3		
	30–40	8.4	±6.8		
	40–50	3.1	±5.9		
	>50	0	0		
Ambrosia acanthicarpa [annual bursage}	(0–50	55	±56)	5	PNL-5247
	(50–100	30	±29)		
	(100–150	15	±18)		
	(>150	0	0)		
Artemisia tridentata [basin big sagebrush]	0–20	22.0	±4.7	5	Reynolds 1990[d]
	20–40	10.6	±0.2		
	40–60	13.9	±1.6		
	60–80	19.1	±1.7		
	80–100	19.7	±2.7		
	100–120	14.7	±2.6		
	0–50	69.6	±70.6	11	PNL-5247
	50–100	23.7	±30.5		
	100–150	5.3	±3.3		
	150–200	1.5	±3.2		
	>200	0	0		
Atriplex canescens [four-winged saltbush]	0–10	43.2	±14.9	6	Winkel et al. 1995[c]
	10–20	25.6	±11.8		
	20–30	19.0	±9.6		
	30–40	9.8	±7.8		
	40–50	10.5	±7.8		
	>50	2.5	±5.1		

Table F-2. Relative Root Distribution with Depth for Desert Shrub Species. (3 Pages)

Species	Reported Root Distribution[a] Depth (cm)	RPD ± s.e.[b]		Number of Observations	Author
Atriplex confertifolia [shadscale saltbush]	0–10	45.8	±19.0	7	Winkel et al. 1995[c]
	10–20	26.1	±11.9		
	20–30	14.1	±8.2		
	30–40	8.4	±5.6		
	40–50	3.8	±4.0		
	>50	1.8	±4.8		
Coleogyne ramosissima [blackbrush]	"diffuse and shallow root[ed]" and "greatest root biomass" at 10-30 cm			--	Anderson 2001
Ephedra nevadensis [Nevada jointfir]	0–10	40.0	±16.7	7	Winkel et al. 1995[c]
	10–20	25.4	±12.4		
	20–30	21.8	±14.0		
	30–40	10.6	±10.6		
	40–50	2.1	±2.4		
	>50	0	0		
Ericameria nauseosa (Chrysothamnus nauseosus) [rubber rabbitbrush]	0–50	31.7	±21.9	9	PNL-5247
	50–100	52.9	±66.0		
	100–150	11.4	±14.7		
	150–200	4.1	±9.9		
	200	0	0		
Krameria erecta [range ratany] (K. parvifolia)	0–10	56.2	±31.1	8	Winkel et al. 1995[c]
	10–20	24.4	±24.0		
	20–30	5.0	±14.1		
	30–40	4.5	±12.7		
	40–50	0	0		
	>50	0	0		
Larrea tridentata [creosote bush]	0–10	26.5	±2.6	3	Winkel et al. 1995[c]
	10–20	33.7	±6.2		
	20–30	19.8	±6.2		
	30–40	11.1	±5.4		
	40–50	6.0	±6.9		
	>50	0	0		

Table F-2. Relative Root Distribution with Depth for Desert Shrub Species. (3 Pages)

Species	Reported Root Distribution[a] Depth (cm)	RPD ± s.e.[b]	Number of Observations	Author
Lycium andersonii [Anderson's wolfberry]	0–10	28.1 ±13.9	5	Winkel et al. 1995[c]
	10–20	23.7 ±12.5		
	20–30	22.4 ±9.6		
	30–40	13.8 ±7.2		
	40–50	11.8 ±10.1		
	>50	0 0		
Lycium pallidum [rabbit thorn]	0–10	30.4 (no s.d. reported)	NR	Wallace et al. 1980
	10–20	38.8		
	20–30	16.3		
	30–40	8.6		
	40–50	6.1		
	>50	0		

[a] Distribution of roots is provided as a measure of the percent root biomass (of the total) observed at the depth increments provided.

[b] RPD ± s.e. = Relative percent distribution, plus or minus the standard error on the mean.

[c] Values from Winkel et al. (1995) are combined average relative percent distribution of large (>2 mm diameter) and small (<2 mm diameter) reported for each species.

[d] Reynolds reports that the artificial methods used for plant growth "most likely limited lateral root growth [lengthwise] and forced some roots to penetrate deeper into the soil."

Anderson 2001, *Coleogyne ramosissima.*
PNL-5247, *Rooting Depth and Distributions of Deep-Rooted Plants in the 200 Area Control Zone of the Hanford Site.*
Reynolds 1990, "Root Mass and Vertical Root Distribution of Five Semi-Arid Plant Species."
Wallace et al. 1980, "Depth Distribution of Roots of Some Perennial Plants in the Nevada Test Site Area North of the Mojave Desert."
Winkel et al. 1995, *Plant and Burrowing Animal Characteristics: Integrated Closure Program for the Area 3 and Area 5Rradioactive Waste Management Sites, Nevada Test Site*, Draft.

NR = Not reported.
RPD = relative percent distribution.
s.d. = standard deviation.
s.e. = standard error.

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APPENDIX G

STATISTICAL DATA EVALUATIONS

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APPENDIX G

STATISTICAL DATA EVALUATIONS

This appendix supports Section 3.2.1 (inorganic chemical data evaluation) to identify statistical outliers for nutrients; it also supports Section 8.2 (spatial distribution of contaminants of potential ecological concern [COPEC]) in the main document.

G1.0 NUTRIENT ASSESSMENT

G1.1 METHODS

Statistical outliers were identified for nutrient metals with soil screening values (SSV) (calcium, iron, magnesium, potassium, and sodium). Outliers were identified by using Rosner's test for multiple outliers (Gilbert 1987, *Statistical Methods for Environmental Pollution Monitoring*, pp 188-191). Rosner's test is appropriate for more than 25 samples and assumes that the data are derived from a normal statistical distribution. The data also were inspected for normality and for outliers using normal quantile plots. Normal quantile plots (also known as a normal quantile-quantile or q-q plot) are a particular type of quantile plot. The data set concentrations are plotted in increasing order and spread out in a manner that allows comparison of their distribution to that of a theoretical distribution, the standard normal distribution. The quantiles of the data set (y-axis) are plotted against the quantiles for a standard normal (x-axis). The quantiles of a standard normal (i.e., normal with mean = 0 and standard deviation = 1) are those for the theoretical distribution and can be found in published tables of the cumulative normal distribution (Gilbert 1987, Table A1). For example, the 50th quantile is zero, the 90th quantile is approximately 1.282, the 95th quantile is about 1.645, etc. If the data are derived from a normal statistical distribution, the points in the plot will lie on a diagonal straight line. Outliers can be visually identified as points that are separated greatly in concentration from the next rank concentration value (e.g., the maximum concentration is two times the value of the second highest concentration).

G1.2 RESULTS

Figures G-1 through G-5 are quantile plots for the five nutrient metals. Between one and four outliers are identified for each metal using Rosner's test. The outliers identified using Rosner's method are listed in Table G-1, which also indicates if the outlier was identified for data transformed to square-root normal or lognormal distributions. A few outliers are identified for the nutrient metals, and generally concentrations of outliers are not greatly larger than the mean or median values. The exceptions are the two largest calcium values: the largest calcium concentration is about 10 times the median calcium concentration.

Figure G-1. Calcium Quantile Plots. Plot on left shows all data (n=94). Plot on right shows four outliers removed.

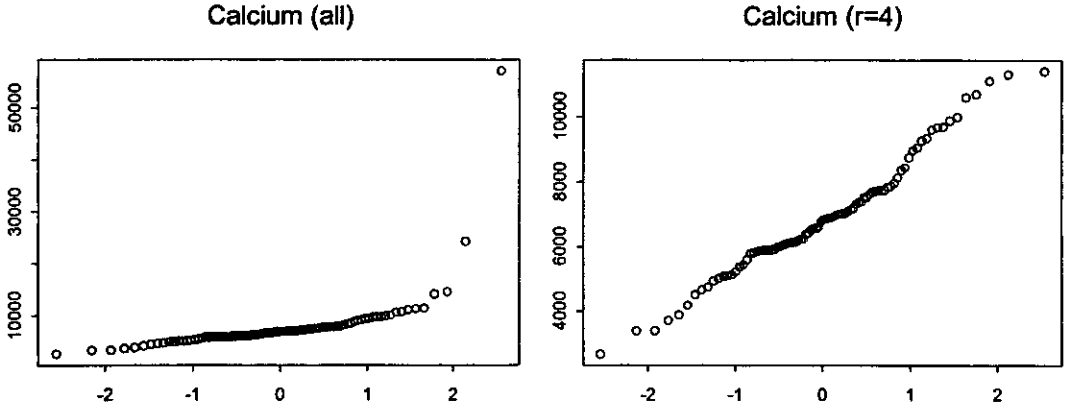


Figure G-2. Iron Quantile Plots.

Plot on left shows all data (n=94). Plot on right shows one outlier removed.

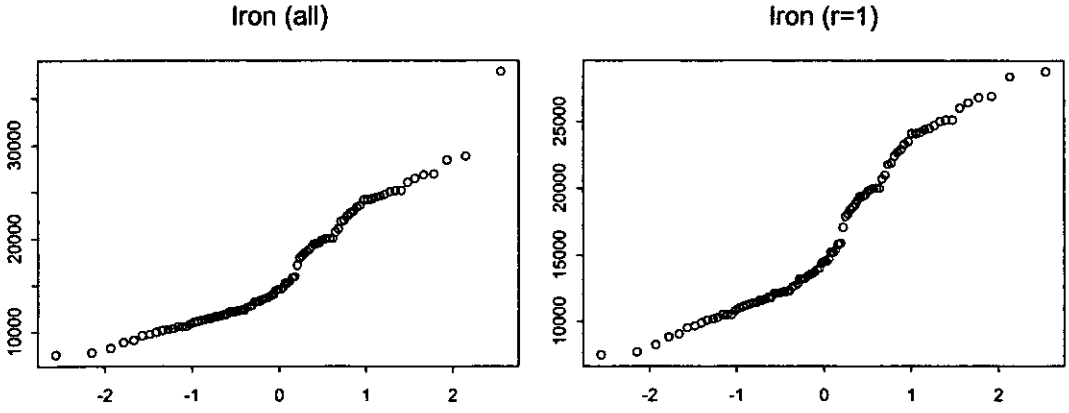


Figure G-3. Magnesium Quantile Plots.

