RCRA Facility Investigation-Remedial Investigation/ Corrective Measures Study-Feasibility Study Report for the Rocky Flats Environmental Technology Site Appendix A – Comprehensive Risk Assessment

Volume 3 of 15

West Area
Exposure Unit

This Report was prepared by Kaiser-Hill Company, L.L.C.
for the U.S. Department of Energy

June 2006

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

μg/kg	microgram per kilogram
μg/L	microgram per liter
AEU	Aquatic Exposure Unit
AI	adequate intake
bgs	below ground surface
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CD	compact disc
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
CMS	Corrective Measures Study
CNHP	Colorado Natural Heritage Program
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
DRI	dietary reference intake
ECOI	ecological contaminant of interest
ECOPC	ecological contaminant of potential concern
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment

ESL	ecological screening level
EU	Exposure Unit
HHRA	Human Health Risk Assessment
HRR	Historical Release Report
IA	Industrial Area
IAG	Interagency Agreement
IDEU	Inter-Drainage Exposure Unit
IHSS	Individual Hazardous Substance Site
MDC	maximum detected concentration
mg	milligram
mg/day	milligram per day
N/A	not applicable or not available
NFA	No Further Action
NFAA	No Further Accelerated Action
NOAEL	no observed adverse effect level
OU	Operable Unit
PAC	Potential Area of Concern
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCOC	potential contaminant of concern
PMJM	Preble’s meadow jumping mouse
PRG	preliminary remediation goal
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RCEU	Rock Creek Drainage Exposure Unit
RCRA	Resource Conservation and Recovery Act

RDA	recommended daily allowance
RDI	recommended daily intake
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SCM	Site Conceptual Model
SEP	Solar Evaporation Ponds
tESL	threshold ESL
UBC	Under Building Contamination
UCL	upper confidence limit
UL	upper limit daily intake
UT	uncertain toxicity
UTL	upper tolerance limit
VOC	volatile organic compound
WAEU	West Area Exposure Unit
WRS	Wilcoxon Rank Sum
WRV	wildlife refuge visitor
WRW	wildlife refuge worker

EXECUTIVE SUMMARY

This report presents the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the 468-acre West Area Exposure Unit (EU) (WAEU) at the Rocky Flats Environmental Technology Site (RFETS). The purpose of this report is to assess potential risks to human health and ecological receptors posed by exposure to all identified contaminants of concern (COCs) and ecological contaminants of potential concern (ECOPCs), respectively, in the WAEU.

No COCs were selected in surface soil/surface sediment and subsurface soil/subsurface sediment during completion of the HHRA COC selection process. Only one analyte (arsenic) had concentrations in WAEU surface soil/surface sediment that were statistically greater than RFETS background. However, arsenic was subsequently eliminated as a COC in the professional judgment evaluation step of the COC selection process because the weight of evidence supports the conclusion that arsenic concentrations in the WAEU are not the result of RFETS activities, but rather are representative of naturally occurring concentrations. For comparison purposes, the cancer risks and noncancer hazard indices were estimated for the wildlife refuge worker (WRW) and wildlife refuge visitor (WRV) for arsenic in WAEU surface soil/surface sediment and in RFETS background surface soil/surface sediment. The estimated cancer risks for the WRW and WRV associated with potential exposure to arsenic in surface soil/surface sediment in the WAEU are both approximately 4E-06. The estimated noncancer hazard indices associated with potential exposure to arsenic in surface soil/surface sediment in the WAEU are approximately 0.03 for the WRW and 0.02 for the WRV. The estimated cancer risks for the WRW and WRV associated with potential exposure to RFETS background levels of arsenic in surface soil/surface sediment are 2E-06 and 1E-06, respectively. The estimated noncancer hazard indices associated with potential exposure to RFETS background levels of arsenic in surface soil/surface sediment are approximately 0.01 for the WRW and 0.007 for the WRV. No analytes in subsurface soil/subsurface sediment were statistically greater than RFETS background. These results indicate that potential health risks for the WRW and WRV in the WAEU are expected to be similar to background risks and there are no significant human health risks from RFETS-related operations at the WAEU.

The ECOPC identification process streamlines the ecological risk characterization by focusing the assessment on ecological contaminants of interest (ECOIs) that are present in the WAEU. The ECOPC identification process is described in the CRA methodology and additional details are provided in Appendix A, Volume 2 of the RI/FS Report. All ECOIs in surface soil for non-Preble's meadow jumping mouse (PMJM) receptors were eliminated from further consideration as ECOPCs based on comparisons of MDCs to NOAEL ESLs, background comparisons, tESL comparisons, or professional judgment. Based on the weight-of-evidence, professional judgment described in Attachment 3, aluminum, arsenic, boron, chromium, lithium, and thallium in surface soil at the WAEU were not considered ECOPCs for non-PMJM receptors and were not further evaluated quantitatively. Following a similar ECOPC identification process for burrowing receptors, no ECOIs in subsurface soil were evaluated in professional judgment (all ECOIs were eliminated in preceding steps) and therefore, no ECOPCs were identified for burrowing receptors. No PMJM habitat was evaluated in the ERA because minimal PMJM habitat exists within WAEU. The assessment of risk to the PMJM is addressed in the Rock Creek Drainage Exposure Unit (RCEU) and Inter-Drainage Exposure Unit (IDEU) because habitat for the PMJM within the WAEU is a small subset of the larger PMJM habitat areas in the RCEU and IDEU.

Because this process did not identify any ECOPCs in the WAEU, no risk characterization was performed and site-related risks are likely to be minimal for the ecological receptors evaluated in the WAEU. In addition, data collected on wildlife abundance and diversity indicate that wildlife species richness remains high at RFETS. Because there are no significant risks to ecological receptors or high levels of uncertainty with the data, there are no ecological contaminants of concern (ECOCs) for the WAEU.

1.0 WEST AREA EXPOSURE UNIT

This volume of the Comprehensive Risk Assessment (CRA) presents the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the West Area Exposure Unit (EU) (WAEU) at Rocky Flats Environmental Technology Site (RFETS) (Figure 1.1).

The HHRA and ERA methods and selection of receptors are described in detail in the Final CRA Work Plan and Methodology (DOE 2005a), hereafter referred to as the CRA Methodology. A summary of the risk assessment methods, including updates made in consultation with the regulatory agencies, are summarized in Appendix A, Volume 2, Section 2.0 of the Resource Conservation and Recovery Act (RCRA) Facility Investigation-Remedial Investigation (RI)/Corrective Measures Study (CMS)-Feasibility Study (FS) Report (hereafter referred to as the RI/FS Report). The anticipated future land use of RFETS is a wildlife refuge. Consequently, two human receptors, a wildlife refuge worker (WRW) and a wildlife refuge visitor (WRV), are evaluated in this risk assessment consistent with this land use. A variety of representative terrestrial and aquatic receptors are evaluated in the ERA. The assessment of the WAEU includes all terrestrial receptors named in the CRA Methodology, with the exception of the Preble's meadow jumping mouse (PMJM), a federally listed threatened species present at RFETS. The limited PMJM habitat within the WAEU boundary is assessed with the more extensive habitat that occurs in the Rock Creek Drainage EU (RCEU) and Inter Drainage Exposure Unit (IDEU) (see Appendix A, Volumes 4 and 5 of the RI/FS Report).

1.1 West Area Exposure Unit Description

This section provides a brief description of the WAEU, including its location at RFETS, historical activities in the area, topography, surface water features, vegetation, and ecological resources. A more detailed description of these features and additional information regarding the geology, hydrology, and soil types at RFETS is included in Section 2.0, Physical Characteristics of the Study Area, of the RI/FS Report.

The Historical Release Report (HRR) and its annual updates provide descriptions of known or suspected releases of hazardous substances that occurred at RFETS. The original HRR (DOE 1992a) organized these known or suspected historical sources of contamination as Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), or Under Building Contamination (UBC) sites (hereafter collectively referred to as historical IHSSs). Individual historical IHSSs and groups of historical IHSSs were also designated as Operable Units (OUs). Over the course of cleanup under the 1991 Interagency Agreement (IAG) (IAG 1991) and the 1996 Rocky Flats Cleanup Agreement (RFCA) (RFCA 1996), the U.S. Department of Energy (DOE) has thoroughly investigated and characterized contamination associated with these historical IHSSs. Historical IHSSs have been dispositioned through appropriate remedial actions or by determining that No Further Accelerated Action (NFAA) is required, pursuant to the applicable IAG and RFCA requirements. Some OUs have also been dispositioned in accordance with an OU-specific Corrective Action Decision/Record of Decision (CAD/ROD).

A more detailed description of the regulatory agreements and the investigation and cleanup history under these agreements is contained in Section 1.0 of the RI/FS Report. Section 1.4.3 of the RI/FS Report describes the accelerated action process, while the disposition of all historic IHSSs at RFETS is summarized in Table 1.4 of the RI/FS Report. The 2005 Annual Update to the HRR (DOE 2005b) provides a description of the potential contaminant releases for each IHSS, and any interim response to the releases; identification of potential contaminants based on process knowledge and site data; data collection activities; accelerated action activities (if any); and the basis for recommending no further accelerated action.

The WAEU is located within the Buffer Zone (BZ) OU, west of the Industrial Area (IA), which was used for RFETS operations (Figure 1.1). There are no known sources of groundwater or soil contamination within the WAEU based on the 2005 Annual Update to the HRR (DOE 2005b). No historical IHSSs or PACs are designated in the WAEU (Figure 1.2). The only potential nearby source area, located in the Inter-Drainage EU (IDEU) (Appendix A, Volume 5 of the RI/FS Report), is IHSS 168, the West Spray Field, which is located east of the WAEU. Excess water from the Solar Evaporation Ponds (SEP) (IHSS 101) was periodically sprayed within IHSS 168 between April 1982 and October 1985 (DOE 1992b). A Colorado Department of Public Health and Environment (CDPHE) risk-based conservative screen was conducted for IHSS 168 by DOE (1995). A No Further Action (NFA) CAD/ROD was approved for IHSS 168 (also designated in the IAG of 1991 as OU 11) in October 1995 (Administrative Record reference OU11-A-000184). It is unlikely that IHSS 168, located outside and downgradient of the WAEU, is a source of contaminants for the WAEU.

1.1.1 Exposure Unit Characteristics and Location

The 468-acre WAEU is located on the western perimeter of RFETS (Figure 1.1) and has several distinguishing features:

- The WAEU is located within the BZ OU and is outside areas that were used historically for operation of the RFETS;
- Sources of contamination are not present within the WAEU boundaries;
- The WAEU is a functionally distinct exposure area due to large areas with disturbed soil (gravel mining), sparse vegetation, and relative scarcity of water and wetland habitat; and
- The WAEU is part of two watersheds: the Rock Creek and Walnut Creek Drainages.

The WAEU is bounded by the RCEU and IDEU to the east and DOE's National Wind Technology Center to the north. Land to the west and south of the WAEU, outside the RFETS boundary, is privately owned. Highway 93, which runs north-south and connects the cities of Boulder and Golden, Colorado, is located approximately 1,500 feet west of the WAEU boundary.

1.1.2 Topography and Surface Water Hydrology

A recent aerial photograph of the WAEU shows that soil in the northern and southern portions of the EU has been disturbed by gravel mining unrelated to RFETS activities (Figure 1.3). The disturbed areas include a majority of the surface area of the WAEU and consist of excavations, ponds, soil piles, and roads.

The WAEU is relatively level compared to the rest of RFETS, which is located on a broad, eastward-sloping pediment that is deeply transected by several stream valleys (eastern portion of RFETS). Although several ephemeral or intermittent creeks originate just west of and within the WAEU (Figure 1.3) and traverse the EU in a west to east-northeast direction, the channels are shallow. Named creeks in the WAEU include the Mahonia, Snowberry, and Lindsay branches of Rock Creek and portions of the Upper Church and McKay ditches (Figure 1.4). Groundwater in the EU originates upgradient of RFETS and is not affected by RFETS activities.

The WAEU contains several water bodies, most of which are a result of mining activities (Figure 1.4). Ponds created as a result of mining activities exist in the mining areas in the northern and southern portions of the EU. These ponds are transient in nature and not related to RFETS activities. A large pond near the southern boundary of the EU is also related to mining activities, but it is not transient. The pond has been present in various configurations prior to 1990. Its steep walled banks and constant water level fluctuation make this pond poor aquatic habitat. A small natural pond is also located in the southern portion of the WAEU. The other water bodies visible in the aerial photograph are a result of mining activities.

Two small ponds exist at the upper ends of the Rock Creek tributaries located in the center of the EU. One pond is in the Mahonia branch and the other in the Lindsay branch. Both ponds are man-made and are unrelated to and pre-date mining activities. They are small on-channel dugouts likely made for stock ponds prior to acquisition by DOE, and are related to ranching activities, not RFETS activities. The pond on the Lindsay branch is only 6 feet in diameter and surrounded by cattails. It is ephemeral but has surface water for the majority of the year, even during dry years. The Mahonia branch pond is larger (8 feet in diameter) and has a combination of cattails and Baltic rush vegetation. This pond is ephemeral, and only holds water during spring runoff and during significant summer storm events.

1.1.3 Flora and Fauna

A vegetation map for the WAEU is shown on Figure 1.4. Areas that have not been disturbed by mining are characterized predominantly by xeric tallgrass prairie on the plains, and wetland and mesic mixed grassland in and adjacent to the drainages. Small areas of tall upland shrubland, Ponderosa pine woodland, and short upland shrubland also exist. The xeric tallgrass prairie is distinguished at RFETS by such plant species as big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), indian grass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), porter aster (Aster porerid), mountain muhly (*Muhlenhogia montana*), and switchgrass (*Panicum virgatum*), essentially the same species that dominate the plant community on the eastern edge of the Great Plains.

No federally listed plant species are known to occur at RFETS. However, the xeric tallgrass prairie, tall upland shrubland, riparian shrubland, and plains cottonwood riparian woodland communities are considered rare and sensitive plant communities by the Colorado Natural Heritage Program (CNHP). RFETS also supports populations of four rare plant species that are listed as rare or imperiled by the CHNP. These include: forktip three-awn (*Aristida basiramea*), mountain-loving sedge (*Carex oreocharis*), carrionflower greenbriar (*Smilax herbacea var. lasioneuron*), and dwarf wild indigo (*Amorpha nana*). Forktip three-awn primarily occurs in disturbed habitat near the western edge of the IAEU. The other three species occur primarily along the piedmont slopes in the Rock Creek drainage (K-H 2002).

Land within the WAEU was heavily grazed during past land use. However, since the purchase of the land by DOE, grazing within the EU has not occurred in decades and plant communities have nearly returned to pre-grazed conditions. As previously discussed, the CNHP (1994) classifies the xeric tallgrass prairie plant community as very rare. Portions of this plant community in the Rock Creek drainage along with other areas within RFETS and surrounding lands comprise the largest remnants of xeric tallgrass prairie. The WAEU contains the forktip three-awn which occurs within the xeric tallgrass prairie in areas that have been disturbed and vegetation has been removed. Few locations are known in Colorado that support forktip three-awn, but RFETS has several sites.

Numerous animal species have been observed at RFETS and the more common ones are also expected to be present in the WAEU. Common large and medium-sized mammals likely to live at or frequent the WAEU include mule deer (*Odocoileus hemionus*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), desert cottontails (*Sylvilagus audubonii*), and white-tailed jackrabbit (*Lepus townsendii*). The western prairie rattlesnake (*Crotalis viridus*) occurs on the xeric tallgrass prairie and the boreal chorus frog (*Pseudacris tryseriatus*) occurs in wetland areas, especially in the spring. Common birds include meadow lark (*Sturnella neglecta*), vesper sparrow (*Pooecetes gramineus*), and mourning dove (*Zenaida macroura*). The most common small mammal species include deer mice (*Peromyscus maniculatus*), prairie voles (*Microtus ochrogaster*), meadow voles (*Microtus pennsylvanicus*), and different species of harvest mice (*Reithrodontomys sp*.). More information on the species that exist within RFETS is provided in Section 2.0 of the RI/FS Report.

The WAEU also acts as a travel corridor for large mammals connecting Coal Creek and the foothills to the west of RFETS. Despite mining activities in the EU, elk (*Cervus canadensis*) and mule deer travel through this corridor to calve and fawn in upper Rock Creek in late spring. Black bear (*Ursus americanus*) also use this corridor to access RFETS, and several individuals have been observed in recent years.

RFETS supports two wildlife species listed as threatened or endangered species under the Endangered Species Act (USFWS 2005) The Preble's meadow jumping mouse (PMJM; *Zapus hudsonius preblei*) and the bald eagle (*Haliaeetus leucocephalus*) are listed as threatened species. The preferred habitat for the PMJM (*Zapus hudsonius preblei*) is the riparian corridors bordering RFETS streams, ponds, and wetlands. Small areas designated as PMJM habitat occur along three drainages in the WAEU as shown on Figure 1.5. No PMJM have ever been captured in the WAEU. The bald eagle occasionally forages at RFETS although no nests have been identified on site.

There are also a number of wildlife species that have been observed at RFETS that are species of concern by the State of Colorado (USFWS 2005). The plains sharp-tailed grouse (*Tympanuchus phasianellus jamesii*) is listed as endangered by the State and has been observed infrequently at RFETS. The western burrowing owl (*Athene cunicularia hypugea*) is listed as threatened by the State and is a known resident or regular visitor at RFETS. The ferruginous hawk (*Buteo regalis*), American peregrine falcon (*Falco peregrinus*), and northern leopard frog (*Rana pipiens*) are listed as species of special concern by the State and are considered known residents or regular visitors at RFETS. The following species are listed as species of special concern and are observed infrequently at RFETS: greater sandhill crane (*Grus canadensis tibida*), long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), and the common garter snake (*Thamnophis sirtalis*).

More detail on the species that use RFETS habitats and the methodology of creating sitewide PMJM habitat patches can be found in Appendix A, Volume 2, Section 3.2 of the RI/FS Report.

1.1.4 Data Description

Data have been collected at RFETS under regulatory agency-approved Work Plans, Sampling and Analysis Plans (SAPs), and Quality Assurance Project Plans (QAPjPs) to meet data quality objectives (DQOs) and appropriate U.S. Environmental Protection Agency (EPA) and CDPHE guidance. Surface soil, subsurface soil, surface sediment, subsurface sediment, and groundwater samples were collected from the WAEU. The data set for the CRA was prepared in accordance with data processing steps described in Appendix A, Volume 2, Attachment 2 of the RI/FS Report. Surface soil/surface sediment, subsurface soil/subsurface sediment, surface soil, and subsurface soil are the media evaluated in the HHRA and ERA (Table 1.1). The sampling locations for these media are shown on Figures 1.6 and 1.7, and data summaries for detected analytes in each medium are provided in Tables 1.2 through 1.5. Potential contaminants of concern (PCOCs) and ecological contaminants of interest (ECOIs) that were analyzed for but not detected, or were detected in less than 5 percent of the samples are presented in Attachment 1. Detection limits for those PCOCs and ECOPCs are compared to preliminary remediation goals (PRGs) and ecological screening levels (ESLs) and discussed in Attachment 1 (Tables A1.1 through A1.4). Only data from June 1991 to the present are used in the CRA because these data meet the approved analytical quality assurance/quality control (QA/QC) requirements.

In accordance with the CRA Methodology, only data collected on or after June 28, 1991, and data for subsurface soil and subsurface sediment samples with a start depth less than or equal to 8 feet below ground surface (bgs) are used in the CRA. Subsurface soil and subsurface sediment data are limited to this depth because it is not anticipated that the WRW or burrowing animals will dig to deeper depths. A detailed description of data storage and processing methods is provided in Appendix A, Volume 2 of the RI/FS Report. The CRA analytical data set for the WAEU is provided on a compact disc (CD) presented in Attachment 4. The CD includes the data used in the CRA as well as data not considered useable based on criteria presented in Appendix A, Volume 2 of the RI/FS Report.

The sampling data used for the WAEU HHRA and ERA are as follows:

- Combined surface soil/surface sediment data (HHRA);
- Combined subsurface soil/subsurface sediment data (HHRA);
- Surface soil data (ERA); and,
- Subsurface soil data (ERA).

The data for these media are briefly described below.

Surface water and sediment are assessed for ecological receptors on an Aquatic Exposure Unit (AEU) basis in Appendix A, Volume 15 of the RI/FS Report. An assessment of the surface water, groundwater-to-surface water, and volatilization pathways for human health are presented in Appendix A, Volume 2 of the RI/FS Report.

Surface Soil/Surface Sediment

The combined surface soil/surface sediment data set for the WAEU consists of up to 20 samples that were analyzed for inorganics (20 samples), organics (10 samples), and radionuclides (18 samples) (Table 1.1). The data include sediment samples collected to depths down to 0.5 feet bgs. The sampling locations for surface soil and surface sediment are shown on Figure 1.6. All sample locations within the WAEU were not necessarily analyzed for all analyte groups (see Table 1.2). Surface soil/surface sediment samples were collected in the WAEU for several months from August 1991 through March 1993, and then again in March 2004. The samples collected in 2004 were located on a 30-acre grid, as described in SAP Addendum #04-01 (DOE 2004). For the grid sampling, five individual samples were collected from each 30-acre cell, one from each quadrant and one in the center, as described in the addendum (DOE 2004). Most of the evenly spaced surface soil sampling locations on Figure 1.6 represent the 30-acre grid samples.

The data summary for detected analytes in surface soil/surface sediment for the WAEU is presented in Table 1.2. Detected analytes include representatives from the inorganics, organics, and radionuclides analyte groups. A summary of analytes that were not detected in, or detected in less than 5 percent of, surface soil/surface sediment samples collected in the WAEU is presented and discussed in Attachment 1.

Subsurface Soil/Subsurface Sediment

Subsurface soil samples used in the CRA are defined in the CRA Methodology as soil samples with a starting depth less than or equal to 8 feet bgs and an ending depth below 0.5 feet bgs. Subsurface sediment samples (sediment samples with a start depth less than or equal to 8 feet bgs and an ending depth below 0.5 feet) were not collected in the WAEU. The combined subsurface soil/subsurface sediment data set for the WAEU consists of up to seven samples that were analyzed for inorganics (seven samples), organics (five samples), and radionuclides (seven samples) (Table 1.1). The sampling locations for subsurface soil are shown on Figure 1.7. All sample locations within the WAEU were not necessarily analyzed for all analyte groups (see Table 1.3). Subsurface soil samples were collected in the WAEU in July 1992 and August 1994.

The data summary for detected analytes in subsurface soil/subsurface sediment for the WAEU is presented in Table 1.3. Detected analytes include representatives from the inorganics, organics, and radionuclides analyte groups. A summary of analytes that were not detected in, or detected in less than 5 percent of, subsurface soil/subsurface sediment samples collected in the WAEU is presented and discussed in Attachment 1.

Surface Soil

Data meeting the CRA requirements are available for up to 10 surface soil samples collected in the WAEU that were analyzed for inorganics (10 samples) and radionuclides (10 samples) (Table 1.1). The surface soil sampling locations for the WAEU are shown on Figure 1.6. All sample locations within the WAEU were not necessarily analyzed for all analyte groups (see Table 1.4). Surface soil samples were collected in the WAEU in March 2004. The samples collected in 2004 were located on a 30-acre grid, as described in SAP Addendum #04-01 (DOE 2004). For the grid sampling, five individual samples were collected from each 30-acre cell, one from each quadrant and one in the center, as described in the addendum (DOE 2004). Most of the evenly spaced surface soil sampling locations on Figure 1.6 represent the 30-acre grid samples.

The data summary for detected analytes in WAEU surface soil is presented in Table 1.4. Radionuclides and inorganics were detected. A summary of analytes that were not detected in, or detected in less than 5 percent of, surface soil samples collected in the WAEU is presented and discussed in Attachment 1.

Subsurface Soil

Subsurface soil samples used in the CRA are defined in the CRA Methodology as soil samples with a starting depth less than or equal to 8 feet bgs and an ending depth below 0.5 feet. The subsurface soil data set for the WAEU consists of up to seven samples that were analyzed for organics (five samples), inorganics (seven samples), and radionuclides (seven samples) (Table 1.1). Subsurface soil sampling locations are shown on Figure 1.7. All sample locations within the WAEU were not necessarily analyzed for all analyte groups (see Table 1.5). Subsurface soil samples were collected in the WAEU in July 1992 and August 1994.

The data summary for detected analytes in subsurface soil for the WAEU is presented in Table 1.5. Subsurface soil samples were analyzed for inorganics, organics, and radionuclides, and representatives from all three analyte groups were detected. A summary of analytes that were not detected in, or detected in less than 5 percent of, subsurface soil samples collected in the WAEU is presented and discussed in Attachment 1.

1.2 Data Adequacy Assessment

A data adequacy assessment was performed to determine whether the available data set discussed in the previous section is adequate for risk assessment purposes. The data adequacy assessment rules are presented in the CRA Methodology, and a detailed data adequacy assessment for the data used in the CRA is presented in Appendix A, Volume 2, Attachment 3 of the RI/FS Report. The adequacy of the data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial and temporal distributions of the data to data adequacy guidelines. If the data do not meet the guidelines, other lines of evidence (e.g., information on potential historical sources of contamination, migration pathways, and the concentration levels in the media) are examined to determine if it is possible to make risk management decisions given the data limitations.

The findings from the data adequacy assessment applicable to all EUs are as follows:

- The radionuclide and inorganic surface soil data are adequate for the purposes of the CRA.
- For herbicides and pesticides, although the existing surface soil and sediment data may not meet the minimal data adequacy guidelines for each EU, there is considerable site-wide data, and pesticides and herbicides are infrequently detected at low concentrations, generally below PRGs and ESLs. This line of evidence indicates that it is possible to make risk management decisions without additional sampling for these analyte groups
- For dioxins, although the existing surface soil and sediment data do not meet the minimal data adequacy guidelines for each EU, sample locations were specifically targeted for dioxin analysis at historical IHSSs in and near the former Industrial Area where dioxins may have been released based on process knowledge. Some of the dioxin concentrations at the historical IHSSs exceed the PRG and/or ESL. Additional samples were collected in targeted locations that represented low-lying or depositional areas where dioxin contamination may have migrated via runoff from these specific IHSSs. Results indicate that dioxin concentrations are not above the minimum ESL in sediment and dioxins are not detected in surface water. Therefore, although the existing data do not meet the minimal data adequacy guidelines for each EU/AEU, it is possible to make risk management decisions without additional sampling. However, unlike pesticides and herbicides

where there is considerably more site-wide data, there is greater uncertainty in the overall risk estimates because fewer samples were collected at the site for dioxins.

- Subsurface soil contamination is largely confined to historical IHSSs (that is, areas of known or suspected historical releases). These areas have been characterized to understand the nature and extent of potential releases. For historical IHSSs where subsurface soil samples were not collected for an analyte group, the presence of this type of subsurface contamination was not expected based on process knowledge. Therefore, the existing subsurface soil data are adequate for the purposes of the CRA.

The findings from the data adequacy report applicable to the WAEU are as follows:

- The number of surface soil/surface sediment samples in the WAEU for VOCs, SVOCs, and PCBs meet the data adequacy guideline. However, surface soil data do not exist for these classes of compounds. The WAEU contains no historical IHSSs, and is hydraulically upgradient and generally upwind of potential historical source areas in and near the IA. Therefore, although the existing data do not meet the minimal data adequacy guidelines for the EU, available information on potential historical sources of contamination, contaminant migration pathways from potential sources in other EUs, as well as concentration levels in adjacent sediment show that the constituents in these analyte groups are not likely to be present in surface soil for this EU, and it is possible to make risk management decisions without additional sampling.

- No surface soil or sediment samples were collected for dioxins in the WAEU. Although this does not meet the minimal data adequacy guideline, as noted above, dioxins are not expected to have been released in WAEU and it is possible to make risk management decisions without additional sampling.

- The sediment sample locations are confined to streams located in the southern half of the EU, and therefore, do not meet the data adequacy guideline for spatial representativeness. However, the absence of potential historical sources within the WAEU, or significant transport mechanisms for contaminants to migrate to the WAEU and establish a spatial concentration pattern indicates the existing data are representative of the entire EU. Therefore, although the existing EU data do not meet the data adequacy guideline for spatial representativeness, it is possible to make risk management decisions without additional sampling.

For analytes not detected or detected in less than 5% of the samples in surface soil/surface sediment and surface soil, very few have detection limits that exceed PRGs/ESLs, and the exceedances are relatively low, i.e., the detection limits are of the same order of magnitude as the PRGs/ESLs. All detection limits are below the PRGs/ESLs in subsurface soil/subsurface sediment and subsurface soil. Therefore, it is concluded that instances where detection limits exceed PRGs and ESLs represent only minimal uncertainty in the overall risk conclusions (see Appendix A, Volume 3, Attachment 1 of the RI/FS report for a more detailed discussion).

1.3 Data Quality Assessment

A Data Quality Assessment (DQA) of the WAEU data was conducted to determine whether the data were of sufficient quality for risk assessment use. The DQA is presented in Attachment 2, and an evaluation of the entire RFETS data set is presented in Appendix A, Volume 2 of the RI/FS Report. The quality of the laboratory results were evaluated for compliance with the CRA Methodology DQOs through an overall review of precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. This review concluded that the data are of sufficient quality for use in the CRA and that the CRA DQOs have been met.

2.0 SELECTION OF HUMAN HEALTH CONTAMINANTS OF CONCERN

The human health contaminant of concern (COC) screening process is described in Section 4.4 of the CRA Methodology and summarized in Appendix A, Volume 2 of the RI/FS Report (Section 2.2).

The human health COC selection process was conducted for surface soil/surface sediment and subsurface soil/subsurface sediment in the WAEU. Results of the COC selection process are summarized below.

2.1 Contaminant of Concern Selection for Surface Soil/Surface Sediment

Detected PCOCs in surface soil/surface sediment samples (Table 1.2) are screened in accordance with the CRA Methodology to identify the COCs.

2.1.1 Surface Soil/Surface Sediment Cation/Anion and Essential Nutrient Screen

The major cations and anions that do not have toxicity criteria are eliminated from assessments in surface soil/surface sediment in accordance with the CRA Methodology.

The essential nutrient screen for analytes detected in surface soil/surface sediment is presented in Table 2.1. The screen includes PCOCs that are essential for human health and do not have toxicity criteria available. Table 2.1 shows the maximum detected concentrations (MDCs) for essential nutrients, daily intake estimates based on the MDCs, and dietary reference intakes (DRIs). The DRIs are identified in the table as recommended daily allowances (RDAs), recommended daily intakes (RDIs), adequate intakes (AIs), and upper limit daily intakes (ULs). The estimated daily maximum intakes based on the nutrients' MDCs and a surface soil/surface sediment ingestion rate of 100 milligrams per day (mg/day) are less than the DRIs. Therefore, these PCOCs were not further evaluated as COCs for surface soil/surface sediment.

2.1.2 Surface Soil/Surface Sediment Preliminary Remediation Goals Screen

Table 2.2 compares the MDCs and upper confidence limits on the means (UCLs) to the WRW PRGs for each PCOC. If the MDC and the UCL are greater than the PRG, the

PCOC is retained for further screening; otherwise, it is not further evaluated. Arsenic, cesium-137, and radium-228 in surface soil/surface sediment had MDCs and UCLs that exceeded the PRGs and were retained as PCOCs. Cesium-134 was also retained as a PCOC because the MDC exceeded the PRG. A comparison of the UCL for cesium-134 could not be performed because a UCL could not be calculated based on the number of samples.

PRGs were not available for several PCOCs in surface soil/surface sediment. Analytes without PRGs are listed on Table 2.2 and their effect on the conclusions of the risk assessment results is discussed in the uncertainty section (Section 6.0).

2.1.3 Surface Soil/Surface Sediment Detection Frequency Screen

Arsenic was detected in more than 5 percent of surface soil/surface sediment samples and, therefore, was retained for further evaluation in the COC screen (Table 1.2). A detection frequency screen was not performed for cesium-134, cesium-137, and radium-228 in surface soil/surface sediment because all reported values for radionuclides are considered detects.

2.1.4 Surface Soil/Surface Sediment Background Analysis

Results of the background statistical comparison for arsenic is presented in Table 2.3 and discussed in Attachment 3. Box plots for arsenic (both WAEU and background) are provided in Attachment 3. Arsenic is the only PCOC that was statistically greater than background at the 0.1 significance level, and it is evaluated further in the professional judgment section.

The PRG exceedances seen for cesium-134, cesium-137, and radium-228 were from samples that are part of the background data set and were not carried forward through the formal statistical analysis. Therefore, these analytes were not further evaluated as PCOCs in surface soil/surface sediment in the WAEU.

2.1.5 Surface Soil/Surface Sediment Professional Judgment Evaluation

Based on the weight of available evidence evaluated by professional judgment, PCOCs will either be included for further evaluation as COCs or excluded as COCs. The professional judgment evaluation takes into account process knowledge, spatial trends, and pattern recognition. As discussed in Section 1.2 and Attachment 2, the sample results are adequate for use in the professional judgment because they are of sufficient quality for use in the CRA.

Based on the weight of evidence described in Attachment 3, arsenic in surface soil/surface sediment in the WAEU is not considered a COC because the weight of evidence supports the conclusion that arsenic concentrations in surface soil/surface sediment in the WAEU are not a result of RFETS activities, but rather are representative of naturally occurring concentrations.

2.2 Contaminant of Concern Selection for Subsurface Soil/Subsurface Sediment

Detected PCOCs in subsurface soil/subsurface sediment samples (Table 1.3) are screened in accordance with the CRA Methodology to identify the COCs.

2.2.1 Subsurface Soil/Subsurface Sediment Cation/Anion and Essential Nutrient Screen

The major cations and anions that do not have toxicity criteria were eliminated from assessments in subsurface soil/subsurface sediment in accordance with the CRA Methodology.

Essential nutrients without toxicity criteria that were detected in subsurface soil/subsurface sediment in the WAEU are compared to DRIs in Table 2.4. The estimated daily maximum intakes for these PCOCs, based on the nutrients' MDCs and a subsurface soil/subsurface sediment ingestion rate of 100 mg/day, are less than the DRIs. Therefore, these PCOCs were not further evaluated as COCs for subsurface soil/subsurface sediment.

2.2.2 Subsurface Soil/Subsurface Sediment Preliminary Remediation Goal Screen

The PRG screen for detected analytes in subsurface soil/subsurface sediment is presented in Table 2.5. The MDC for all PCOCs were less than the PRGs and, therefore, the UCLs were not compared to the PRGs. No detected PCOCs in subsurface soil/subsurface sediment in the WAEU were retained for further evaluation in the COC selection process.

PRGs were not available for several PCOCs in subsurface soil/subsurface sediment. Analytes without PRGs are listed on Table 2.5 and their effect on the conclusions of the risk assessment results is discussed in the uncertainty section (Section 6.0).

2.2.3 Subsurface Soil/Subsurface Sediment Detection Frequency Screen

The detection frequency screen was not performed for subsurface soil/subsurface sediment because there were no PCOCs with concentrations greater than the PRGs.

2.2.4 Subsurface Soil/Subsurface Sediment Background Analysis

The background analysis was not performed for subsurface soil/subsurface sediment because there were no PCOCs with concentrations greater than the PRGs.

2.2.5 Subsurface Soil/Subsurface Sediment Professional Judgment Evaluation

The professional judgment step was not performed for subsurface soil/subsurface sediment because there were no PCOCs with concentrations greater than the PRGs.

2.3 Contaminant of Concern Selection Summary

A summary of the results of the COC screening process is presented in Table 2.6. No COCs were selected for any of the media at the WAEU.

3.0 HUMAN HEALTH EXPOSURE ASSESSMENT

The Site Conceptual Model (SCM), presented in Figure 2.1 of the CRA Methodology and discussed in Appendix A, Volume 2 of the RI/FS Report, provides an overview of potential human exposures at RFETS for reasonably anticipated land use. However, all PCOCs were eliminated from further consideration as human health COCs for the WAEU based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). A quantitative risk characterization is not necessary for the WAEU and, therefore, an exposure assessment was not conducted.

4.0 HUMAN HEALTH TOXICITY ASSESSMENT

Procedures and assumptions for the toxicity assessment are presented in the CRA Methodology. All PCOCs were eliminated from further consideration as human health COCs for the WAEU based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). A quantitative risk characterization is not necessary for the WAEU and therefore, a toxicity assessment was not conducted.

5.0 HUMAN HEALTH RISK CHARACTERIZATION

Information from the exposure assessment and the toxicity assessment is integrated in this section to characterize risk to the WRW and WRV receptors. However, all PCOCs were eliminated from further consideration as human health COCs based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). Therefore, a quantitative risk characterization was not performed for the WAEU.

6.0 UNCERTAINTIES ASSOCIATED WITH THE HUMAN HEALTH RISK ASSESSMENT

There are various types of uncertainties associated with steps of an HHRA. General uncertainties common to the EUs are discussed in Appendix A, Volume 2, of the RI/FS Report. Uncertainties specific to the EU are described below.

