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Date: June 21, 1996
Refer to: EM/ER:96-357

ENTERED

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87502

SUBJECT: SUBMITTAL OF THE RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION (RFI) REPORT FOR POTENTIAL RELEASE SITES (PRSs) IN TECHNICAL AREA (TA) 36

Dear Mr. Garcia:

Enclosed are two copies of the Los Alamos National Laboratory's RFI Report concerning PRSs 36-001, 36-004(d), and 36-006 in TA-36. One report is for your information and the second should go to your technical branch. The report documents the field work performed as detailed in the approved RFI Work Plan for Operable Unit 1130 and the results of the sampling.

Please ask your office to contact Gene Gould at (505) 667-0402 or Everett Trollinger at (505) 667-5801, if you have any questions.

Sincerely,

Jorg Jansen, Program Manager
LANL/ER Project

Sincerely,

Theodore J. Taylor, Program Manager
DOE/LAAO

JJ/TT/bp

Enclosures: RFI Report for PRSs at TA-36
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Document Title: Submittal of RFI Report for PRSs 36-001, 36-004(d), and 36-006 in TA-36

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RFI Report for Potential Release Sites at TA-36

36-001,
36-004(d)
(Skunk Works and Burn Bits),
36-006

(located in former
Operable Unit 1130)

Field Unit 2

Environmental Restoration Project

June 1996

A Department of Energy
Environmental Cleanup Program

Los Alamos
NATIONAL LABORATORY

LA-UR-96-2139

TV

96-357

RFI Report for Potential Release Sites In TA-36

(located in former Operable Unit 1130)

Field Unit

Environmental Restoration Project

June 1996

A Department of Energy Environmental Cleanup Program

EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report describes some Phase I investigations performed at the formerly designated Operable Unit (OU) 1130. The field activities were conducted from the summer of 1993 to January 1996, for four areas, including two Potential Release Sites (PRSs) and parts of a third PRS, as follows:

- PRS 36-001, Materials Disposal Area (MDA) AA
- PRS 36-004(d), Lower Slobbovia Firing Site
  - > Skunk Works
  - > Burn Pits
- PRS 36-006, Surface Disposal Area (SDA)

PRS 36-004(d) consisted of three areas, two of which are included in this report, the Skunk Works and the Burn Pits. However, action has been deferred at the remaining area, Lower Slobbovia Firing Site.

The objectives of these investigations were

- to determine the nature and extent of contamination;
- to determine the need for corrective action; and
- to satisfy regulatory requirements that pertain to these sites.

This report satisfies the site-specific regulatory requirements contained in the Los Alamos National Laboratory (Laboratory) RCRA operating permit, specifically in Module VIII, which contain the Hazardous and Solid Waste Amendments (HSWA) corrective action requirements. The potential release of radioactive constituents is included in the RFI even though such releases are not regulated by RCRA.

Investigations were begun in 1993 using geophysics and radioactivity surveys to locate the trenches at MDA AA and the Burn Pits. The geophysics survey identified the general location of the trenches, but drilling in MDA AA revealed the need to better delineate trench locations to meet sampling data quality objectives. In 1995, an extensive investigation was conducted at MDA AA to locate the trenches. In 1995 field investigations were also conducted at Skunk Works, Burn Pits, and SDA to locate areas of contamination.

Chemicals of potential concern (COPCs) at these sites include high explosives, volatile and semi-volatile organic compounds, metals, and uranium. Analytical results, received from the fixed analytical laboratory, underwent a quality assurance/quality control assessment, and the results indicated that nearly 100% of the data are acceptable and defensible. Sampling results were evaluated to determine whether they provided enough information to make decisions regarding cleanup, no further action (NFA), or the need for further investigation.

No COPCs were retained at Skunk Works, Burn Pits, or SDA. A risk assessment was performed using the intrusive industrial scenario for the MDA AA, and the results indicated that the risk at the area from the contaminants is acceptable based on the exposure scenario. Thus, all four sites are recommended for NFA based on Criterion 5 of the Project Consistency Team Policy regarding no further action. However, permit modifications will not be requested for Skunk Works and Burn Pits, both areas within PRS 36-004(d), until the associated unit, Lower Slobbovia Firing Site, is resolved. Table ES-1 presents a summary of the PRSs and the proposed actions.