Plot on left shows all data (n=95). Plot on right shows one outlier removed.

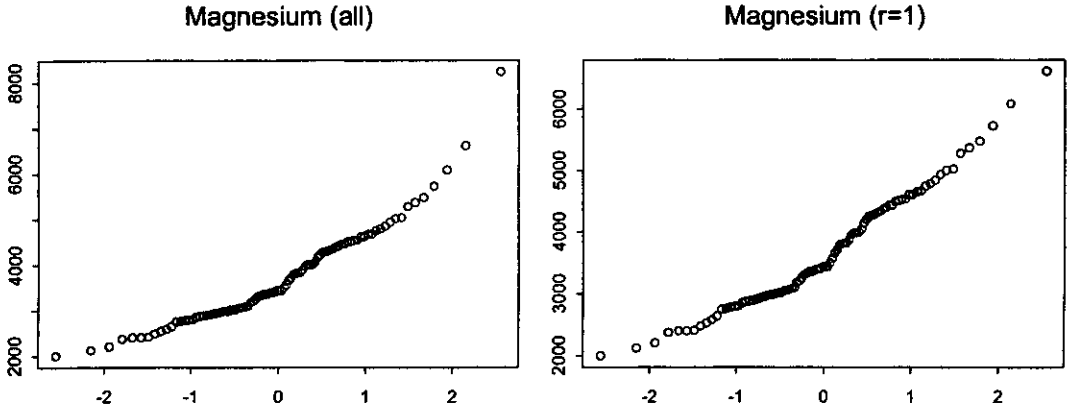


Figure G-4. Potassium Quantile Plots.

Plot on left shows all data (n=94). Plot on right shows three outliers removed.

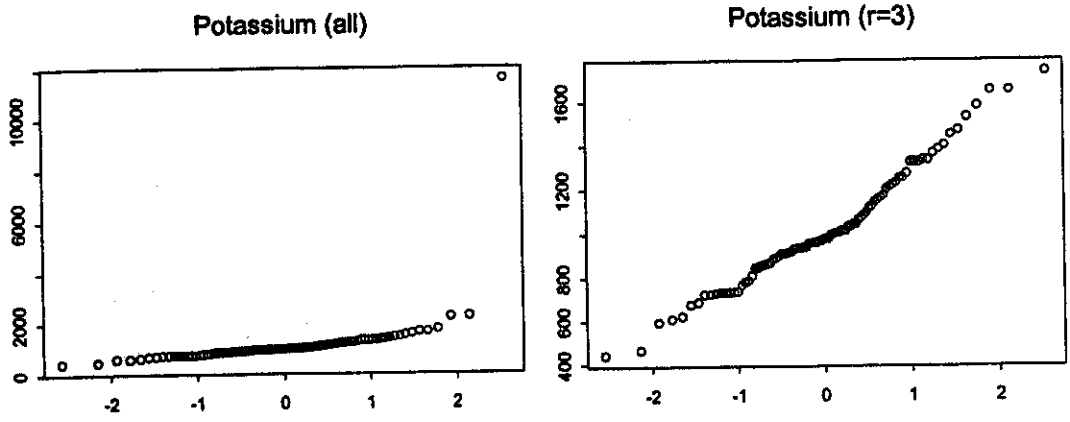


Figure G-5. Sodium Quantile Plots.

Plot on left shows all data (n=94). Plot on right shows three outliers removed.

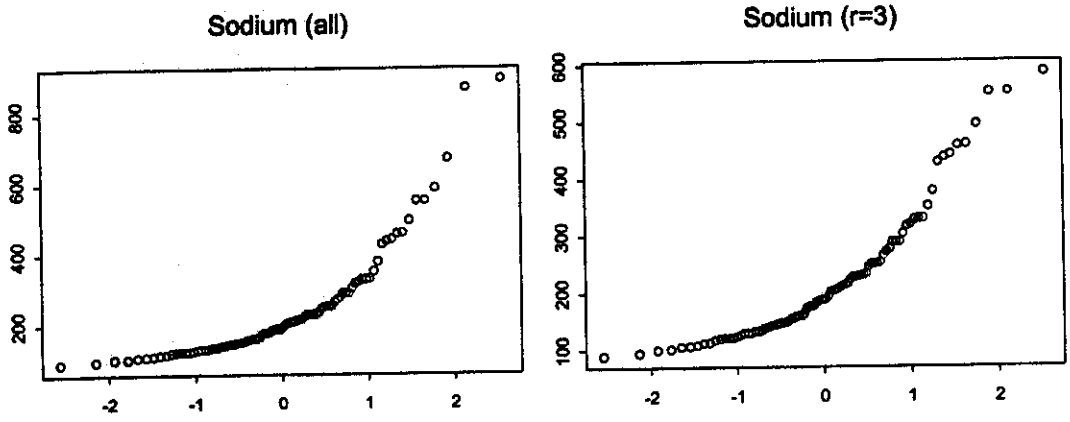


Table G-1. Summary of Statistical Outliers.

Analyte*	Distribution for outlier	Result (mg/kg)	Depth (feet)	SAF or OU	Site name	Sample ID	Date collected
Calcium	Sqrt, lognormal	57,000	6.5	200-UP-2	216-U-10-TP2	B09316	08/21/1993
	Sqrt, lognormal	24,300	6-7	B02-008	216-A-29	B13C81	10/30/2001
	Normal	14,500	4-6	200-UP-2	299-W19-94	B09DQ0	12/03/1993
	Normal	14,100	4-6	200-UP-2	299-W19-94	B09DP0	11/05/1993
Iron	Normal	37,900	12.5-15	F03-020	C3245	B183L7	12/09/2003
Magnesium	Sqrt	8,240	6.5	200-UP-2	216-U-10-TP2	B09316	08/21/1993
Potassium	Sqrt, lognormal	11,600	3.2-5.7	200-TW-1	216-B-47	B067Z7	04/27/1992
	Sqrt	2,260	6-7	B02-008	216-A-29	B13C81	10/30/2001
	Sqrt	2,230	5-6	B02-008	216-A-29	B13CR9	11/01/2001
Sodium	Sqrt	898	12.5-15	F03-020	C3245	B183L7	12/09/2003
	Sqrt	873	4-5	B02-008	216-A-29	B13CK9	10/31/2001
	Normal	671	10.5-13	B98-004	299-E33-333	B0MJC8	12/30/1997

*94 results for all analytes, except magnesium with 95 sample results.

ID = identification.
OU = operable unit.
SAF = Sampling Authorization Form.
Sqrt = square root.

G2.0 SPATIAL DISTRIBUTION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

G2.1 METHODS

Scatter plots and box plots were prepared to evaluate general trends in study design COPEC concentrations or Hazard Indices (see Chapter 3.0 of the main document for an explanation of Hazard Quotient and Hazard Index) versus location and sample depth. Scatter plots were used to looks for differences in study design COPEC concentrations or Hazard Indices versus sample collection starting depth. Box plots were used to compare differences in study design COPEC concentrations or Hazard Index between locations. Scatter plots show the data for one variable (y-axis) plotted against data from a second variable (x-axis). Box plots are used to show differences between two or more categories of data. Box plots summarize information about the shape and spread of the distribution of results. Box plots consist of a box and a line (the median value) across the box. The y-axis displays the observed values in the reported units. The area enclosed by the box shows the range containing the middle half of the data; that is, the lower box edge is at the 25th percentile, and the upper box edge is at the 75th percentile. The horizontal line above each box represents the 90th percentile, and the line beneath the box represents the 10th percentile of the sample results. The height of the box is a measure of the spread of the results. The horizontal line across the box represents the median (50th percentile) of the data,

a measure of the center of the distribution. If the median line divides the box into two approximately equal parts, the shape of the distribution of results could be symmetric; if not, the distribution is skewed or asymmetric. Thus, each box indicates values for the central half of the data, and comparing the location of boxes can readily assess shifts in the results.

G2.2 RESULTS

Figures G-6 through G-20 show the differences in Hazard Indices between locations or with sample depth. Figures G-21 through G-53 show the differences in study design COPEC concentrations between locations or with sample depth. The open symbols on Figures G-21 through G-53 are nondetected sample results, and the filled symbols are detected concentrations. Note that some Sr-90 concentrations were negative; and to plot these results on a log-scale, they were replaced with a number just smaller than the smallest positive result (0.003).

Figure G-6. Comparison of Radionuclide Hazard Indices Between Operable Unit or Sampling Authorization Form Groupings.

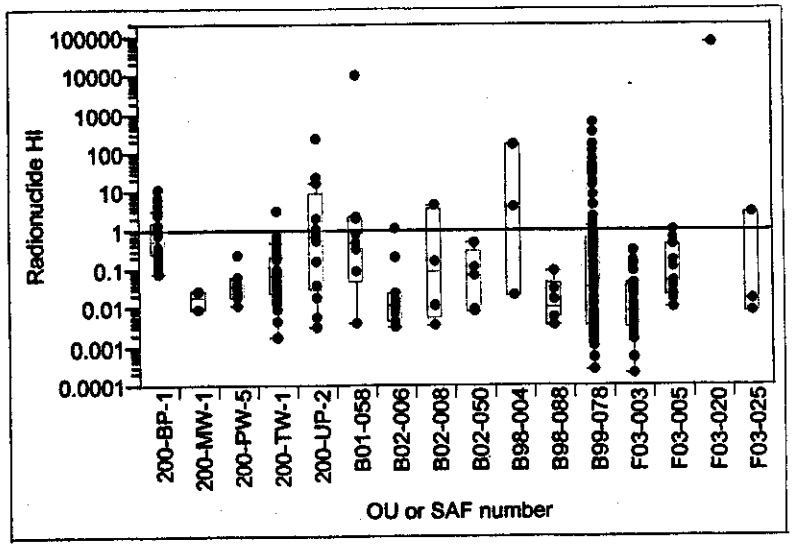


Figure G-7. Comparison of Radionuclide Hazard Indices Between Areas.