6.1 Uncertainties Associated With the Data

Data adequacy for this CRA is evaluated and discussed in Appendix A, Volume 2 of the RI/FS Report. Although there are some uncertainties associated with the sampling and analyses conducted for surface soil/surface sediment and subsurface soil/subsurface sediment at the WAEU, data are considered adequate for the characterization of risk at the EU. The environmental samples for the WAEU were collected from 1991 through 2004. The sampling and analysis requirements for the BZ (DOE 2004, 2005a) specify that the minimum sampling density requirement for surface soil/surface sediment is one five-sample composite for every 30-acre grid cell. In surface soil/surface sediment, there are up to 20 samples in the WAEU depending on the analyte. In subsurface soil/subsurface sediment, there are up to seven samples in the WAEU depending on the analyte.

Another source of uncertainty in the data is the relationship of detection limits to the PRGs for analytes eliminated as COCs because they were either not detected or had a low detection frequency (i.e., less than five percent). The detection limits were appropriate for the analytical methods used, and this is examined in greater detail in Attachment 1.

6.2 Uncertainties Associated With Screening Values

The COC screening analyses utilized RFETS-specific PRGs based on a WRW scenario. The assumptions used in the development of these values were conservative. For example, it is assumed that a future WRW will consume 100 mg of surface soil/surface sediment for 230 days per year for a period of 18.7 years. In addition, a WRW is assumed to be dermally exposed to and inhale surface soil and surface sediment particles in the air. These assumptions are likely to overestimate actual exposures to surface soil for WRWs in the WAEU because a WRW will not spend 100 percent of his or her time in this area. Exposure to subsurface soil and subsurface sediment is assumed to occur 20 days per year. The WRW PRGs for subsurface soil/subsurface sediment are also expected to conservatively estimate potential exposures because it is unlikely a WRW will excavate extensively in the WAEU.

6.3 Uncertainties Associated with Potential Contaminants of Concern without Preliminary Remediation Goals

PCOCs for the WAEU for which PRGs are not available are listed in Table 6.1.

Uncertainties associated with the lack of PRGs for analytes listed in Table 6.1 are considered small. The listed inorganics are not usually included in HHRAs because they are not expected to result in significant human health impacts. Radionuclide PRGs are available for all detected individual radionuclides. Therefore, the lack of PRGs for the gross alpha and gross beta activities is not expected to affect the results of the HHRA.

6.4 Uncertainties Associated with Eliminating Potential Contaminants of Concern Based on Professional Judgment

Arsenic in surface soil/surface sediment was eliminated as a COC based on professional judgment. There is no identified source or pattern of release in the WAEU and the slightly elevated median value of arsenic in the WAEU is most likely due to natural variation. The weight of evidence presented in Attachment 3, Section 4.0 supports the conclusion that concentrations of arsenic are naturally occurring and not due to site activities. Uncertainty associated with the elimination of this chemical as a COC is low.

No PCOCs were eliminated in subsurface soil/subsurface sediment based on professional judgment in the WAEU.

6.5 Uncertainties Evaluation Summary

Evaluation of the uncertainties associated with the data and the COC screening process indicates there is reasonable confidence in the conclusions of the WAEU risk characterization.

7.0 IDENTIFICATION OF ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN

The ecological contaminant of potential concern (ECOPC) identification process streamlines the ecological risk characterization for each EU by focusing the assessment on ECOIs that are present in the WAEU. ECOIs are defined as any chemical detected in the WAEU and are assessed for surface soils and subsurface soils. ECOIs for sediments and surface water are assessed in Appendix A, Volume 15 of the RI/FS Report. The ECOPC process is described in the CRA Methodology and additional details are provided in Appendix A, Volume 2 of the RI/FS Report.

The process is based on the site conceptual model (SCM) presented in the CRA Methodology and described in detail in Appendix A, Volume 2 of the RI/FS Report. The SCM presents the pathways of potential exposure from documented historical source areas (IHSSs and PACs) to the receptors of concern. Generally the most significant exposure pathways for wildlife at the WAEU are the ingestion of plant, invertebrate, or animal tissue that could have accumulated ECOIs from the source areas through direct uptake or dietary routes, as well as the direct ingestion of potentially contaminated media. For terrestrial plans and invertebrates, the most significant exposure pathway is direct contact with potentially contaminated soil.

The receptors of concern that were selected for assessment are listed in Table 7.1 and discussed in detail in Appendix A, Volume 2 of the RI/FS Report, and include representative birds and mammals in addition to the general plant and terrestrial invertebrate communities. The receptors were selected based on several criteria, including their potential to be found in the various habitats present within RFETS, their potential to come into contact with ECOIs, and the amount of life history and behavioral information available.

The ECOPC process consists of two separate evaluations, one for the PMJM receptor and one for non-PMJM receptors. The ECOPC identification process for the PMJM is conducted separately from non-PMJM receptors because the PMJM is a federally listed threatened species under the Endangered Species Act (63 FR 26517). The assessment of risk to the PMJM is addressed in the RCEU and IDEU because habitat for the PMJM within the WAEU is a small subset of the larger PMJM habitat areas in the RCEU and IDEU (Figure 1.5)

7.1 Data Used in the Ecological Risk Assessment

The following WAEU data are used in the CRA:

- A total of 10 surface soil samples were collected and analyzed for inorganics (10 samples) and radionuclides (10 samples) (Table 1.1).
- A total of seven subsurface soil samples were collected and analyzed for inorganics (seven samples), organics (five samples), and radionuclides (seven samples) (Table 1.1).

A data summary is provided in Table 1.4 for surface soil and Table 1.5 for subsurface soil.

Sediment and surface water data for the WAEU were collected (Section 1.2) and are evaluated for the ERA in Appendix A, Volume 15 of the RI/FS Report.

7.2 Identification of Surface Soil Ecological Contaminants of Potential Concern

ECOPCs for surface soil were identified for non-PMJM receptors in accordance with the sequence presented in the CRA Methodology.

7.2.1 Comparison to No Observed Adverse Effect Level Ecological Screening Levels

In the first step of the ECOPC identification process, the MDCs of ecological contaminants of interest (ECOIs) in surface soil were compared to receptor-specific no observed adverse effect level (NOAEL) ESLs. NOAEL ESLs for surface soil were developed in the CRA Methodology for three receptor groups: terrestrial vertebrates, terrestrial invertebrates, and terrestrial plants.

Non-PMJM Receptors

The NOAEL ESLs for non-PMJM receptors are compared to MDCs in surface soil in Table 7.1. The results of the NOAEL ESL screening analyses for all receptor types are summarized in Table 7.2. Analytes with a "Yes" in any of the "Exceedance" columns in Table 7.2 are evaluated further.

NOAEL ESLs were not available for several ECOI/receptor pairs (Tables 7.1 and 7.2). These ECOI/receptor pairs are discussed as ECOIs with uncertain toxicity in Section 10.0, along with the potential impacts to the risk assessment.

PMJM Receptors

No screening for PMJM receptors was conducted in the WAEU.

7.2.2 Surface Soil Frequency of Detection Evaluation

The ECOPC identification process for non-PMJM receptors includes an evaluation of detection frequency for each ECOI retained after the NOAEL screening step. If the detection frequency is less than 5 percent, then population-level risks are considered highly unlikely and the ECOI is not further evaluated. The detection frequencies for chemicals in surface soil are presented in Table 7.3. None of the chemicals in surface soil at the WAEU that were retained after the NOAEL ESL screening step had a detection frequency of less than 5 percent. Therefore, no ECOIs were excluded based on the detection frequency evaluation for surface soil in the WAEU.

7.2.3 Surface Soil Background Comparisons

The ECOIs retained after the NOAEL ESL screening and the detection frequency evaluation were then compared to site-specific background concentrations where available. The background comparison is presented in Table 7.3 and discussed in Attachment 3. The statistical methods used for the background comparison are summarized in Appendix A, Volume 2 of the RI/FS Report.

Non-PMJM Receptors

The results of the background comparisons for the non-PMJM receptors are presented in Table 7.3 and discussed in Attachment 3. Aluminum, arsenic, boron, chromium, lithium, and thallium are retained as ECOIs and are evaluated further using upper-bound EPCs in the following section.

PMJM Receptors

No background analysis was conducted for PMJM receptors in the WAEU.

7.2.4 Exposure Point Concentration Comparisons to Threshold ESLs

The ECOIs retained after completion of all previous evaluations for non-PMJM receptors were compared to threshold ESLs (tESLs) using upper-bound EPCs specific to small and large home-range receptors. The calculation of EPCs is discussed in Appendix A, Volume 2 of the RI/FS Report.

Statistical concentrations for each ECOI retained for the tESL screen are presented in Table 7.4. The EPC for the small home-range receptors is the 95 percent UCL of the 90th percentile (upper tolerance limit [UTL]), or the MDC in the event that the UTL is greater than the MDC. The EPC for large home-range receptors is the UCL, or the MDC in the event that the UCL is greater than the MDC.

Small home-range receptors include terrestrial plants, terrestrial invertebrates, mourning dove, American kestrel, deer mouse, and black-tailed prairie dog. These receptors are evaluated by comparing the small home-range EPC (UTL) for each ECOI to the limiting (or lowest) small home-range receptor tESL (if available). In the event that tESLs are not available, the limiting NOAEL ESL is used in accordance with the CRA Methodology.

Large home-range receptors, such as the coyote and mule deer are evaluated by comparing the large home-range EPC (UCL) for each ECOI to the limiting large home-range receptor tESL (if available). In the event that tESLs are not available, the limiting NOAEL ESL is used in accordance with the CRA Methodology.

The EPC comparison to limiting tESLs for small and large home-range receptors is presented in Table 7.5. Analytes exceeding the limiting tESLs for small home-range receptors are compared to receptor-specific tESLs in Table 7.6. No analytes exceeded the limiting tESLs for large home-range receptors.

Chemicals that exceed any tESLs (if available) are assessed in the professional judgment evaluation. Any analyte/receptor pairs that are retained through professional judgment are identified as ECOPCs and are carried forward in the risk characterization.

7.2.5 Surface Soil Professional Judgment Evaluation

Non-PMJM Receptors

Based on the weight-of-evidence, professional judgment described in Attachment 3, aluminum, arsenic, boron, chromium, lithium, and thallium in surface soil in the WAEU were not considered ECOPCs for non-PMJM receptors and are not further evaluated quantitatively.

PMJM Receptors

No professional judgment evaluation was conducted for PMJM receptors in the WAEU.

7.2.6 Summary of Surface Soil Ecological Contaminants of Potential Concern

The ECOPC screening process for surface soil is summarized below for non-PMJM receptors and PMJM receptors.

Non-PMJM Receptors

All surface soil ECOIs for non-PMJM receptors in the WAEU were eliminated from further consideration as ECOPCs based on one of the following: 1) the MDC of the ECOI was less than the lowest ESL; 2) no ESLs were available (these ECOIs are discussed in Section 10.0); 3) the concentration of the ECOI in WAEU surface soil was not statistically greater than background surface soils; 4) the upper-bound EPC did not exceed the limiting tESL; or 5) the weight-of-evidence, professional judgment evaluation indicated that the ECOI was not a site-related contaminant of potential concern. No chemicals were retained as surface soil ECOPCs for the WAEU.

A summary of the ECOPC screening process for non-PMJM receptors is presented in Table 7.7.

PMJM Receptors

No ECOPC identification for PMJM receptors was conducted in the WAEU.

7.3 Identification of Subsurface Ecological Contaminants of Potential Concern

Subsurface soil sampling locations for soil collected at a starting depth of 0.5 to 8 feet bgs in the WAEU are identified on Figure 1.7. A data summary for subsurface soil less than 8 feet bgs is presented in Table 1.5. Soil in the area where the subsurface soil samples were collected has subsequently been impacted by mining activities and the data from the impacted soil are not representative of current conditions. For purposes of conservatism, the subsurface soil data are assessed as though no disturbance has occurred.

7.3.1 Comparison to No Observed Adverse Effect Level Ecological Screening Levels

The CRA Methodology indicates subsurface soil is evaluated for those ECOIs that have greater concentrations in the subsurface than in surface soil. As a conservative screening step, subsurface soil is evaluated for all EUs regardless of the presence/absence of a change in concentrations from surface soil and subsurface soil. The MDCs of ECOIs in subsurface soil were compared to NOAEL ESLs for burrowing receptors (Table 7.8). There were no ECOIs with MDCs greater than the NOAEL ESL for the prairie dog; therefore, no analytes were further evaluated in the ECOPC identification process.

NOAEL ESLs are not available for some analytes, and these are identified as “N/A” in Table 7.8. These constituents are considered ECOIs with uncertain toxicity (UT) and are discussed in the uncertainty section (Section 10.0).

7.3.2 Subsurface Soil Detection Frequency Evaluation

All ECOIs were eliminated from further consideration as ECOPCs in the WAEU subsurface soils in the preceding step. Therefore, no detection frequency evaluation is necessary.

7.3.3 Subsurface Soil Background Comparison

All ECOIs were eliminated from further consideration as ECOPCs in the WAEU subsurface soils in the preceding steps. Therefore, no subsurface soil background comparison is necessary.

7.3.4 Exposure Point Concentration Comparisons to Threshold ESLs

All ECOIs were eliminated from further consideration as ECOPCs in the WAEU subsurface soils in the preceding steps. Therefore, no EPC comparisons to tESLs are necessary.

7.3.5 Subsurface Soil Professional Judgment

All ECOIs were eliminated from further consideration as ECOPCs in the WAEU subsurface soils in the preceding steps. Therefore, no professional judgment evaluation is necessary.

7.3.6 Summary of Subsurface Soil Ecological Contaminants of Potential Concern

All subsurface soil ECOIs for burrowing receptors in the WAEU were eliminated from further consideration as ECOPCs. These ECOIs were eliminated during the first step of the ECOPC identification process because the MDC of the ECOI was less than the NOAEL ESL for the burrowing receptor. The results of the subsurface soil ECOPC identification process for burrowing receptors are summarized in Table 7.9.

7.4 Summary of Ecological Contaminants of Potential Concern

ECOIs in surface and subsurface soil in the WAEU were evaluated in the ECOPC identification process for non-PMJM receptors and burrowing receptors. No ECOPCs were identified in surface (Table 7.7) or subsurface soil (Table 7.9) for non-PMJM or burrowing receptors.

8.0 ECOLOGICAL EXPOSURE ASSESSMENT

The ECOPC identification steps did not identify any ECOPCs for either surface or subsurface soil in the WAEU. Therefore, no exposure assessment for the WAEU was performed.

9.0 ECOLOGICAL TOXICITY ASSESSMENT

The ECOPC identification steps did not identify any ECOPCs for either surface or subsurface soil in the WAEU. Therefore, no toxicity assessment for the WAEU was performed.

10.0 ECOLOGICAL RISK CHARACTERIZATION

Risk characterization includes risk estimation and risk description. Details of these components are described in the CRA Methodology and in Appendix A, Volume 2 of the RI/FS Report. Predicted risks should be viewed in terms of the potential for the assumptions used in the risk characterization to occur in nature, the uncertainties associated with the assumptions, and of the potential for effects on the population of receptors that could inhabit the WAEU.

Because this process did not identify any ECOPCs in either surface or subsurface soil, no risk characterization was performed for the WAEU.

10.1 General Uncertainty Analysis

Quantitative evaluation of ecological risks is limited by uncertainties regarding the assumptions used to predict risk and the data available for quantifying risk. These limitations are usually addressed by making estimates based on the data available or by making assumptions based on professional judgment when data are limited. Because of these assumptions and estimates, the results of the risk calculations themselves are uncertain, and it is important for risk managers and the public to view the results of the risk assessment with this in mind. The following general uncertainties associated with the ERAs for all of the EUs may under- or overestimate risk to an unknown degree. A full discussion of these general uncertainties is provided in Volume 2 of Appendix A of the RI/FS Report:

- Uncertainties associated with data quality and adequacy;
- Uncertainties associated with the ECOPC identification process;
- Uncertainties associated with the selection of representative receptors;
- Uncertainties associated with exposure calculations;
- Uncertainties associated with the development of NOAEL ESLs;
- Uncertainties associated with the lack of toxicity data for ECOIs; and,
- Uncertainties associated with eliminating ECOIs based on professional judgment.

The following sections are potential sources of general uncertainty that are specific to the WAEU ERA.

10.1.1 Uncertainties Associated With Data Adequacy and Quality

Sections 1.2 and 1.3 summarize the general data adequacy and data quality for the WAEU, respectively. A more detailed discussion is presented in Appendix A, Volume 2, Attachments 2 and 3 of the RI/FS Report, and Attachment 2 of this volume. The data quality assessment indicates the data are of sufficient quality for use in the CRA. The adequacy of the WAEU data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial distributions of the data to data adequacy guidelines. The assessment indicates an absence of surface soil organic data, including dioxins. However, other lines of evidence (e.g., information on potential historical sources of contamination, migration pathways, and the concentration levels in the media) indicate organics are not likely to be present in surface soil in the WAEU. Therefore, it is possible to make risk management decisions without additional sampling.

Data used in the CRA must have detection limits to allow meaningful comparison to ESLs. When these detection limits exceed the respective ESLs, this is a source of uncertainty in the risk assessment. Attachment 1 to this volume provides a detection limit adequacy screen where detection limits for non-detected analytes as well as analytes detected in less than 5 percent of the samples are compared to ESLs. For surface soil, only selenium has detection limits that exceed the ESLs, and the exceedances are relatively low, i.e., the detection limits are of the same order of magnitude as the ESLs. All detection limits are below the ESLs in subsurface soil. Therefore, it is concluded that instances where detection limits exceed ESLs represent only minimal uncertainty in the overall risk conclusions.

10.1.2 Uncertainties Associated with the Lack of Toxicity Data for Ecological Contaminant of Interest Detected at the West Area Exposure Unit

Several ECOIs detected in the WAEU do not have adequate toxicity data for the derivation of ESLs (CRA Methodology [DOE 2005a]). These ECOIs are listed in Tables 7.1, 7.2, and 7.8 with a “UT” designation. Included as a subset of the ECOIs with a “UT designation are the essential nutrients (calcium, iron, magnesium, potassium, and sodium). Although these nutrients may be potentially toxic to certain ecological receptors at high concentrations, the uncertainty associated with the toxicity of these nutrients is expected to be low. Appendix B of the CRA Methodology outlines a detailed search process that was intended to provide high-quality toxicological information for a large proportion of the chemicals detected at RFETS. Although the toxicity is uncertain for those ECOIs that do not have ESLs calculated due to a lack of identified toxicity data, the overall effect on the risk assessment is small because the primary chemicals historically used at RFETS have adequate toxicity data for use in the CRA. Therefore, while the potential for risk from these ECOIs is uncertain and will tend to underestimate the overall risk calculated, the magnitude of underestimation is likely to be low.

10.1.3 Uncertainties Associated With Eliminating Ecological Contaminants of Interest Based on Professional Judgment

Aluminum, arsenic, boron, chromium, lithium, and thallium were eliminated as ECOIs in surface soil based on professional judgment. The professional judgment evaluation is intended to identify those ECOIs that have a limited potential for contamination in the WAEU. The weight-of-evidence approach indicates that the ECOI concentrations likely represent variations in the naturally occurring elements because there is no identified contaminant source or pattern of release in the WAEU, and the WAEU is hydraulically isolated from historical IHSSs in the former Industrial Area. Furthermore, the ECOI concentrations in the WAEU are unlikely to result in risk concerns for ecological receptors. Therefore, the professional judgment evaluation is unlikely to have a significant effect on the overall risk calculations.

10.1.4 Summary of Significant Sources of Uncertainty

The preceding discussion outlined the significant sources of uncertainty in the CRA process for assessing ecological risk. While some of the general sources of uncertainty discussed tend to either underestimate risk or overestimate risk, many result in an unknown effect on the potential risks. However, the CRA Methodology outlines a tiered process of risk evaluation that includes conservative assumptions for the ECOPC identification process and more realistic assumptions, as appropriate, for risk characterization.

11.0 SUMMARY AND CONCLUSIONS

A summary of the results of this CRA for human health and ecological receptors in the WAEU is presented below.

11.1 Data Adequacy

The adequacy of the WAEU data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial distributions of the data to data adequacy guidelines. The assessment indicates an absence of surface soil organic data. Furthermore, the sediment sample locations are confined to streams located in the southern half of the EU, and therefore, do not meet the data adequacy guideline for spatial representativeness. However, other lines of evidence (e.g., information on potential historical sources of contamination, migration pathways, and the concentration levels in the media) indicate organics are not likely to be present in surface soil in the WAEU, and existing sediment data are representative of the entire EU. Therefore, it is possible to make risk management decisions without additional sampling. In addition, for analytes that are not detected or detected at a frequency less than 5%, in surface soil/surface sediment and surface soil, very few have detection limits that exceed PRGs/ESLs, and the exceedances are relatively low, i.e., the detection limits are of the same order of magnitude as the PRGs/ESLs. All detection limits are below the PRGs/ESLs in subsurface soil/subsurface sediment and subsurface soil. Therefore, it is concluded that instances where detection limits exceed PRGs and ESLs represent only minimal uncertainty in the overall risk estimates.

11.2 Human Health

The COC screening analyses compared MDCs and UCLs of chemicals and radionuclides in WAEU media to PRGs for the WRW receptor. PCOCs with UCLs greater than the PRGs were statistically compared to the background concentration data set. Inorganic analytes that were statistically greater than background at the 0.1 significance level, and organics with UCL concentrations greater than the PRG were carried forward to professional judgment evaluation. Based on the COC selection process, no COCs were selected for surface soil/surface sediment and subsurface soil/subsurface sediment in the WAEU and a risk characterization was not performed for the WAEU. Only one analyte (arsenic) had concentrations in WAEU surface soil/surface sediment that were statistically greater than RFETS background. However, arsenic was subsequently eliminated as a COC in the professional judgment evaluation step of the COC selection process because the weight of evidence supports the conclusion that arsenic concentrations in the WAEU are not the result of RFETS activities, but rather are representative of naturally occurring concentrations. For comparison purposes, the cancer risks and noncancer hazard indices were estimated for the wildlife refuge worker (WRW) and wildlife refuge visitor (WRV) for arsenic in WAEU surface soil/surface sediment and in RFETS background surface soil/surface sediment. The estimated cancer risks for the WRW and WRV associated with potential exposure to arsenic in surface soil/surface sediment in the WAEU are both approximately 4E-06. The estimated noncancer hazard indices associated with potential exposure to arsenic in surface soil/surface sediment in the WAEU are approximately 0.03 for the WRW and 0.02 for the WRV. The estimated cancer risks for the WRW and WRV associated with potential exposure to RFETS background levels of arsenic in surface soil/surface sediment are 2E-06 and 1E-06, respectively. The estimated noncancer hazard indices associated with potential exposure to RFETS background levels of arsenic in surface soil/surface sediment are approximately 0.01 for the WRW and 0.007 for the WRV. No analytes in subsurface soil/subsurface sediment were statistically greater than RFETS background. These results indicate that potential health risks for the WRW and WRV in the WAEU are expected to be similar to background risks and there are no significant human health risks from RFETS-related operations at the WAEU.

11.3 Ecological Risk

The ECOPC identification process streamlines the ecological risk characterization by focusing the assessment on ECOIs that are present in the WAEU. The ECOPC identification process is described in the CRA methodology and additional details are provided in Appendix A, Volume 2 of the RI/FS Report. All ECOIs in surface soil were eliminated from further consideration as ECOPCs based on comparisons of MDCs to NOAEL ESLs, background comparisons, tESL comparisons, or professional judgment. Based on the weight-of-evidence, professional judgment described in Attachment 3, aluminum, arsenic, boron, chromium, lithium, and thallium in surface soil in the WAEU were not considered ECOPCs for non-PMJM receptors and were not further evaluated quantitatively. Although there are no organic data for surface soil, other lines of evidence indicate organics are not expected to be present in WAEU surface soil , and accordingly, are not of concern to ecological receptors. Following a similar ECOPC identification process for burrowing receptors, no ECOIs in subsurface soil were evaluated in professional judgment (all ECOIs were eliminated in previous steps) and therefore, no ECOPCs were identified for burrowing receptors. No PMJM habitat was evaluated in the ERA because minimal PMJM habitat exists within WAEU. The assessment of risk to the PMJM is addressed in the RCEU and IDEU because habitat for the PMJM within the WAEU is a small subset of the larger PMJM habitat areas in the RCEU and IDEU.

Because this process did not identify any ECOPCs in the WAEU, no risk characterization was performed and site-related risks are likely to be minimal for the ecological receptors evaluated in the WAEU. In addition, data collected on wildlife abundance and diversity indicate that wildlife species richness remains high at RFETS. Because there are no significant risks to ecological receptors or high levels of uncertainty with the data, there are no ecological contaminants of concern (ECOCs) for the WAEU.

12.0 REFERENCES

CNHP, 1994. Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation. Phase 1: Lower Woman. Final Report. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

DOE, 1992a. Final Historical Release Report for Rocky Flats Plant, Golden, Colorado. June.

DOE, 1992b. Environmental Restoration Final Phase I RFI/RI Work Plan for OU 11 (West Spray Field), Rocky Flats Environmental Technology Site, Golden, Colorado. September 14.

DOE, 1995. Final Letter Report – Colorado Department of Public Health and Environment Source Area Delineation and Risk-Based Conservative Screen and Environmental Protection Agency Area of Concern Delineation. Rocky Flats Environmental Technology Site OU 11, West Spray Field, Golden, Colorado. June.

DOE, 2004. Comprehensive Risk Assessment Sampling and Analysis Plan Addendum, #04-01, Rocky Flats Environmental Technology Site, Golden, Colorado. March.

DOE, 2005a. Final Comprehensive Risk Assessment Work Plan and Methodology, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1. September.

DOE, 2005b. 2005 Annual Update to the Historical Release Report, Rocky Flats Environmental Technology Site, Golden, Colorado.

Interagency Agreement (IAG), 1991. Federal Facility Agreement and Consent Order CERCLA VIII-91-03, RCRA (3008(h)) VIII-91-07 and State of Colorado Docket Number 91-01-22-01.

K-H, 2002. 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

National Academy of Sciences (NAS), 2000. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Institute of Medicine, Food and Nutrition Board.

Rocky Flats Cleanup Agreement (RFCA), 1996. CERCLA Federal Facility Agreement and RCRA/CHWA Consent Order (CERCLA VIII-96-21; RCRA (3008(h)) VIII-96-01; State of Colorado Docket #96-07-19-0).

United States Fish and Wildlife Service (USFWS), 2005. Rocky Flats National Wildlife Refuge, Final Comprehensive Conservation Plan. U.S. Fish and Wildlife Service. April.

TABLES

Table 1.1
Number of Samples in Each Medium by Analyte Suite

Analyte Suite	Surface Soil/Surface Sediment[a]	Subsurface Soil/Subsurface Sediment[a]	Surface Soil[b]	Subsurface Soil[b]
Inorganics	20	7	10	7
Organics	10	5	0	5
Radionuclides	18	7	10	7

[a] Used in the HHRA.

[b] Used in the ERA.

Note: The total number of results (samples) for the analytes listed in Tables 1.2 to 1.5 may differ from the number of samples presented in Table 1.1 because not all analyses are necessarily performed for each sample.

Table 1.2
Summary of Detected Analytes in Surface Soil/Surface Sediment

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum		20	100	2,390	19,400	11,521	5,128
Antimony[c]	0.3 - 14.1	20	20	0.340	12.4	2.67	3.71
Arsenic		20	100	1.40	22.0	5.83	4.57
Barium		20	100	22.2	244	106	51.7
Beryllium	0.26 - 0.83	20	50	0.250	1.40	0.415	0.285
Boron		10	100	2.80	7.10	5.11	1.20
Cadmium	0.069 - 1.3	20	15	0.410	1.30	0.298	0.345
Calcium		20	100	530	4,800	2,489	1,242
Cesium[c]	1.7 - 275	10	10	4.90	4.90	24.1	42.9
Chromium		20	100	2.10	24.8	11.9	5.30
Cobalt		20	100	2.60	10.1	5.73	1.97
Copper	4.7 - 4.7	20	95	4.30	25.9	11.8	6.45
Iron		20	100	4,440	23,400	13,142	4,549
Lead		20	100	2.80	48.0	22.3	12.7
Lithium		20	100	2.70	20.3	8.82	4.29
Magnesium		20	100	662	4,330	2,055	934
Manganese		20	100	101	470	249	92.8
Mercury	0.06 - 0.21	20	50	0.020	0.030	0.045	0.026
Molybdenum	0.9 - 4.1	20	65	0.320	2.40	0.934	0.596
Nickel	7.9 - 7.9	20	95	3.10	17.6	9.10	3.70
Nitrate / Nitrite	0.1 - 2.8	10	60	0.300	76.0	15.1	29.2
Potassium		20	100	423	2,890	1,679	711
Silica		10	100	670	790	735	42.5
Silicon[c]		2	100	187	252	220	46.0
Silver	0.084 - 1.7	19	10.5	0.120	2.00	0.323	0.454
Sodium	140 - 150	20	60	75.2	559	176	132
Strontium		20	100	4.10	41.2	21.4	9.45
Thallium[c]	0.24 - 1	20	10	0.400	1.30	0.409	0.257
Tin	0.89 - 45.8	20	15	3.60	17.5	3.97	5.99
Titanium[c]		10	100	150	320	236	58.2
Vanadium		20	100	8.00	51.9	27.0	9.88
Zinc		20	100	21.0	720	129	202
Organics (ug/kg)							
2-Butanone	13 - 29	9	11.1	3	3	7.67	3.05
4-Methylphenol	390 - 1,200	10	10	95	95	394	184
Benzoic Acid	1,900 - 5,600	10	30	380	480	1,442	937
bis(2-ethylhexyl)phthalate	390 - 1,200	10	30	69	250	377	201
Di-n-butylphthalate	390 - 1,200	10	40	52	150	289	186
Fluoranthene	390 - 1,200	10	10	88	88	411	180
Pyrene	390 - 1,200	10	10	61	61	409	186
Toluene	6 - 14	10	10	2	2	4.00	1.29
Radionuclides (pCi/g)[d]							
Americium-241		18	N/A	-0.016	0.087	0.023	0.032
Cesium-134		2	N/A	0.079	0.087	0.083	0.006
Cesium-137		8	N/A	0.002	1.50	0.382	0.507
Gross Alpha		8	N/A	15.3	72.0	35.0	19.7
Gross Beta		8	N/A	35.0	59.0	43.3	7.41
Plutonium-239/240		18	N/A	-0.078	0.250	0.044	0.073
Radium-226		4	N/A	0.390	1.80	1.06	0.693
Radium-228		4	N/A	0.940	4.10	2.41	1.39
Strontium-89/90		8	N/A	0.080	0.319	0.217	0.091
Uranium-233/234		18	N/A	0.630	3.08	1.28	0.745
Uranium-235		18	N/A	-0.011	0.189	0.076	0.067
Uranium-238		18	N/A	0.65	2.81	1.29	0.716

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.

[c]All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] All radionuclide values are considered detects.

N/A = Not applicable; not calculated. Only one sample was collected.

Table 1.3
Summary of Detected Analytes in Subsurface Soil/Subsurface Sediment

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum		7	100	3,130	15,400	9,153	4,749
Arsenic		7	100	2.40	5.90	3.36	1.25
Barium		7	100	21.9	64.0	45.1	14.3
Beryllium		7	100	0.270	1.20	0.656	0.357
Calcium		7	100	347	3,160	1,237	995
Cesium[c]	8.4 - 8.8	7	28.6	1.20	1.70	3.49	1.40
Chromium		7	100	13.1	22.8	15.7	3.60
Cobalt		7	100	3.50	13.7	7.17	3.29
Copper		7	100	4.80	12.5	8.63	2.93
Iron		7	100	6,830	18,100	10,736	4,093
Lead[c]		7	100	2.80	13.9	6.91	3.97
Lithium[c]		7	100	2.00	7.80	5.20	2.27
Magnesium		7	100	308	3,160	1,223	954
Manganese		7	100	90.5	295	151	67.5
Mercury[c]	0.05 - 0.1	7	14.3	0.100	0.100	0.048	0.025
Nickel	7.9 - 7.9	7	85.7	5.70	12.6	7.89	2.81
Nitrate / Nitrite[c]		5	100	0.100	1.00	0.380	0.356
Potassium		7	100	318	1,010	780	249
Selenium	0.21 - 0.43	7	14.3	0.390	0.390	0.204	0.093
Sodium		7	100	30.3	559	152	202
Strontium		7	100	7.10	45.0	17.0	13.8
Tin[c]	2.3 - 2.4	7	28.6	32.9	33.9	10.4	15.7
Vanadium		7	100	9.10	36.1	20.9	9.19
Zinc	4.2 - 10.1	7	57.1	14.3	26.9	12.5	9.23
Organics (ug/kg)							
Acetone		1	100	2.00	2.00	2.00	N/A
bis(2-ethylhexyl)phthalate	340 - 340	5	80.0	38.0	93.0	86.8	51.3
Diethylphthalate	330 - 350	5	20.0	130	130	163	18.9
Di-n-butylphthalate		5	100	240	410	350	66.7
Fluoranthene	330 - 350	5	20.0	48.0	48.0	146	54.7
Toluene	5 - 5	4	50.0	2.00	3.00	2.50	0.408
Radionuclides (pCi/g)[d]							
Americium-241		5	N/A	0.002	0.013	0.006	0.004
Gross Alpha		2	N/A	13.9	21.1	17.5	5.09
Gross Beta		2	N/A	18.1	20.6	19.4	1.77
Plutonium-239/240		5	N/A	-0.002	0.032	0.007	0.014
Strontium-89/90		2	N/A	-0.030	0.133	0.052	0.115
Uranium-233/234		5	N/A	0.840	2.30	1.57	0.541
Uranium-235		5	N/A	0.033	0.100	0.063	0.026
Uranium-238		5	N/A	0.710	2.30	1.52	0.607

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] All radionuclide values are considered detects

N/A = Not applicable.

Table 1.4
Summary of Detected Analytes in Surface Soil

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum		10	100	8,200	18,000	13,520	3,168
Antimony[c]	0.3 - 0.34	10	20	0.340	0.600	0.219	0.146
Arsenic		10	100	3.60	22.0	8.48	5.07
Barium		10	100	68.0	140	109	24.5
Beryllium[c]	0.36 - 0.83	10	40	0.250	0.520	0.358	0.099
Boron		10	100	2.80	7.10	5.11	1.20
Calcium		10	100	880	4,600	2,308	943
Chromium		10	100	8.10	17.0	13.3	2.65
Cobalt		10	100	3.80	6.40	5.04	0.934
Copper		10	100	5.20	13.0	9.77	2.20
Iron		10	100	8,900	16,000	13,190	2,414
Lead		10	100	9.90	48.0	30.5	11.3
Lithium[c]		10	100	5.70	12.0	9.28	1.74
Magnesium		10	100	1,000	2,500	1,920	432
Manganese		10	100	150	320	260	55.8
Mercury		10	100	0.020	0.030	0.025	0.003
Molybdenum		10	100	0.320	0.910	0.613	0.200
Nickel		10	100	4.90	11.0	8.79	1.62
Potassium		10	100	1,200	2,800	2,050	455
Silica[c]		10	100	670	790	735	42.5
Silver	0.084 - 0.4	10	10	0.120	0.120	0.086	0.052
Sodium	140 - 150	10	20	140	200	91.5	43.8
Strontium		10	100	9.60	24.0	20.3	4.20
Thallium[c]	0.96 - 1	10	10	1.30	1.30	0.571	0.256
Titanium		10	100	150	320	236	58.2
Vanadium		10	100	19.0	34.0	28.0	5.06
Zinc		10	100	21.0	50.0	37.0	9.01
Radionuclides (pCi/g)[d]							
Americium-241		10	N/A	-0.016	0.080	0.028	0.034
Plutonium-239/240		10	N/A	-0.078	0.250	0.066	0.094
Uranium-233/234		10	N/A	0.710	1.27	0.888	0.203
Uranium-235		10	N/A	-0.011	0.189	0.084	0.084
Uranium-238		10	N/A	0.678	1.70	0.985	0.331

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics, statistics are computed using one-half the reported value for nondetects.

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection

[d] All radionuclide values are considered detects.

N/A = Not applicable.