TABLE ES-1
SUMMARY OF PROPOSED ACTIONS

PRS	HSWA	NFA[1] Criterion	Further Action	Rationale	Section
36-001, MDA AA	A	5	None	RCRA COPCs present acceptable risk.	5.1
36-004(d)[2] Lower Slobbovia	A		Deferred Action	Active firing site	N/A[3]
Skunk Works		5	None	No RCRA COPCs have been retained.	5.2
Burn Pits		5	None	No RCRA COPCs have been retained.	5.3
36-006, SDA	A	5	None	No RCRA COPCs have been retained.	5.4

[1]No further action criteria based on the Project Consistency Team Policy (PCT, 1210)

[2]Permit modifications will not be requested for the Skunk Works and Burn Pits areas within PRS 36-004(d), until the associated unit, Lower Slobbovia Firing Site, is resolved.

[3]N/A = Not applicable

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1.0 INTRODUCTION

1.1 General Site History

This Resource Conservation Recovery Act (RCRA) Field Investigation (RFI) Report addresses Potential Release Sites (PRS) 36-001, Materials Disposal Area (MDA) AA, and 36-006, Surface Disposal Area (SDA). The report also addresses two areas of PRS 36-004(d), Skunk Works and Burn Pits, but does not address the Lower Slobbovia Firing Site.

Technical Area (TA)-36 is part of Field Unit 2 and was included in the formerly designated Operable Unit (OU) 1130. OU 1130 consisted of TAs -36, -68, and -71 at Los Alamos National Laboratory (Laboratory) in Los Alamos, New Mexico (Figures 1.1-1 and 1.1-2). These TAs are contiguous and cover a total of about 7 mi^2. TAs-68 and -71 are buffer areas, and no Laboratory activities were conducted in these TAs.

TA-36, an explosives-testing area, consists of five firing sites that are used to conduct a total of 1,500 explosives tests annually. Supporting activities include storage and assembly of prefabricated metal and explosives components, detonators, cables, and instrumentation for the shots.

TA-36 was originally designated as Kappa Site in the late 1940s by Norris Bradbury and the site selection committee. TA-36 was put into operation in 1950 as the test area for four firing sites, including Lower Slobbovia. Before 1950 a few shots of bare explosives were detonated on the mesas in the area, but since 1950, all the shots were confined to the designated firing sites (LANL 1993, 1088). The firing sites at TA-36 are still active firing sites (LANL 1993, 1088).

Explosives testing at TA-36 included numerous types of high explosives (HE), depleted uranium, lead, barium, and other metals, and test debris could be spread over large areas, depending on the size of the shots. After the tests, firing site areas were cleaned of residual material, including residual HE, wood, sand, cable, and other materials. All this test debris was collected and burned to prevent the collection of debris and HE on the ground surface.

In addition to the explosives testing at a number of sites, TA-36 is used for storing explosives, assembling and photographing the tests (LANL 1993, 1088) although a number of these activities are not active now. Supporting facilities include assembly buildings, bunkers, burn areas, septic systems, and storage areas.

From early testing days the staff at the site had colloquial names for an number of the different areas, particularly the firing sites, and those names became commonly used (Lower Slobbovia, Eenie, Skunk Works) to name the ones addressed in this report.

PRSs investigated and included in this report are: PRS 36-001, MDA AA, was an excavated area that was used for burning explosives test debris, including wood, pieces of HE, cable, and sand. The debris was burned and covered with clean soils. MDA AA was closed on May 2, 1989. PRS 36-006, Surface Disposal Area (SDA), was a site along a canyon wall where cables and other debris from HE tests were dumped from about 1955 to 1970 (Jansen and Taylor 1995, 44186). SDA is about 100 ft northeast of Eenie Firing Site [(PRS 36-004(a)], and SDA received debris from tests at Eenie. A web of cable several feet thick follows the canyon wall into the narrow canyon below. Figure 1.1-3 shows the locations of all areas discussed in this report.