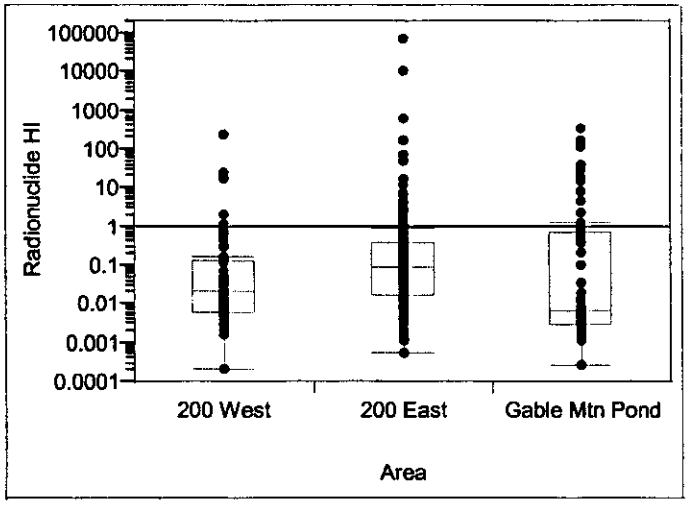


Figure G-8. Scatter Plot of Radionuclide Hazard Indices versus Sample Depth.

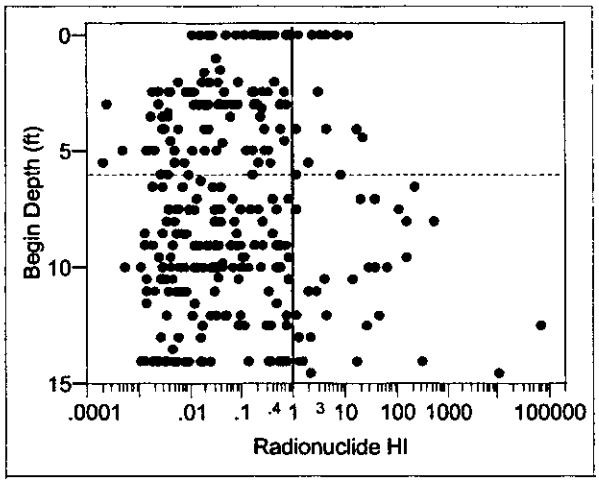


Figure G-9. Comparison of Hazard Indices Metals – Shrew Between Operable Unit or Sampling Authorization Form Groupings.

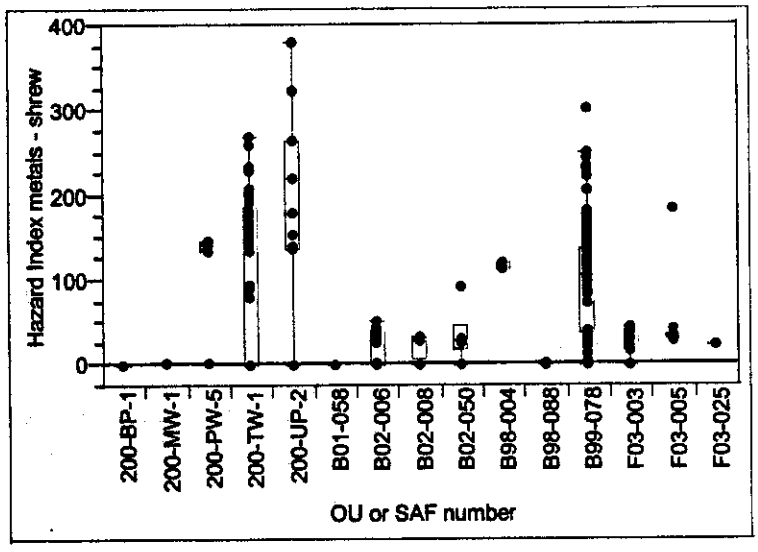


Figure G-10. Comparison of Hazard Indices Metals – Shrew Between Areas.

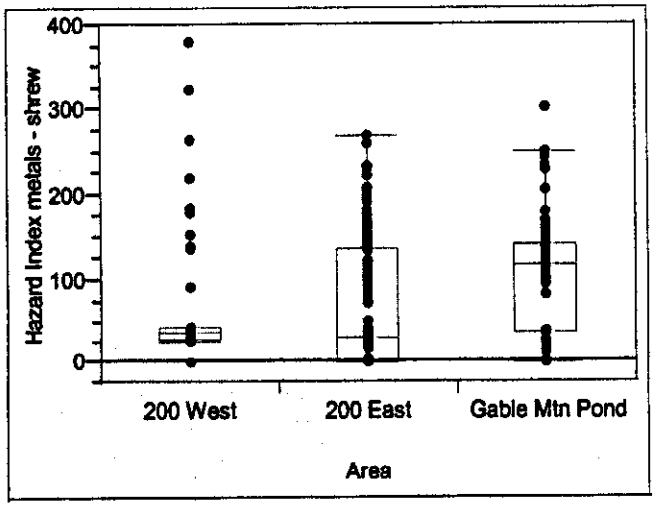


Figure G-11. Scatter Plot of Hazard Indices Metals – Shrew versus Sample Depth.

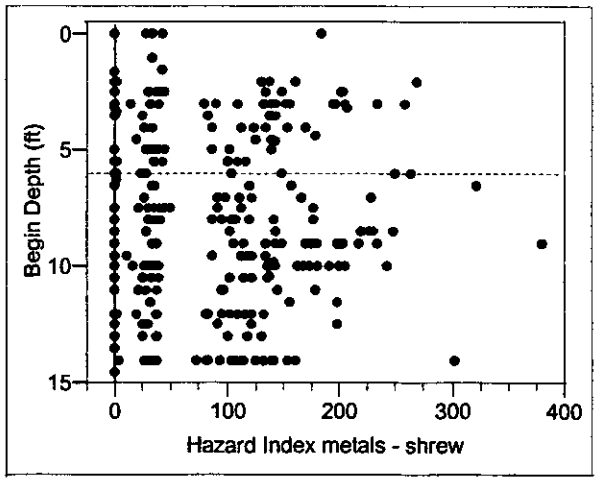


Figure G-12. Comparison of Hazard Indices Organics – Shrew Between Operable Unit or Sampling Authorization Form Groupings.

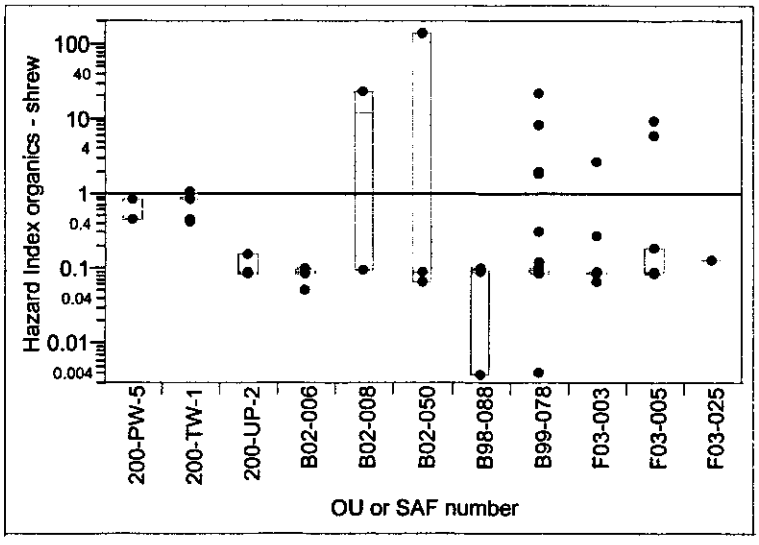


Figure G-13. Comparison of Hazard Indices Organics – Shrew Between Areas.

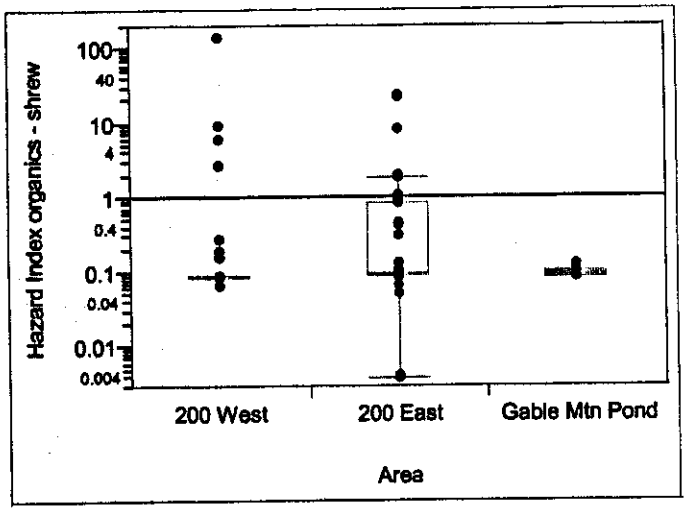


Figure G-14. Scatter Plot of Hazard Indices Organics – Shrew versus Sample Depth.