Table 1.5
Summary of Detected Analytes in Subsurface Soil

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum		7	100	3,130	15,400	9,153	4,749
Arsenic		7	100	2.40	5.90	3.36	1.25
Barium		7	100	21.9	64.0	45.1	14.3
Beryllium		7	100	0.270	1.20	0.656	0.357
Calcium		7	100	347	3,160	1,237	995
Cesium[c]	8.4 - 8.8	7	28.6	1.20	1.70	3.49	1.40
Chromium		7	100	13.1	22.8	15.7	3.60
Cobalt		7	100	3.50	13.7	7.17	3.29
Copper		7	100	4.80	12.5	8.63	2.93
Iron		7	100	6,830	18,100	10,736	4,093
Lead[c]		7	100	2.80	13.9	6.91	3.97
Lithium[c]		7	100	2.00	7.80	5.20	2.27
Magnesium		7	100	308	3,160	1,223	954
Manganese		7	100	90.5	295	151	67.5
Mercury[c]	0.05 - 0.1	7	14.3	0.100	0.100	0.048	0.025
Nickel	7.9 - 7.9	7	85.7	5.70	12.6	7.89	2.81
Nitrate / Nitrite[c]		5	100	0.100	1.00	0.380	0.356
Potassium		7	100	318	1,010	780	249
Selenium	0.21 - 0.43	7	14.3	0.390	0.390	0.204	0.093
Sodium		7	100	30.3	559	152	202
Strontium		7	100	7.10	45.0	17.0	13.8
Tin[c]	2.3 - 2.4	7	28.6	32.9	33.9	10.4	15.7
Vanadium		7	100	9.10	36.1	20.9	9.19
Zinc	4.2 - 10.1	7	57.1	14.3	26.9	12.5	9.23
Organics (ug/kg)							
Acetone		1	100	2.00	2.00	2.00	N/A
bis(2-ethylhexyl)phthalate	340 - 340	5	80.0	38.0	93.0	86.8	51.3
Diethylphthalate	330 - 350	5	20.0	130	130	163	18.9
Di-n-butylphthalate		5	100	240	410	350	66.7
Fluoranthene	330 - 350	5	20.0	48.0	48.0	146	54.7
Toluene	5 - 5	4	50.0	2.00	3.00	2.50	0.408
Radionuclides (pCi/g)[d]							
Americium-241		5	N/A	0.002	0.013	0.006	0.004
Gross Alpha		2	N/A	13.9	21.1	17.5	5.09
Gross Beta		2	N/A	18.1	20.6	19.4	1.77
Plutonium-239/240		5	N/A	-0.002	0.032	0.007	0.014
Strontium-89/90		2	N/A	-0.030	0.133	0.052	0.115
Uranium-233/234		5	N/A	0.840	2.30	1.57	0.541
Uranium-235		5	N/A	0.033	0.100	0.063	0.026
Uranium-238		5	N/A	0.710	2.30	1.52	0.607

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] All radionuclide values are considered detects.

N/A = Not applicable.

Table 2.1
Essential Nutrient Screen for Surface Soil/Surface Sediment

Analyte	MDC (mg/kg)	Estimated Maximum Daily Intake[a] (mg/day)	RDA/RDI/AI[b] (mg/day)	UL[b] (mg/day)	Retain for PRG Screen?
Calcium	4,800	0.480	500-1,200	2,500	No
Magnesium	4,330	0.433	80-420	65-110	No
Potassium	2,890	0.289	2,000-3,500	N/A	No
Sodium	559	0.056	500-2,400	N/A	No

[a] Based on the MDC and a 100 mg/day soil ingestion rate for a WRW.

[b] RDA/RDI/AI/UL taken from NAS 2000, 2002.

N/A = Not available.

Table 2.2
PRG Screen for Surface Soil/Surface Sediment

Analyte	PRG[a]	MDC	MDC Greater Than PRG?	UCL[b]	UCL Greater Than PRG?	Retain for Detection Frequency Screen?
Inorganics (mg/kg)						
Aluminum	24,774	19,400	No	--	--	No
Antimony	44.4	12.4	No	--	--	No
Arsenic	**2.41**	**22.0**	**Yes**	**11.6**	**Yes**	**Yes**
Barium	2,872	244	No	--	--	No
Beryllium	100	1.40	No	--	--	No
Boron	9,477	7.10	No	--	--	No
Cadmium	91.4	1.30	No	--	--	No
Cesium	N/A	4.90	UT	--	--	UT
Chromium[c]	28.4	24.8	No	--	--	No
Cobalt	122	10.1	No	--	--	No
Copper	4,443	25.9	No	--	--	No
Iron	33,326	23,400	No	--	--	No
Lead	1,000	48.0	No	--	--	No
Lithium	2,222	20.3	No	--	--	No
Manganese	419	470	Yes	292	No	No
Mercury	32.9	0.030	No	--	--	No
Molybdenum	555	2.40	No	--	--	No
Nickel	2,222	17.6	No	--	--	No
Nitrate / Nitrite[d]	177,739	76.0	No	--	--	No
Silica	N/A	790	UT	--	--	UT
Silicon	N/A	252	UT	--	--	UT
Silver	555	2.00	No	--	--	No
Strontium	66,652	41.2	No	--	--	No
Thallium	7.78	1.30	No	--	--	No
Tin	66,652	17.5	No	--	--	No
Titanium	169,568	320	No	--	--	No
Vanadium	111	51.9	No	--	--	No
Zinc	33,326	720	No	--	--	No
Organics (ug/kg)						
2-Butanone	4.64E+07	3.00	No	--	--	No
4-Methylphenol	400,718	95.0	No	--	--	No
Benzoic Acid	3.21E+08	480	No	--	--	No
bis(2-ethylhexyl)phthalate	213,750	250	No	--	--	No
Di-n-butylphthalate	8.01E+06	150	No	--	--	No
Fluoranthene	2.96E+06	88.0	No	--	--	No
Pyrene	2.22E+06	61.0	No	--	--	No
Toluene	3.09E+06	2.00	No	--	--	No
Radionuclides (pCi/g)						
Americium-241	7.69	0.087	No	--	--	No
Cesium-134	**0.080**	**0.087**	**Yes**	**N/A**	**N/A**	**Yes**
Cesium-137	**0.221**	**1.50**	**Yes**	**1.22**	**Yes**	**Yes**
Gross alpha	N/A	72.0	UT	--	--	UT
Gross beta	N/A	59.0	UT	--	--	UT
Plutonium-239/240	9.80	0.250	No	--	--	No
Radium-226	2.69	1.80	No	--	--	No
Radium-228	**0.111**	**4.10**	**Yes**	**4.04**	**Yes**	**Yes**
Strontium-89/90	13.2	0.319	No	--	--	No
Uranium-233/234	25.3	3.08	No	--	--	No
Uranium-235	1.05	0.189	No	--	--	No
Uranium-238	29.3	2.81	No	--	--	No

[a] The value shown is equal to the most stringent of the PRGs based on a risk of 1E-06 or an HQ of 0.1.

[b] UCL = Upper confidence limit on the mean, unless the MDC < UCL, then the MDC is used as the UCL.

[c] The PRG for chromium (VI) is used in the PRG screen because it is more conservative than the PRG for chromium (III).

[d] The PRG for nitrate is used.

N/A = Not available.

UT = Uncertain toxicity; no PRG available (assessed in Section 6.0).

-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Bold = Analyte retained for further consideration in the next COC selection step.

Table 2.3

Statistical Distributions and Comparison to Background for the WAEU [a]

	Statistical Distribution Testing Results						Background Comparison		
	Background			WAEU					
Analyte	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Test	1 - p	Retain as PCOC?
Surface Soil/Surface Sediment									
Arsenic	**73**	**GAMMA**	**91.8**	**10**	**GAMMA**	**100**	**WRS**	**7.00E-05**	**Yes**

[a]EU data used for background comparisons do not include data from background locations.

Bold = Analyte retained for further consideration in the next COC selection step.

WRS = Wilcoxon Rank Sum.

Table 2.4

Essential Nutrient Screen for Subsurface Soil/Subsurface Sediment[a]

Analyte	MDC (mg/kg)	Estimated Maximum Daily Intake[b] (mg/day)	RDA/RDI/AI[c] (mg/day)	UL[c] (mg/day)	Retain for PRG Screen?
Calcium	3,160	0.3160	500-1,200	2,500	No
Magnesium	3,160	0.3160	80-420	65-110	No
Potassium	1,010	0.1010	2,000-3,500	N/A	No
Sodium	559	0.0559	500-2,400	N/A	No

[a] Sediment greater than 0.5 feet deep was not sampled at the WAEU. Data in this table are for subsurface soil only.

[b] Based on the MDC and a 100 mg/day soil ingestion rate for a WRW.

[c] RDA/RDI/AI/UL taken from NAS 2000, 2002.

N/A = Not available.

Table 2.5
PRG Screen for Subsurface Soil/Subsurface Sediment[a]

Analyte	PRG[b]	MDC	MDC Greater Than PRG?	UCL[c]	UCL Greater Than PRG?	Retain for Detection Frequency Screen?
Inorganics (mg/kg)						
Aluminum	284,902	15,400	No	--	--	No
Arsenic	27.7	5.90	No	--	--	No
Barium	33,033	64.0	No	--	--	No
Beryllium	1,151	1.20	No	--	--	No
Cesium	N/A	1.70	UT	--	--	UT
Chromium[d]	327	22.8	No	--	--	No
Cobalt	1,401	13.7	No	--	--	No
Copper	51,100	12.5	No	--	--	No
Iron	383,250	18,100	No	--	--	No
Lead	1,000	13.9	No	--	--	No
Lithium	25,550	7.80	No	--	--	No
Manganese	4,815	295	No	--	--	No
Mercury	379	0.100	No	--	--	No
Nickel	25,550	12.6	No	--	--	No
Nitrate / Nitrite[e]	2.04E+06	1.00	No	--	--	No
Selenium	6,388	0.390	No	--	--	No
Strontium	766,500	45.0	No	--	--	No
Tin	766,500	33.9	No	--	--	No
Vanadium	1,278	36.1	No	--	--	No
Zinc	383,250	26.9	No	--	--	No
Organics (ug/kg)						
Acetone	1.15E+09	2.00	No	--	--	No
bis(2-ethylhexyl)phthalate	2.46E+06	93.0	No	--	--	No
Diethylphthalate	7.37E+08	130	No	--	--	No
Di-n-butylphthalate	9.22E+07	410	No	--	--	No
Fluoranthene	3.40E+07	48.0	No	--	--	No
Toluene	3.56E+07	3.00	No	--	--	No
Radionuclides (pCi/g)						
Americium-241	88.4	0.013	No	--	--	No
Gross alpha	N/A	21.1	UT	--	--	UT
Gross beta	N/A	20.6	UT	--	--	UT
Plutonium-239/240	112	0.032	No	--	--	No
Strontium-89/90	152	0.133	No	--	--	No
Uranium-233/234	291	2.30	No	--	--	No
Uranium-235	12.1	0.100	No	--	--	No
Uranium-238	337	2.30	No	--	--	No

[a] Sediment greater than 0.5 feet deep was not sampled at the WAEU. Data in this table are for subsurface soil only.
[b] The value shown is equal to the most stringent of the PRGs based on a risk of 1E-06 or an HQ of 0.1.
[c] UCL = 95 percent upper confidence limit on the mean, unless the MDC < UCL, then the MDC is used as the UCL.
[d] The PRG for chromium (VI) is used in the PRG screen because it is more conservative than the PRG for chromium (III).
[e] The PRG for nitrate is used.
N/A = Not available.
UT = Uncertain toxicity; no PRG available (assessed in Section 6.0).
-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Table 2.6
Summary of the COC Selection Process

Analyte	MDC Exceeds PRG?	UCL Exceeds PRG?	Detection Frequency > 5%?[a]	Exceeds 30x the PRG?	Exceeds Background?	Professional Judgment - Retain?	Retain as COC?
Surface Soil/Surface Sediment							
Arsenic	Yes	Yes	Yes	N/A	Yes	No	No
Manganese	Yes	No	– –	– –	– –	– –	No
Cesium-134	Yes	N/A	N/A	N/A	No[b]	– –	No
Cesium-137	Yes	Yes	N/A	N/A	No[b]	– –	No
Radium-228	Yes	Yes	N/A	N/A	No[b]	– –	No
Subsurface Soil/Subsurface Sediment[c]							
None > PRG	No	– –	– –	– –	– –	– –	No

[a] All radionuclide values are considered detects.

[b] The radionuclide was only detected in surface sediment at background locations within the EU.

[c] Sediment greater than 0.5 ft deep was not sampled at the WAEU. Data in this table are for subsurface soil only.

N/A = Not applicable or not available.

-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Table 6.1
Summary of Detected PCOCs Without PRGs[a]

Analyte	Surface Soil/Surface Sediment	Subsurface Soil/Subsurface Sediment
Inorganics		
Cesium	X[b]	X[b]
Silica	X	N/A
Silicon	X[b]	N/A
Radionuclides		
Gross-Alpha	X	X
Gross-Beta	X	X

[a] Does not include essential nutrients. Essential nutrients without PRGs were evaluated by comparing estimated intakes to recommended intakes.

[b]All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

X = PRG is unavailable.

N/A = Not applicable. Analyte not detected or not analyzed.

Table 7.1
Comparison of MDCs in Surface Soil to NOAEL ESLs for Terrestrial Plants, Invertebrates, and Vertebrates (Non-PMJM)

Analyte	MDC	Terrestrial Plants		Terrestrial Invertebrates		Mourning Dove Herbivore		Mourning Dove Insectivore		American Kestrel		Deer Mouse Herbivore		Deer Mouse Insectivore		Prairie Dog		Mule Deer		Coyote Carnivore		Coyote Generalist		Coyote Insectivore		Terrestrial Receptor[a]		Most Sensitive Receptor	Retain for Further Analysis?
		NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	Results	
Inorganics (mg/kg)																													
Aluminum	18,000	**50**	**Yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Plant	**Yes**
Antimony	0.600	5	No	78	No	N/A	N/A	N/A	N/A	N/A	N/A	9.89	No	0.905	No	18.7	No	57.6	No	138	No	13.2	No	3.85	No	N/A	N/A	Deer Mouse Insectivore	No
Arsenic	22	**10**	**Yes**	60	No	**20.0**	**Yes**	164	No	1,028	No	**2.57**	**Yes**	51.4	No	**9.35**	**Yes**	**13.0**	**Yes**	709	No	341	No	293	No	N/A	N/A	Deer Mouse Herbivore	**Yes**
Barium	140	500	No	330	No	159	No	357	No	1,317	No	930	No	4,427	No	3,224	No	4,766	No	24,896	No	19,838	No	18,369	No	N/A	N/A	Dove Herbivore	No
Beryllium	0.520	10	No	40	No	N/A	N/A	N/A	N/A	N/A	N/A	160	No	6.82	No	211	No	896	No	1,072	No	103	No	29.2	No	N/A	N/A	Deer Mouse Insectivore	No
Boron	7.10	**0.500**	**Yes**	N/A	N/A	30.3	No	115	No	167	No	62.1	No	422	No	237	No	314	No	929	No	6,070	No	1,816	No	N/A	N/A	Plant	**Yes**
Calcium	4,600	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Chromium[b]	17	**1**	**Yes**	**0.400**	**Yes**	24.6	No	**1.34**	**Yes**	14.0	**Yes**	281	No	**15.9**	**Yes**	703	No	1,461	No	4,173	No	250	No	68.5	No	N/A	N/A	Invertebrates	**Yes**
Cobalt	6.40	13	No	N/A	N/A	278	No	87.0	No	440	No	1,476	No	363	No	2,461	No	7,902	No	3,785	No	2,492	No	1,519	No	N/A	N/A	Dove Insectivore	No
Copper	13	100	No	50	No	28.9	No	**8.25**	**Yes**	164	No	295	No	605	No	838	No	4,119	No	5,459	No	3,000	No	4,641	No	N/A	N/A	Dove Insectivore	**Yes**
Iron	16,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Lead	48	110	No	1,700	No	49.9	No	**12.1**	**Yes**	95.8	No	1,344	No	242	No	1,850	No	9,798	No	8,927	No	3,066	No	1,393	No	N/A	N/A	Dove Insectivore	**Yes**
Lithium	12	**2**	**Yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,882	No	610	No	3,178	No	10,173	No	18,431	No	5,608	No	2,560	No	N/A	N/A	Plant	**Yes**
Magnesium	2,500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Manganese	320	500	No	N/A	N/A	1,032	No	2,631	No	9,917	No	486	No	4,080	No	1,519	No	2,506	No	14,051	No	10,939	No	19,115	No	N/A	N/A	Deer Mouse Herbivore	No
Mercury	0.0300	0.300	No	0.100	No	0.197	No	**1.00E-04**	**Yes**	1.57	No	0.439	No	0.179	No	3.15	No	7.56	No	8.18	No	8.49	No	37.3	No	N/A	N/A	Dove Insectivore	**Yes**
Molybdenum	0.910	2	No	N/A	N/A	44.4	No	6.97	No	76.7	No	8.68	No	1.90	No	27.1	No	44.3	No	275	No	28.9	No	8.18	No	N/A	N/A	Deer Mouse Insectivore	No
Nickel	11	30	No	200	No	44.1	No	**1.24**	**Yes**	13.1	No	16.4	No	**0.431**	**Yes**	38.3	No	124	No	90.9	No	**6.02**	**Yes**	**1.86**	**Yes**	N/A	N/A	Deer Mouse Insectivore	**Yes**
Potassium	2,800	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Silica	790	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Silver	0.120	2	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Plant	No
Sodium	200	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Strontium	24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	940	No	13,578	No	3,519	No	4,702	No	584,444	No	144,904	No	57,298	No	N/A	N/A	Deer Mouse Herbivore	No
Thallium	1.30	**1**	**Yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	180	No	7.24	No	204	No	1,039	No	212	No	81.6	No	30.8	No	N/A	N/A	Plant	**Yes**
Titanium	320	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Vanadium	34	**2**	**Yes**	N/A	N/A	503	No	274	No	1,514	No	63.7	No	**29.9**	**Yes**	83.5	No	358	No	341	No	164	No	121	No	N/A	N/A	Plant	**Yes**
Zinc	50	50	No	200	No	109	No	**0.646**	**Yes**	113	No	171	No	**5.29**	**Yes**	1,174	No	2,772	No	16,489	No	3,887	No	431	No	N/A	N/A	Dove Insectivore	**Yes**
Radionuclides (pCi/g)																													
Americium-241	0.0804	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,890	No	N/A	No
Plutonium-239/240	0.250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,110	No	N/A	No
Uranium-233/234	1.27	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,980	No	N/A	No
Uranium-235	0.189	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,770	No	N/A	No
Uranium-238	1.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,580	No	N/A	No

[a] Radionuclide ESLs are not receptor-specific. They are considered protective of all terrestrial ecological species.

[b] The ESLs for chromium were developed using toxicity data based on chromium III (birds) and chromium VI (plants, invertebrates, and mammals).

N/A = No ESL was available for that ECOI/receptor pair.

UT = Uncertain toxicity; no ESL available (assessed in Section 10.0).

Bold = MDC exceeds one or more ESLs. Analyte retained for further consideration in the next ECOPC selection step.

Table 7.2
Summary of Non-PMJM NOAEL ESL Screening Results for Surface Soil in the WAEU

Analyte	Terrestrial Plant Exceedance?	Terrestrial Invertebrate Exceedance?	Terrestrial Vertebrate Exceedance?
Inorganics			
Aluminum	**Yes**	UT	UT
Antimony	No	No	No
Arsenic	**Yes**	No	**Yes**
Barium	No	No	No
Beryllium	No	No	No
Boron	**Yes**	UT	No
Calcium	UT	UT	UT
Chromium	**Yes**	**Yes**	**Yes**
Cobalt	No	UT	No
Copper	No	No	**Yes**
Iron	UT	UT	UT
Lead	No	No	**Yes**
Lithium	**Yes**	UT	No
Magnesium	UT	UT	UT
Manganese	No	UT	No
Mercury	No	No	**Yes**
Molybdenum	No	UT	No
Nickel	No	No	**Yes**
Potassium	UT	UT	UT
Silica	UT	UT	UT
Silver	No	UT	UT
Sodium	UT	UT	UT
Strontium	UT	UT	No
Thallium	**Yes**	UT	No
Titanium	UT	UT	UT
Vanadium	**Yes**	UT	**Yes**
Zinc	No	No	**Yes**
Radionuclides			
Americium-241	UT	UT	No
Plutonium-239/240	UT	UT	No
Uranium-233/234	UT	UT	No
Uranium-235	UT	UT	No
Uranium-238	UT	UT	No

UT = Uncertain toxicity; no ESLs available (assessed in Section 10).
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.3
Statistical Distributions and Comparisons to Background for WAEU Surface Soil

Analyte	Statistical Distribution Testing Results						Background Comparison		
	Background			WAEU					
	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Test	1 - p	Retain as ECOI?
Aluminum	**20**	**NORMAL**	**100**	**10**	**NORMAL**	**100**	**t-Test_N**	**0.00649**	**Yes**
Arsenic	**20**	**NORMAL**	**100**	**10**	**GAMMA**	**100**	**WRS**	**0.0673**	**Yes**
Boron	**N/A**	**N/A**	**N/A**	**10**	**NORMAL**	**100**	**N/A**	**N/A**	**N/A**
Chromium	**20**	**NORMAL**	**100**	**10**	**NORMAL**	**100**	**t-Test_N**	**0.0305**	**Yes**
Copper	20	NON-PARAMETRIC	100	10	NORMAL	100	WRS	0.999	No
Lead	20	NORMAL	100	10	NORMAL	100	t-Test_N	0.764	No
Lithium	**20**	**NORMAL**	**100**	**10**	**NORMAL**	**100**	**t-Test_N**	**0.0156**	**Yes**
Mercury	20	NON-PARAMETRIC	40	10	NORMAL	100	WRS	1.000	No
Nickel	20	NORMAL	100	10	NORMAL	100	t-Test_N	0.812	No
Thallium	**14**	**NORMAL**	**0**	**10**	**NON-PARAMETRIC**	**10**	**N/A**	**N/A**	**N/A**
Vanadium	20	NORMAL	100	10	NORMAL	100	t-Test_N	0.461	No
Zinc	20	NORMAL	100	10	NORMAL	100	t-Test_N	0.997	No

N/A = Not applicable. Background comparison was not performed because background data were not available or detection frequency of on analyte in EU or background data set is less 20 percent.
Test: WRS = Wilcoxon Rank Sum, t-Test_N = Student's t-test using normal data, t-Test-LN = Student's t-test using log-transformed data.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.4
Statistical Concentrations in WAEU Surface Soil

Analyte	Units	Number of Samples	Mean	Median	75th percentile	95th percentile	UCL[a]	UTL[b]	Maximum[c]
Aluminum	mg/kg	10	13,500	13,500	15,000	18,000	15,400	21,000	18,000
Arsenic	mg/kg	10	8.48	7.60	8.85	16.3	11.6	22	22
Boron	mg/kg	10	5.11	5	5.73	6.79	5.80	7.93	7.10
Chromium	mg/kg	10	13.3	13.5	14.8	16.6	14.8	19.5	17
Lithium	mg/kg	10	9.28	9.40	10	11.6	10.3	13.4	12
Thallium	mg/kg	10	0.571	0.493	0.499	0.940	0.720	1.30	1.30

[a] UCL = Upper confidence limit on the mean, unless the MDC < UCL, then the MDC is used as the UCL.

[b] UTL = 95% upper confidence limit on the 90th percentile value, unless the MDC < UCL, then the MDC is used as the UCL.

[c] Maximum = Maximum proxy result; may be MDC or reporting limit greater than MDC.

Table 7.5
Upper-Bound Exposure Point Concentration Comparison to Limiting ESLs

Analyte	Small Home Range Receptors			Large Home Range Receptors		
	EPC (UTL)	Limiting ESL[a]	EPC>ESL?	EPC (UCL)	Limiting ESL[b]	EPC>ESL?
Inorganics (mg/kg)						
Aluminum	**21,000**	**50**	**Yes**	15,400	N/A	N/A
Arsenic	**22**	**9.87**	**Yes**	11.6	49.9	No
Boron	**7.93**	**0.500**	**Yes**	5.80	314	No
Chromium[c]	**19.5**	**0.400**	**Yes**	14.8	68.5	No
Lithium	**13.4**	**2**	**Yes**	10.3	2,560	No
Thallium	**1.30**	**1**	**Yes**	0.720	53.3	No

[a]Lowest ESL (threshold if available) for the plant, invertebrate, deer mouse, prairie dog, dove, or kestrel receptors.

[b]Lowest ESL (threshold if available) for the coyote and mule deer receptors.

[c] The ESLs for chromium (VI) are used.

N/A = Not applicable; ESL not available (assessed in Section 10).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.6
Upper-Bound Exposure Point Concentration Comparison to Receptor-Specific ESLs for Small Home Range Receptors

Analyte	Small Home Range Receptor UTL	Receptor-Specific ESLs[a]							
		Terrestrial Plant	Terrestrial Invertebrate	American Kestrel	Mourning Dove (herbivore)	Mourning Dove (insectivore)	Deer Mouse (herbivore)	Deer Mouse (insectivore)	Prairie Dog
Inorganics (mg/kg)									
Aluminum	21,000	N/A	**50**	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	22	**10**	60	1,028	**20**	164	**2.57**	51.4	**9.35**
Boron	7.93	**0.500**	N/A	167	30.3	115	62.1	422	237
Chromium[b]	19.5	**1**	**0.400**	**14.2**	24.6	**1.34**	281	**15.9**	703
Lithium	13.4	**2**	N/A	N/A	N/A	N/A	1,880	610	3,180
Thallium	1.30	**1**	N/A	N/A	N/A	N/A	312	12.5	350

[a] Lowest ESL (threshold if available) for that receptor.

[c] The ESLs for chromium (VI) are used.

N/A = Not applicable; ESL not available (assessed in Section 10).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.7
Summary of ECOPC Screening Steps for Surface Soil Non-PMJM Receptors

Analyte	Exceeds Any NOAEL ESL?	Detection Frequency >5%?	Exceeds Background?[a]	Upper-Bound EPC > Limiting tESL?	Professional Judgment - Retain?	Retain as ECOPC?	Receptor(s) of Potential Concern
Inorganics							
Aluminum	Yes	Yes	Yes	Yes	No	No	--
Antimony	No	--	--	--	--	No	--
Arsenic	Yes	Yes	Yes	Yes	No	No	--
Barium	No	--	--	--	--	No	--
Beryllium	No	--	--	--	--	No	--
Boron	Yes	Yes	N/A	Yes	No	No	--
Calcium	UT	--	--	--	--	No	--
Chromium	Yes	Yes	Yes	Yes	No	No	--
Cobalt	No	--	--	--	--	No	--
Copper	Yes	Yes	No	--	--	No	--
Iron	UT	--	--	--	--	No	--
Lead	Yes	Yes	No	--	--	No	--
Lithium	Yes	Yes	Yes	Yes	No	No	--
Magnesium	UT	--	--	--	--	No	--
Manganese	No	--	--	--	--	No	--
Mercury	Yes	Yes	No	--	--	No	--
Molybdenum	No	--	--	--	--	No	--
Nickel	Yes	Yes	No	--	--	No	--
Potassium	UT	--	--	--	--	No	--
Silica	UT	--	--	--	--	No	--
Silver	No	--	--	--	--	No	--
Sodium	UT	--	--	--	--	No	--
Strontium	No	--	--	--	--	No	--
Thallium	Yes	Yes	N/A	Yes	No	No	--
Titanium	UT	--	--	--	--	No	--
Vanadium	Yes	Yes	No	--	--	No	--
Zinc	Yes	Yes	No	--	--	No	--
Radionuclides							
Americium-241	No	--	--	--	--	No	--
Plutonium-239/240	No	--	--	--	--	No	--
Uranium-233	No	--	--	--	--	No	--
Uranium-235	No	--	--	--	--	No	--
Uranium-238	No	--	--	--	--	No	--

[a] Based on results of statistical analysis at the 0.1 level of significance.
-- = Screen not performed because analyte was eliminated from further consideration in a previous ECOPC selection step.
UT = Uncertain toxicity; ESL not available (assessed in Section 10.0).
N/A = Not applicable.

Table 7.8
Comparison of MDCs in WAEU Subsurface Soil to NOAEL ESLs for Burrowing Receptors

Analyte	MDC	Prairie Dog NOAEL ESL	MDC > ESL?
Inorganics (mg/kg)			
Aluminum	15,400	N/A	UT
Arsenic	5.90	9.35	No
Barium	64	3,220	No
Beryllium	1.20	211	No
Calcium	3,160	N/A	UT
Cesium	1.70	N/A	UT
Chromium[b]	22.8	703	No
Cobalt	13.7	2,461	No
Copper	12.5	838	No
Iron	18,100	N/A	UT
Lead	13.9	1,850	No
Lithium	7.80	3,180	No
Magnesium	3,160	N/A	UT
Manganese	295	1,519	No
Mercury	0.100	3.15	No
Nickel	12.6	38.3	No
Nitrate / Nitrite	1	16,200	No
Potassium	1,010	N/A	UT
Selenium	0.390	2.80	No
Sodium	559	N/A	UT
Strontium	45	3,519	No
Tin	33.9	80.6	No
Vanadium	36.1	83.5	No
Zinc	26.9	1,170	No
Organics (ug/kg)			
Acetone[a]	2	248	No
bis(2-Ethylhexyl)phthalate[a]	93	2,760	No
Diethylphthalate[a]	130	221,000	No
Di-nbutylphthalate	410	40,600	No
Fluoranthene	48	N/A	UT
Toluene[a]	3	1,220	No
Radionuclides (pCi/g)			
Americium-241	0.0130	3,890	No
Gross Alpha	21.1	N/A	UT
Gross Beta	20.6	N/A	UT
Plutonium-239/240	0.0320	6,110	No
Strontium-89/90	0.133	22.5	No
Uranium-233/234	2.30	4,980	No
Uranium-235	0.100	2,770	No
Uranium-238	2.30	1,580	No

[a.] All detections are "J" qualified, signifying that the reported result is an estimated value that is below the method detection limit, but above the instrument detection limit.

[b] The ESL for chromium (VI) is used.

N/A = ESL not available.

UT = Uncertain toxicity; ESL not available (assessed in Section 10).

Table 7.9
Summary of ECOPC Screening Steps for Subsurface Soil

Analyte	Exceeds Any NOAEL ESL?	Frequency of Detection >5%	Exceeds Background?[a]	Upper Bound EPC > Limiting ESL?	Professional Judgment - Retain?	Retain as ECOPC?	Receptor(s) of Potential Concern
Inorganics							
Aluminum	UT	--	--	--	--	No	--
Arsenic	No	--	--	--	--	No	--
Barium	No	--	--	--	--	No	--
Beryllium	No	--	--	--	--	No	--
Calcium	UT	--	--	--	--	No	--
Cesium	UT	--	--	--	--	No	--
Chromium	No	--	--	--	--	No	--
Cobalt	No	--	--	--	--	No	--
Copper	No	--	--	--	--	No	--
Iron	UT	--	--	--	--	No	--
Lead	No	--	--	--	--	No	--
Lithium	No	--	--	--	--	No	--
Magnesium	UT	--	--	--	--	No	--
Manganese	No	--	--	--	--	No	--
Mercury	No	--	--	--	--	No	--
Nickel	No	--	--	--	--	No	--
Nitrate / Nitrite	No	--	--	--	--	No	--
Potassium	UT	--	--	--	--	No	--
Selenium	No	--	--	--	--	No	--
Sodium	UT	--	--	--	--	No	--
Strontium	No	--	--	--	--	No	--
Tin	No	--	--	--	--	No	--
Vanadium	No	--	--	--	--	No	--
Zinc	No	--	--	--	--	No	--
Organics							
Acetone	No	--	--	--	--	No	--
bis(2-Ethylhexyl)phthalate	No	--	--	--	--	No	--
Diethylphthalate	No	--	--	--	--	No	
Di-nbutylphthalate	No	--	--	--	--	No	--
Fluoranthene	UT	--	--	--	--	No	--
Toluene	No	--	--	--	--	No	--
Radionuclides							
Americium-241	No	--	--	--	--	No	--
Gross Alpha	UT	--	--	--	--	No	--
Gross Beta	UT	--	--	--	--	No	--
Plutonium-239/240	No	--	--	--	--	No	--
Strontium-89/90	No	--	--	--	--	No	--
Uranium-233/234	No	--	--	--	--	No	--
Uranium-235	No	--	--	--	--	No	--
Uranium-238	No	--	--	--	--	No	--

[a] Based on results of statistical analysis at the 0.1 level of significance.
-- = Screen not performed because analyte was eliminated from further consideration in a previous ECOPC selection step.
UT = Uncertain toxicity; ESL not available (assessed in Section 10).

FIGURES

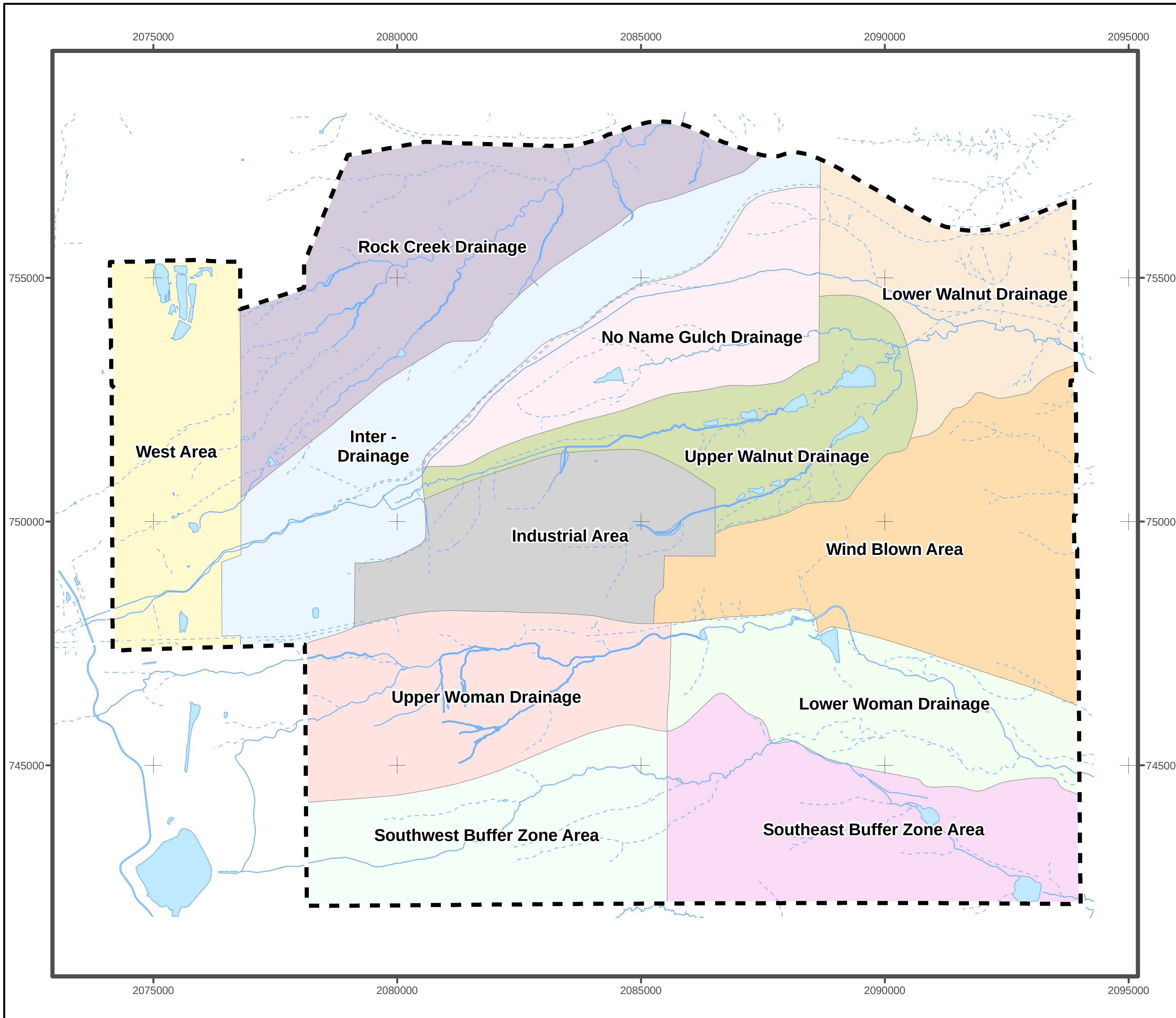


Figure 1.1
Rocky Flats Environmental Technology Site
Exposure Units

KEY

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N S W E

0 1,500 3,000 Feet

Scale 1:36,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\FY2005\CRA\GIS_Final\ArcMap\Section1\EU_Figure_1_1.mxd

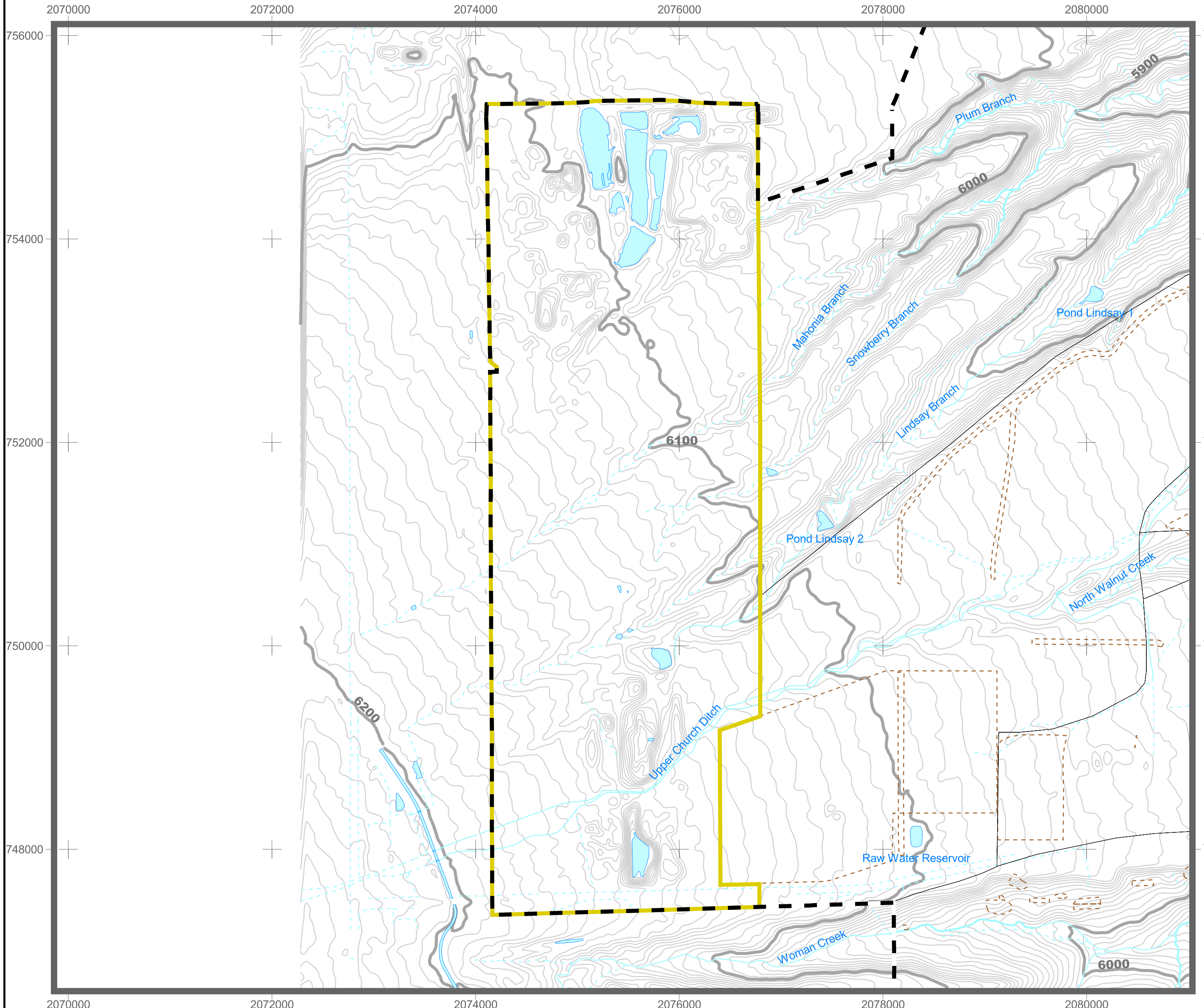


Figure 1.2
Topography and Historical IHSS Locations in the West Area Exposure Unit

KEY

- West Area EU
- Historical IHSS/PAC
- Topographic contour interval = 5 ft.