The other sites that were investigated and are included in this report are portions of PRS 36-004(d), Skunk Works and Burn Pits. The main solid waste management unit at the site, Lower Slobbovia Firing Site, has been deffered. Skunk Works was actively used for small explosives test in the mid-1950s. It is located about 2,300 ft upstream and west of Lower Slobbovia. Burn Pits were undesignated areas used for burning residual HE and other explosive testing debris before the MDA AA was prepared for use.

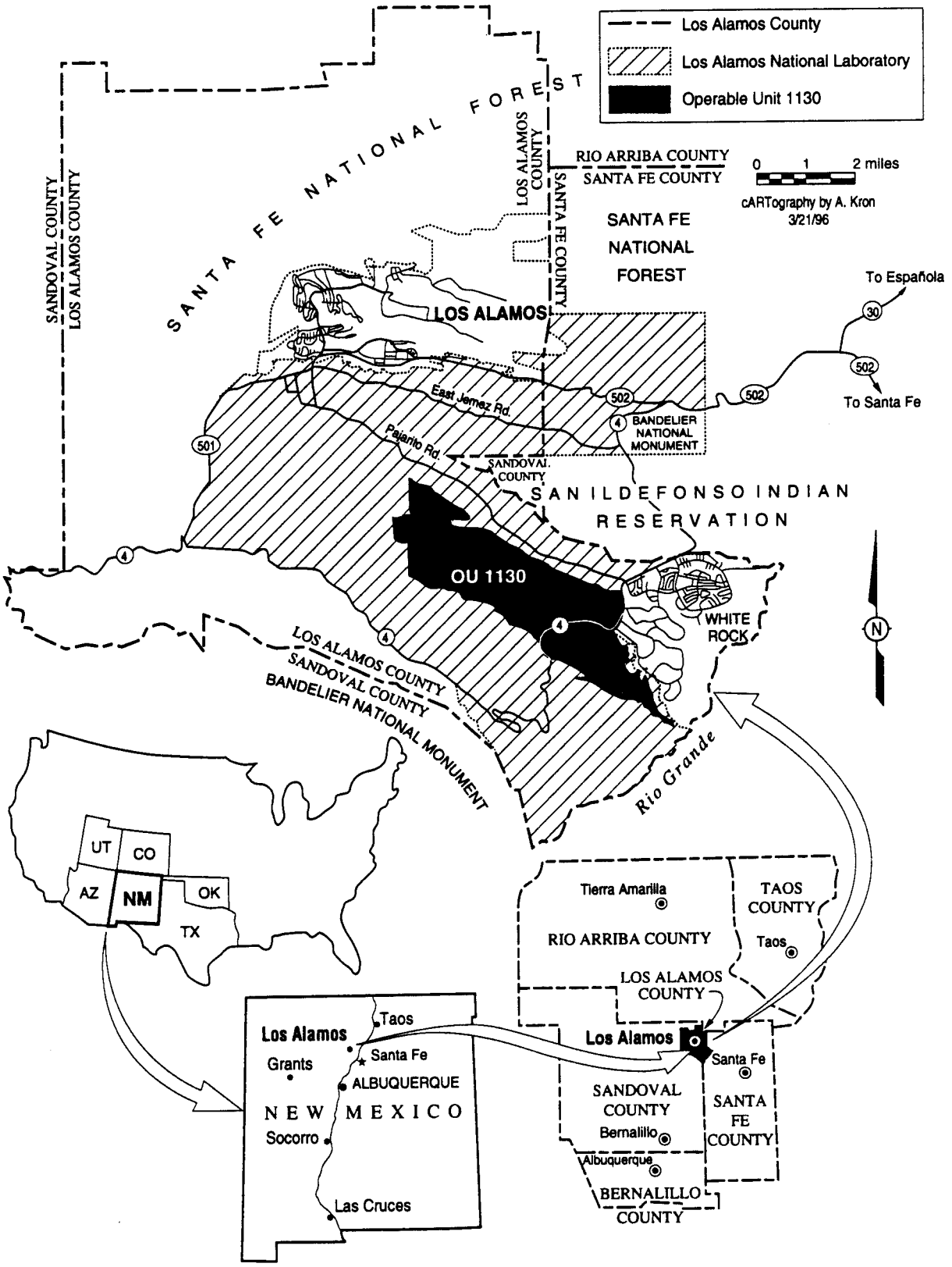


Figure 1.1-1 Location of OU 1130 within Los Alamos National Laboratory, Los Alamos County, NM