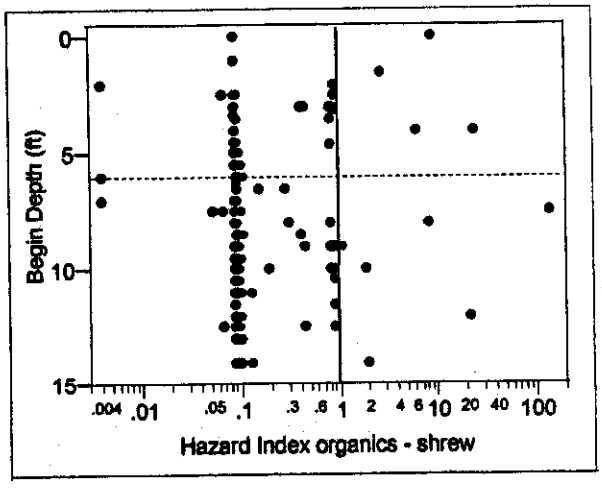


Figure G-15. Comparison of Hazard Indices Metals – Robin Between Operable Unit or Sampling Authorization Form Groupings.

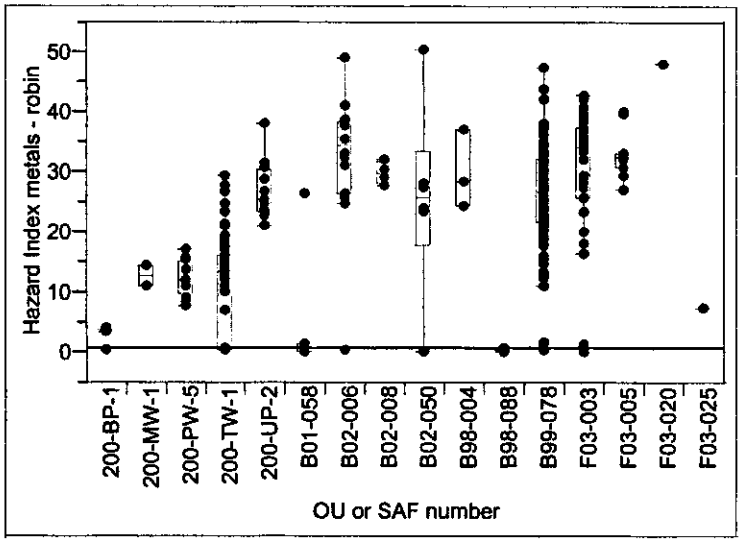


Figure G-16. Comparison of Hazard Indices Metals – Robin Between Areas.

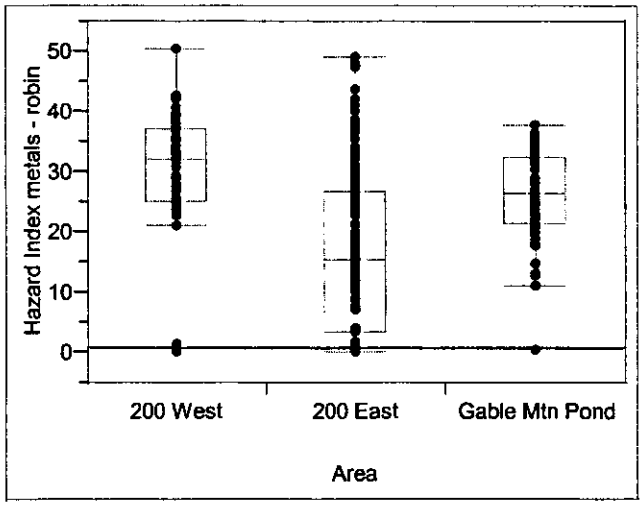


Figure G-17. Scatter Plot of Hazard Indices Metals – Robin versus Sample Depth.

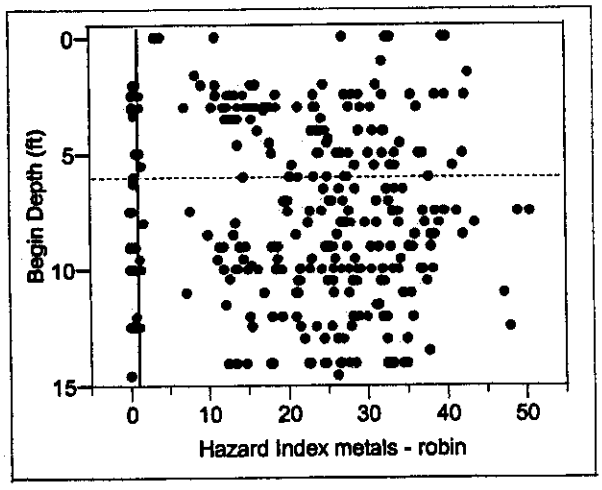


Figure G-18. Comparison of Hazard Indices Organics – Robin Between Operable Unit or Sampling Authorization Form Groupings.

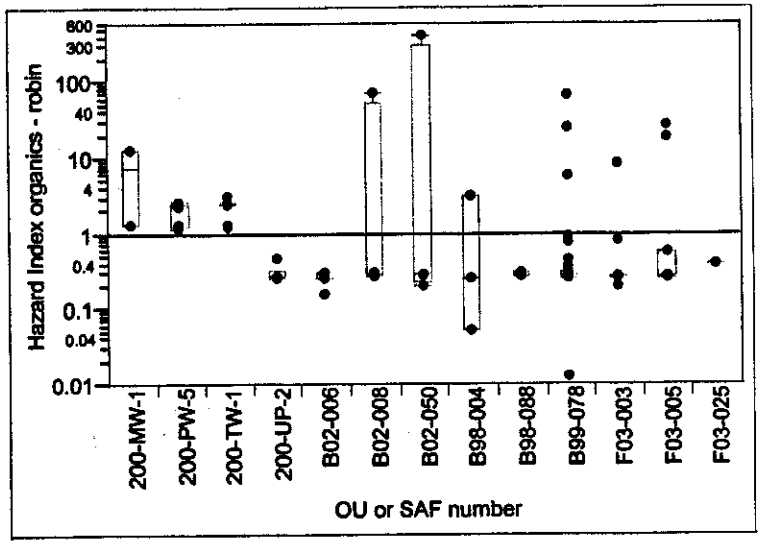


Figure G-19. Comparison of Hazard Indices Organics – Robin Between Areas.

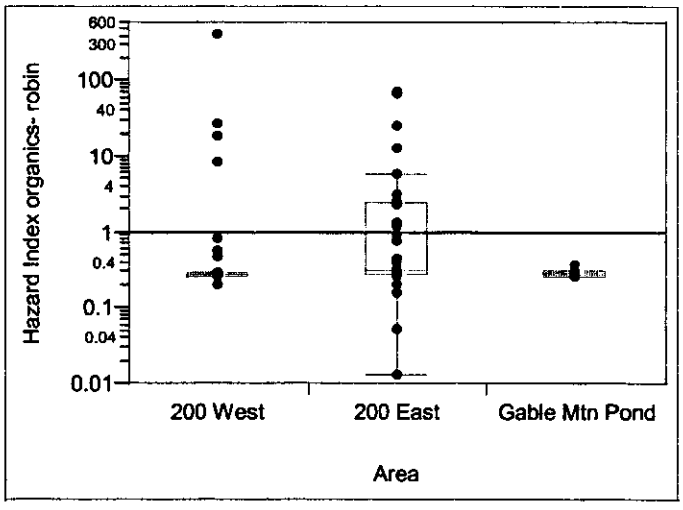


Figure G-20. Scatter Plot of Hazard Indices Organics – Robin versus Sample Depth.

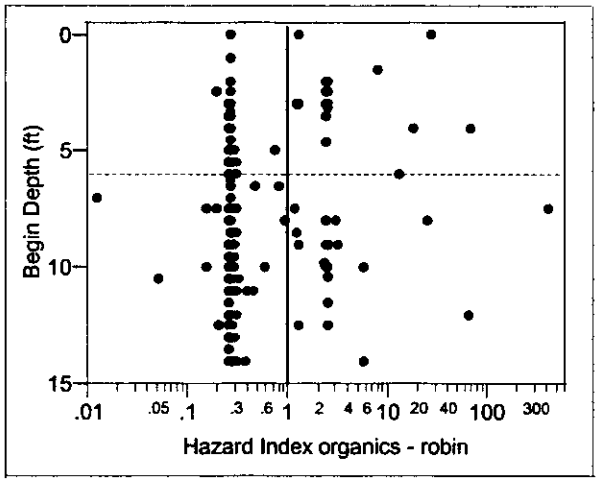


Figure G-21. Comparison of Antimony Concentration Between Operable Unit or Sampling Authorization Form Groupings.

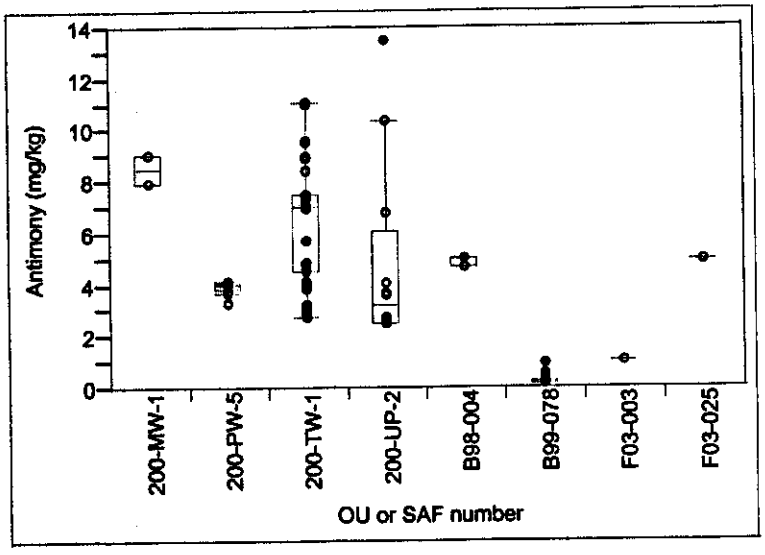


Figure G-22. Comparison of Antimony Concentrations Between Areas.