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N W E S

0 750 1500 Feet

Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

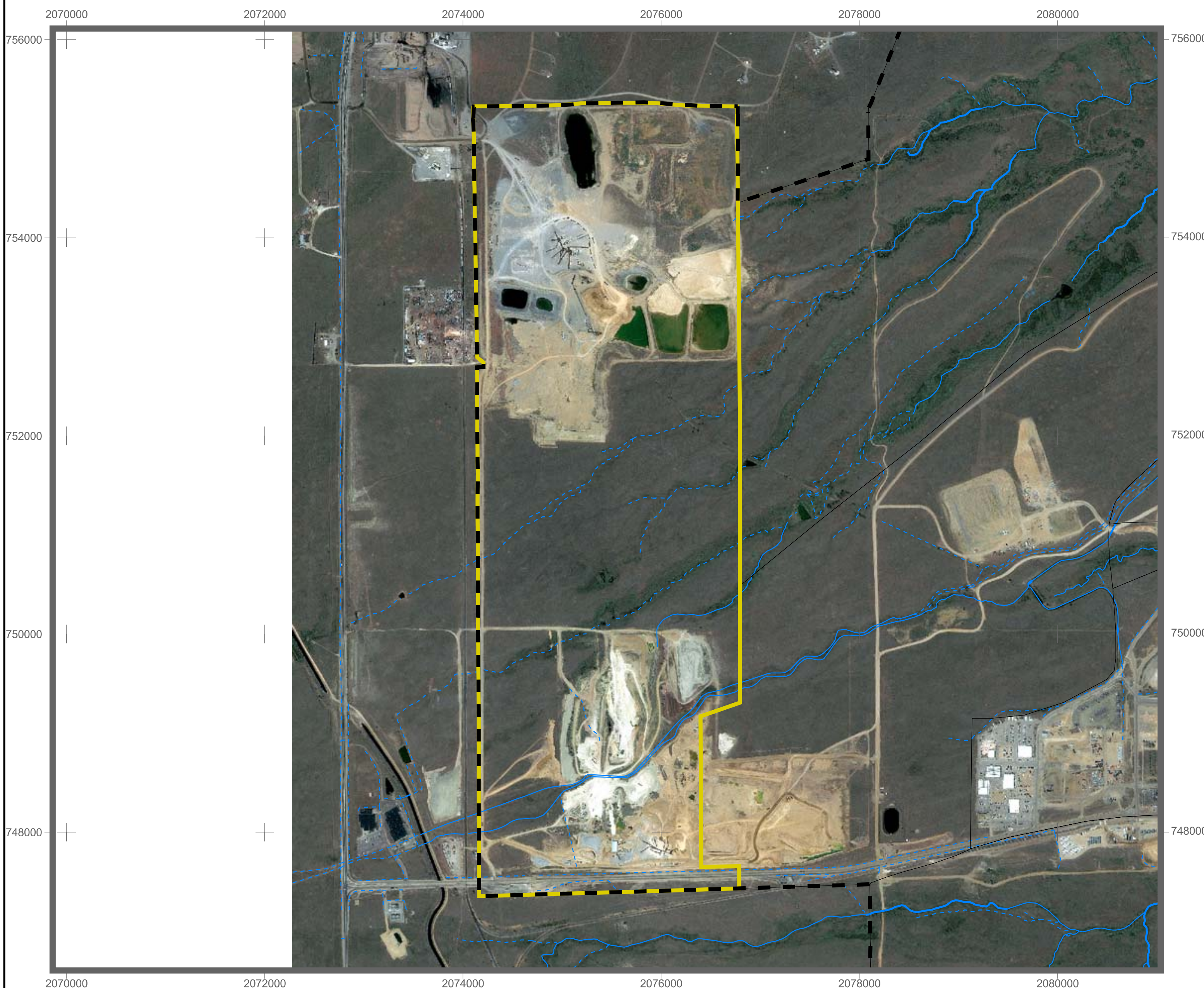


Figure 1.3
Aerial Photograph of the
West Area Exposure Unit
July 2005

KEY

West Area EU

Standard Map Features

Exposure unit boundary
Pond
Site boundary
Perennial stream
Intermittent stream
Ephemeral stream

N
W E
S

0 750 1500 Feet

Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

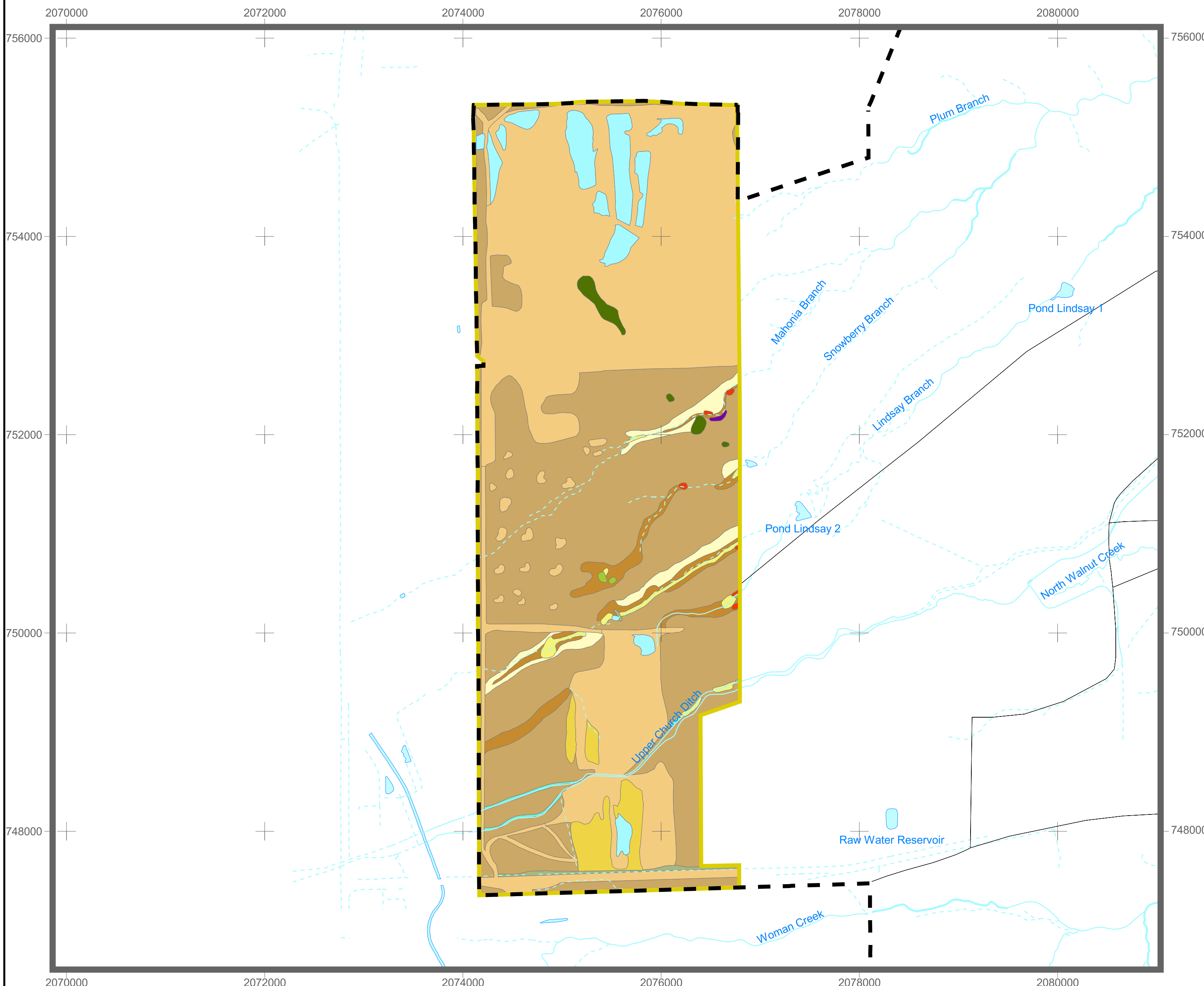


Figure 1.4
Vegetation in the West Area Exposure Unit

KEY

West Area EU

Vegetation, 2005

- Annual grass/forb community
- Disturbed areas
- Disturbed and revegetated areas
- Leadplant riparian shrubland
- Mesic mixed grassland
- Mudflats
- Open water
- Ponderosa woodland
- Reclaimed mixed grassland
- Riparian woodland
- Riprap, rock, and gravel piles
- Savannah shrubland
- Short grassland
- Short marsh
- Short upland shrubland
- Tall marsh
- Tall upland shrubland
- Tree plantings
- Wet meadow/marsh ecotone
- Willow riparian shrubland
- Xeric needle and thread grass prairie
- Xeric tallgrass prairie

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W E
S

0 750 1500 Feet

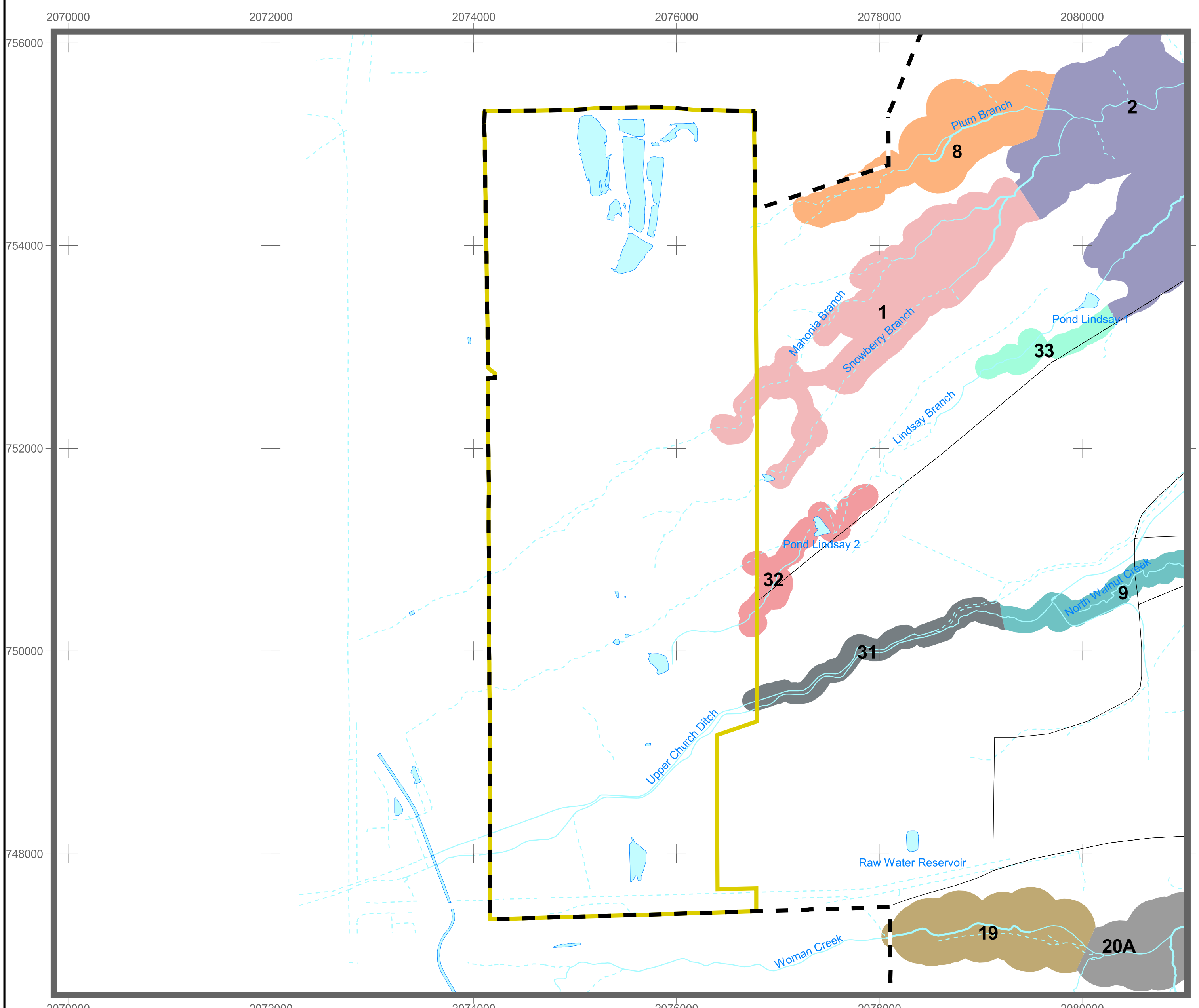
Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

Figure 1.5
Preble's Meadow Jumping Mouse Habitat and Surface Soil Sample Locations in the West Area Exposure Unit



KEY

- Surface soil sample location
- West Area EU
- PMJM habitat patch
- 1 PMJM habitat patch ID

Note: Not all analyte groups were analyzed at every sample location.

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W
E
S

0 750 1500 Feet

Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

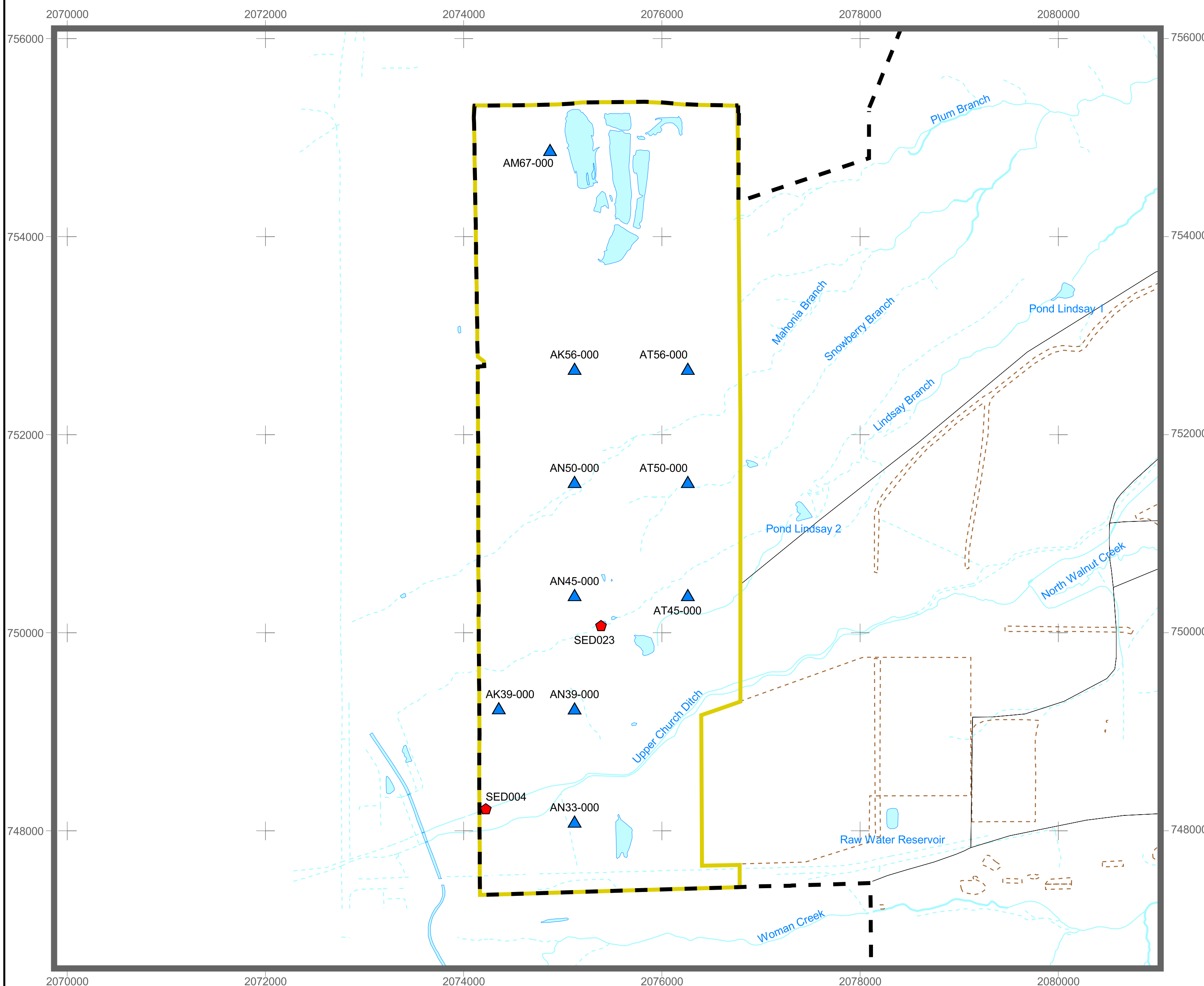


Figure 1.6
West Area Exposure
Unit Surface Soil and Surface
Sediment Sample Locations

KEY

Sample location
- Surface sediment sample location
- Surface soil sample location

(Background locations shown in red)
- Surface sediment sample location
- West Area EU
- Historical IHSS/PAC

Standard Map Features
- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W E
S

0 750 1500 Feet

Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

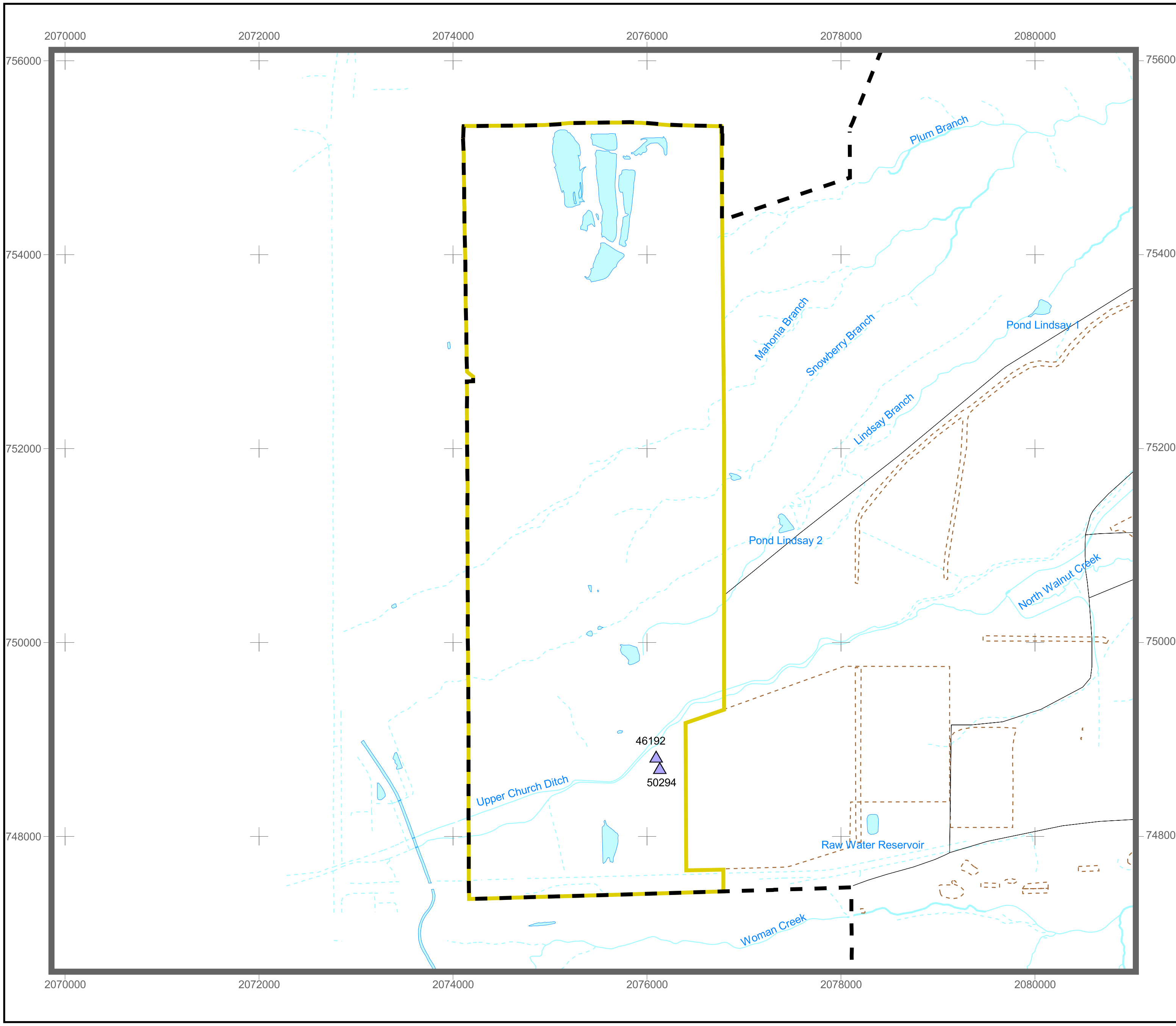


Figure 1.7
West Area Exposure Unit Subsurface Soil and Subsurface Sediment Sample Locations

KEY

Sample location
- Subsurface sediment sample location
- Subsurface soil sample location
- West Area EU
- Historical IHSS/PAC

Standard Map Features
- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W
E
S

0 750 1500 Feet

Scale 1:18000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\WestArea.apr

COMPREHENSIVE RISK ASSESSMENT

WEST AREA EXPOSURE UNIT

VOLUME 3: ATTACHMENT 1

Detection Limit Screen

TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
CD	compact disc
CRA	Comprehensive Risk Assessment
ESL	ecological screening level
EU	Exposure Unit
IDL	instrument detection limit
IHSS	Individual Hazardous Substance Site
MDL	method detection limit
mg/kg	milligrams per kilogram
N/A	not available or not applicable
NOAEL	no observed adverse effect level
PAC	Potential Area of Concern
pCi/g	picocuries per gram
PRG	preliminary remediation goal
RL	reporting limit
SWD	soil water database
SQL	sample quantitation limit
TIC	tentatively identified compound
VOC	volatile organic compound
WAEU	West Area Exposure Unit
WRW	wildlife refuge worker

For the West Area Exposure Unit (EU) (WAEU), the detection limits for non-detected analytes as well as analytes detected in less than 5 percent of the samples are compared to human health preliminary remediation goals (PRGs) for the wildlife refuge worker (WRW) and the minimum ecological screening levels (ESLs). The comparisons are made in the tables to this attachment for potential contaminants of concern (PCOCs) in surface soil/surface sediment and subsurface soil/subsurface sediment, and ecological contaminants of interest (ECOIs) in surface soil and subsurface soil. The percent of the samples with detection limits that exceed the PRGs and ESLs are listed in these tables. When these detection limits exceed the respective PRGs and ESLs, this is a source of uncertainty in the risk assessment process, which is discussed herein.

Laboratory reported results for “U” qualified data (nondetects) are used to perform the detection limit screen rather than the detection limit identified in the detection limit field within the Soil Water Database (SWD). The basis for the detection limit is not always certain, i.e., Instrument Detection Limit (IDL), Method Detection Limit (MDL), Reporting Limit (RL), Sample Quantitation Limit (SQL), etc. Therefore, to be consistent in reporting, the “reported results” are presented in the tables to this attachment. Also, for statistical computations and risk estimations presented in the main text and tables to this volume, one-half the reported results are used as proxy values for nondetected data.

The term analyte as used in the following sections refers to analytes that are non-detected or detected in less than 5 percent of the samples. PRGs and ESLs do not exist for some of these analytes, which is also a source of uncertainty for the risk assessment. This uncertainty is discussed in Sections 6.2.1 and 10.3.2 of the main text of this volume.

1.0 COMPARISON OF REPORTED RESULTS TO PRELIMINARY REMEDIATION GOALS

1.1 Surface Soil/Surface Sediment

As shown in Table A1.1, there are only 3 analytes in surface soil/surface sediment where some percent of the reported results exceed the PRG: benzo(a) pyrene (100%), dibenz(a,h)anthracene (100%), and N-nitroso-di-n-propylamine (90 %). In these cases, the maximum reported results are within a factor of 3 of the PRG. Therefore, because only three analytes have reported results that exceed the PRGs, and for these analytes, the reported results are the same order of magnitude as the PRGs, this represents only minimal uncertainty in the overall risk conclusions.

1.2 Subsurface Soil/Subsurface Sediment

All reported results are below the PRGs in subsurface soil/subsurface sediment (Table A1.2).

2.0 COMPARISON OF REPORTED RESULTS TO ECOLOGICAL SCREENING LEVELS

2.1 Surface Soil

As shown in Table A1.3, only selenium in surface soil has reported results that exceed the minimum ESL. In this case, all of the reported results exceed the minimum ESL. However, the reported results are within a factor of 2 of the minimum ESL. Therefore, because only one analyte has reported results that exceed the minimum ESL, and for this analyte, the reported results are the same order of magnitude as the minimum ESL, this represents only minimal uncertainty in the overall risk conclusions.

2.2 Subsurface Soil

All reported results are below the ESLs in subsurface soil (Table A1.4).

TABLES

Table A1.1
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil/Surface Sediment in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Inorganic (mg/kg)								
Nitrite	0.300	-	0.400	2	11,109	0	0	No
Selenium	0.240	-	1.10	20	555	0	0	No
Uranium	1.50	-	1.70	10	333	0	0	No
Organic (ug/kg)								
1,1,1-Trichloroethane	6	-	14	10	9.18E+06	0	0	No
1,1,2,2-Tetrachloroethane	6	-	14	10	10,483	0	0	No
1,1,2-Trichloroethane	6	-	14	10	28,022	0	0	No
1,1-Dichloroethane	6	-	14	10	2.72E+06	0	0	No
1,1-Dichloroethene	6	-	14	10	17,366	0	0	No
1,2,4-Trichlorobenzene	390	-	1,200	10	151,360	0	0	No
1,2-Dichlorobenzene	390	-	1,200	10	2.89E+06	0	0	No
1,2-Dichloroethane	6	-	14	10	13,270	0	0	No
1,2-Dichloroethene	6	-	14	10	999,783	0	0	No
1,2-Dichloropropane	6	-	14	10	38,427	0	0	No
1,3-Dichlorobenzene	390	-	1,200	10	3.33E+06	0	0	No
1,4-Dichlorobenzene	390	-	1,200	10	91,315	0	0	No
2,4,5-Trichlorophenol	1,900	-	5,900	10	8.01E+06	0	0	No
2,4,6-Trichlorophenol	390	-	1,200	10	272,055	0	0	No
2,4-Dichlorophenol	390	-	1,200	10	240,431	0	0	No
2,4-Dimethylphenol	390	-	1,200	10	1.60E+06	0	0	No
2,4-Dinitrophenol	1,900	-	5,900	10	160,287	0	0	No
2,4-Dinitrotoluene	390	-	1,200	10	160,287	0	0	No
2,6-Dinitrotoluene	390	-	1,200	10	80,144	0	0	No
2-Chloronaphthalene	390	-	1,200	10	6.41E+06	0	0	No
2-Chlorophenol	390	-	1,200	10	555,435	0	0	No
2-Hexanone	13	-	29	9	N/A	0	0	No
2-Methylnaphthalene	390	-	1,200	10	320,574	0	0	No
2-Methylphenol	390	-	1,200	10	4.01E+06	0	0	No
2-Nitroaniline	1,900	-	5,900	10	192,137	0	0	No
2-Nitrophenol	390	-	1,200	10	N/A	0	0	No
3,3'-Dichlorobenzidine	780	-	2,300	7	6,667	0	0	No
3-Nitroaniline	1,900	-	5,600	8	N/A	0	0	No
4,4'-DDD	19	-	57	10	15,528	0	0	No
4,4'-DDE	19	-	57	10	10,961	0	0	No
4,4'-DDT	19	-	57	10	10,927	0	0	No
4,6-Dinitro-2-methylphenol	1,900	-	5,900	10	8,014	0	0	No
4-Bromophenyl-phenylether	390	-	1,200	10	N/A	0	0	No
4-Chloro-3-methylphenol	390	-	1,200	10	N/A	0	0	No
4-Chloroaniline	390	-	1,200	10	320,574	0	0	No
4-Chlorophenyl-phenyl ether	390	-	1,200	10	N/A	0	0	No
4-Methyl-2-pentanone	13	-	29	10	8.32E+07	0	0	No
4-Nitroaniline	1,900	-	5,900	8	207,917	0	0	No
4-Nitrophenol	1,900	-	5,600	9	641,148	0	0	No
Acenaphthene	390	-	1,200	10	4.44E+06	0	0	No
Acenaphthylene	390	-	1,200	10	N/A	0	0	No
Acetone	13	-	190	7	1.00E+08	0	0	No
Aldrin	9.50	-	29	10	176	0	0	No
alpha-BHC	9.50	-	29	10	570	0	0	No
alpha-Chlordane	95	-	290	10	10,261	0	0	No
Anthracene	390	-	1,200	10	2.22E+07	0	0	No
Benzene	6	-	14	10	23,563	0	0	No
Benzo(a)anthracene	390	-	1,200	10	3,793	0	0	No
Benzo(a)pyrene	390	-	1,200	10	379	10	100	No
Benzo(b)fluoranthene	390	-	1,200	10	3,793	0	0	No
Benzo(g,h,i)perylene	390	-	1,200	9	N/A	0	0	No

Table A1.1
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil/Surface Sediment in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Benzo(k)fluoranthene	390	-	1,200	10	37,927	0	0	No
Benzyl Alcohol	390	-	1,200	10	2.40E+07	0	0	No
beta-BHC	9.50	-	29	10	1,995	0	0	No
beta-Chlordane	95	-	280	4	10,261	0	0	No
bis(2-Chloroethoxy) methane	390	-	1,200	10	N/A	0	0	No
bis(2-Chloroethyl) ether	390	-	1,200	10	3,767	0	0	No
bis(2-Chloroisopropyl) ether	390	-	1,200	10	59,301	0	0	No
Bromodichloromethane	6	-	14	10	67,070	0	0	No
Bromoform	6	-	14	10	419,858	0	0	No
Bromomethane	13	-	29	9	20,959	0	0	No
Butylbenzylphthalate	390	-	1,200	9	1.60E+07	0	0	No
Carbon Disulfide	6	-	14	10	1.64E+06	0	0	No
Carbon Tetrachloride	6	-	14	10	8,446	0	0	No
Chlorobenzene	6	-	14	10	666,523	0	0	No
Chloroethane	13	-	29	9	1.43E+06	0	0	No
Chloroform	6	-	14	10	7,850	0	0	No
Chloromethane	13	-	29	10	115,077	0	0	No
Chrysene	390	-	1,200	10	379,269	0	0	No
cis-1,3-Dichloropropene	6	-	14	10	19,432	0	0	No
delta-BHC	9.50	-	29	10	570	0	0	No
Dibenz(a,h)anthracene	390	-	1,200	10	379	10	100	No
Dibenzofuran	390	-	1,200	10	222,174	0	0	No
Dibromochloromethane	6	-	14	10	49,504	0	0	No
Dieldrin	19	-	57	10	187	0	0	No
Diethylphthalate	390	-	1,200	10	6.41E+07	0	0	No
Dimethylphthalate	390	-	1,200	10	8.01E+08	0	0	No
Di-n-octylphthalate	390	-	1,200	10	3.21E+06	0	0	No
Endosulfan I	9.50	-	29	10	480,861	0	0	No
Endosulfan II	19	-	57	10	480,861	0	0	No
Endosulfan sulfate	19	-	57	10	480,861	0	0	No
Endrin	19	-	57	10	24,043	0	0	No
Endrin ketone	19	-	57	10	33,326	0	0	No
Ethylbenzene	6	-	14	10	5.39E+06	0	0	No
Fluorene	390	-	1,200	10	3.21E+06	0	0	No
gamma-BHC (Lindane)	9.50	-	29	10	2,771	0	0	No
gamma-Chlordane	110	-	290	6	10,261	0	0	No
Heptachlor	9.50	-	29	10	665	0	0	No
Heptachlor epoxide	9.50	-	29	10	329	0	0	No
Hexachlorobenzene	390	-	1,200	10	1,870	0	0	No
Hexachlorobutadiene	390	-	1,200	10	22,217	0	0	No
Hexachlorocyclopentadiene	390	-	1,200	10	380,452	0	0	No
Hexachloroethane	390	-	1,200	10	111,087	0	0	No
Indeno(1,2,3-cd)pyrene	390	-	1,200	9	3,793	0	0	No
Isophorone	390	-	1,200	10	3.16E+06	0	0	No
Methoxychlor	95	-	290	10	400,718	0	0	No
Methylene Chloride	6	-	63	10	271,792	0	0	No
Naphthalene	390	-	1,200	10	1.40E+06	0	0	No
Nitrobenzene	390	-	1,200	10	43,246	0	0	No
N-Nitroso-di-n-propylamine	390	-	1,200	10	429	9	90	No
N-nitrosodiphenylamine	390	-	1,200	10	612,250	0	0	No
PCB-1016	95	-	290	10	1,349	0	0	No
PCB-1221	95	-	290	10	1,349	0	0	No
PCB-1232	95	-	290	10	1,349	0	0	No
PCB-1242	95	-	290	10	1,349	0	0	No
PCB-1248	95	-	290	10	1,349	0	0	No
PCB-1254	190	-	570	10	1,349	0	0	No

Table A1.1
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil/Surface Sediment in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
PCB-1260	190	-	570	10	1,349	0	0	No
Pentachlorophenol	1,900	-	5,900	10	17,633	0	0	No
Phenanthrene	390	-	1,200	10	N/A	0	0	No
Phenol	390	-	1,200	10	2.40E+07	0	0	No
Styrene	6	-	14	10	1.38E+07	0	0	No
Tetrachloroethene	6	-	14	10	6,705	0	0	No
Toxaphene	190	-	570	10	2,720	0	0	No
trans-1,3-Dichloropropene	6	-	14	10	20,820	0	0	No
Trichloroethene	6	-	14	10	1,770	0	0	No
Vinyl acetate	13	-	29	10	2.65E+06	0	0	No
Vinyl Chloride	13	-	29	10	2,169	0	0	No
Xylene	6	-	14	10	1.06E+06	0	0	No

N/A = Not available.