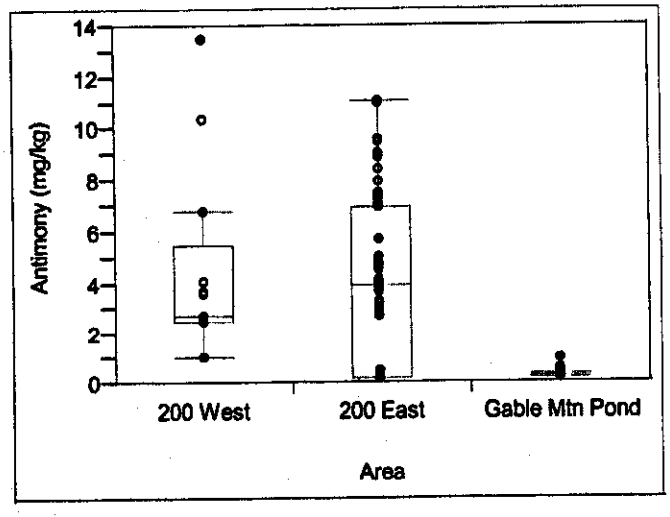


Figure G-23. Scatter Plot of Antimony Concentrations versus Sample Depth.

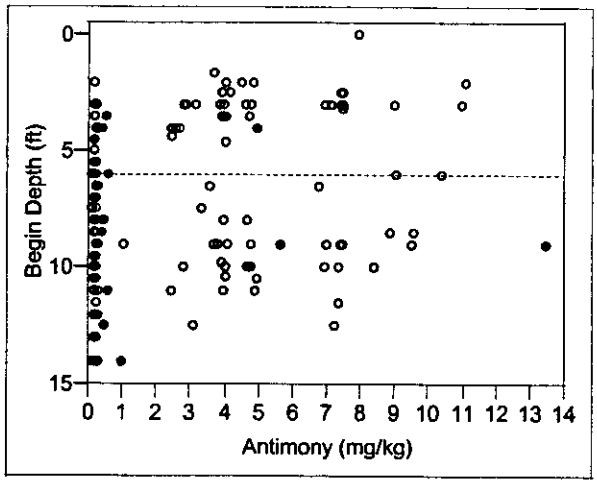


Figure G-24. Comparison of Hexavalent Chromium Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

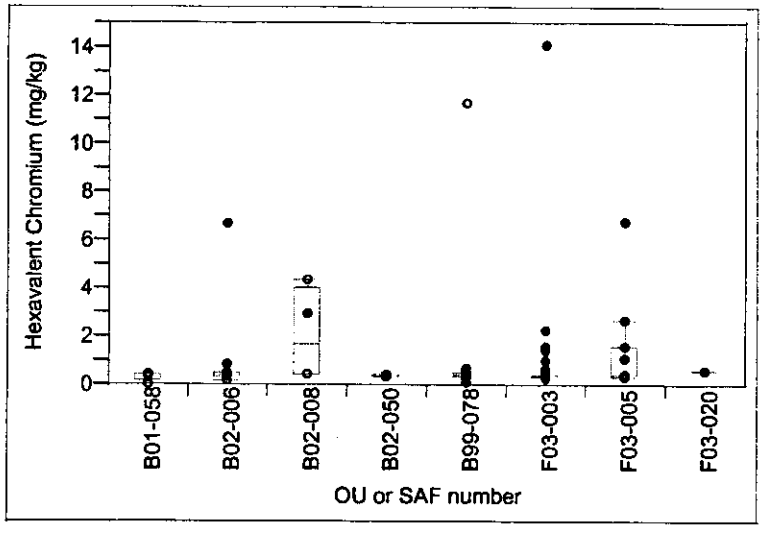


Figure G-25. Comparison of Hexavalent Chromium Concentrations Between Areas.

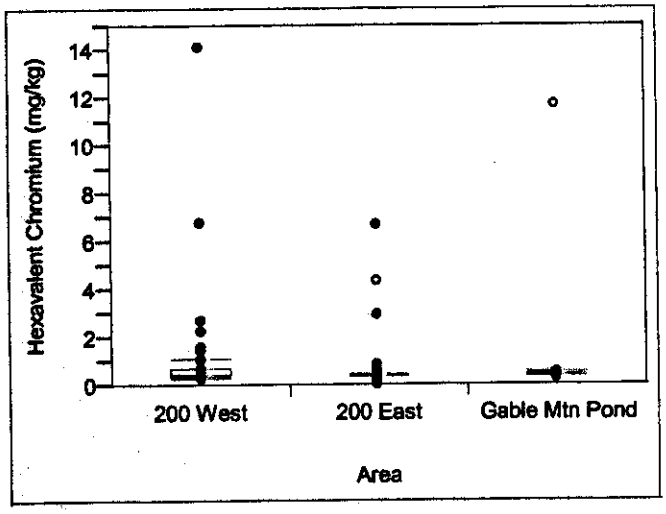


Figure G-26. Scatter Plot of Hexavalent Chromium Concentrations versus Sample Depth.

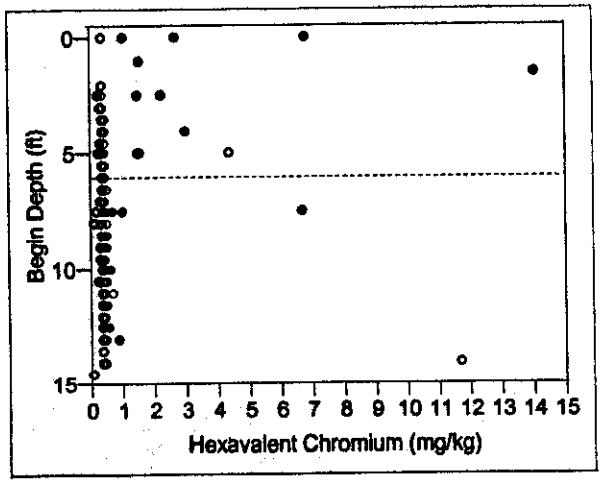


Figure G-27. Comparison of Mercury Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

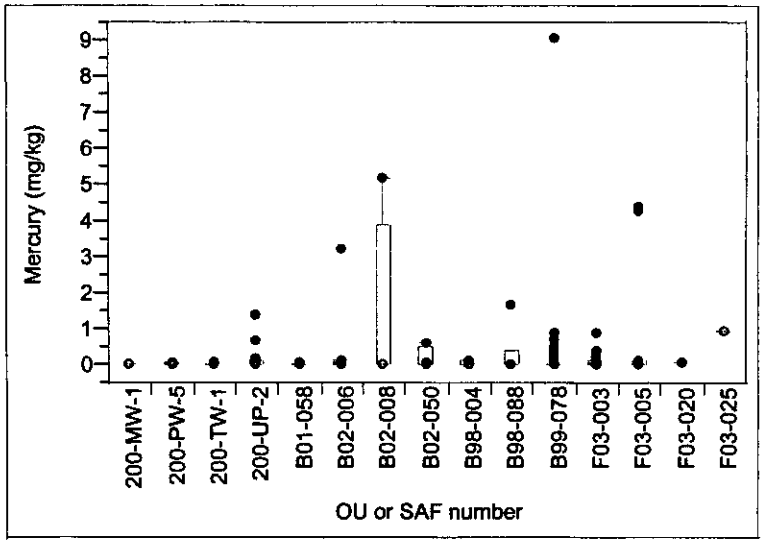


Figure G-28. Comparison of Mercury Concentrations Between Areas.

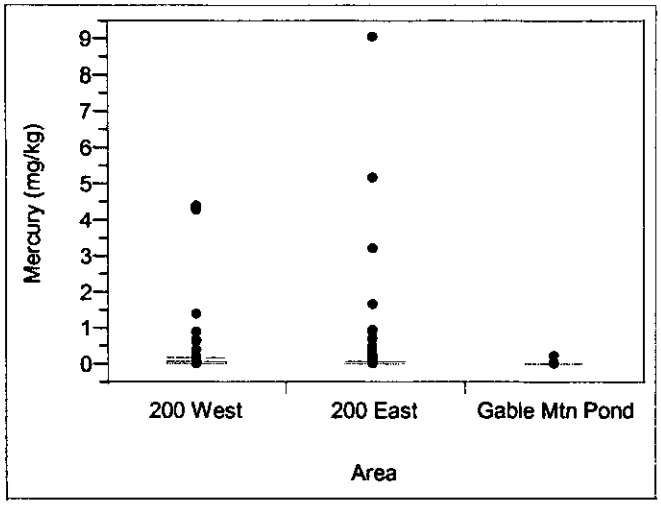


Figure G-29. Scatter Plot of Mercury Concentrations versus Sample Depth.

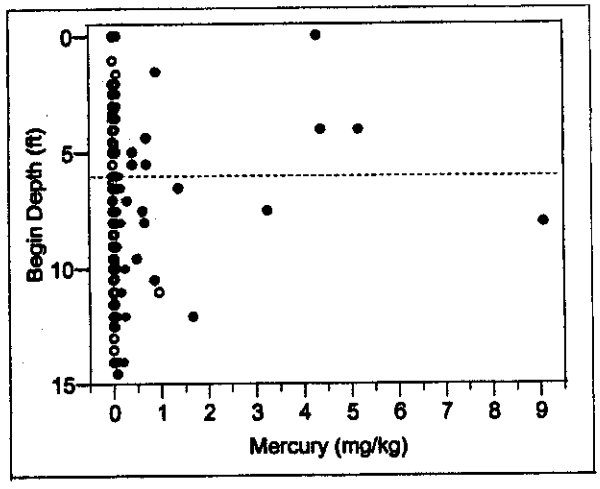


Figure G-30. Comparison of Selenium Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

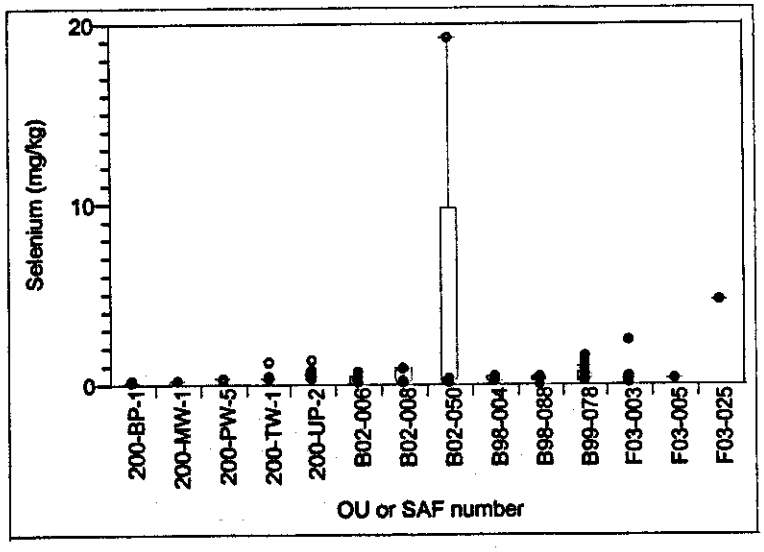


Figure G-31. Comparison of Selenium Concentrations Between Areas.