Table A1.2
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil/Subsurface Sediment in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Inorganic (mg/kg)								
Antimony	2.50	-	11.8	7	511	0	0	No
Cadmium	0.580	-	1	7	1,051	0	0	No
Cyanide	2.50	-	2.70	5	25,550	0	0	No
Molybdenum	1.10	-	4.10	7	6,388	0	0	No
Silver	0.390	-	0.950	7	6,388	0	0	No
Thallium	0.200	-	0.240	7	89.4	0	0	No
Organic (ug/kg)								
1,1,1-Trichloroethane	5	-	5	4	1.06E+08	0	0	No
1,1,2,2-Tetrachloroethane	5	-	5	4	120,551	0	0	No
1,1,2-Trichloroethane	5	-	5	4	322,253	0	0	No
1,1-Dichloroethane	5	-	5	4	3.12E+07	0	0	No
1,1-Dichloroethene	5	-	5	4	199,706	0	0	No
1,2,4-Trichlorobenzene	330	-	350	5	1.74E+06	0	0	No
1,2-Dichlorobenzene	330	-	350	5	3.32E+07	0	0	No
1,2-Dichloroethane	5	-	5	4	152,603	0	0	No
1,2-Dichloroethene	5	-	5	4	1.15E+07	0	0	No
1,2-Dichloropropane	5	-	5	4	441,907	0	0	No
1,3-Dichlorobenzene	330	-	350	5	3.83E+07	0	0	No
1,4-Dichlorobenzene	330	-	350	5	1.05E+06	0	0	No
2,4,5-Trichlorophenol	1,600	-	1,800	5	9.22E+07	0	0	No
2,4,6-Trichlorophenol	330	-	350	5	3.13E+06	0	0	No
2,4-Dichlorophenol	330	-	350	5	2.76E+06	0	0	No
2,4-Dimethylphenol	330	-	350	5	1.84E+07	0	0	No
2,4-Dinitrophenol	1,600	-	1,800	5	1.84E+06	0	0	No
2,4-Dinitrotoluene	330	-	350	5	1.84E+06	0	0	No
2,6-Dinitrotoluene	330	-	350	5	921,651	0	0	No
2-Butanone	10	-	11	4	5.33E+08	0	0	No
2-Chloronaphthalene	330	-	350	5	7.37E+07	0	0	No
2-Chlorophenol	330	-	350	5	6.39E+06	0	0	No
2-Methylnaphthalene	330	-	350	5	3.69E+06	0	0	No
2-Methylphenol	330	-	350	5	4.61E+07	0	0	No
2-Nitroaniline	1,600	-	1,800	5	2.21E+06	0	0	No
2-Nitrophenol	330	-	350	5	N/A	0	0	No
3,3'-Dichlorobenzidine	660	-	710	5	76,667	0	0	No
3-Nitroaniline	1,600	-	1,800	5	N/A	0	0	No
4,6-Dinitro-2-methylphenol	1,600	-	1,800	5	92,165	0	0	No
4-Bromophenyl-phenylether	330	-	350	5	N/A	0	0	No
4-Chloro-3-methylphenol	330	-	350	5	N/A	0	0	No
4-Chloroaniline	330	-	350	5	3.69E+06	0	0	No
4-Chlorophenyl-phenyl ether	330	-	350	5	N/A	0	0	No
4-Methylphenol	330	-	350	5	4.61E+06	0	0	No
4-Nitroaniline	1,600	-	1,800	5	2.39E+06	0	0	No
4-Nitrophenol	1,600	-	1,800	5	7.37E+06	0	0	No
Acenaphthene	330	-	350	5	5.10E+07	0	0	No
Acenaphthylene	330	-	350	5	N/A	0	0	No
Anthracene	330	-	350	5	2.55E+08	0	0	No
Benzene	5	-	5	4	270,977	0	0	No
Benzo(a)anthracene	330	-	350	5	43,616	0	0	No
Benzo(a)pyrene	330	-	350	5	4,357	0	0	No
Benzo(b)fluoranthene	330	-	350	5	43,616	0	0	No
Benzo(g,h,i)perylene	330	-	350	5	N/A	0	0	No
Benzo(k)fluoranthene	330	-	350	5	436,159	0	0	No
Benzoic Acid	1,600	-	1,800	5	3.69E+09	0	0	No
Benzyl Alcohol	330	-	350	5	2.76E+08	0	0	No
bis(2-Chloroethoxy) methane	330	-	350	5	N/A	0	0	No

Table A1.2
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil/Subsurface Sediment in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
bis(2-Chloroethyl) ether	330	-	350	5	43,315	0	0	No
bis(2-Chloroisopropyl) ether	330	-	350	5	681,967	0	0	No
Bromodichloromethane	5	-	5	4	771,304	0	0	No
Bromoform	5	-	5	4	4.83E+06	0	0	No
Bromomethane	10	-	11	4	241,033	0	0	No
Butylbenzylphthalate	330	-	350	5	1.84E+08	0	0	No
Carbon Disulfide	5	-	5	4	1.88E+07	0	0	No
Carbon Tetrachloride	5	-	5	4	97,124	0	0	No
Chlorobenzene	5	-	5	4	7.67E+06	0	0	No
Chloroethane	10	-	11	4	1.65E+07	0	0	No
Chloroform	5	-	5	4	90,270	0	0	No
Chloromethane	10	-	11	4	1.32E+06	0	0	No
Chrysene	330	-	350	5	4.36E+06	0	0	No
cis-1,3-Dichloropropene	5	-	5	4	223,462	0	0	No
Dibenz(a,h)anthracene	330	-	350	5	4,362	0	0	No
Dibenzofuran	330	-	350	5	2.56E+06	0	0	No
Dibromochloromethane	5	-	5	4	569,296	0	0	No
Dimethylphthalate	330	-	350	5	9.22E+09	0	0	No
Di-n-octylphthalate	330	-	350	5	3.69E+07	0	0	No
Ethylbenzene	5	-	5	4	6.19E+07	0	0	No
Fluorene	330	-	350	5	3.69E+07	0	0	No
Hexachlorobenzene	330	-	350	5	21,508	0	0	No
Hexachlorobutadiene	330	-	350	5	255,500	0	0	No
Hexachlorocyclopentadiene	330	-	350	5	4.38E+06	0	0	No
Hexachloroethane	330	-	350	5	1.28E+06	0	0	No
Indeno(1,2,3-cd)pyrene	330	-	350	5	43,616	0	0	No
Isophorone	330	-	350	5	3.63E+07	0	0	No
Methylene Chloride	5	-	5	4	3.13E+06	0	0	No
Naphthalene	330	-	350	5	1.61E+07	0	0	No
Nitrobenzene	330	-	350	5	497,333	0	0	No
N-Nitroso-di-n-propylamine	330	-	350	5	4,929	0	0	No
N-nitrosodiphenylamine	330	-	350	5	7.04E+06	0	0	No
Pentachlorophenol	1,600	-	1,800	5	202,777	0	0	No
Phenanthrene	330	-	350	5	N/A	0	0	No
Phenol	330	-	350	5	2.76E+08	0	0	No
Pyrene	330	-	350	5	2.55E+07	0	0	No
Styrene	5	-	5	4	1.59E+08	0	0	No
Tetrachloroethene	5	-	5	4	77,111	0	0	No
trans-1,3-Dichloropropene	5	-	5	4	239,434	0	0	No
Trichloroethene	5	-	5	4	20,354	0	0	No
Vinyl acetate	10	-	11	4	3.04E+07	0	0	No
Vinyl Chloride	10	-	11	4	24,948	0	0	No
Xylene	5	-	5	4	1.22E+07	0	0	No

N/A = Not available.

Table A1.3
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil in the WAEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest ESL	Number of Nondetected Results > ESL	Percent Nondetected Results > ESL	Analyte Detected?
Inorganic (mg/kg)								
Cadmium	0.0690	-	0.350	10	0.705	0	0	No
Selenium	0.850	-	1.10	10	0.754	10	100	No
Tin	0.890	-	2.20	10	2.90	0	0	No
Uranium	1.50	-	1.70	10	5	0	0	No

Table A1.4
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
Inorganics (mg/kg)								
Aluminum	2,622	99.9	2,620	1,450	61,000	10.9	70	50
Ammonia	32	78.1	25	0.335	4.81	0.338	6.12	586
Antimony	2,482	20.0	497	0.270	348	0.0360	19.3	0.905
Arsenic	2,613	99.0	2,586	0.290	56.2	0.400	6.20	2.57
Barium	2,624	99.9	2,622	0.640	1,500	2.20	95	159
Beryllium	2,623	81.7	2,142	0.0710	26.8	0.0620	1.90	6.82
Boron	1,303	85.7	1,117	0.350	28	0.340	7	0.500
Cadmium	2,603	36.1	940	0.0600	270	0.0300	2.80	0.705
Chromium	2,624	99.2	2,604	1.20	210	2.20	19.8	0.400
Chromium VI	17	5.88	1.000	0.850	0.850	0.530	1.20	1.34
Cobalt	2,622	98.1	2,573	1.10	137	2.10	10.4	13
Copper	2,621	98.2	2,575	1.70	1,860	2.20	22.8	8.25
Cyanide	245	2.45	6.00	0.170	0.290	0.180	4.70	607
Fluoride	9	100	9	1.87	3.61	N/A	N/A	1.33
Lead	2,618	100	2,618	0.870	814	N/A	N/A	12.1
Lithium	2,433	94.5	2,300	0.990	50	1.60	20.6	2
Manganese	2,617	99.9	2,615	15	2,220	2.20	130	486
Mercury	2,541	48.8	1,239	0.00140	48	0.00120	0.190	1.00E-04
Molybdenum	2,421	47.0	1,138	0.140	19.1	0.0990	7.50	1.84
Nickel	2,620	97.5	2,554	1.90	280	1.60	19.1	0.431
Nitrate / Nitrite	450	83.3	375	0.216	765	0.200	5.60	4,478
Selenium	2,590	13.3	345	0.220	2.20	0.0540	4.50	0.754
Silver	2,589	28.4	735	0.0580	364	0.0490	7	2
Strontium	2,423	100.0	2,422	2.40	413	1.10	1.10	940
Thallium	2,597	14.1	366	0.100	5.80	0.0160	2.50	1
Tin	2,423	10.0	243	0.289	161	0.0780	58.5	2.90
Uranium	1,296	8.80	114	0.430	370	0.130	16.8	5
Vanadium	2,622	100.0	2,621	4.40	5,300	2.20	2.20	2
Zinc	2,622	99.8	2,617	4.20	11,900	2.20	99.8	0.646
Organics (ug/kg)								
1,1,1-Trichloroethane	633	1.58	10.00	1.10	47.7	0.587	680	551,453
1,1,2,2-Tetrachloroethane	632	0.158	1.000	1.39	1.39	0.527	680	60,701
1,1-Dichloroethane	633	0	0	N/A	N/A	0.512	680	3,121
1,1-Dichloroethene	633	0.158	1.000	7.90	7.90	0.610	680	16,909

Table A1.4
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
1,2,3-Trichloropropane	517	0.193	1.000	1.47	1.47	0.525	129	13,883
1,2,4-Trichlorobenzene	1,549	0.323	5.00	0.870	150	0.621	7,000	777
1,2-Dichloroethane	629	0	0	N/A	N/A	0.522	680	2,764
1,2-Dichloroethene	101	0.990	1.000	16	16	5	680	25,617
1,2-Dichloropropane	633	0.316	2.00	18	140	0.413	680	49,910
1,3,5-Trimethylbenzene	515	6.60	34.0	0.610	490	0.535	65.2	7,598
1,4-Dichlorobenzene	1,329	0.677	9.00	0.450	110	0.649	6,900	20,000
2,4,5-T	9	11.1	1.000	1.80	1.80	21	100	162
2,4,5-Trichlorophenol	1,180	0.0847	1.000	1,100	1,100	330	34,000	4,000
2,4,6-Trichlorophenol	1,180	0.0847	1.000	950	950	330	7,000	161
2,4,6-Trinitrotoluene	8	12.5	1	56	56	0.220	250	283
2,4-DB	9	0	0	N/A	N/A	83	100	426
2,4-Dichlorophenol	1,180	0	0	N/A	N/A	330	7,000	2,744
2,4-Dinitrophenol	1,173	0	0	N/A	N/A	850	35,000	20,000
2,4-Dinitrotoluene	1,232	0	0	N/A	N/A	250	7,000	32.1
2,6-Dinitrotoluene	1,232	0	0	N/A	N/A	250	7,000	6,186
2378-TCDD	22	68.2	15.0	2.59E-05	0.00680	2.20E-04	0.00106	0.00425
2-Butanone	631	2.54	16.0	3	155	2.72	1,400	1.07E+06
2-Chlorophenol	1,180	0	0	N/A	N/A	330	7,000	281
2-MethylN/Aphthalene	1,223	6.95	85.0	34	12,000	330	7,000	2,769
2-Methylphenol	1,180	0	0	N/A	N/A	330	7,000	123,842
2-Nitroaniline	1,224	0	0	N/A	N/A	370	35,000	5,659
4,4'-DDD	468	0.427	2.00	3.50	10	1.80	190	13,726
4,4'-DDE	468	1.50	7.00	0.600	7.20	1.80	190	7.95
4,4'-DDT	468	0.855	4.00	9.10	26	1.80	190	1.20
4,6-Dinitro-2-methylphenol	1,176	0.0850	1.000	390	390	850	35,000	560
4-Chloroaniline	1,217	0	0	N/A	N/A	330	14,000	716
4-Methyl-2-pentanone	630	2.38	15.0	4	73	1.94	2,960	14,630
4-Nitroaniline	1,218	0.328	4.00	62	820	850	55,000	41,050
4-Nitrophenol	1,169	0.171	2.00	53	320	850	35,000	7,000
4-Nitrotoluene	5	0	0	N/A	N/A	250	250	61,422
Acenaphthene	1,239	22.3	276	21	44,000	330	6,900	20,000
Acetone	632	19.3	122	1.70	1,280	2.65	2,960	6,182
Aldrin	468	0.855	4.00	0.590	17	1.80	95	47.0
alpha-BHC	468	0.214	1.000	7.90	7.90	1.80	95	18,662

Table A1.4
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
alpha-Chlordane	433	0	0	N/A	N/A	1.80	950	289
Benzene	633	0.948	6.00	1	11	0.502	680	500
Benzo(a)pyrene	1,235	41.2	509	36	43,000	19	7,000	631
Benzyl Alcohol	1,114	0.718	8.00	140	2,800	330	14,000	4,403
beta-BHC	467	0.428	2.00	11	11	1.80	95	207
beta-Chlordane	411	0.243	1.000	2.60	2.60	1.80	950	289
bis(2-ethylhexyl)phthalate	1,227	29.7	365	29	75,000	330	7,000	137
Bromodichloromethane	633	0	0	N/A	N/A	0.502	680	5,750
Bromoform	633	0	0	N/A	N/A	0.525	680	2,855
Butylbenzylphthalate	1,226	9.79	120	35	7,100	330	7,000	24,155
Carbon Disulfide	633	0.158	1.000	4	4	0.535	680	5,676
Carbon Tetrachloride	633	3.32	21.0	0.340	103	0.575	680	8,906
Chlordane	34	0	0	N/A	N/A	18	220	289
Chlorobenzene	633	0.316	2.00	2	2.03	0.484	680	4,750
Chloroform	633	1.11	7.00	1.30	7	0.543	680	8,655
cis-1,2-Dichloroethene	517	1.74	9.00	1.10	15	0.502	590	1,814
cis-1,3-Dichloropropene	633	0	0	N/A	N/A	0.502	680	2,800
delta-BHC	468	0.214	1.000	23	23	1.80	95	25.9
Dibenzofuran	1,227	10.9	134	36	20,000	330	7,000	21,200
Dibromochloromethane	633	0	0	N/A	N/A	0.502	680	5,730
Dicamba	9	55.6	5.00	2.30	150	42	100	1,690
Dichlorodifluoromethane	499	0	0	N/A	N/A	1.73	398	855
Dieldrin	468	2.35	11.0	1.80	92	1.80	190	7.40
Diethylphthalate	1,224	0.654	8.00	33	420	330	7,000	100,000
Dimethoate	7	0	0	N/A	N/A	18	180	13.7
Dimethylphthalate	1,227	1.47	18.0	69	460	330	7,000	200,000
Di-n-butylphthalate	1,227	7.99	98.0	35	10,000	330	7,000	15.9
Di-n-octylphthalate	1,225	3.92	48.0	38	11,000	330	7,000	731,367
Endosulfan I	468	0.427	2.00	3.90	7.40	1.80	95	80.1
Endosulfan II	461	0.651	3.00	0.700	9.90	1.80	170	80.1
Endosulfan sulfate	468	0.641	3.00	5.50	24	1.80	190	80.1
Endrin	468	1.28	6.00	2.40	17	1.80	200	1.40
Endrin aldehyde	66	3.03	2.00	8.70	9.20	1.80	38	1.40
Endrin ketone	437	0.229	1.000	36	36	1.80	190	1.40
Fluorene	1,244	18.8	234	27	39,000	140	7,000	30,000

Table A1.4
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
gamma-BHC (Lindane)	468	0.214	1.000	8.30	8.30	1.80	95	25.9
gamma-Chlordane	23	0	0	N/A	N/A	2	260	289
Heptachlor	468	0	0	N/A	N/A	1.80	95	63.3
Heptachlor epoxide	467	0.642	3.00	7.20	23	1.80	95	64.0
Hexachlorobenzene	1,224	0.327	4.00	110	380	330	7,000	7.73
Hexachlorobutadiene	1,550	0.0645	1.000	2.20	2.20	0.508	7,000	431
Hexachlorocyclopentadiene	1,208	0	0	N/A	N/A	330	7,000	5,518
Hexachloroethane	1,227	0	0	N/A	N/A	330	7,000	366
HMX	5	20	1	230	230	250	250	16,012
Methoxychlor	468	1.71	8.00	0.280	450	3.50	950	1,226
Methylene Chloride	631	12.0	76.0	0.790	45	0.502	2,200	3,399
N/Naphthalene	1,567	14.1	221	0.850	41,000	0.751	7,000	27,048
Nitrobenzene	1,218	0	0	N/A	N/A	250	7,000	40,000
N-nitrosodiphenylamine	1,227	0	0	N/A	N/A	330	7,000	20,000
PCB-1016	795	0.755	6.00	13	95	33	4,500	172
PCB-1221	845	0	0	N/A	N/A	33	4,500	172
PCB-1232	845	0	0	N/A	N/A	33	4,500	172
PCB-1242	845	0.237	2.00	23	350	33	4,500	172
PCB-1248	845	0.710	6.00	17	840	33	4,500	172
PCB-1254	842	17.9	151	6.80	8,900	33	9,000	172
PCB-1260	838	17.2	144	6.20	7,800	33	4,300	172
Pentachlorophenol	1,180	1.02	12.0	39	39,000	850	35,000	122
Phenol	1,180	0.424	5.00	33	130	330	7,000	23,090
Styrene	633	0.158	1.000	7.80	7.80	0.550	680	16,408
Tetrachloroethene	633	8.53	54.0	0.380	29,000	0.641	680	763
Toluene	633	9.00	57.0	0.0990	990	0.528	60.8	14,416
Toxaphene	468	0	0	N/A	N/A	86	2,200	3,756
trans-1,2-Dichloroethene	532	0	0	N/A	N/A	0.738	93.3	25,617
trans-1,3-Dichloropropene	633	0	0	N/A	N/A	0.502	680	2,800
Trichloroethene	633	4.11	26.0	0.170	200	0.500	680	389
Vinyl acetate	78	0	0	N/A	N/A	10	1,400	13,986
Vinyl Chloride	633	0	0	N/A	N/A	0.748	1,400	97.7
Xylene	633	10.4	66.0	0.600	933	0.502	680	1,140

N/A = Not available.

COMPREHENSIVE RISK ASSESSMENT

WEST AREA EXPOSURE UNIT

VOLUME 3: ATTACHMENT 2

Data Quality Assessment

TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ASD	Analytical Services Division
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
CRDL	contract required detection limit
DAR	data adequacy report
DER	duplicate error ratio
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	data quality objective
DRC	data review checklist
ECOPC	ecological contaminant of potential concern
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ESL	ecological screening level
EU	exposure unit
FD	field duplicate
IAG	Interagency Agreement
ICP	inductively couple plasma
IDL	instrument detection limit
LCS	laboratory control sample
MDA	minimum detectable activity

MDL	method detection limit
MS	matrix spike
MSA	method of standard additions
MSD	matrix spike duplicate
N/A	not applicable
PARCC	precision, accuracy, representativeness, completeness, and comparability
PPT	Pipette
PRG	preliminary remediation goal
PCB	polychlorinated biphenyl
QC	quality control
RDL	required detection limit
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
RPD	relative percent difference
SDP	standard data package
SOW	Statement of Work
SVOC	semi-volatile organic compound
SWD	Soil Water Database
TCLP	Toxicity Characteristic Leaching Procedure
TIC	tentatively identified compound
V&V	verification and validation
VOC	volatile organic compound
WAEU	West Area Exposure Unit

1.0 INTRODUCTION

This document provides an assessment of the quality of the data used in the human health and ecological risk assessments for the West Area Exposure Unit (WAEU). The data quality was evaluated against standard precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters by the data validator under the multiple work plans that guided the data collection over the past 15 years, as well as the requirements for the PARCC parameters provided in the Comprehensive Risk Assessment (CRA) Methodology (DOE 2005). The details of this data quality assessment (DQA) process are presented in the Sitewide DQA contained in Appendix A, Volume 2, Attachment 2 of the Remedial Investigation/Feasibility Study (RI/FS).

Of the 24,778 environmental sampling records in the RFETS database associated with the WAEU, 12,121 were used in the WAEU risk assessment based on the data processing rules described in Section 2.0 of the Sitewide DQA. Of the 12,121 analytical records existing in the WAEU CRA data set, 88 percent (10,722 records) have undergone verification or validation (V&V) (Table A2.1). The V&V review involved applying observation notes and qualifiers flags or observation notes without qualifier flags to the data.

PARCC parameter analysis was used to determine if the data quality could affect the risk assessment decisions (i.e., have significant impact on risk calculations or selection of contaminants of concern [COCs] for human health or ecological contaminants of potential concern [ECOPCs]). In consultation with the data users and project team, the primary ways in which the PARCC parameters could impact the risk assessment decisions were identified and these include the following:

- Detect results are falsely identified as nondetects;
- Nondetect results are falsely identified as detects;
- Issues that cause detection limit uncertainty;
- Issues that cause significant overestimation of detect results; and
- Issues that cause significant underestimation of detect results.

2.0 SUMMARY OF FINDINGS

2.1 PARCC Findings

A summary of V&V observations and the associated, affected PARCC parameter is presented in Table A2.2 by analyte group and matrix (i.e., “soil” includes soil and sediment, and “water” includes surface water and groundwater). Table A2.3 presents the percentage of the WAEU V&V data that were qualified as estimated and/or undetected by analyte group and matrix. Overall, approximately 15 percent of the WAEU CRA data were qualified as estimated or undetected. Less than 2 percent of the data reported as detected by the laboratory were qualified as undetected by the validator due to blank contamination (Table A2.4). In general, data qualified as estimated or undetected are marked as such because of various laboratory noncompliance issues that are not serious enough to render the data unusable. The precision between field duplicate (FD)/target sample analyte pairs is summarized in Table A2.5.

Of the 88 percent of the WAEU data set that underwent V&V, 82 percent were qualified as having no QC issues, and approximately 15 percent were qualified as estimated or undetected (Table A2.3). The remaining 3 percent of the V&V data are made up of records qualified with additional flags indicating acceptable and non-estimated data such as “A”, “C”, or “E”.

Less than 5 percent of the entire data set was rejected during the V&V process (Table A2.6). Rejected data were removed from the WAEU CRA data set during the data processing as defined in Section 2.0 of the Sitewide DQA.

The general discussion below summarizes the data quality as presented by the data validator’s observations. The relationship between these observations and the PARCC parameters can be found in the Sitewide DQA. Several observations have no impact on data quality because they represent issues that were noted but corrected, or represent other, general observations such as missing documentation that was not required for data assessment. Approximately 11 percent of the WAEU V&V data were marked with these V&V observations that have no affect on any of the PARCC parameters.

Of the V&V data, approximately 2 percent were noted for observations related to precision. Of that 2 percent, 98 percent contained issues related to sample matrices. Result confirmation observations make up the other 2 percent.

Of the V&V data, 32 percent were noted for accuracy-related observations. Of that 32 percent, 69 percent was noted for laboratory practice-related observations, while sample-specific accuracy observations make up the other 31 percent. It is important to note that not all accuracy-related observations resulted in data qualification. Only 15 percent of the WAEU CRA data set was qualified as estimated and/or undetected (Table A2.3).

The data were determined to meet the representativeness parameter because sampling locations are spatially distributed such that contaminant randomness and bias considerations are addressed based on the site-specific history (see the Data Adequacy Report [DAR] in Appendix A, Volume 2, Attachment 3). Samples were also analyzed by the SW-846 or alpha-spectroscopy methods and results were documented as quality records according to approved procedures and guidelines (V&V).

Of the V&V data, approximately 37 percent were noted for observations related to representativeness. Of that 37 percent, 85 percent was marked for blank observations, 8 percent for failure to observe allowed holding times, 4 percent for documentation issues, 1 percent for sample preparation observations, and 1 percent for instrument sensitivity issues. Matrix, LCS, instrument set-up, and other observations make up the other 1 percent of the data noted for observations related to sample representativeness. Reportable levels of target analytes were not routinely detected in the laboratory blanks greater than the laboratory RLs and samples were generally stored and preserved properly.

The CRA Methodology specifies completeness criteria based on data adequacy and these criteria and the findings are discussed in the DAR in Appendix A, Volume 2, Attachment 3 of the RI/FS. Additionally, it should be noted that less than 5 percent of all V&V data associated with the WAEU were rejected.

Comparability of the WAEU CRA data set is ensured as all analytical results have been converted into common units. Comparability is addressed more specifically in Appendix A, Volume 2, Attachment 2 of the RI/FS.

2.2 PARCC Findings Potential Impact on Data Usability

PARCC parameter influence on data usability is discussed below with an emphasis on the risk assessment decisions as described in the Introduction to this document.

Table A2.3 summarizes the overall percentage of qualified data, independent of validation observation. The table is used for overall guidance in selecting analyte group and matrix combinations of interest in the analysis of the risk assessment decisions, the impact on data usability is better analyzed using Tables A2.5 through A2.7, as these can be more directly related to the 5 key risk assessment decision factors described in the introduction.

A summary of FD/target sample precision information can be found in Table A2.5. Where there are analyte group and matrix combinations failures that have the potential to impact risk assessment decisions, the data quality is discussed in further detail in the bulleted list below.

Table A2.7 lists V&V observations where the number of observations by analyte group and matrix exceeds 5 percent of the associated records (see column "Percent Observed") with the exception of those observations that were determined to have no impact on any of the PARCC parameters. Such observations are identified in Table A2.2 by an "Affected PARCC Parameter" of not applicable (N/A). Additionally the analyte group and matrix is broken down further in the columns "Percent Qualified U" and "Percent Qualified J". Data qualifications that are considered to have potential impact on risk assessment decisions were reviewed and are discussed in detail in the bulleted list below. Other issues are not considered to have the potential for significant impacts on the results of the risk assessments because the uncertainty associated with these data quality issues is assumed to be less than the overall uncertainty in the risk assessment process (e.g., uncertainties such as exposure assumptions, toxicity values, and statistical methods for calculating exposure point concentrations).

Data qualifications associated with the water matrix are not discussed below. Surface water data are used in the ecological risk assessment for an EU only for those analytes identified as ECOPCs, and the surface water component of exposure contributes only minimally to the overall risk estimates. As described in the Sitewide DQA (Attachment 2 of Volume 2 of Appendix A of the RI/FS Report), groundwater data are not used in the ecological risk assessment and the groundwater evaluations for the human health portion of the risk assessment are performed on a sitewide basis. In addition, surface water is evaluated for the human health risk assessment on a sitewide basis. Therefore, data quality evaluations for groundwater and surface water are presented in the Sitewide DQA.

Issues that have the potential to impact the risk assessment decisions include the following:

- Greater than 12 percent of the herbicide/soil data set was noted for V&V observations related to surrogate analyses that did not meet recovery criteria and were also qualified as estimated. This V&V observation has the potential to affect the accuracy of associated data. Data accuracy is important at or near the contract required detection limit (CRDL) as false nondetect results have the potential to impact the ECOPC and/or COC selection processes. As all records qualified due to this V&V observation are nondetect results, and no herbicides were selected as COCs or as ECOPCs in the WAEU, the potential impacts to the COC and ECOPC selection processes were reviewed. All nondetect herbicide results associated with the WAEU soils were reported at levels well below human health preliminary remediation goals (PRGs) and the lowest associated ecological screening level (ESL). As a result, the impact to both the human health and the ecological portions of the risk assessment is determined to be minimal.

- Greater than 10 percent of the semi-volatile organic compound (SVOC)/soil results were noted with V&V observations related to surrogate recoveries and were also qualified as estimated. All of the qualified records are nondetect results. All nondetected SVOC surface and subsurface soil results were reported at concentrations well below the lowest associated ESL. The impact on ecological risk assessment decisions is therefore determined to be minimal.

- Although three SVOC results associated with WAEU soils were reported as nondetects at concentrations that exceed human health PRGs, it is important to note that very few SVOCs were detected in the WAEU soils, those that were detected were reported at concentrations well below the associated PRG. In addition SVOC contaminants are not expected to be present in WAEU soils as no sources or contamination migration pathways are known to exist. The impact on the human health risk assessment decisions is also determined to be minimal.

- Several V&V observations related to the wet chemistry/soil analyte group and matrix combination resulted in data qualifications in notable percentages of the data set (Table A2.7). It is important to note, however, that this analyte group contains general chemistry parameters such as ions/anions and alkalinity that are not directly related to site characterization. Therefore, the impact of these qualifications on risk assessment results is determined to be minimal.

3.0 CONCLUSIONS

This review concludes that the quality of the WAEU data is acceptable and the CRA objectives for PARCC performance have generally been met. Where either CRA Methodology or V&V guidance have not been met, the data are either flagged by the V&V process, or for those instances where the frequency of issues may influence the risk assessment decisions, the data quality issues were reviewed for potential impact on risk assessment results.

Those elements of data quality that could affect risk assessment decisions in the WAEU have been analyzed and it was concluded that the noted deviations from the PARCC parameter criteria have minimal impact on risk assessment results related to the WAEU.

4.0 REFERENCES

DOE, 2002, Final Work Plan for the Development of the Remedial Investigation and Feasibility Study Report, Rocky Flats Environmental Technology Site, Golden, Colorado, March.

DOE, 2005. Final Comprehensive Risk Assessment Work Plan and Methodology, Environmental Restoration, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1, September 2005.

TABLES

Table A2.1
CRA Data V&V Summary

Analyte Group	Matrix	Total No. of CRA V&V Records	Total No. of CRA Records	Percent V&V (%)
Herbicide	Soil	8	14	57.14
Herbicide	Water	6	9	66.67
Metal	Soil	777	777	100.00
Metal	Water	3,916	4,323	90.59
PCB	Soil	56	70	80.00
PCB	Water	42	56	75.00
Pesticide	Soil	169	215	78.60
Pesticide	Water	127	172	73.84
Radionuclide	Soil	161	163	98.77
Radionuclide	Water	597	725	82.34
SVOC	Soil	545	875	62.29
SVOC	Water	413	589	70.12
VOC	Soil	494	518	95.37
VOC	Water	2,855	3,004	95.04
Wet Chem	Soil	31	32	96.88
Wet Chem	Water	525	579	90.67
	Total	**10,722**	**12,121**	**88.46%**

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Herbicide	Soil	Other	Sample results were not validated due to re-analysis	No	5	8	62.50	N/A
Herbicide	Soil	Surrogates	Surrogate recovery criteria were not met	No	1	8	12.50	Accuracy
Metal	Soil	Blanks	Calibration verification blank contamination	No	26	777	3.35	Representativeness
Metal	Soil	Blanks	Calibration verification blank contamination	Yes	5	777	0.64	Representativeness
Metal	Soil	Blanks	Method, preparation, or reagent blank contamination	No	19	777	2.45	Representativeness
Metal	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	4	777	0.51	Representativeness
Metal	Soil	Blanks	Negative bias indicated in the blanks	No	7	777	0.90	Representativeness
Metal	Soil	Blanks	Negative bias indicated in the blanks	Yes	9	777	1.16	Representativeness
Metal	Soil	Calibration	Calibration correlation coefficient did not meet requirements	Yes	3	777	0.39	Accuracy
Metal	Soil	Documentation Issues	Transcription error	Yes	3	777	0.39	N/A
Metal	Soil	LCS	CRDL check sample recovery criteria were not met	No	3	777	0.39	Accuracy
Metal	Soil	LCS	CRDL check sample recovery criteria were not met	Yes	4	777	0.51	Accuracy
Metal	Soil	LCS	LCS recovery criteria were not met	No	32	777	4.12	Accuracy
Metal	Soil	LCS	LCS recovery criteria were not met	Yes	67	777	8.62	Accuracy
Metal	Soil	LCS	Low level check sample recovery criteria were not met	No	11	777	1.42	Accuracy
Metal	Soil	LCS	Low level check sample recovery criteria were not met	Yes	21	777	2.70	Accuracy
Metal	Soil	Matrices	Duplicate sample precision criteria were not met	No	4	777	0.51	Precision
Metal	Soil	Matrices	Duplicate sample precision criteria were not met	Yes	11	777	1.42	Precision
Metal	Soil	Matrices	Post-digestion MS did not meet control criteria	No	2	777	0.26	Accuracy
Metal	Soil	Matrices	Post-digestion MS did not meet control criteria	Yes	2	777	0.26	Accuracy
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	No	21	777	2.70	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	Yes	43	777	5.53	Accuracy
Metal	Soil	Matrices	Serial dilution criteria were not met	Yes	20	777	2.57	Accuracy
Metal	Soil	Other	IDL is older than 3 months from date of analysis	No	80	777	10.30	Accuracy
Metal	Soil	Other	IDL is older than 3 months from date of analysis	Yes	220	777	28.31	Accuracy
Metal	Soil	Other	See hard copy for further explanation	No	5	777	0.64	N/A
Metal	Soil	Other	See hard copy for further explanation	Yes	20	777	2.57	N/A
Metal	Soil	Sensitivity	IDL changed due to a significant figure discrepancy	No	1	777	0.13	Representativeness
Metal	Water	Blanks	Calibration verification blank contamination	No	66	3,916	1.69	Representativeness
Metal	Water	Blanks	Calibration verification blank contamination	Yes	7	3,916	0.18	Representativeness
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	No	236	3,916	6.03	Representativeness
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	78	3,916	1.99	Representativeness
Metal	Water	Blanks	Negative bias indicated in the blanks	No	45	3,916	1.15	Representativeness
Metal	Water	Blanks	Negative bias indicated in the blanks	Yes	23	3,916	0.59	Representativeness
Metal	Water	Calculation Errors	Control limits not assigned correctly	Yes	1	3,916	0.03	N/A
Metal	Water	Calibration	Calibration correlation coefficient did not meet requirements	No	16	3,916	0.41	Accuracy
Metal	Water	Calibration	Calibration correlation coefficient did not meet requirements	Yes	8	3,916	0.20	Accuracy
Metal	Water	Calibration	Frequency or sequencing verification criteria not met	No	1	3,916	0.03	Accuracy
Metal	Water	Calibration	Frequency or sequencing verification criteria not met	Yes	6	3,916	0.15	Accuracy
Metal	Water	Documentation Issues	Key data fields incorrect	No	4	3,916	0.10	N/A
Metal	Water	Documentation Issues	Key data fields incorrect	Yes	18	3,916	0.46	N/A
Metal	Water	Documentation Issues	Missing deliverables (not required for validation)	No	18	3,916	0.46	N/A