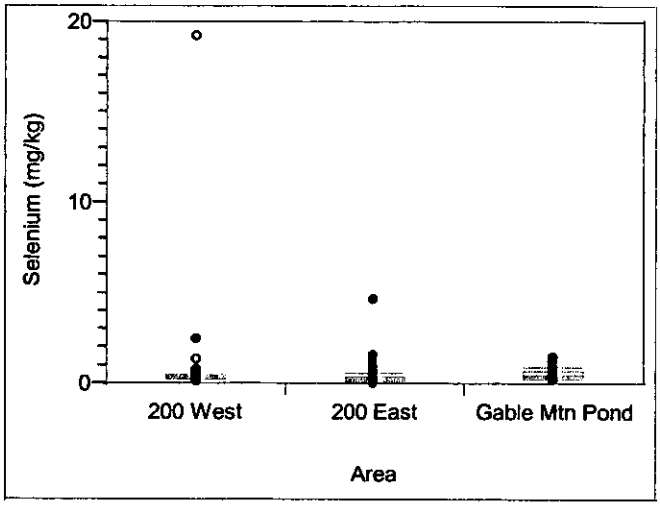


Figure G-32. Scatter Plot of Selenium Concentrations versus Sample Depth.

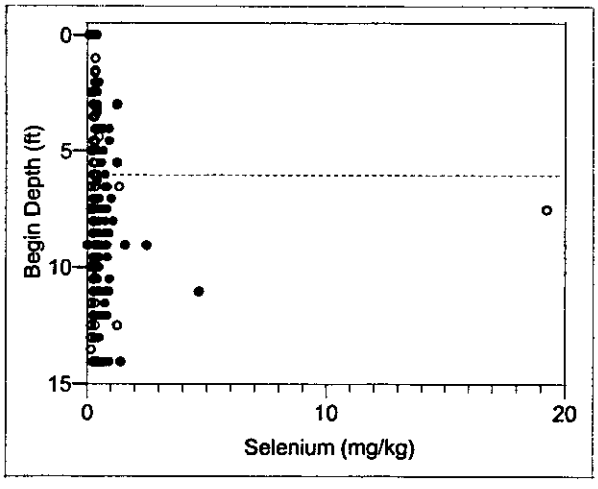


Figure G-33. Comparison of Silver Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

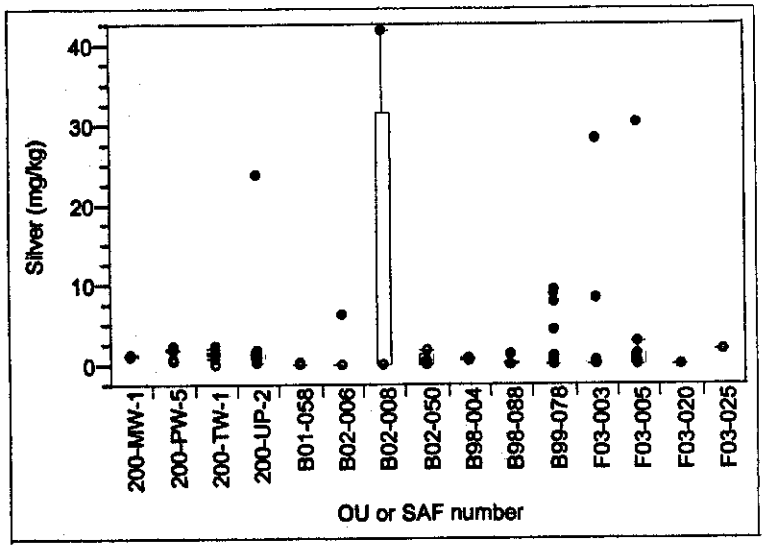


Figure G-34. Comparison of Silver Concentrations Between Areas.

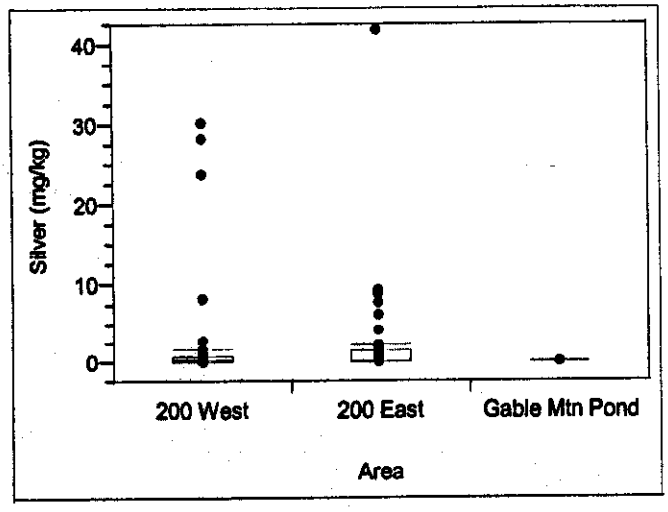


Figure G-35. Scatter Plot of Silver Concentrations versus Sample Depth.

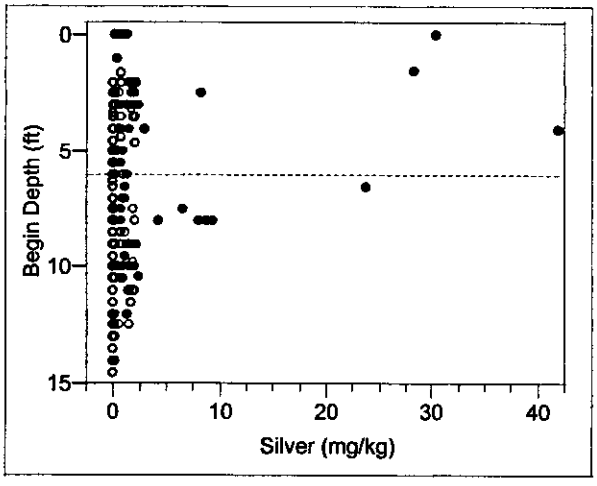


Figure G-36. Comparison of Thallium Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

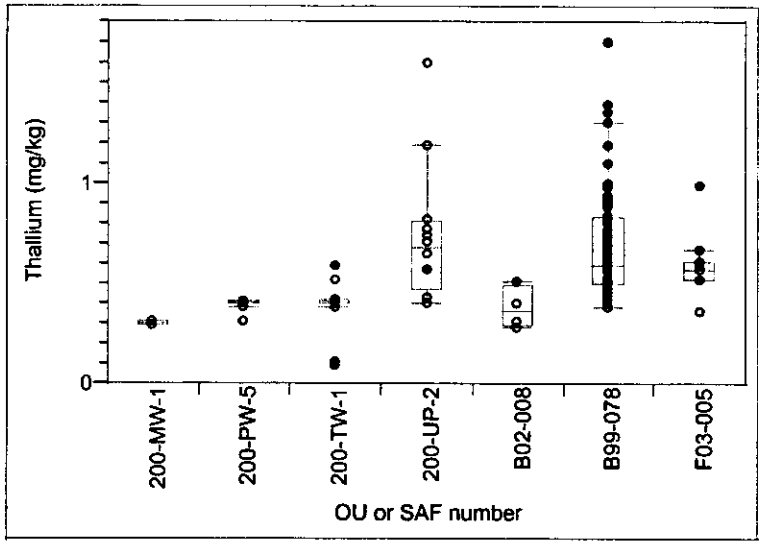


Figure G-37. Comparison of Thallium Concentrations Between Areas.

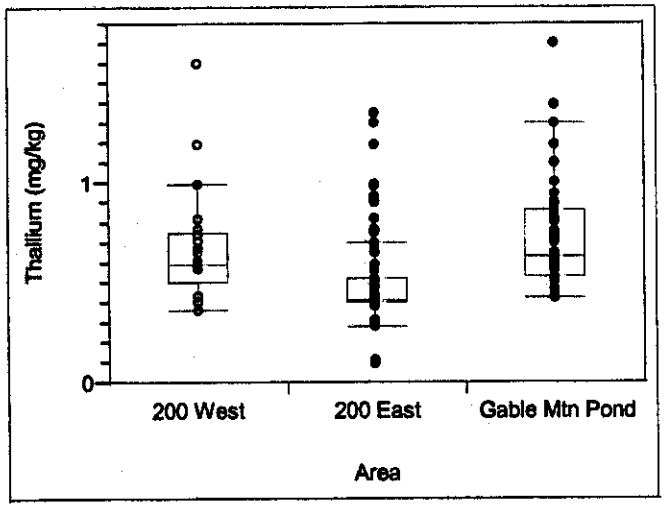


Figure G-38. Scatter Plot of Thallium Concentrations versus Sample Depth.

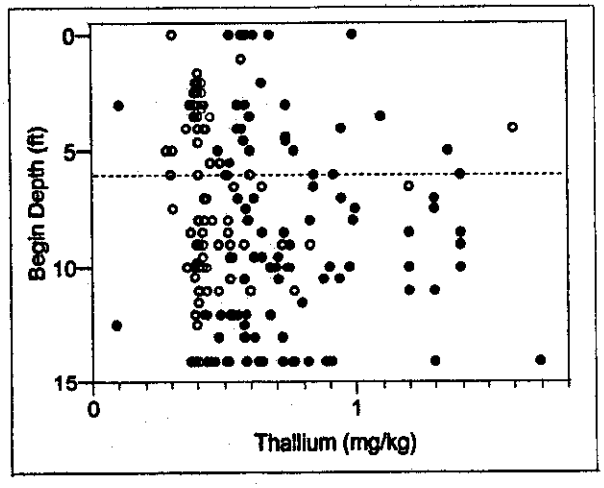


Figure G-39. Comparison of Zinc Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

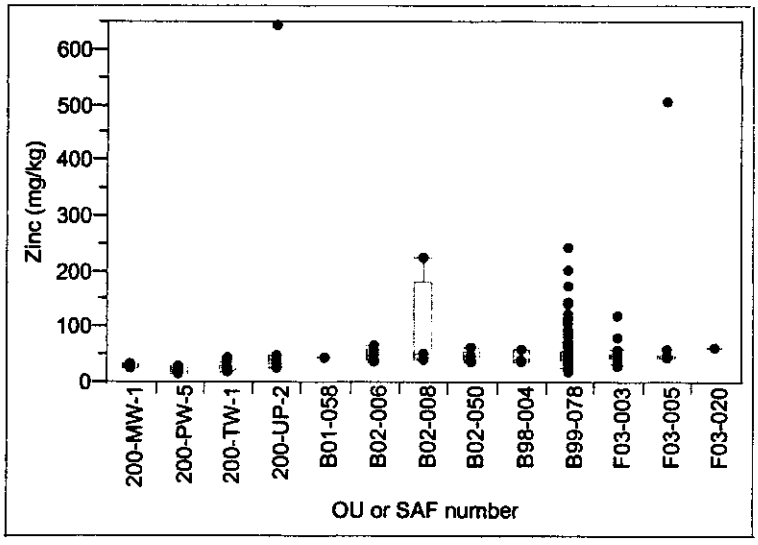


Figure G-40. Comparison of Zinc Concentrations Between Areas.

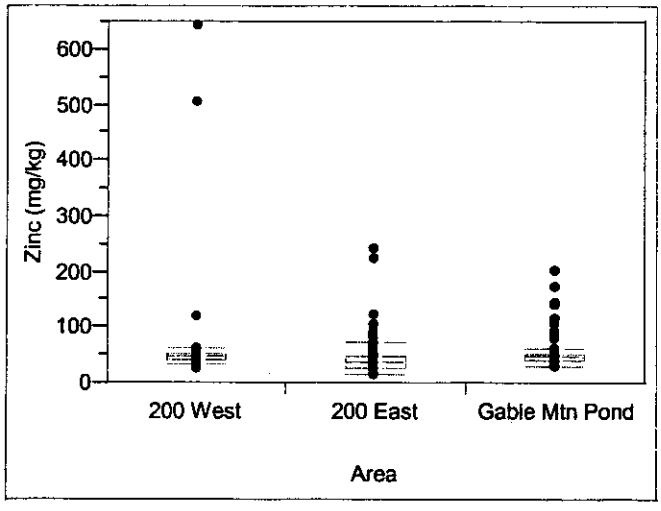


Figure G-41. Scatter Plot of Zinc Concentrations versus Sample Depth.

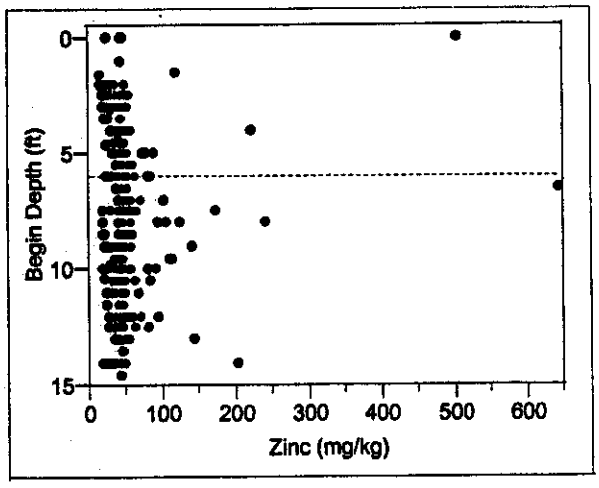


Figure G-42. Comparison of Aroclor-1254 Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

Aroclor is an expired trademark.

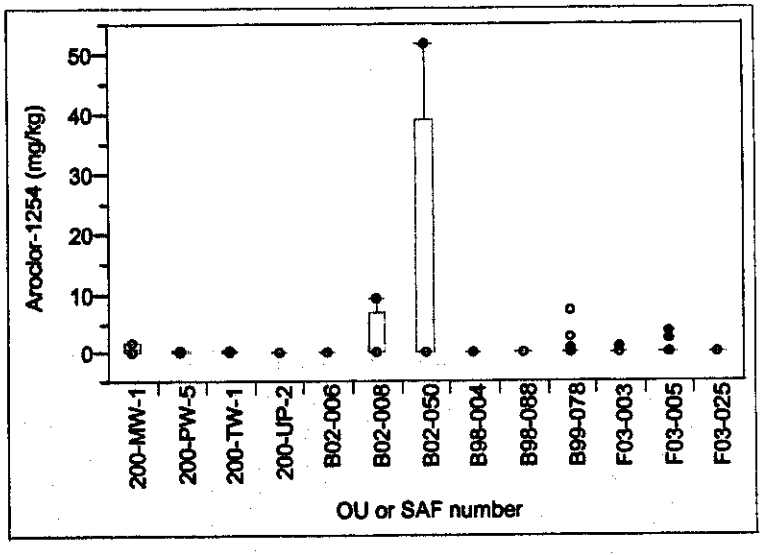


Figure G-43. Comparison of Aroclor-1254 Concentrations Between Areas.

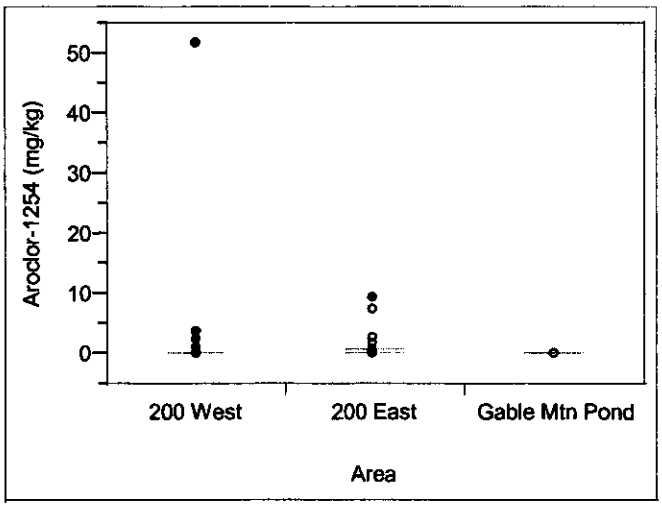


Figure G-44. Scatter Plot of Aroclor-1254 Concentrations versus Sample Depth.

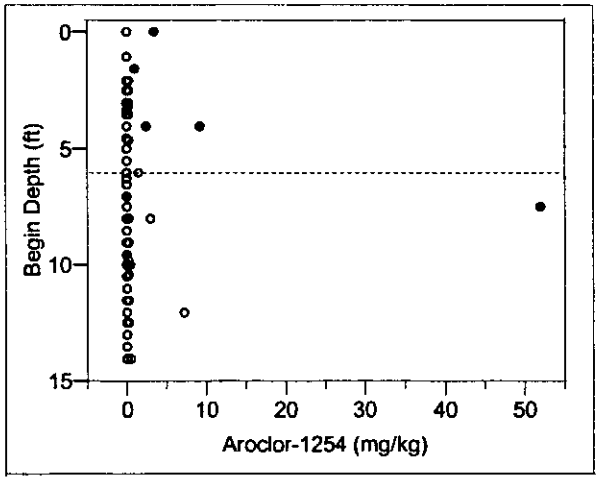


Figure G-45. Comparison of Aroclor-1260 Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

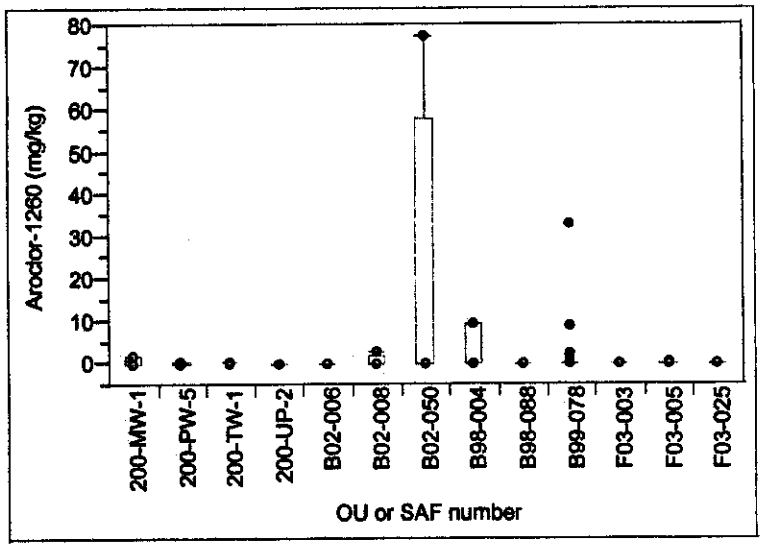


Figure G-46. Comparison of Aroclor-1260 Concentrations Between Areas.