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Water	Documentation Issues	Missing deliverables (not required for validation)	Yes	12	3,916	0.31	N/A
Metal	Water	Documentation Issues	Missing deliverables (required for validation)	No	23	3,916	0.59	Representativeness
Metal	Water	Documentation Issues	Missing deliverables (required for validation)	Yes	32	3,916	0.82	Representativeness
Metal	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	No	46	3,916	1.17	N/A
Metal	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	Yes	122	3,916	3.12	N/A
Metal	Water	Documentation Issues	Omissions or errors in data package (required for validation)	No	1	3,916	0.03	Representativeness
Metal	Water	Documentation Issues	Transcription error	No	44	3,916	1.12	N/A
Metal	Water	Documentation Issues	Transcription error	Yes	34	3,916	0.87	N/A
Metal	Water	Holding Times	Holding times were exceeded	No	3	3,916	0.08	Representativeness
Metal	Water	Holding Times	Holding times were grossly exceeded	Yes	1	3,916	0.03	Representativeness
Metal	Water	Instrument Set-up	Interference was indicated in the interference check sample	No	2	3,916	0.05	Accuracy
Metal	Water	Instrument Set-up	Interference was indicated in the interference check sample	Yes	3	3,916	0.08	Accuracy
Metal	Water	LCS	CRDL check sample recovery criteria were not met	No	29	3,916	0.74	Accuracy
Metal	Water	LCS	CRDL check sample recovery criteria were not met	Yes	27	3,916	0.69	Accuracy
Metal	Water	LCS	LCS recovery criteria were not met	No	26	3,916	0.66	Accuracy
Metal	Water	LCS	LCS recovery criteria were not met	Yes	62	3,916	1.58	Accuracy
Metal	Water	LCS	Low level check sample recovery criteria were not met	No	14	3,916	0.36	Accuracy
Metal	Water	LCS	Low level check sample recovery criteria were not met	Yes	9	3,916	0.23	Accuracy
Metal	Water	Matrices	Duplicate sample precision criteria were not met	No	7	3,916	0.18	Precision
Metal	Water	Matrices	Duplicate sample precision criteria were not met	Yes	18	3,916	0.46	Precision

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Water	Matrices	LCS/LCSD precision criteria were not met	No	2	3,916	0.05	Precision
Metal	Water	Matrices	LCS/LCSD precision criteria were not met	Yes	12	3,916	0.31	Precision
Metal	Water	Matrices	MSA calibration correlation coefficient < 0.995	No	1	3,916	0.03	Accuracy
Metal	Water	Matrices	MSA was required, but not performed	Yes	1	3,916	0.03	Representativeness
Metal	Water	Matrices	Post-digestion MS did not meet control criteria	No	29	3,916	0.74	Accuracy
Metal	Water	Matrices	Post-digestion MS did not meet control criteria	Yes	6	3,916	0.15	Accuracy
Metal	Water	Matrices	Predigestion MS recovery criteria were not met	No	42	3,916	1.07	Accuracy
Metal	Water	Matrices	Predigestion MS recovery criteria were not met	Yes	64	3,916	1.63	Accuracy
Metal	Water	Matrices	Serial dilution criteria were not met	No	3	3,916	0.08	Accuracy
Metal	Water	Matrices	Serial dilution criteria were not met	Yes	61	3,916	1.56	Accuracy
Metal	Water	Other	IDL is older than 3 months from date of analysis	No	12	3,916	0.31	Accuracy
Metal	Water	Other	IDL is older than 3 months from date of analysis	Yes	19	3,916	0.49	Accuracy
Metal	Water	Sample Preparation	Samples were not properly preserved in the field	No	13	3,916	0.33	Representativeness
Metal	Water	Sample Preparation	Samples were not properly preserved in the field	Yes	41	3,916	1.05	Representativeness
Metal	Water	Sensitivity	IDL changed due to a significant figure discrepancy	No	4	3,916	0.10	Representativeness
PCB	Soil	Documentation Issues	Transcription error	No	7	56	12.50	N/A
PCB	Water	Documentation Issues	Transcription error	No	7	42	16.67	N/A
PCB	Water	Surrogates	Surrogate recovery criteria were not met	No	7	42	16.67	Accuracy
Pesticide	Soil	Other	Sample results were not validated due to re-analysis	No	5	169	2.96	N/A
Pesticide	Soil	Surrogates	Surrogate recovery criteria were not met	No	1	169	0.59	Accuracy
Pesticide	Water	Documentation Issues	Transcription error	No	11	127	8.66	N/A

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Pesticide	Water	Surrogates	Surrogate recovery criteria were not met	No	21	127	16.54	Accuracy
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	No	1	161	0.62	Representativeness
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	12	161	7.45	Representativeness
Radionuclide	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	3	161	1.86	Accuracy
Radionuclide	Soil	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	20	161	12.42	Representativeness
Radionuclide	Soil	Documentation Issues	Transcription error	No	2	161	1.24	N/A
Radionuclide	Soil	Documentation Issues	Transcription error	Yes	20	161	12.42	N/A
Radionuclide	Soil	LCS	LCS recovery > +/- 3 sigma	Yes	8	161	4.97	Accuracy
Radionuclide	Soil	LCS	LCS recovery criteria were not met	No	1	161	0.62	Accuracy
Radionuclide	Soil	LCS	LCS relative percent error criteria not met	Yes	6	161	3.73	Accuracy
Radionuclide	Soil	Matrices	Recovery criteria were not met	Yes	4	161	2.48	Accuracy
Radionuclide	Soil	Matrices	Replicate analysis was not performed	No	1	161	0.62	Precision
Radionuclide	Soil	Matrices	Replicate precision criteria were not met	No	1	161	0.62	Precision
Radionuclide	Soil	Matrices	Replicate precision criteria were not met	Yes	7	161	4.35	Precision
Radionuclide	Soil	Other	Lab results not verified due to unsubmitted data	Yes	2	161	1.24	Representativeness
Radionuclide	Soil	Other	QC sample does not meet method requirements	No	15	161	9.32	Representativeness
Radionuclide	Soil	Other	QC sample does not meet method requirements	Yes	10	161	6.21	Representativeness
Radionuclide	Soil	Other	Sample exceeded efficiency curve weight limit	Yes	3	161	1.86	Accuracy
Radionuclide	Soil	Other	See hard copy for further explanation	Yes	14	161	8.70	N/A
Radionuclide	Soil	Sample Preparation	Improper aliquot size	Yes	1	161	0.62	Accuracy
Radionuclide	Soil	Sensitivity	MDA exceeded the RDL	Yes	5	161	3.11	Representativeness
Radionuclide	Soil	Sensitivity	MDA was calculated by reviewer	Yes	43	161	26.71	N/A
Radionuclide	Soil	Sensitivity	Results considered qualitative not quantitative	Yes	2	161	1.24	Accuracy
Radionuclide	Water	Blanks	Blank recovery criteria were not met	Yes	3	597	0.50	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	No	11	597	1.84	Representativeness
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	38	597	6.37	Representativeness
Radionuclide	Water	Calibration	Calibration counting statistics did not meet criteria	No	4	597	0.67	Accuracy
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	No	14	597	2.35	Accuracy
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	Yes	95	597	15.91	Accuracy
Radionuclide	Water	Documentation Issues	Sufficient documentation not provided by the laboratory	No	6	597	1.01	Representativeness
Radionuclide	Water	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	71	597	11.89	Representativeness
Radionuclide	Water	Documentation Issues	Transcription error	No	55	597	9.21	N/A
Radionuclide	Water	Documentation Issues	Transcription error	Yes	34	597	5.70	N/A
Radionuclide	Water	Holding Times	Holding times were exceeded	No	4	597	0.67	Representativeness
Radionuclide	Water	Holding Times	Holding times were exceeded	Yes	3	597	0.50	Representativeness
Radionuclide	Water	Holding Times	Holding times were grossly exceeded	No	1	597	0.17	Representativeness
Radionuclide	Water	Holding Times	Holding times were grossly exceeded	Yes	1	597	0.17	Representativeness
Radionuclide	Water	Instrument Set-up	Resolution criteria were not met	Yes	4	597	0.67	Representativeness
Radionuclide	Water	LCS	Expected LCS value not submitted/verifiable	No	1	597	0.17	Representativeness
Radionuclide	Water	LCS	Expected LCS value not submitted/verifiable	Yes	6	597	1.01	Representativeness
Radionuclide	Water	LCS	LCS recovery > +/- 3 sigma	No	16	597	2.68	Accuracy
Radionuclide	Water	LCS	LCS recovery > +/- 3 sigma	Yes	19	597	3.18	Accuracy
Radionuclide	Water	LCS	LCS recovery criteria were not met	No	2	597	0.34	Accuracy
Radionuclide	Water	LCS	LCS recovery criteria were not met	Yes	10	597	1.68	Accuracy
Radionuclide	Water	LCS	LCS relative percent error criteria not met	No	3	597	0.50	Accuracy
Radionuclide	Water	LCS	LCS relative percent error criteria not met	Yes	28	597	4.69	Accuracy
Radionuclide	Water	Matrices	Recovery criteria were not met	No	1	597	0.17	Accuracy
Radionuclide	Water	Matrices	Recovery criteria were not met	Yes	5	597	0.84	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Water	Matrices	Replicate analysis was not performed	No	4	597	0.67	Precision
Radionuclide	Water	Matrices	Replicate analysis was not performed	Yes	9	597	1.51	Precision
Radionuclide	Water	Matrices	Replicate precision criteria were not met	No	7	597	1.17	Precision
Radionuclide	Water	Matrices	Replicate precision criteria were not met	Yes	27	597	4.52	Precision
Radionuclide	Water	Matrices	Replicate recovery criteria were not met	No	2	597	0.34	Accuracy
Radionuclide	Water	Matrices	Replicate recovery criteria were not met	Yes	4	597	0.67	Accuracy
Radionuclide	Water	Other	Lab results not verified due to unsubmitted data	Yes	1	597	0.17	Representativeness
Radionuclide	Water	Other	See hard copy for further explanation	No	3	597	0.50	N/A
Radionuclide	Water	Other	See hard copy for further explanation	Yes	36	597	6.03	N/A
Radionuclide	Water	Sensitivity	Incorrect reported activity or MDA	Yes	1	597	0.17	N/A
Radionuclide	Water	Sensitivity	MDA exceeded the RDL	No	1	597	0.17	Representativeness
Radionuclide	Water	Sensitivity	MDA exceeded the RDL	Yes	15	597	2.51	Representativeness
Radionuclide	Water	Sensitivity	MDA was calculated by reviewer	Yes	185	597	30.99	N/A
SVOC	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	1	545	0.18	Accuracy
SVOC	Soil	Internal Standards	Internal standards did not meet criteria	No	7	545	1.28	Accuracy
SVOC	Soil	Other	Sample results were not validated due to re-analysis	No	261	545	47.89	N/A
SVOC	Soil	Other	Sample results were not validated due to re-analysis	Yes	10	545	1.83	N/A
SVOC	Soil	Surrogates	Surrogate recovery criteria were not met	No	56	545	10.28	Accuracy
SVOC	Soil	Surrogates	Surrogate recovery criteria were not met	Yes	1	545	0.18	Accuracy
SVOC	Water	Blanks	Method, preparation, or reagent blank contamination	No	2	413	0.48	Representativeness
SVOC	Water	Calibration	Continuing calibration verification criteria were not met	No	4	413	0.97	Accuracy
SVOC	Water	Documentation Issues	Transcription error	No	2	413	0.48	N/A
SVOC	Water	Documentation Issues	Transcription error	Yes	3	413	0.73	N/A
SVOC	Water	Holding Times	Holding times were exceeded	No	3	413	0.73	Representativeness
SVOC	Water	Internal Standards	Internal standards did not meet criteria	No	23	413	5.57	Accuracy
SVOC	Water	LCS	LCS recovery criteria were not met	No	1	413	0.24	Accuracy
SVOC	Water	Other	Sample results were not validated due to re-analysis	No	2	413	0.48	N/A

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
SVOC	Water	Other	Sample results were not validated due to re-analysis	Yes	3	413	0.73	N/A
VOC	Soil	Blanks	Method, preparation, or reagent blank contamination	No	10	494	2.02	Representativeness
VOC	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	2	494	0.40	Accuracy
VOC	Soil	Internal Standards	Internal standards did not meet criteria	No	9	494	1.82	Accuracy
VOC	Soil	Other	Sample results were not validated due to re-analysis	No	20	494	4.05	N/A
VOC	Soil	Surrogates	Surrogate recovery criteria were not met	No	4	494	0.81	Accuracy
VOC	Water	Blanks	Method, preparation, or reagent blank contamination	No	20	2,855	0.70	Representativeness
VOC	Water	Calibration	Continuing calibration verification criteria were not met	No	4	2,855	0.14	Accuracy
VOC	Water	Calibration	Continuing calibration verification criteria were not met	Yes	1	2,855	0.04	Accuracy
VOC	Water	Confirmation	Results were not confirmed	No	2	2,855	0.07	Precision
VOC	Water	Documentation Issues	Record added by the validator	No	33	2,855	1.16	N/A
VOC	Water	Holding Times	Holding times were exceeded	No	55	2,855	1.93	Representativeness
VOC	Water	Internal Standards	Internal standards did not meet criteria	No	34	2,855	1.19	Accuracy
VOC	Water	LCS	LCS recovery criteria were not met	No	20	2,855	0.70	Accuracy
VOC	Water	LCS	LCS recovery criteria were not met	Yes	1	2,855	0.04	Accuracy
VOC	Water	Surrogates	Surrogate recovery criteria were not met	No	100	2,855	3.50	Accuracy
VOC	Water	Surrogates	Surrogate recovery criteria were not met	Yes	1	2,855	0.04	Accuracy
Wet Chem	Soil	Holding Times	Holding times were exceeded	Yes	5	31	16.13	Representativeness
Wet Chem	Soil	Holding Times	Holding times were grossly exceeded	No	2	31	6.45	Representativeness
Wet Chem	Soil	Matrices	Predigestion MS recovery criteria were not met	No	1	31	3.23	Accuracy
Wet Chem	Soil	Matrices	Predigestion MS recovery was < 30 percent	Yes	10	31	32.26	Accuracy
Wet Chem	Soil	Other	IDL is older than 3 months from date of analysis	Yes	10	31	32.26	Accuracy
Wet Chem	Water	Blanks	Calibration verification blank contamination	No	1	525	0.19	Representativeness
Wet Chem	Water	Blanks	Method, preparation, or reagent blank contamination	No	5	525	0.95	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Wet Chem	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	1	525	0.19	Representativeness
Wet Chem	Water	Blanks	Negative bias indicated in the blanks	No	2	525	0.38	Representativeness
Wet Chem	Water	Blanks	Negative bias indicated in the blanks	Yes	2	525	0.38	Representativeness
Wet Chem	Water	Calibration	Calibration correlation coefficient did not meet requirements	Yes	3	525	0.57	Accuracy
Wet Chem	Water	Calibration	Continuing calibration verification criteria were not met	Yes	3	525	0.57	Accuracy
Wet Chem	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	Yes	12	525	2.29	N/A
Wet Chem	Water	Documentation Issues	Transcription error	No	11	525	2.10	N/A
Wet Chem	Water	Documentation Issues	Transcription error	Yes	14	525	2.67	N/A
Wet Chem	Water	Holding Times	Holding times were exceeded	No	5	525	0.95	Representativeness
Wet Chem	Water	Holding Times	Holding times were exceeded	Yes	8	525	1.52	Representativeness
Wet Chem	Water	Holding Times	Holding times were grossly exceeded	No	8	525	1.52	Representativeness
Wet Chem	Water	Holding Times	Holding times were grossly exceeded	Yes	3	525	0.57	Representativeness
Wet Chem	Water	Matrices	Duplicate sample precision criteria were not met	Yes	1	525	0.19	Precision
Wet Chem	Water	Matrices	Predigestion MS recovery criteria were not met	Yes	14	525	2.67	Accuracy
Wet Chem	Water	Other	Lab results not verified due to unsubmitted data	No	1	525	0.19	Representativeness
Wet Chem	Water	Other	Lab results not verified due to unsubmitted data	Yes	4	525	0.76	Representativeness
Wet Chem	Water	Sample Preparation	Samples were not properly preserved in the field	Yes	3	525	0.57	Representativeness

Table A2.3
Summary of Data Estimated or Undetected Due to V&V Determinations

Analyte Group	Matrix	No. of CRA Data Records Qualified	Total No. of V&V CRA Records	Detect	Percent Qualified (%)
Herbicide	Soil	1	8	No	12.50
Metal	Soil	114	777	No	14.67
Metal	Soil	179	777	Yes	23.04
Metal	Water	485	3916	No	12.39
Metal	Water	351	3916	Yes	8.96
PCB	Water	7	42	No	16.67
Pesticide	Soil	1	169	No	0.59
Pesticide	Water	21	127	No	16.54
Radionuclide	Soil	1	161	Yes	0.62
Radionuclide	Water	4	597	No	0.67
Radionuclide	Water	12	597	Yes	2.01
SVOC	Soil	63	545	No	11.56
SVOC	Water	27	413	No	6.54
VOC	Soil	23	494	No	4.66
VOC	Water	219	2855	No	7.67
VOC	Water	3	2855	Yes	0.11
Wet Chem	Soil	3	31	No	9.68
Wet Chem	Soil	15	31	Yes	48.39
Wet Chem	Water	21	525	No	4.00
Wet Chem	Water	38	525	Yes	7.24
	Total	**1,588**	**10,722**		**14.81%**

Table A2.4
Summary of Data Qualified as Undetected Due to Blank Contamination

Analyte Group	Matrix	No. of CRA Records Qualified as Undetected Due to Blank Contaimination	Total No. of CRA Records with Detected Results[a]	Percent Qualified as Undetected
Metal	Soil	14	555	2.52
Metal	Water	38	1,930	1.97
Wet Chem	Water	1	374	0.27
	Total	**53**	**2,859**	**1.85%**

[a] As determined by the laboratory prior to V&V.

Table A2.5
Summary of RPDs/DERs of Field Duplicate Analyte Pairs

Analyte Group	Matrix	No. of Duplicates Failing RPD/DER Criteria	Total No. of Duplicate Pairs	Percent Failure (%)	Field Duplicate Frequency (%)
Metal	Soil	5	30	16.67	3.86
Metal	Water	5	331	1.51	7.66
Radionuclide	Water	0	32	0.00	4.41
SVOC	Water	0	3	0.00	0.51
VOC	Water	0	197	0.00	6.56
Wet Chem	Soil	0	1	0.00	3.13
Wet Chem	Water	0	41	0.00	7.08

Table A2.6
Summary of Data Rejected During V&V

Analyte Group	Matrix	Total No. of Rejected Records	Total No. of V&V Records	Percent Rejected (%)
Herbicide	Soil	1	21	4.76
Herbicide	Water	0	7	0.00
Metal	Soil	14	1,454	0.96
Metal	Water	101	5,662	1.78
PCB	Soil	0	98	0.00
PCB	Water	0	49	0.00
Pesticide	Soil	1	301	0.33
Pesticide	Water	0	148	0.00
Radionuclide	Soil	155	481	32.22
Radionuclide	Water	205	1,158	17.70
SVOC	Soil	11	1,239	0.89
SVOC	Water	2	493	0.41
VOC	Soil	32	832	3.85
VOC	Water	296	4,421	6.70
Wet Chem	Soil	0	41	0.00
Wet Chem	Water	13	782	1.66
	Total	**831**	**17,187**	**4.84%**

Table A2.7
Summary of Data Quality Issues Identified by V&V

Analyte Group	Matrix	Categories Description	V&V Observation	Detect	Percent Observed	Percent Qualified U[a]	Percent Qualified J[b]	PARCC Parameter Affected	Impacts Risk Assessment Decisions
Herbicide	Soil	Surrogates	Surrogate recovery criteria were not met	No	12.50	0.00	12.50	Accuracy	No
Metal	Soil	LCS	LCS recovery criteria were not met	Yes	8.62	0.00	8.62	Accuracy	No
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	Yes	5.53	0.00	5.53	Accuracy	No
Metal	Soil	Other	IDL is older than 3 months from date of analysis	No	10.30	2.32	2.06	Accuracy	No
Metal	Soil	Other	IDL is older than 3 months from date of analysis	Yes	28.31	0.00	5.28	Accuracy	No
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	No	6.03	0.03	6.00	Representativeness	No
PCB	Water	Surrogates	Surrogate recovery criteria were not met	No	16.67	0.00	16.67	Accuracy	No
Pesticide	Water	Surrogates	Surrogate recovery criteria were not met	No	16.54	0.00	16.54	Accuracy	No
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	7.45	0.00	0.62	Representativeness	No
Radionuclide	Soil	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	12.42	0.00	0.00	Representativeness	No
Radionuclide	Soil	Other	QC sample does not meet method requirements	No	9.32	0.00	0.00	Representativeness	No
Radionuclide	Soil	Other	QC sample does not meet method requirements	Yes	6.21	0.00	0.00	Representativeness	No
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	6.37	0.00	1.01	Representativeness	No
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	Yes	15.91	0.00	0.67	Accuracy	No
Radionuclide	Water	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	11.89	0.00	0.34	Representativeness	No
SVOC	Soil	Surrogates	Surrogate recovery criteria were not met	No	10.28	0.00	10.28	Accuracy	No
SVOC	Water	Internal Standards	Internal standards did not meet criteria	No	5.57	0.00	5.57	Accuracy	No
Wet Chem	Soil	Holding Times	Holding times were exceeded	Yes	16.13	0.00	16.13	Representativeness	No
Wet Chem	Soil	Holding Times	Holding times were grossly exceeded	No	6.45	0.00	6.45	Representativeness	No
Wet Chem	Soil	Matrices	Predigestion MS recovery was < 30 percent	Yes	32.26	0.00	32.26	Accuracy	No
Wet Chem	Soil	Other	IDL is older than 3 months from date of analysis	Yes	32.26	0.00	32.26	Accuracy	No

[a]Defined as validation qualifier codes containing "U"

[b]Defined as validation qualifier codes containing "J", except "UJ"

COMPREHENSIVE RISK ASSESSMENT

WEST AREA EXPOSURE UNIT

VOLUME 3: ATTACHMENT 3

Statistical Analyses and Professional Judgment

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AI	adequate intake
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
ECOI	ecological contaminant of interest
EcoSSL	Ecological Soil Screening Level
ECOPC	ecological contaminant of potential concern
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ESL	ecological screening level
EU	Exposure Unit
HHRA	Human Health Risk Assessment
IDEU	Inter-Drainage Exposure Unit
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
NCP	National Contingency Plan
NOAEL	no observed adverse effect level
PCOC	potential contaminant of concern
PMJM	Preble's meadow jumping mouse
PRG	preliminary remediation goal
RCEU	Rock Creek Drainage Exposure Unit
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study

tESL	threshold ESL
UCL	upper confidence limit
UTL	upper tolerance limit
WAEU	West Area Exposure Unit
WRW	wildlife refuge worker

1.0 INTRODUCTION

This attachment presents the results for the statistical analyses and professional judgment evaluation used to select human health contaminants of concern (COCs) as part of the Human Health Risk Assessment (HHRA) and ecological contaminants of potential concern (ECOPCs) as part of the Ecological Risk Assessment (ERA) for the West Area Exposure Unit (EU) (WAEU) at the Rocky Flats Environmental Technology Site (RFETS). The methods used to perform the statistical analysis and the professional judgment evaluation that follow the Final Comprehensive Risk Assessment (CRA) Work Plan and Methodology (DOE 2005) are described in Sections 2.2.5 (HHRA) and 2.3.4 (ERA) of Appendix A, Volume 2 of the RCRA Facility Investigation (RFI)-Remedial Investigation (RI)/Corrective Measures Study (CMS)-Feasibility Study (FS) Report (hereafter referred to as the RI/FS Report).

2.0 RESULTS OF STATISTICAL COMPARISONS TO BACKGROUND FOR THE WEST AREA EXPOSURE UNIT

The results of the statistical background comparisons for inorganic and radionuclide potential contaminants of concern (PCOCs) and ecological contaminants of interest (ECOIs) in surface soil/surface sediment, subsurface soil/subsurface sediment, surface soil, and subsurface soil samples collected from the WAEU are presented in this section. Box plots are provided for analytes that were carried forward into the statistical comparison step and are presented in Figures A3.2.1 to A3.2.11.[1] The box plots display several reference points: 1) the line inside the box is the median; 2) the lower edge of the box is the 25th percentile; 3) the upper edge of the box is the 75th percentile; 4) the upper lines (called whiskers) are drawn to the greatest value that is less than or equal to 1.5 times the inter-quartile range (the inter-quartile range is between the 75th and 25th percentiles); 5) the lower whiskers are drawn to the lowest value that is greater than or equal to 1.5 times the inter-quartile range; and 6) solid circles are data points greater or less than the whiskers.

PCOCs with concentrations in the WAEU that are statistically greater than background (or if background comparisons were not performed) are carried through to the professional judgment evaluation step of the COC selection process. ECOIs (for non-Preble's meadow jumping mouse [PMJM] receptors) with concentrations in the WAEU that are statistically greater than background (or if background comparisons are not performed) are carried through to the upper-bound exposure point concentration (EPC)-

[1] Statistical background comparisons are not performed for analytes if: 1) the background concentrations are nondetections; 2) background data are unavailable; 3) the analyte has low detection frequency in the WAEU or background data set (less than 20 percent); or 4) the analyte is an organic compound. Box plots are not provided for these analytes. However, these analytes are carried forward into the professional judgment evaluation.

to-threshold ecological screening level (ESL) comparison step of the ECOPC selection process. ECOIs with surface soil concentrations in PMJM habitat that are statistically greater than background (or if background comparisons were not performed) are carried through to the professional judgment evaluation step of the ECOPC selection process.

PCOCs and ECOIs with concentrations that are not statistically greater than background are not identified as COCs/ECOPCs and are not evaluated further.

2.1 Surface Soil/Surface Sediment Data Used in the HHRA

For the WAEU surface soil/surface sediment data set, the maximum detected concentration (MDC) for manganese exceeded the wildlife refuge worker (WRW) preliminary remediation goals (PRGs), but the upper confidence limit (UCL) on the mean concentration for the site data set for manganese does not exceed the PRG. Consequently, manganese is not evaluated further.

The MDCs and UCLs for arsenic, cesium-134, cesium-137, and radium-228 exceed the PRGs for the WAEU data set. However, it is important to note that the PRG exceedances observed for cesium-134, cesium-137, and radium-228 were from samples that are part of the background data set; therefore, these three analytes were not carried forward through the formal statistical analysis. Consequently, of these four analytes, only arsenic was carried forward into the statistical background comparison step. The results of the statistical comparison of the WAEU surface soil/surface sediment data to background data for arsenic are presented in Table A3.2.1, while the summary statistics for background and WAEU surface soil/surface sediment data are shown in Table A3.2.2.

The results of the statistical comparisons of the WAEU surface soil/surface sediment data to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Arsenic

Background Comparison Not Performed[1]

- Cesium-134
- Cesiuim-137
- Radium-228

2.2 Subsurface Soil/Subsurface Sediment Data Used in the HHRA

No analytes exceeded the applicable PRG for the combined WAEU subsurface soil and subsurface sediment data set.

2.3 Surface Soil Data Used in the ERA (Non-PMJM Receptors)

For the WAEU surface soil data set, the MDCs for aluminum, arsenic, boron, chromium, copper, lead, lithium, mercury, nickel, thallium, vanadium, and zinc exceeded a non-PMJM ESL and, consequently, these analytes were carried forward into the statistical background comparison step. The results of the statistical comparison of the WAEU surface soil data to background data are presented in Table A3.2.3 and the summary statistics for background and WAEU surface soil data are shown in Table A3.2.4.

The results of the statistical comparisons of the WAEU surface soil to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Aluminum
- Arsenic
- Chromium
- Lithium

Not Statistically Greater than Background at the 0.1 Significance Level

- Copper
- Lead
- Mercury
- Nickel
- Vanadium
- Zinc

Background Comparison not Performed[1]

- Boron
- Thallium

2.4 Surface Soil Data used in the ERA (PMJM Receptors)

No PMJM receptors were evaluated in the WAEU data set because the limited habitat within the WAEU boundary is assessed with the more extensive PMJM habitat that occurs in the Rock Creek Drainage EU (RCEU) and the Inter-Drainage EU (IDEU). See Appendix A, Volumes 4 (RCEU) and 5 (IDEU) of the RI/FS Report for additional information. The HHRA and ERA methods and selection of receptors are described in detail in Appendix A, Volume 2, Section 2.0 of the RI/FS Report.

2.5 Subsurface Soil Data used in the ERA

No analytes exceeded the applicable ESL for the subsurface soil data set at the WAEU.

3.0 UPPER-BOUND EXPOSURE POINT CONCENTRATION COMPARISON TO LIMITING ECOLOGICAL SCREENING LEVELS

ECOIs in surface soil and subsurface soil with concentrations that are statistically greater than background (or if background comparisons were not performed) are evaluated further by comparing the EPC concentrations to the threshold ESLs (tESLs). The upper-bound EPCs are the 95 percent UCL of the 90th percentile [upper tolerance limit (UTL)] for small home-range receptors, the UCL for large home-range receptors, or the MDC in the event that the UCL or UTL is greater than the MDC.

3.1 ECOIs in Surface Soil (Non-PMJM)

All six ECOIs (aluminum, arsenic, boron, chromium, lithium, and thallium) whose concentrations were considered to be statistically greater than background were also found to have upper-bound EPCs greater than the tESLs. These six ECOIs are evaluated in the professional judgment evaluation screening step (Section 4.0).

3.2 ECOIs in Subsurface Soil

No ECOIs were found to be statistically greater than background and above an ESL in accordance with the ECOPC selection process. Therefore, the upper-bound EPC comparison to tESLs was not performed.

4.0 PROFESSIONAL JUDGMENT

This section describes the professional judgment applied in the COC and ECOPC selection processes for the HHRA and ERA, respectively, for the WAEU. Based on the weight of evidence evaluated in the professional judgment step, PCOCs and ECOIs are either included for further evaluation as COCs/ECOPCs in the risk characterization step, or excluded from further evaluation.

The professional judgment evaluation takes into account the following lines of evidence: process knowledge, spatial trends, pattern recognition[2], comparison to RFETS

---

[2] The pattern recognition evaluation includes the use of probability plots. If two or more distinct populations are evident in the probability plot, this suggests that one or more local releases may have occurred. Conversely, if only one distinct low-concentration population is defined, likely representing a background population, a local release may or may not have occurred. Similar to all statistical methods, the probability plot has limitations in cases where there is inadequate sampling and the magnitude of the release is relatively small. Thus, absence of two clear populations in the probability plots is consistent with, but not definitive proof of, the hypothesis that no releases have occurred. However, if a release has occurred within the sampled area and has been included in the samples, then the elemental concentrations associated with that release are either within the background concentration range or the entire sampled population represents a release, a highly unlikely probability.

background and other background data sets[3], and risk potential to human health receptors or plants and wildlife. For PCOCs or ECOIs where the process knowledge and/or spatial trends indicate that the presence of the analyte in the EU may be related to site activities, the professional judgment discussion includes only two of the lines of evidence listed above, and it is concluded that these analytes are COCs/ECOPCs and are carried forward into risk characterization. For the other PCOCs and ECOIs that are evaluated in the professional judgment step, each of the lines of evidence listed above are included in the discussion.

Details of the process knowledge and spatial trend evaluations for metals are provided in Appendix A, Volume 2, Attachment 8 of the RI/FS Report. The conclusions for these evaluations for the WAEU are noted in this attachment.

The following PCOCs/ECOIs are evaluated further in the professional judgment step for WAEU:

- Surface soil/surface sediment (HHRA)
  - Arsenic
- Surface soil for non-PMJM receptors (ERA)
  - Aluminum
  - Arsenic
  - Boron
  - Chromium
  - Lithium
  - Thallium

The following sections provide the professional judgment evaluations, by analyte and then by medium, for the PCOCs/ECOIs listed above.

4.1 Aluminum

Aluminum has an EPC in surface soil (for non-PMJM receptors) greater than the tESL and, therefore, was carried forward to the professional judgment step. The lines of

[3] The regional background data set for Colorado and the bordering states was extracted from data for the western United States (Shacklette and Boerngen 1984) and is composed of data from Colorado as well as Arizona, Kansas, Nebraska, New Mexico, Oklahoma, Utah, and Wyoming. Although the background data set for Colorado and bordering states is not specific to Colorado's Front Range, it is useful for the professional judgment evaluation in the absence of a robust data set for the Front Range. Colorado's Front Range has highly variable terrain that changes elevation over short distances. Consequently, numerous soil types and geologic materials are present at RFETS, and the data set for Colorado and bordering states provides regional benchmarks for naturally-occurring metals in soil. The comparison of RFETS's soil data to these regional benchmarks is only performed for non-PMJM professional judgment because the PMJM habitat is restricted to the front range of Colorado..

evidence used to determine if aluminum should be retained for risk characterization are summarized below.

4.1.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential to have been released into the RFETS soil because of the aluminum metal inventory and presence of aluminum in waste generated during former operations. However, the localized documented source areas are remote from WAEU.

4.1.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that aluminum concentrations in WAEU surface soil reflect variations in naturally occurring aluminum.

4.1.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for the natural log transformed data set for aluminum (Figure A3.4.1) suggests a single background population, which is indicative of background conditions. However, 10 sampling locations represent a limited data set for conclusive definition of the full range of a background population.

4.1.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Within the WAEU, eight of the 10 surface soil samples have concentrations within the background range. There are two surface soil samples with aluminum concentrations of 18,000 milligrams per kilogram (mg/kg). Aluminum concentrations collected in the 10 surface soil samples at the WAEU range from 8,200 to 18,000 mg/kg, with a mean concentration of 13,520 mg/kg and a standard deviation of 3,168 mg/kg. Background aluminum concentrations range from 4,050 to 17,100 mg/kg, with a mean concentration of 10,203 mg/kg and a standard deviation of 3,256 mg/kg (Table A3.2.4). The ranges of the WAEU and background data sets significantly overlap, with the means and standard deviations being extremely close for the two data sets. The two locations whose concentrations of 18,000 mg/kg exceed the background MDC are only slightly above the maximum background concentration of 17,100 mg/kg. Because these two points are extremely close to background concentrations and do not show a concentration gradient, they are considered to be indicative of background concentrations.

Although the site-specific background MDC is exceeded, aluminum concentrations at the WAEU are well within the range of reported literature values. Aluminum concentrations reported in surface soil samples at the WAEU are well within the range for aluminum in soils of Colorado and the bordering states (5,000 to 100,000 mg/kg, with mean concentration of 50,800 mg/kg and a standard deviation of 23,500 mg/kg) (Table A3.4.1).

4.1.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The MDC for aluminum in the WAEU (18,000 mg/kg) exceeds the no observed adverse effect level (NOAEL) ESL for only one receptor group, terrestrial plants (50 mg/kg). However, U.S. Environmental Protection Agency (EPA) Ecological Soil Screening Level (EcoSSL) guidance (EPA 2003) for aluminum recommends that aluminum not be considered an ECOPC for soils at sites where the soil pH exceeds 5.5 due to its limited bioavailability in non-acidic soils. The average pH value for RFETS surface soils is 8.2. Aluminum concentrations in the WAEU show a distribution similar to sitewide background concentrations and there are no historical records of a source area in the WAEU. Therefore, it is unlikely that the aluminum concentrations in surface soil within the WAEU could represent potential risk concerns for wildlife populations.

4.1.6 Conclusion

Review of process knowledge indicates that aluminum may be a present in RFETS soils as a result of historical site-related activities; however, the weight of evidence presented above shows that aluminum concentrations in WAEU surface soil (non-PMJM receptors) have a spatial distribution and a single data population indicative of naturally occurring aluminum, are well within regional background levels, and are unlikely to result in risk concerns for wildlife populations. Aluminum is not considered an ECOPC in surface soil for the WAEU and, therefore, is not further evaluated quantitatively.

4.2 Arsenic

Arsenic has concentrations statistically greater than background in surface soil/surface sediment and, therefore, was carried forward to the professional judgment step. In addition, arsenic had an EPC in surface soil (for non-PMJM receptors) greater than the tESL. The lines of evidence used to determine whether arsenic should be retained for risk characterization are summarized below.

4.2.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates arsenic is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.2.2 Evaluation of Spatial Trends

Surface Soil/ Surface Sediment

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that arsenic concentrations in WAEU surface soil/surface sediment reflect variations in naturally occurring arsenic.

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that arsenic concentrations in WAEU surface soil reflect variations in naturally occurring arsenic.

4.2.3 Pattern Recognition

Surface Soil/Surface Sediment and Surface Soil (Non-PMJM)

The probability plot for the natural log transformed data set for arsenic (Figure A3.4.2) suggests a single population which is indicative of background conditions. However, 10 sampling locations represent a limited data set for a conclusive definition of the full range of a background population. Although the highest concentration of arsenic (22 mg/kg in sample 04F0707-002) does not fit the distribution of the other data, this single data point does not provide sufficient evidence of a second population.

4.2.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil/Surface Sediment and Surface Soil (Non-PMJM)

Arsenic was detected in each of the 10 surface soil/surface sediment samples, excluding the 10 surface sediment samples assigned to background, collected in the WAEU. These 10 samples also correspond to the 10 surface soil (non-PMJM) samples in the WAEU. Arsenic concentrations in these samples range from 3.60 to 22.0 mg/kg, with a mean concentration of 8.48 mg/kg and a standard deviation of 5.07 mg/kg. Arsenic concentrations in the background data set range from 0.270 to 9.6 mg/kg, with a mean concentration of 3.42 mg/kg and a standard deviation of 2.55 mg/kg (Table A3.2.2).

Arsenic concentrations reported in surface soil samples at the WAEU are well within the range for arsenic in soils of Colorado and the bordering states (1.22 to 97 mg/kg, with a mean concentration of 6.9 mg/kg and a standard deviation of 7.64 mg/kg) (Table A3.4.1).

4.2.5 Risk Potential for HHRA

Surface Soil/Surface Sediment

The arsenic MDC for surface soil/surface sediment is 22 mg/kg and the UCL is 11.6 mg/kg. Although the UCL of 11.6 mg/kg is more than four times greater than the PRG (2.41 mg/kg), the surface soil/surface sediment concentrations for arsenic within the WAEU are within naturally occurring concentrations in soils in Colorado and bordering states. The cancer risks and noncancer hazard indices were estimated for the wildlife refigure work (WRW) and wildlife refuge visitor (WRV) for arsenic in WAEU surface soil/surface sediment and in background surface soil/surface sediment. Exposure parameters from the CRA Methodology (DOE 2005) were used for the risk and hazard index calculations. Details of the background risk and hazard index calculations are presented in Attachment 9 of Volume 2, Appendix A of the RI/FS Report. The estimated cancer risks for the WRW and WRV associated with potential exposure to arsenic in surface soil/surface sediment are both approximately 4E-06. These risk results are well within the National Contingency Plan (NCP) risk range of 1E-06 to 1E-04. The estimated noncancer hazard indices associated with potential exposure to arsenic in surface soil/surface sediment are approximately 0.03 for the WRW and 0.02 for the WRV. The estimated cancer risks for the WRW and WRV associated with potential exposure to background levels of arsenic in surface soil/surface sediment are 2E-06 and 1E-06, respectively. The estimated noncancer hazard indices associated with potential exposure to background levels of arsenic in surface soil/surface sediment are approximately 0.01 for the WRW and 0.007 for the WRV. Furthermore, because arsenic concentrations in the WAEU appear to represent naturally occurring arsenic, this risk is unassociated with arsenic releases from RFETS.

4.2.6 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL, 22 mg/kg, exceeds ESLs for the herbivorous deer mouse (2.57 mg/kg), the prairie dog (9.35 mg/kg), terrestrial plants (10 mg/kg), mule deer (13 mg/kg), and herbivorous mourning dove (20 mg/kg). The UTL also exceeds the Eco-SSL for plants (18 mg/kg) but is less than the Eco-SSL for birds (43 mg/kg) and mammals (46 mg/kg) (EPA 2005a). The ESLs for the herbivorous deer mouse and prairie dog are both below background concentrations, with the deer mouse ESL less than the average background concentration. These are screening level values for assessing risks to the deer mouse and prairie dog receptor populations. The MDC is also located within an active gravel mining operation that does not represent an attractive area of habitat for the terrestrial receptors discussed above. Therefore, it is highly unlikely that one slightly elevated arsenic detection which exceeds several ESLs within an area of active mining has the potential to cause risk to populations of terrestrial receptors in the WAEU.

4.2.7 Conclusion

The weight of evidence presented above shows that arsenic concentrations in WAEU surface soil/surface sediment and surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; have a spatial distribution and a single data population indicative of naturally occurring arsenic; are well within regional background levels; result in estimated risks to WRW that would be similar to background risks (2E-06); and are unlikely to result in risk concerns for wildlife populations. Arsenic is not considered a COC in surface soil/surface sediment and is not considered an ECOPC in surface soil for the WAEU. Therefore, arsenic is not further evaluated quantitatively.

4.3 Boron

For boron in surface soil, a statistical comparison between WAEU and RFETS background data could not be performed because RFETS background surface soil samples were not analyzed for boron. Boron has an EPC in surface soil (for non-PMJM receptors) greater than the tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine if boron should be retained for risk characterization are summarized below.

4.3.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates boron is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.3.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that boron concentrations in WAEU surface soil reflect variations in naturally occurring boron.

4.3.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for the natural log transformed data set for boron (Figure A3.4.4) suggests a single background population indicative of background conditions. However, 10 sampling locations represent a limited data set for a conclusive definition of the full range of a background population.

4.3.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

RFETS background data were not collected for boron. However, the reported range for boron in surface soil within Colorado and the bordering states is 20 to 150 mg/kg, with a mean concentration of 27.9 mg/kg and a standard deviation of 19.7 mg/kg (Table A3.4.1). Boron concentrations reported in surface soil samples at the WAEU ranged from 2.80 to 7.10 mg/kg, with a mean concentration of 5.11 mg/kg and a standard deviation of 1.20 mg/kg (Table A3.2.4). The range of boron concentrations in surface soil at the WAEU are well within the range for boron in soils of Colorado and the bordering states.

4.3.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The MDC and UTL for boron in the WAEU (10.4 mg/kg and 7.93 mg/kg, respectively) exceed the NOAEL ESL for only one receptor group, terrestrial plants (0.5 mg/kg). All other NOAEL ESLs were greater than the MDC and ranged from 30 to 6,070 mg/kg. Site-specific background data for boron were not available, but the MDC did not exceed the low end (20 mg/kg) of the background range presented in Shacklette and Boerngen (1984). This indicates the terrestrial plant NOAEL ESL (0.5 mg/kg) is well below expected background concentrations, and MDCs above the NOAEL ESL are not likely to be indicative of site-related risk to the terrestrial plant community in the WAEU. Kabata-Pendias and Pendias (1992) indicate soil with boron concentrations equal to 0.3 mg/kg is critically deficient in boron, and effects on plant reproduction would be expected. Additionally, the summary of boron toxicity in Efroymson et al. (1997) notes that the source of the 0.5-mg/kg NOAEL ESL indicates boron was toxic when added at 0.5 mg/kg to soil, but gives no indication of the boron concentration in the baseline soil before the addition. The confidence placed by Efroymson et al. (1997) was low. No boron Eco-SSLs are currently available for any receptor. Because no NOAEL ESLs other than the terrestrial plant NOAEL ESL are exceeded by the MDC, boron is highly unlikely to present a risk to terrestrial receptor populations in the WAEU.

4.3.6 Conclusion

The weight of evidence presented above shows that boron concentrations in WAEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; have a spatial distribution and single data population indicative of naturally occurring boron; are well within regional background levels; and are unlikely to result in risk concerns for wildlife populations. Boron is not considered an ECOPC in surface soil for the WAEU and, therefore, is not further evaluated quantitatively.

4.4 Chromium

Chromium has concentrations statistically greater than background in surface soil/surface sediment and, therefore, was carried forward to the professional judgment step. In addition, chromium had an upper-bound EPC in surface soil (for non-PMJM receptors) greater than the tESL. The lines of evidence used to determine if chromium should be retained for risk characterization are summarized below.

4.4.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates the potential for chromium to be a ECOPC in the WAEU is low due to a moderate inventory, and limited identification as a constituent in wastes generated at RFETS and localized documented historical source areas remote from WAEU.

4.4.2 Evaluation of Spatial Trends

Surface Soil (non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that chromium concentrations in WAEU surface soil reflect variation in naturally occurring chromium.

4.4.3 Pattern Recognition

Surface Soil (non-PMJM)

The probability plot for the natural log transformed data set for chromium (Figure A3.4.5) suggests a single background population indicative of background conditions. However, 10 sampling locations represent a limited data set for a conclusive definition of the full range of a background population.

4.4.4 Comparison to RFETS Background and Other Background Data Sets

Chromium was detected in each of the 10 surface soil samples collected in the WAEU. Chromium concentrations at the WAEU range from 8.10 to 17 mg/kg, with a mean concentration of 13.3 mg/kg and a standard deviation of 2.65 mg/kg. Background chromium concentrations range from 5.50 to 16.9 mg/kg, with a mean concentration of 11.2 mg/kg and a standard deviation of 2.78 mg/kg (Table A3.2.4). The reported range for chromium in surface soils of Colorado and the bordering states is 3 to 500 mg/kg, with an arithmetic mean of 48.2 mg/kg (Table A3.4.1). Chromium concentrations reported in surface soil samples at the WAEU are well within this range.

4.4.5 Risk Potential for Plants and Wildlife

The UTL for chromium (19.5 mg/kg) exceeds NOAEL ESLs for the terrestrial invertebrate (0.4 mg/kg), terrestrial plant (1.0 mg/kg), insectivorous mourning dove (1.34 mg/kg), American kestrel (14.2 mg/kg), and insectivore deer mouse (15.9 mg/kg) receptors, but the MDC is similar to the maximum detected background concentration (16.9 mg/kg) and less than the EPA EcoSSLs for birds (26 mg/kg) and mammals (34 mg/kg), which is based on chromium III (EPA 2005b). An EPA EcoSSL for chromium VI is not available for birds and is 81 mg/kg for mammals (EPA 2005b). The chromium ESLs are based on toxicity of hexavalent chromium, which is likely to represent only a small fraction of the total chromium detected in soils. The mammalian ESLs for trivalent chromium are considerably greater than the hexavalent chromium ESLs. This indicates that the ESL based on hexavalent chromium may be overly conservative for use in assessing risk to plants and wildlife.

A chromium source was not identified in the WAEU, indicating that chromium concentrations are due to local variations. It is unlikely that chromium poses a risk potential to non-PMJM receptors in the WAEU.

4.4.6 Conclusion

Based on process knowledge, chromium may be present in RFETS soil as a result of historical site-related activities. However, the weight of evidence presented above shows that chromium concentrations in WAEU surface soil (non-PMJM receptors) appear to suggest a single data population indicative of naturally occurring chromium; are well within regional background levels; and are unlikely to result in risk concerns for wildlife populations. Chromium is not considered an ECOPC in surface soil for the WAEU and, therefore, is not further evaluated quantitatively.

4.5 Lithium

Lithium had an upper-bound EPC in surface soil (for non-PMJM receptors) greater than the tESL so was carried forward to the professional judgment step. The lines of evidence used to determine if lithium should be retained as an ECOPC are summarized below.

4.5.1 Summary of Process Knowledge

Based on process knowledge as detailed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the potential for lithium to be an ECOPC in the WAEU is low due to localized documented historical source areas remote from the WAEU. Based on process knowledge, lithium is unlikely to be a site-related contaminant.

4.5.2 Evaluation of Spatial Trends

Surface Soil (non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that lithium concentrations in WAEU surface soil reflect variations in naturally occurring lithium.

4.5.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for the natural log-transformed data set for lithium (Figure A3.4.6) suggests a single background population indicative of background conditions. However, 10 sampling locations represent a limited data set for a conclusive definition of the full range of a background population.

4.5.4 Comparison to RFETS Background and Other Background Data Sets

Lithium was detected in 100 percent of the 10 surface soil samples collected at the WAEU in a range from 5.70 to 12.00 mg/kg, with a mean concentration of 9.28 and a standard deviation of 1.74 mg/kg. Background concentrations of lithium range from 4.8 to 11.6 mg/kg, with a mean of 7.66 mg/kg and a standard deviation of 1.89 mg/kg (Table A3.2.4).

The reported range for lithium in surface soils within Colorado and the bordering states is 5 to 130 mg/kg, with an arithmetic mean of 25.3 mg/kg and a standard deviation of 14.4 mg/kg (Table A3.4.1). Lithium concentrations reported in surface soil samples at the WAEU are well within this range.

4.5.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The lithium MDC (12.0 mg/kg) exceeds the NOAEL ESL for only one receptor, terrestrial plants (2.0 mg/kg), which is lower than the minimum detection of lithium in background surface soil (4.80 mg/kg). None of the NOAEL ESLs for mammalian receptors are exceeded by the MDC. NOAEL ESLs were not available for avian receptors due to lack of toxicity information. The authors of the document from which the lithium NOAEL ESL was selected (Efroymson et al. 1997) placed a low confidence rating on the value. Other studies reported in Efroymson et al. (1997) cited no observed adverse effects at 25 mg/kg, which is greater than the MDC. No lithium Eco-SSLs are currently available for any receptor. Lithium concentrations in WAEU surface soil have the same range as the background concentrations and are most likely due to local variations in natural sources and are below available ESLs for vertebrate receptors. The ESL for terrestrial plants is lower than all detected background concentrations.

4.5.6 Conclusion

Process knowledge indicates lithium may be present in RFETS soil as a result of historical site-related activities. However, the weight of evidence presented above shows that lithium concentrations in WAEU surface soil (non-PMJM receptors) have a spatial distribution and single data population indicative of naturally occurring lithium; are well within regional background levels; and are unlikely to result in risk concerns for wildlife populations. Lithium is not considered an ECOPC in surface soil for the WAEU and, therefore, is not further evaluated quantitatively.

4.6 Thallium

Thallium has an EPC in surface soil (for non-PMJM receptors) greater than the tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine if thallium should be retained for risk characterization are summarized below.

4.6.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates thallium is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.6.2 Evaluation of Spatial Trends

Surface Soil (non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that thallium concentrations in WAEU surface soil reflect variations in naturally occurring thallium.

4.6.3 Pattern Recognition

Surface Soil (Non-PMJM)

Thallium was detected in only one of the 10 samples (at sample location 040732-001) collected within WAEU, this at a concentration of 1.30 mg/kg. All other nine locations were nondetects. Because there was only one detected concentration within the WAEU, it was not possible to use a probability plot to evaluate a background concentration range.

4.6.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Thallium was detected in only 10 percent (one) of the 10 surface soil samples collected at the WAEU. The thallium concentration of this single detected sample was 1.30 mg/kg, with a mean concentration for the data set of 0.571 and a standard deviation of 0.256 mg/kg. Site-specific background data for thallium were all nondetect and, therefore, a statistical background comparison could not be made. The reported range for thallium in surface soil of Colorado and bordering states is 2.45 to 20.79 mg/kg (Table A3.4.1). The thallium concentration reported in a single surface soil sample at the WAEU (1.30 mg/kg) is below reported regional ranges.

4.6.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The single detected sample within the WAEU, which is evaluated as the MDC and UTL for thallium in the WAEU (1.30 mg/kg), exceeds the NOAEL ESL for only one receptor group, terrestrial plants (1.0 mg/kg). All other NOAEL ESLs were greater than the MDC and ranged from 7.24 to 1,038.96 mg/kg. No thallium Eco-SSLs are currently available for any receptor. Site-specific background data for thallium were not available, but the MDC did not exceed the low end (2.4 mg/kg) of the background range for Colorado and bordering states (Table A3.4.1). This indicates the terrestrial plant NOAEL ESL (1.0 mg/kg) is well below expected background concentrations, and the MDC of 1.30 mg/kg is just above the conservative NOAEL ESL, and is not likely to be indicative of site-related risk to the terrestrial plant community in the WAEU. Because no NOAEL ESLs other than the terrestrial plant NOAEL ESL are exceeded by the MDC, thallium is highly unlikely to present a risk to terrestrial receptor populations in the WAEU.

4.6.6 Conclusion

Although no site-specific background data are available, the weight of evidence presented above shows that thallium concentrations in WAEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; have a spatial distribution indicative of naturally occurring thallium; are well within regional background levels; and are unlikely to result in risk concerns for wildlife populations. Only the lowest ESL for thallium (1.0 mg/kg) was exceeded by the MDC of 1.30 mg/kg. Thallium is not considered an ECOPC in surface soil for the WAEU and, therefore, is not further evaluated quantitatively.

5.0 REFERENCES

U.S. Department of Energy (DOE), 2005. Final Comprehensive Risk Assessment Work Plan and Methodology, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1.September.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants. 1997 Revision, ES/ER/TM-85/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

EPA, 2003. Ecological Soil Screening Level for Aluminum. OSWER Directive 9285.7-60. Office of Solid Waste and Emergency Response. November.

EPA, 2005a. Ecological Soil Screening Level for Arsenic. OSWER Directive 9285.7-62. Office of Solid Waste and Emergency Response, March.

EPA, 2005b. Ecological Soil Screening Level for Chromium. OSWER Directive 9285-66. Office of Solid Waste and Emergency Response. March.

Kabata-Pendias, A., and H. Pendias, 1992. Trace Elements in Soils and Plants. Second Edition. CRC Press, Boca Raton, Florida. 365 pp.

Shacklette, H.T., and J.G. Boerngen, 1984. Element Concentrations in Soils and Other Surface Materials of the Contiguous United States. Professional Paper 1270. U.S. Geological Survey, Washington, D.C.

TABLES

Table A3.2.1
Statistical Distribution and Comparison to Background for WAEU Surface Soil/Surface Sediment

		Statistical Distribution Testing Results						Background Comparison Test Results		
		Background Dataset			WAEU Dataset (excluding background samples)					
Analyte	**Units**	**Total Samples**	**Distribution Recommended by ProUCL**	**Detects (%)**	**Total Samples**	**Distribution Recommended by ProUCL**	**Detects (%)**	**Test**	**1 - p**	**Statistically Greater than Background?**
Arsenic	**mg/kg**	**73**	**GAMMA**	**91.8**	**10**	**GAMMA**	**100.00**	**WRS**	**7.07E-05**	**Yes**

WRS = Wilcoxon Rank Sum
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table A3.2.2
Summary Statistics for WAEU Surface Soil/Surface Sediment [a]

		Background					WAEU (excluding background samples)				
Analyte	Units	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation
Arsenic	mg/kg	73	0.270	9.60	3.42	2.55	10	3.60	22.0	8.48	5.07

[a] Statistics are computed using one-half of the reported values for nondetects.

Table A3.2.3
Statistical Distribution and Comparison to Background for WAEU Surface Soil

		Statistical Distribution Testing Results						Background Comparison Test Results		
		Background Data Set			WAEU Data Set (excluding background samples)					
Analyte	Units	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Test	1 - p	Statistically Greater than Background?
Aluminum	**mg/kg**	**20**	**NORMAL**	**100.0**	**10**	**NORMAL**	**100.00**	**t-Test_N**	**0.006**	**Yes**
Arsenic	**mg/kg**	**20**	**NORMAL**	**100.0**	**10**	**GAMMA**	**100.00**	**WRS**	**0.067**	**Yes**
Boron	mg/kg	N/A	N/A	N/A	10	NORMAL	100.00	N/A	N/A	N/A
Chromium	**mg/kg**	**20**	**NORMAL**	**100.0**	**10**	**NORMAL**	**100.00**	**t-Test_N**	**0.030**	**Yes**
Copper	mg/kg	20	NON-PARAMETRIC	100.0	10	NORMAL	100.00	WRS	0.999	No
Lead	mg/kg	20	NORMAL	100.0	10	NORMAL	100.00	t-Test_N	0.764	No
Lithium	**mg/kg**	**20**	**NORMAL**	**100.0**	**10**	**NORMAL**	**100.00**	**t-Test_N**	**0.016**	**Yes**
Mercury	mg/kg	20	NON-PARAMETRIC	40.0	10	NORMAL	100.00	WRS	1.000	No
Nickel	mg/kg	20	NORMAL	100.0	10	NORMAL	100.00	t-Test_N	0.812	No
Thallium	mg/kg	14	NORMAL	0.0	10	NON-PARAMETRIC	10.00	N/A	N/A	N/A
Vanadium	mg/kg	20	NORMAL	100.0	10	NORMAL	100.00	t-Test_N	0.461	No
Zinc	mg/kg	20	NORMAL	100.0	10	NORMAL	100.00	t-Test_N	0.997	No

WRS = Wilcoxon Rank Sum
t-Test_N = Student's t-test using normal data
N/A = Not applicable. Background comparison was not performed because background data were not available or detection frequency of an analyte in EU or background data set is less than 20 percent.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table A3.2.4
Summary Statistics for Background and WAEU Surface Soil[a]

		Background					WAEU (excluding background samples)				
Analyte	**Units**	**Total Samples**	**Minimum Detected Concentration**	**Maximum Detected Concentration**	**Mean Concentration**	**Standard Deviation**	**Total Samples**	**Minimum Detected Concentration**	**Maximum Detected Concentration**	**Mean Concentration**	**Standard Deviation**
Aluminum	mg/kg	20	4,050	17,100	10,203	3,256	10	8,200	18,000	13,520	3,168
Arsenic	mg/kg	20	2.30	9.60	6.09	2.00	10	3.60	22.0	8.48	5.07
Boron	mg/kg	N/A	N/A	N/A	N/A	N/A	10	2.80	7.10	5.11	1.20
Chromium	mg/kg	20	5.50	16.9	11.2	2.78	10	8.10	17.0	13.3	2.65
Copper	mg/kg	20	5.20	16.0	13.0	2.58	10	5.20	13.0	9.77	2.20
Lead	mg/kg	20	8.60	53.3	33.5	10.5	10	9.90	48.0	30.5	11.3
Lithium	mg/kg	20	4.80	11.6	7.66	1.89	10	5.70	12.0	9.28	1.74
Manganese	mg/kg	20	129	357	237	63.9	10	150	320	260	55.8
Mercury	mg/kg	20	0.090	0.120	0.072	0.031	10	0.020	0.030	0.025	0.003
Nickel	mg/kg	20	3.80	14.0	9.60	2.59	10	4.90	11.0	8.79	1.62
Thallium	mg/kg	14	N/A	N/A	0.414	0.015	10	1.30	1.30	0.571	0.256
Vanadium	mg/kg	20	10.8	45.8	27.7	7.68	10	19.0	34.0	28.0	5.06
Zinc	mg/kg	20	21.1	75.9	49.8	12.2	10	21.0	50.0	37.0	9.01

[a] Statistics are computed using one-half of the reported values for nondetects.
N/A = Not applicable.

Table A3.4.1
Summary of Element Concentrations in Colorado and Bordering States Surface Soil[a]

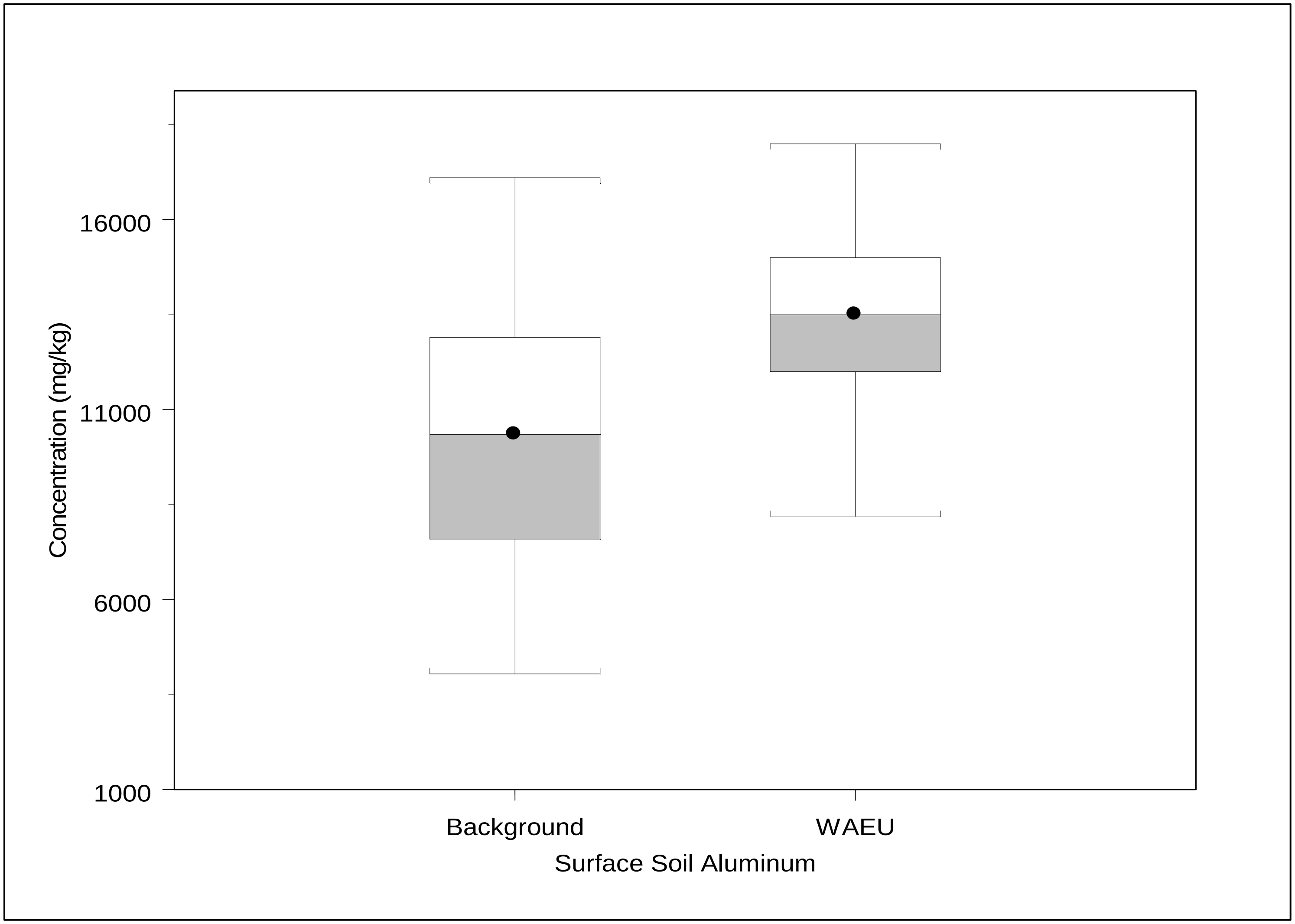
Analyte	Total Number of Results	Detection Frequency (%)	Range of Detected Values (mg/kg)	Average (mg/kg)[b]	Standard Deviation (mg/kg)[b]
Aluminum	303	100%	5,000 - 100,000	50,800	23,500
Antimony	84	15%	1.038 - 2.531	0.647	0.378
Arsenic	307	99%	1.224 - 97	6.9	7.64
Barium	342	100%	100 - 3,000	642	330
Beryllium	342	36%	1 - 7	0.991	0.876
Boron	342	67%	20 - 150	27.9	19.7
Bromine	85	51%	0.5038 - 3.522	0.681	0.599
Calcium	342	100%	0.055 - 32	3.09	4.13
Carbon	85	100%	0.3 - 10	2.18	1.92
Cerium	291	16%	150 - 300	90	38.4
Chromium	342	100%	3 - 500	48.2	41
Cobalt	342	89%	3 - 30	8.09	5.03
Copper	342	100%	2 - 200	23.1	17.7
Fluorine	264	97%	10 - 1,900	394	261
Gallium	340	99%	5 - 50	18.3	8.9
Germanium	85	100%	0.5777 - 2.146	1.18	0.316
Iodine	85	79%	0.516 - 3.487	1.07	0.708
Iron	342	100%	3,000 - 100,000	21,100	13,500
Lanthanum	341	66%	30 - 200	39.8	28.8
Lead	342	93%	10 - 700	24.8	41.5
Lithium	307	100%	5 - 130	25.3	14.4
Magnesium	341	100%	300 - 50,000	8,630	6,400
Manganese	342	100%	70 - 2,000	414	272
Mercury	309	99%	0.01 - 4.6	0.0768	0.276
Molybdenum	340	4%	3 - 7	1.59	0.522
Neodymium	256	23%	70 - 300	47.1	31.7
Nickel	342	96%	5 - 700	18.8	39.8
Niobium	335	63%	10 - 100	11.4	8.68
Phosphorus	249	100%	40 - 4,497	399	397
Potassium	341	100%	1,900 - 63,000	18,900	6,980
Rubidium	85	100%	35 - 140	75.8	25
Scandium	342	85%	5 - 30	8.64	4.69
Selenium	309	81%	0.1023 - 4.3183	0.349	0.415
Silicon	85	100%	149,340 - 413,260	302,000	61,500
Sodium	335	100%	500 - 70,000	10,400	6,260
Strontium	342	100%	10 - 2,000	243	212
Sulfur	85	16%	816 - 47,760	1,250	5,300
Thallium	76	100%	2.45 - 20.79	9.71	3.54
Tin	85	96%	0.117 - 5.001	1.15	0.772
Titanium	342	100%	500 - 7,000	2,290	1,350
Uranium	85	100%	1.11 - 5.98	2.87	0.883
Vanadium	342	100%	7 - 300	73	41.7
Ytterbium	330	99%	1 - 20	3.33	2.06
Yttrium	342	98%	10 - 150	26.9	18.1
Zinc	330	100%	10 - 2,080	72.4	159
Zirconium	342	100%	30 - 1,500	220	157

[a] Based on data from Shacklette and Boerngen 1984 for the states of Colorado, Arizona, Kansas, Nebraska, New Mexico, Oklahoma, Utah, and Wyoming.

[b] One-half the detection limit used as proxy value for nondetects in computation of the mean and standard deviation.

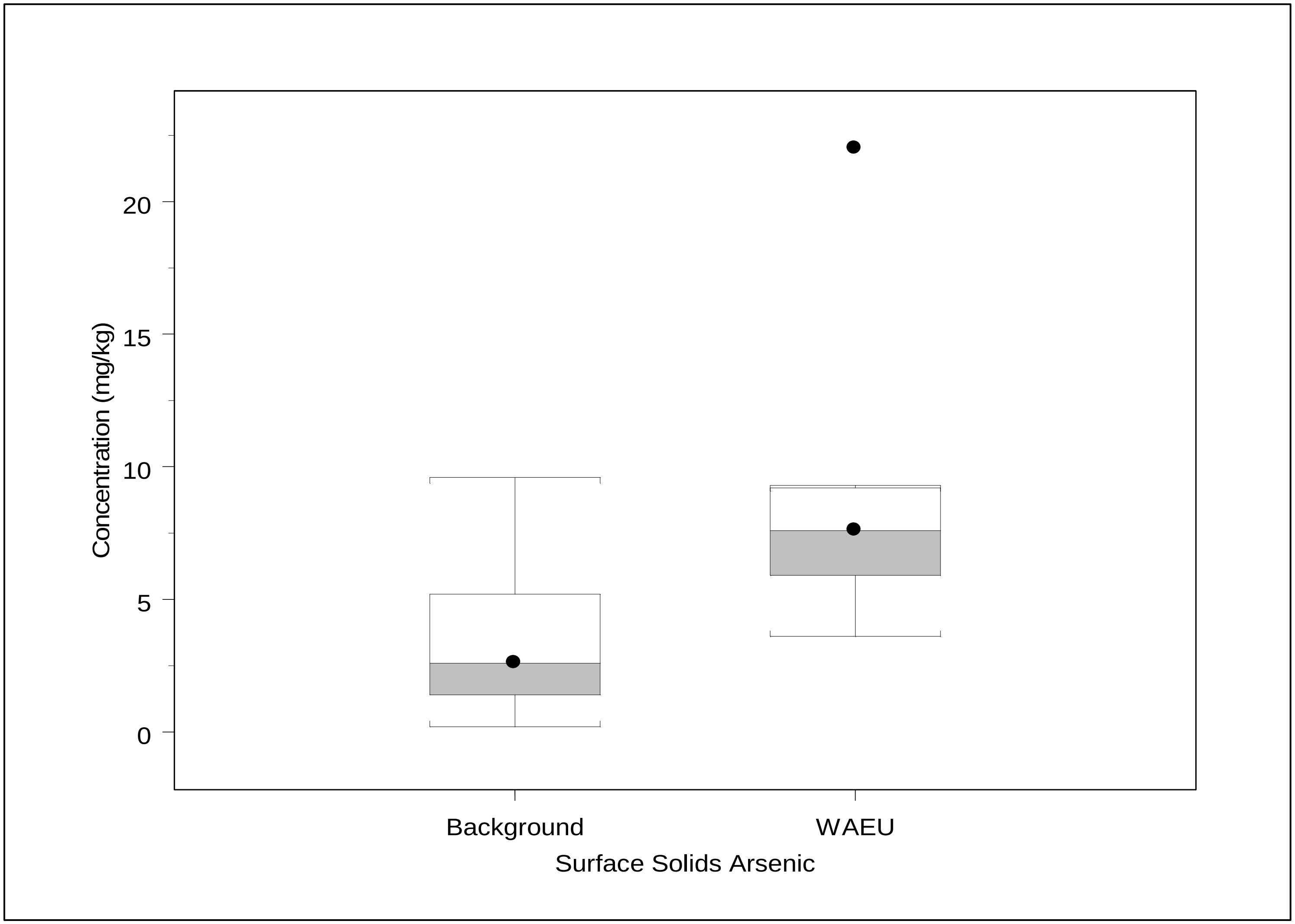
FIGURES

Figure A3.2.1
WAEU Surface Soil Box Plot for Aluminum



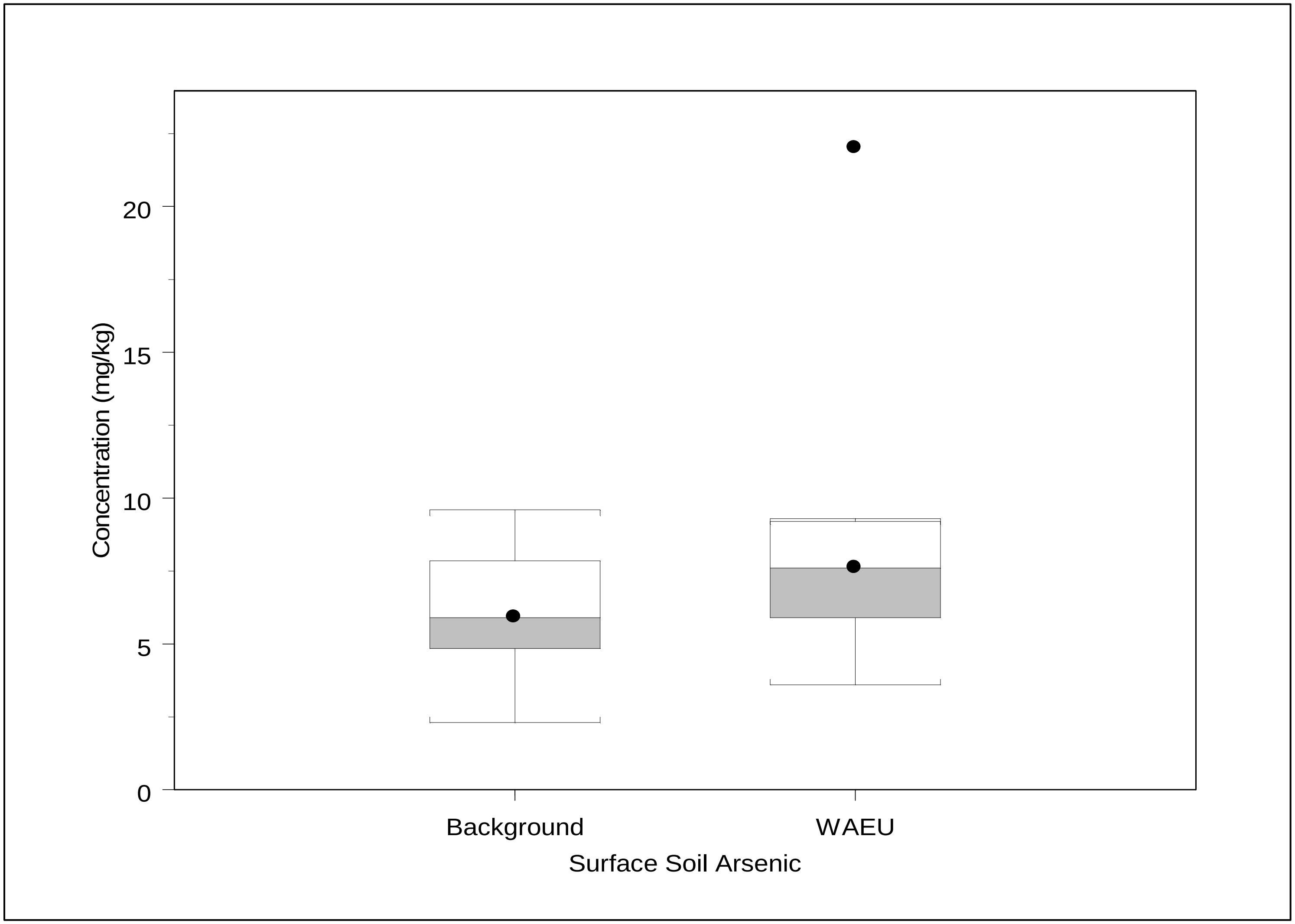
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.2
WAEU Surface Soil/Surface Sediment Box Plot for Arsenic