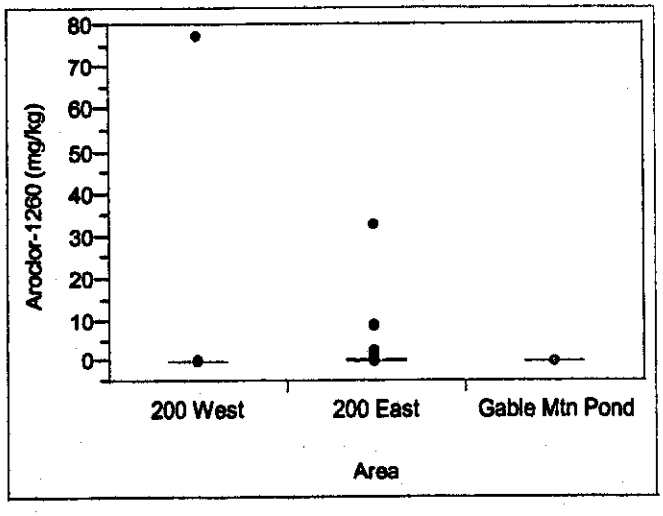


Figure G-47. Scatter Plot of Aroclor-1260 Concentrations versus Sample Depth.

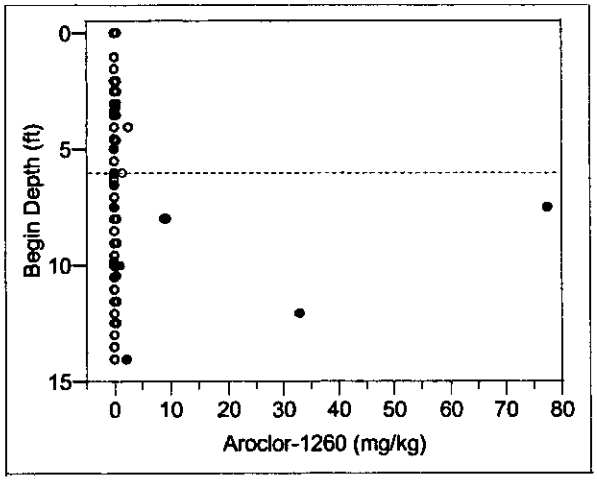


Figure G-48. Comparison of Cesium-137 Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

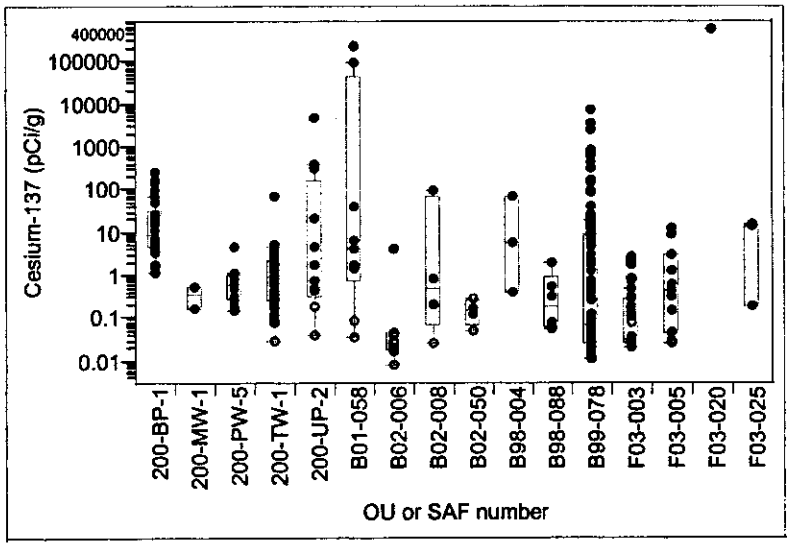


Figure G-49. Comparison of Cesium-137 Concentrations Between Areas.

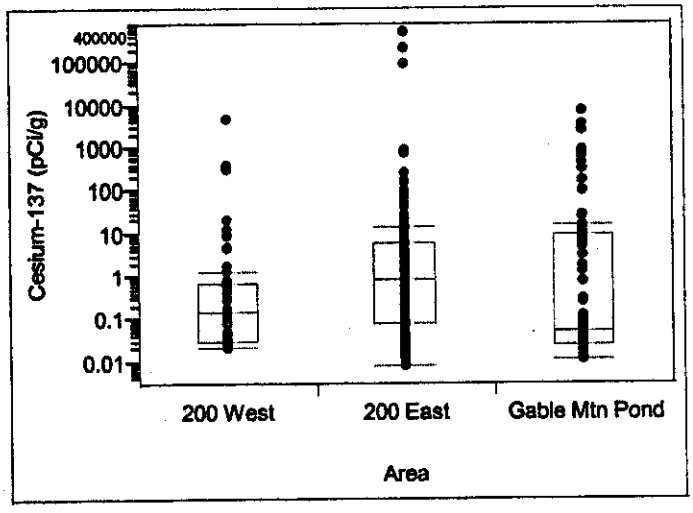


Figure G-50. Scatter Plot of Cesium-137 Concentrations versus Sample Depth.

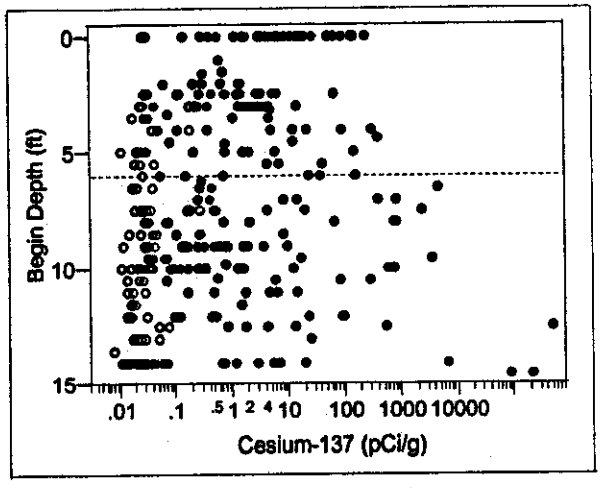


Figure G-51. Comparison of Strontium-90 Concentrations Between Operable Unit or Sampling Authorization Form Groupings.

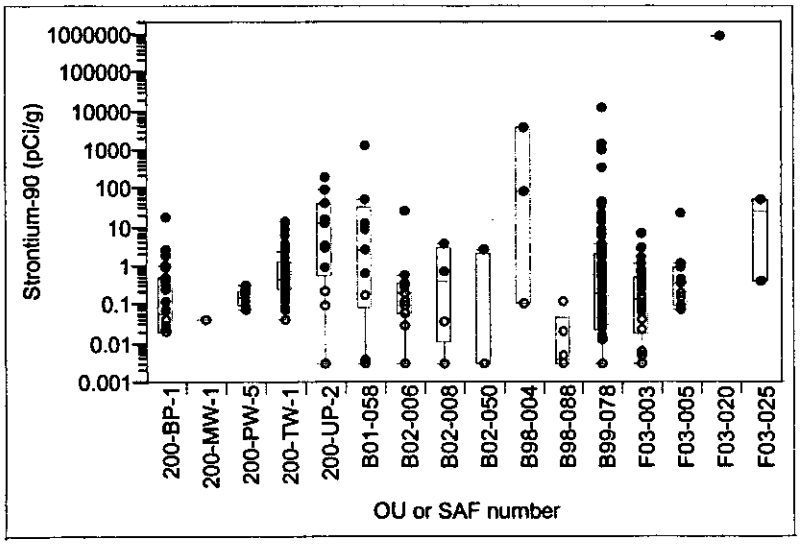


Figure G-52. Comparison of Strontium-90 Concentrations Between Areas.

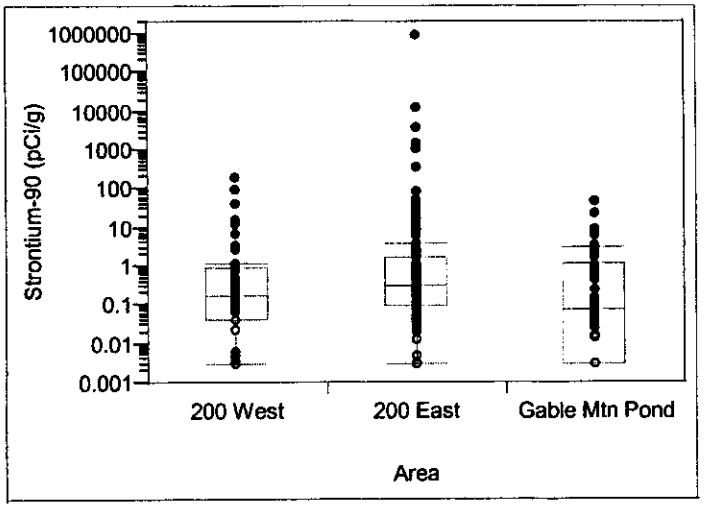
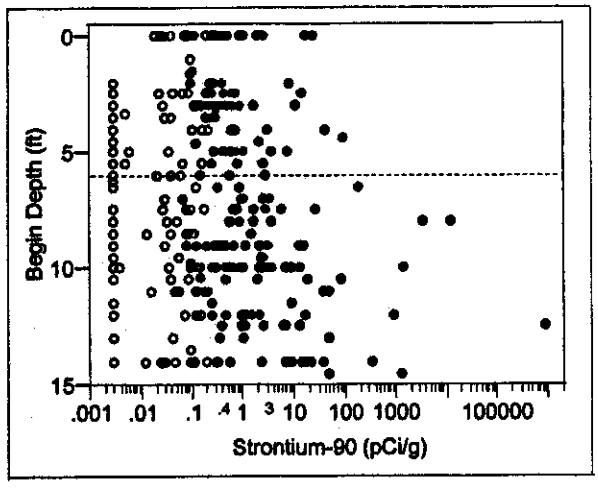


Figure G-53. Scatter Plot of Strontium-90 Concentrations versus Sample Depth.



G3.0 REFERENCE

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