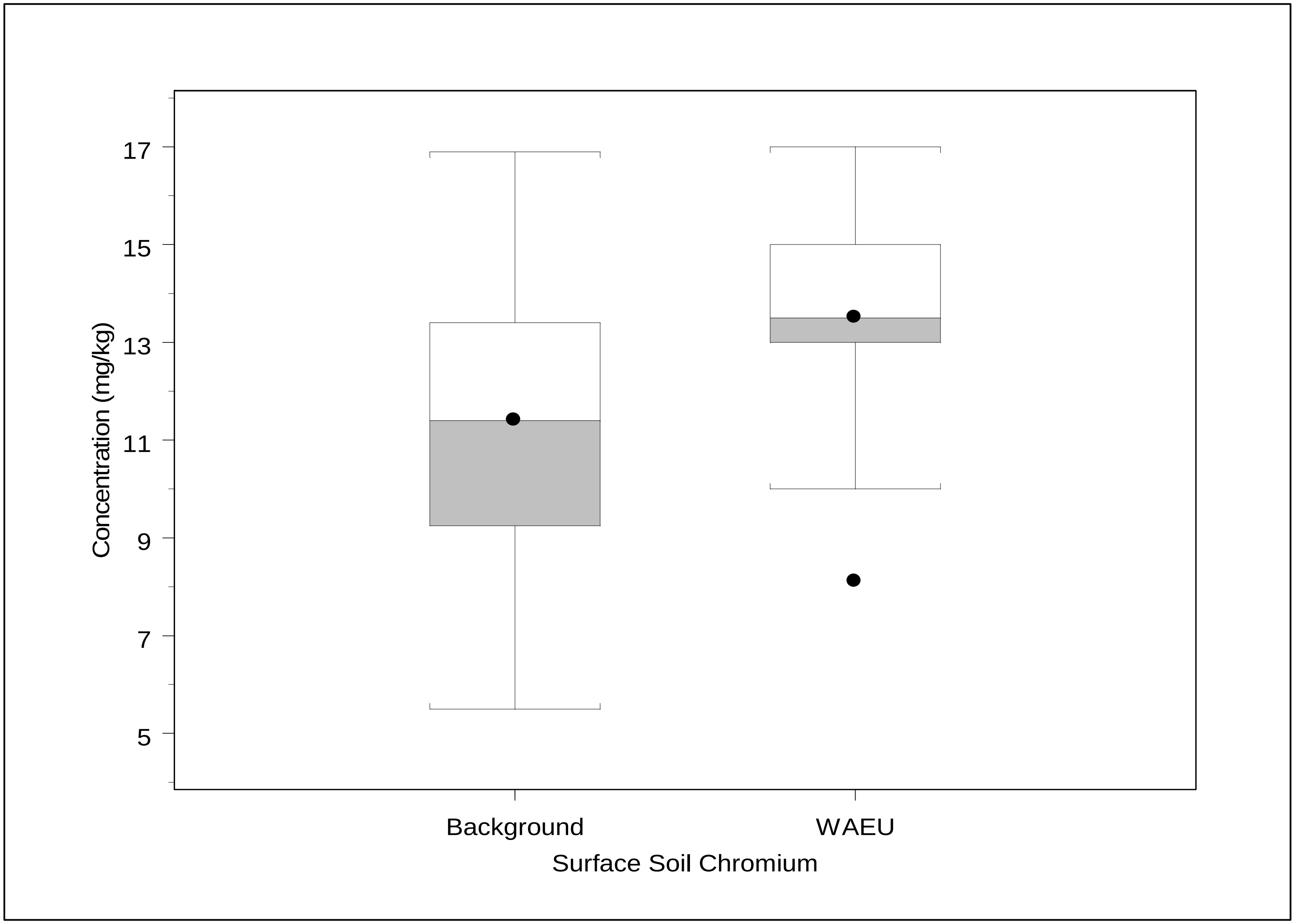
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.3
WAEU Surface Soil Box Plot for Arsenic



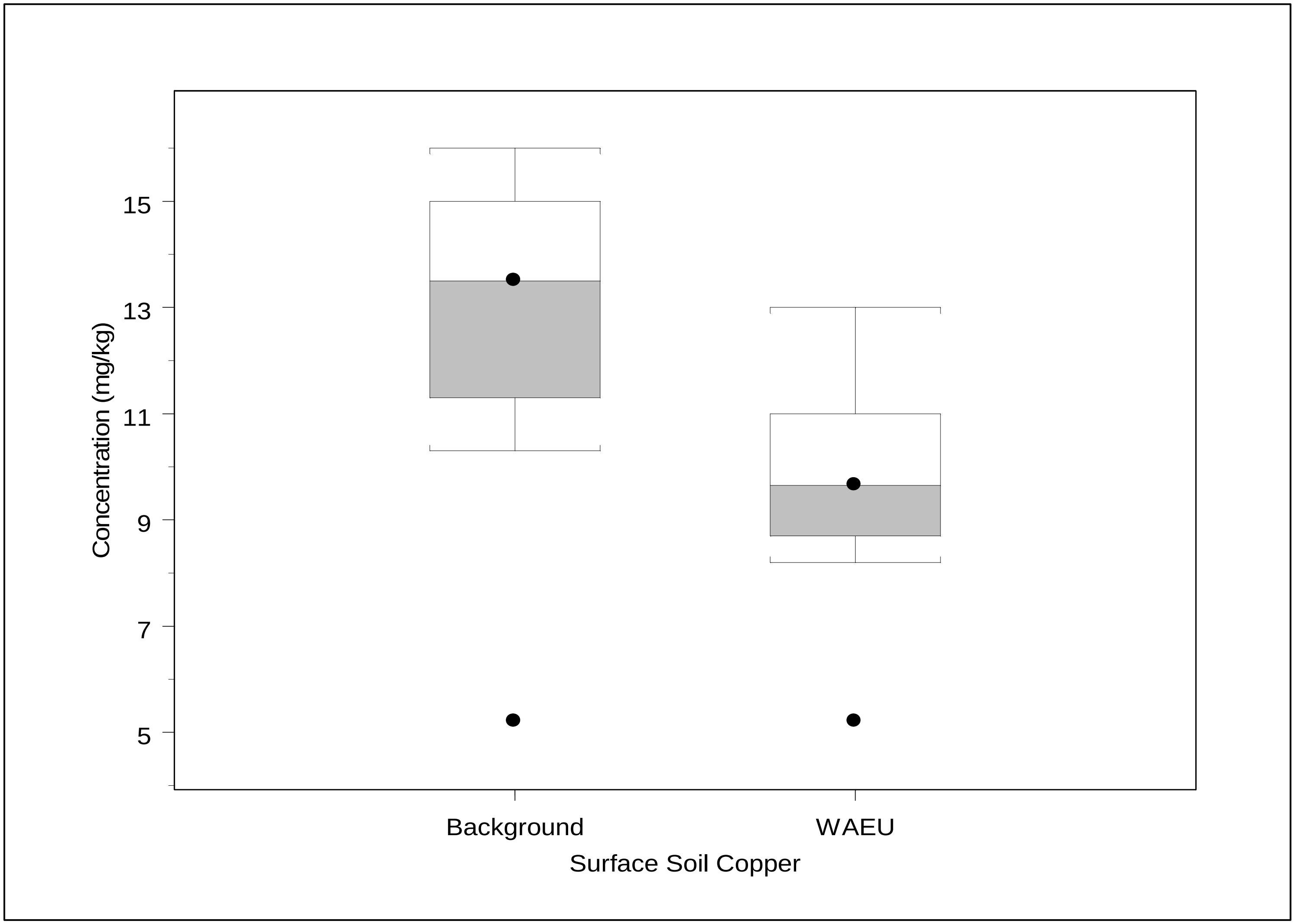
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.4
WAEU Surface Soil Box Plot for Chromium



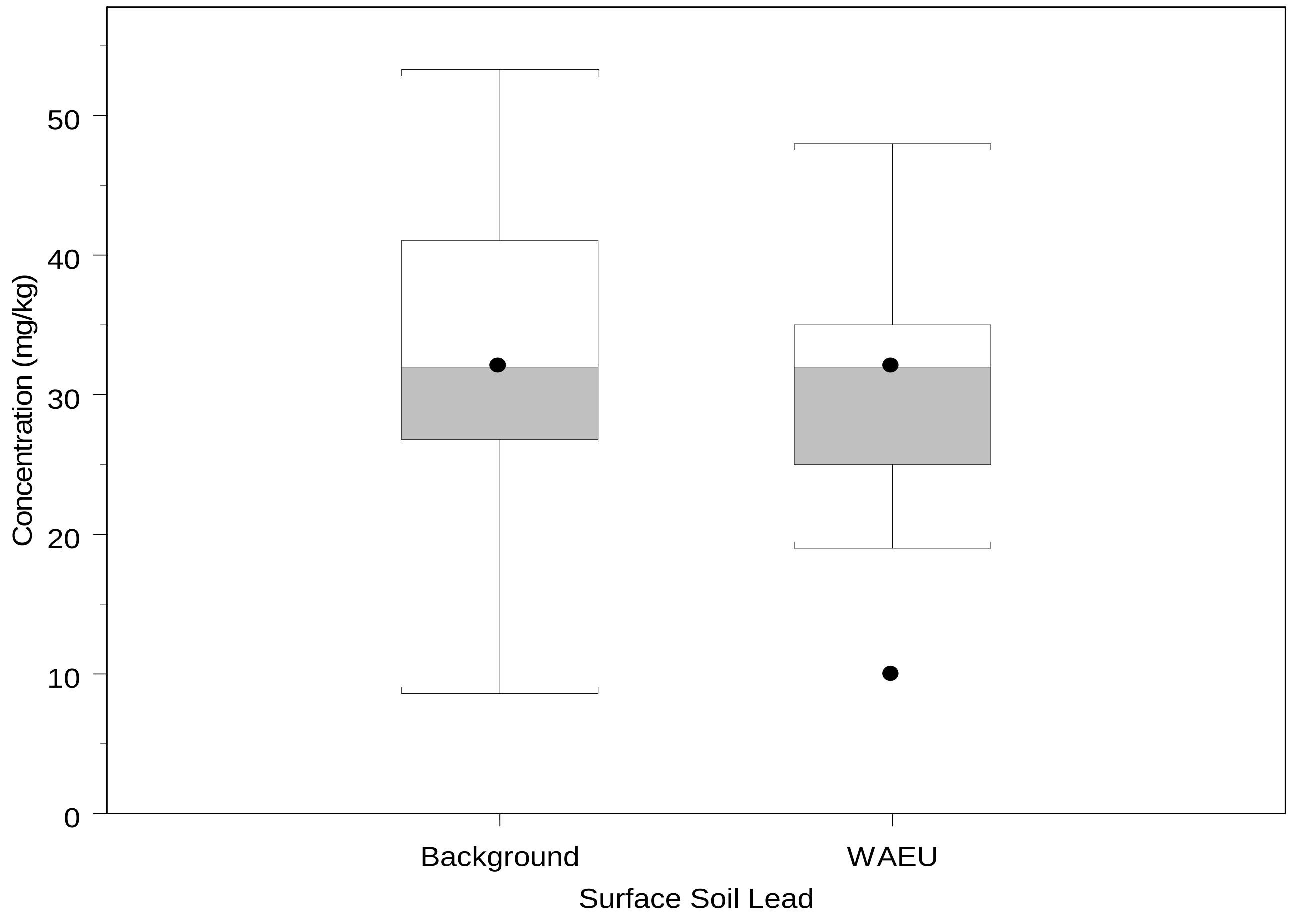
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.5
WAEU Surface Soil Box Plot for Copper



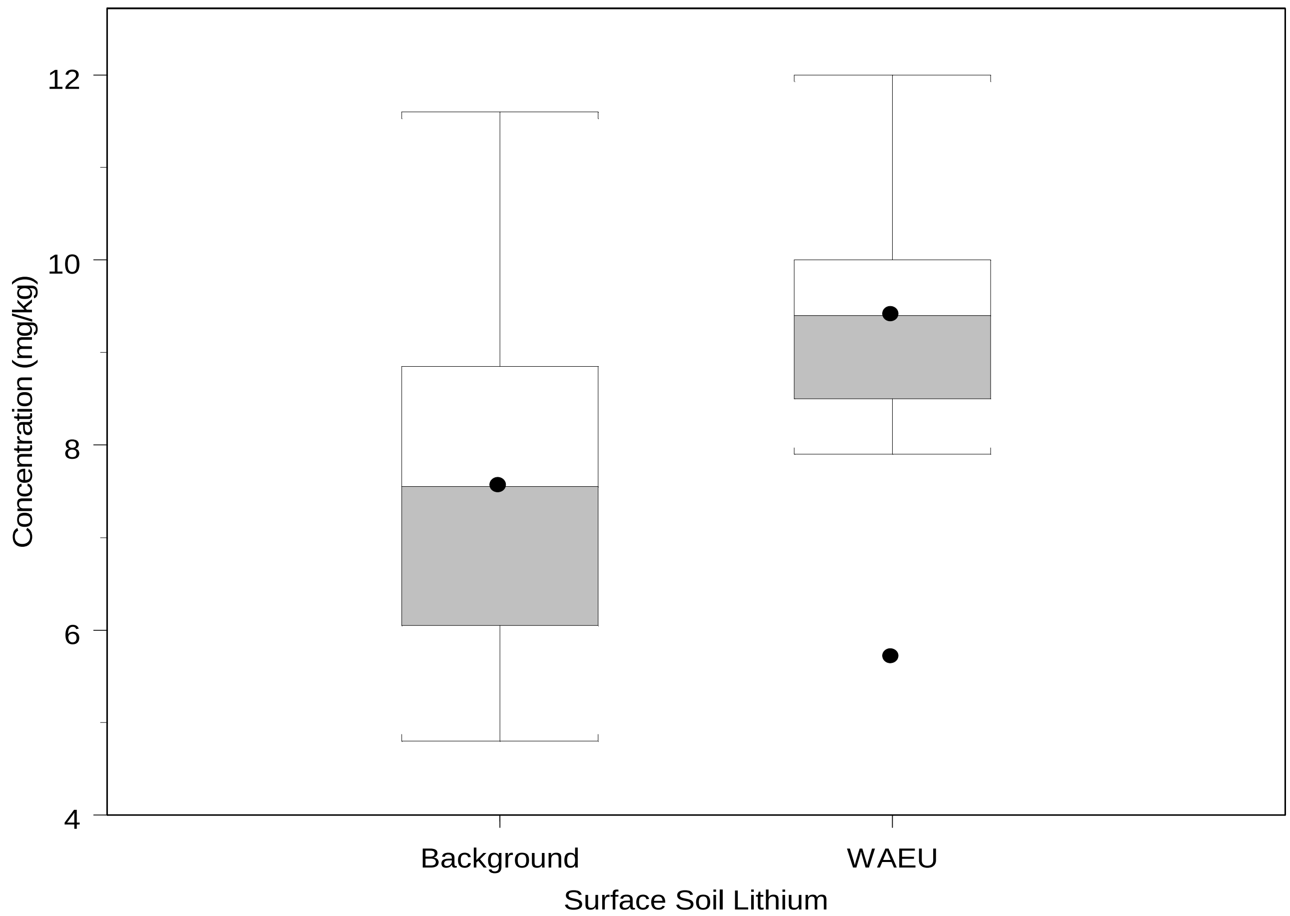
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.6
WAEU Surface Soil Box Plot for Lead



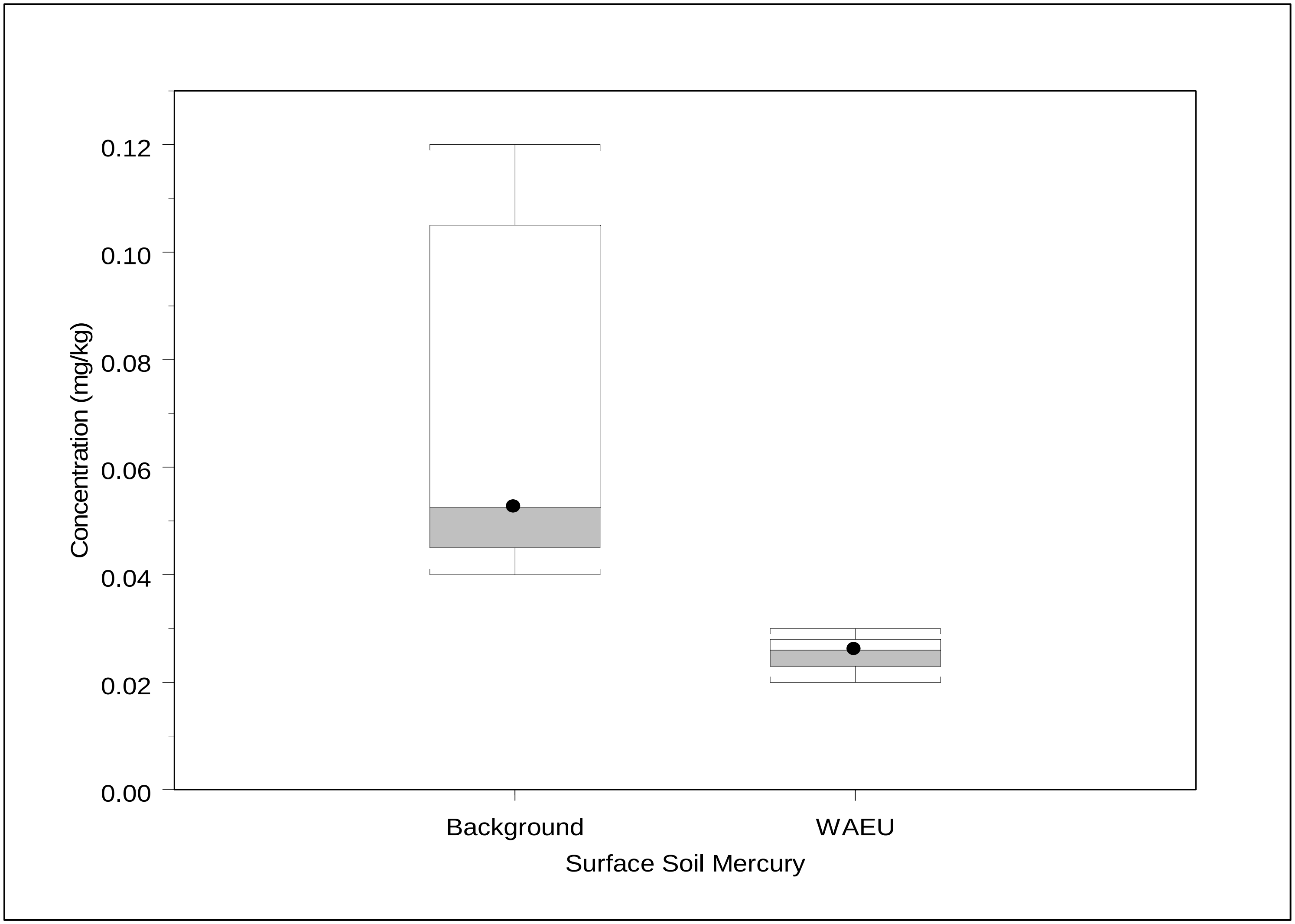
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.7
WAEU Surface Soil Box Plot for Lithium



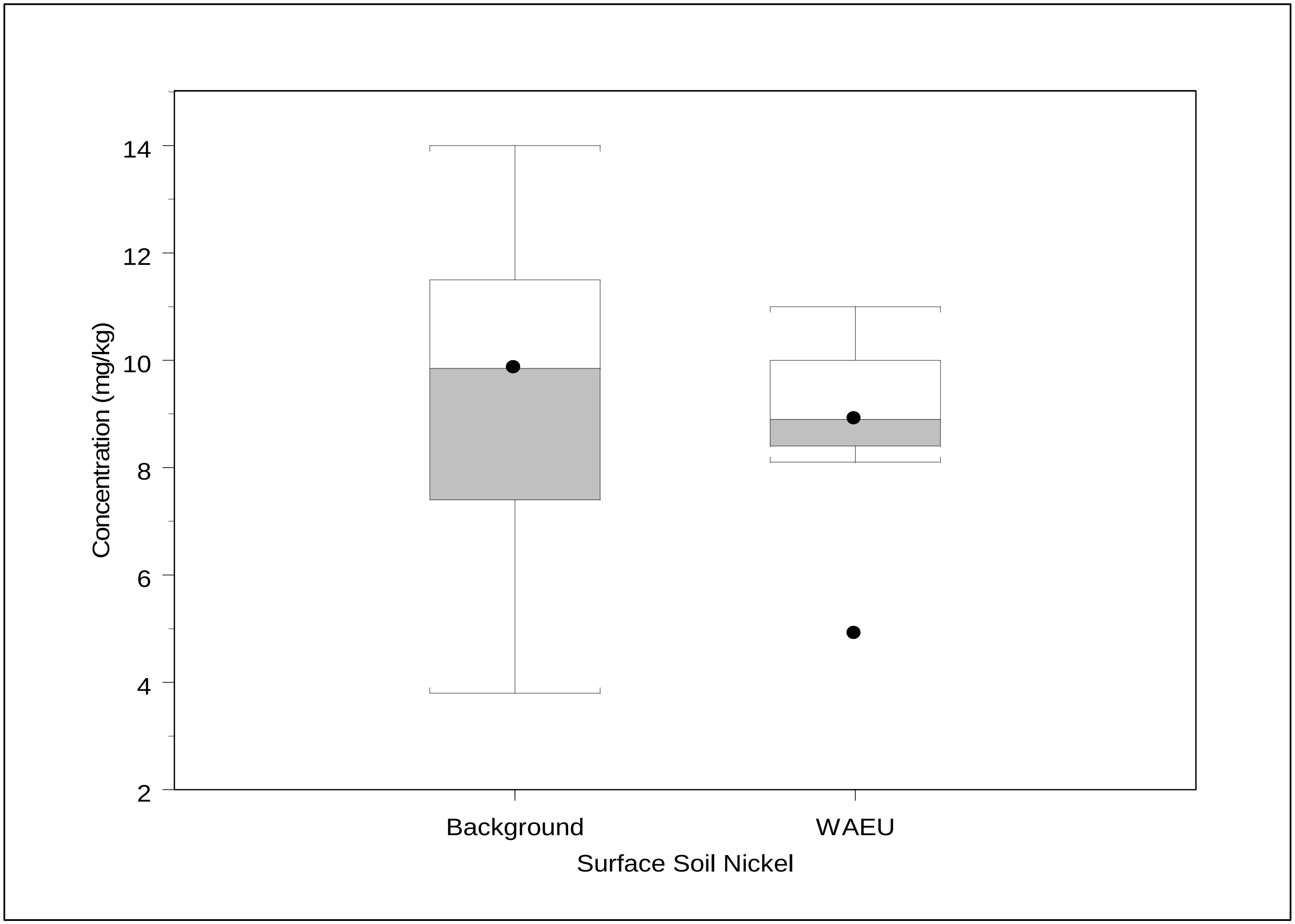
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.8
WAEU Surface Soil Box Plot for Mercury



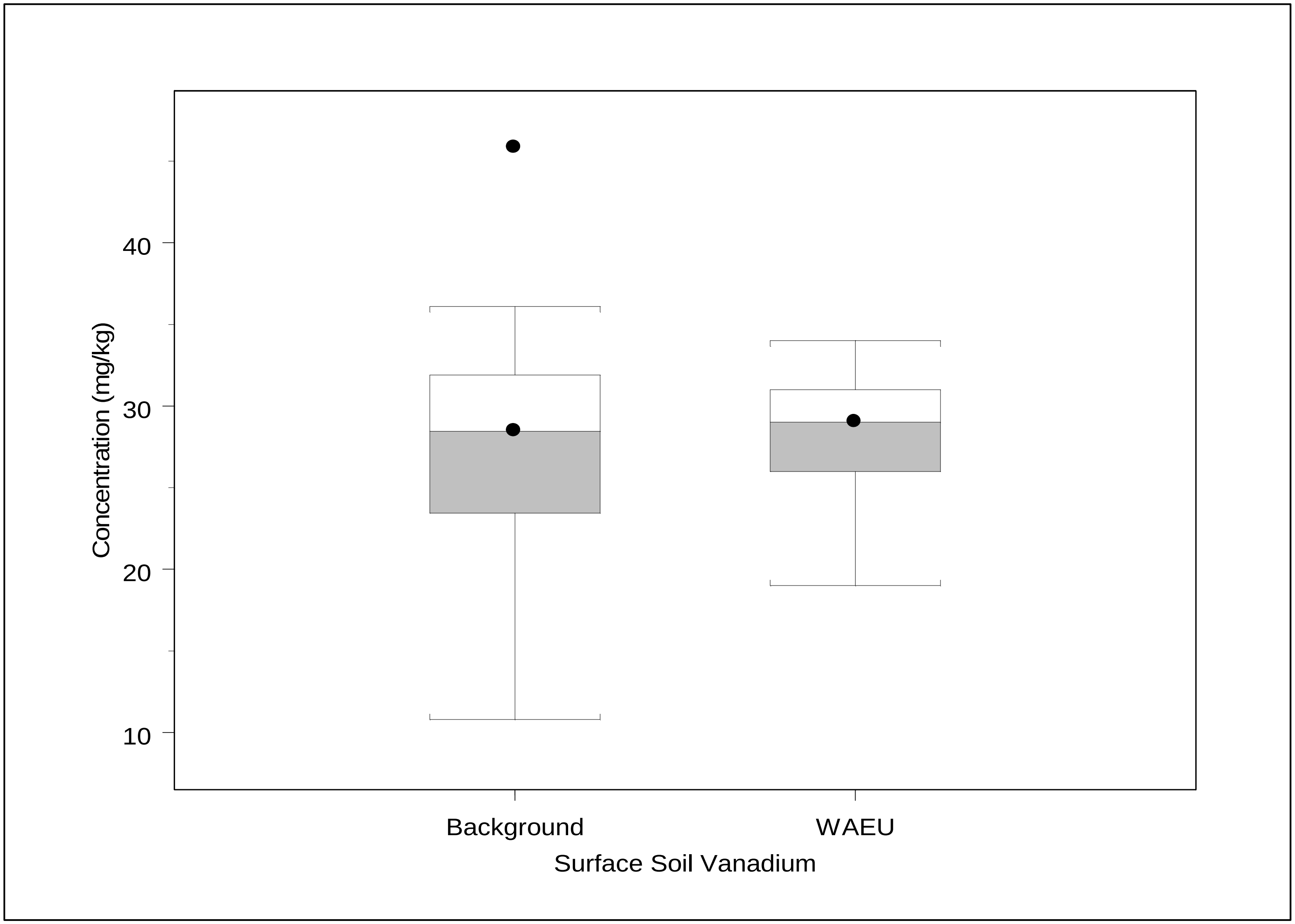
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.9
WAEU Surface Soil Box Plot for Nickel



Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.10
WAEU Surface Soil Box Plot for Vanadium



Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.11
WAEU Surface Soil Box Plot for Zinc

Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

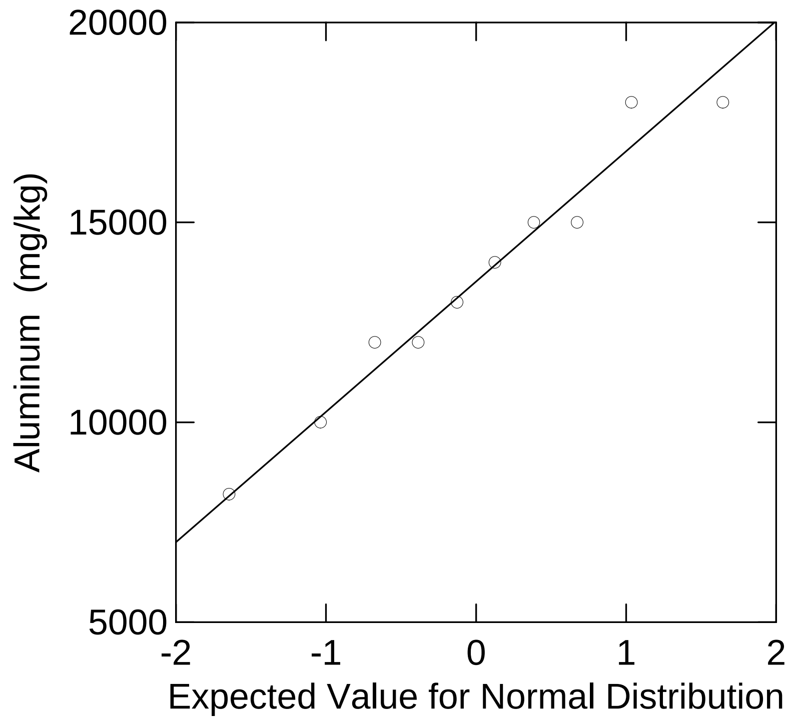


Figure A3.4.1. Probability Plot for Aluminum Concentrations (Natural Logarithm) in WAEU Surface Soil

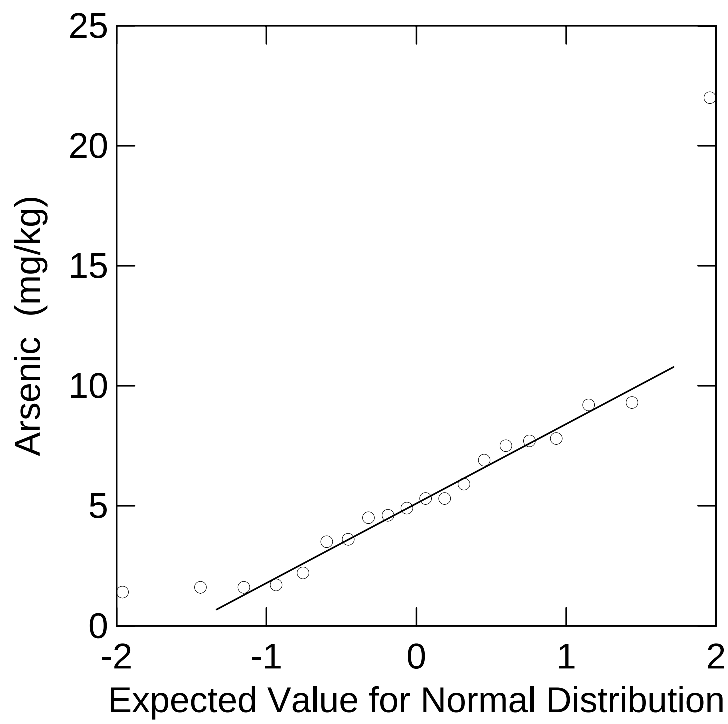


Figure A3.4.2. Probability Plot for Arsenic Concentrations (Natural Logarithm) in WAEU Surface Soil/Surface Sediment

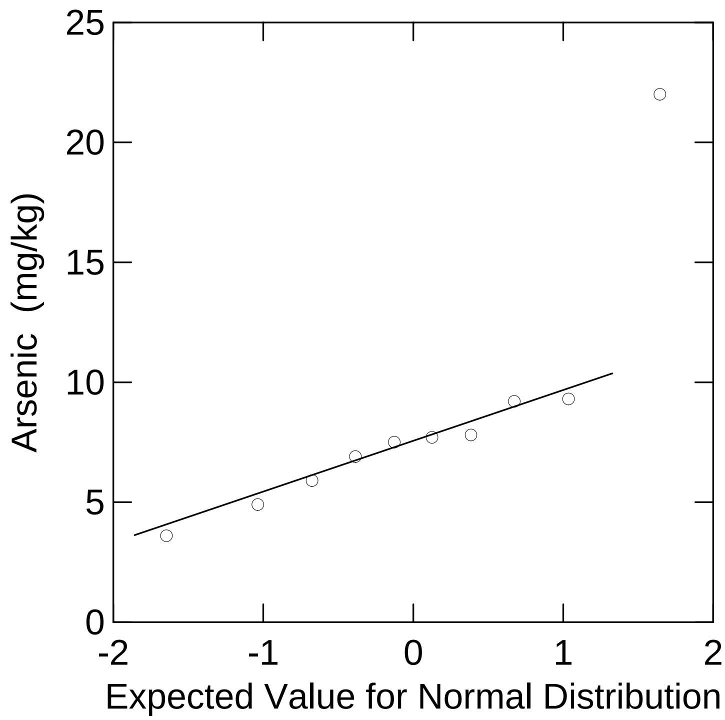


Figure A3.4.3. Probability Plot for Arsenic Concentrations (Natural Logarithm) in WAEU Surface Soil

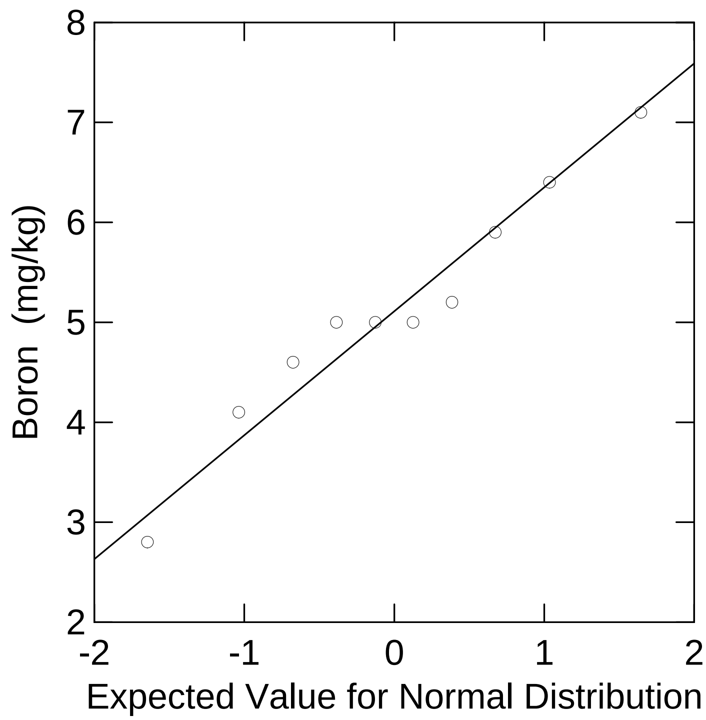


Figure A3.4.4. **Probability Plot for Boron Concentrations (Natural Logarithm) in WAEU Surface Soil**

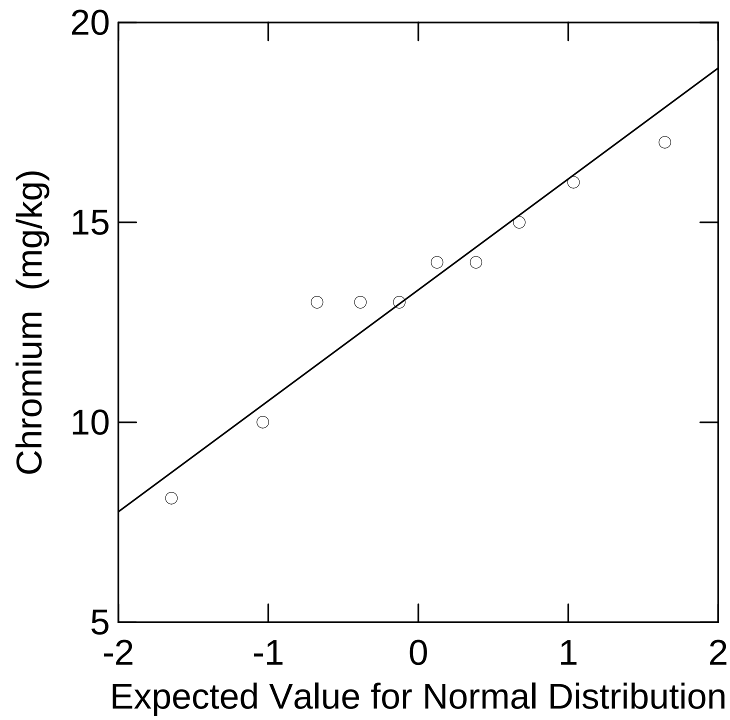


Figure A3.4.5. Probability Plot for Chromium Concentrations (Natural Logarithm) in WAEU Surface Soil

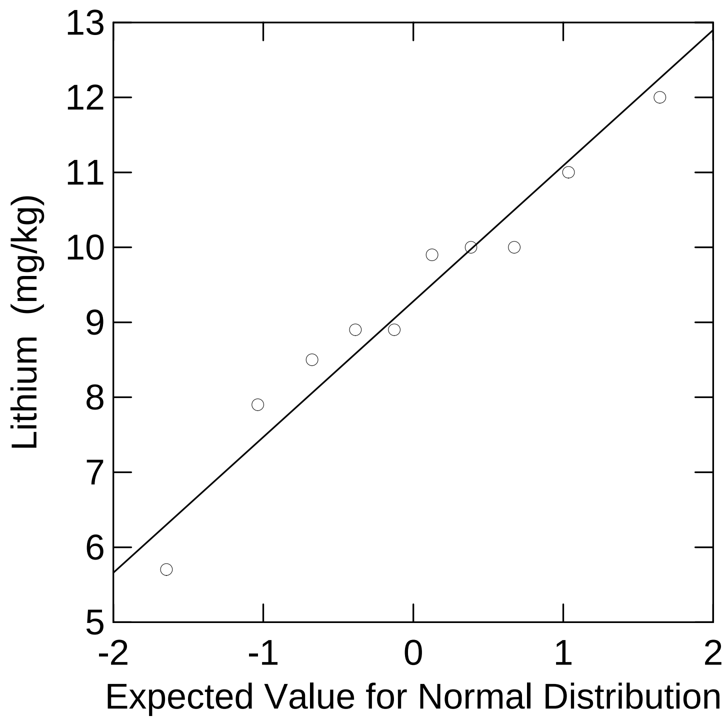


Figure A3.4.6. Probability Plot for Lithium Concentrations (Natural Logarithm) in WAEU Surface Soil