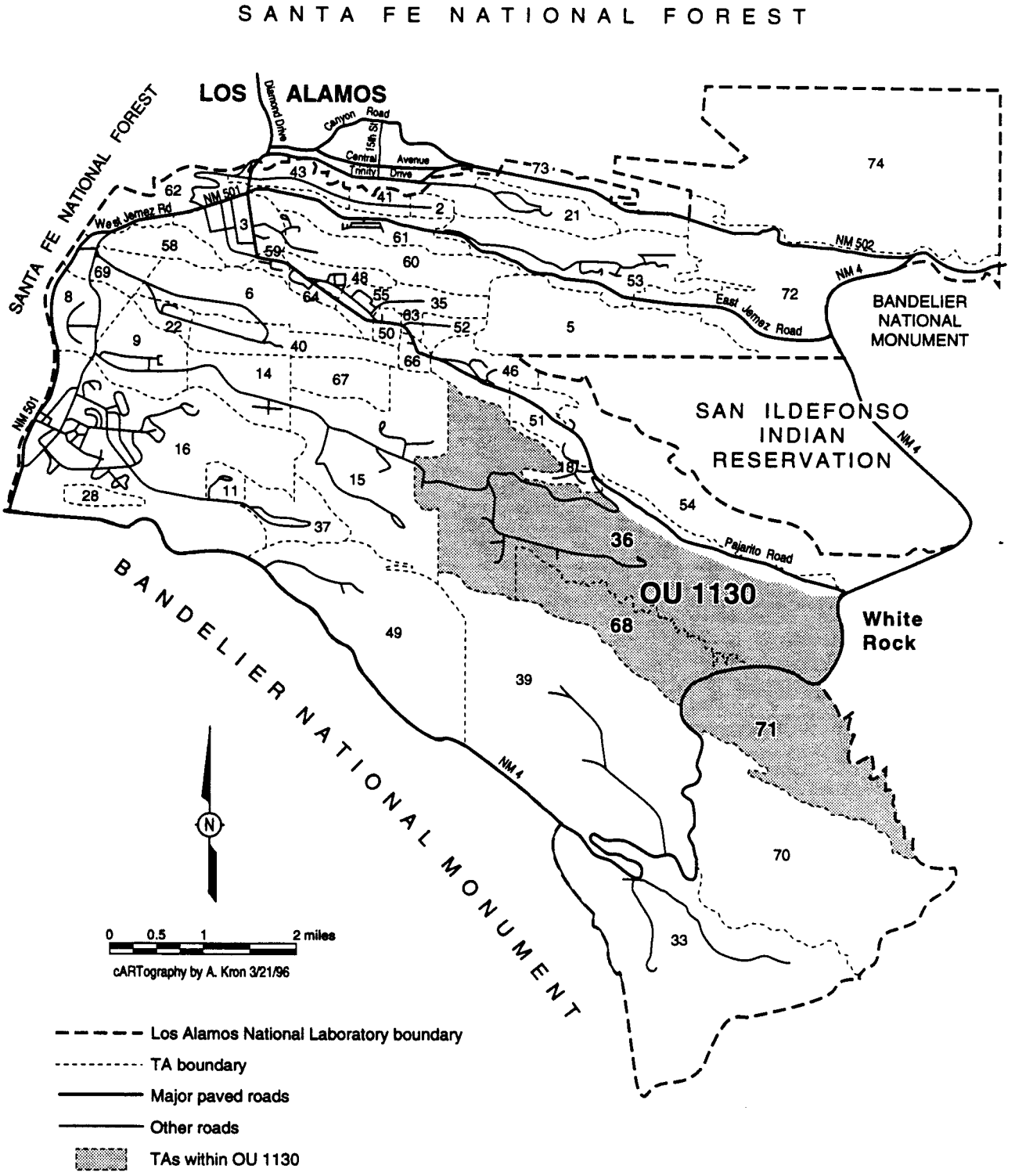


Figure 1.1-2 Location of OU 1130 with respect to Laboratory TAs and surrounding landholdings

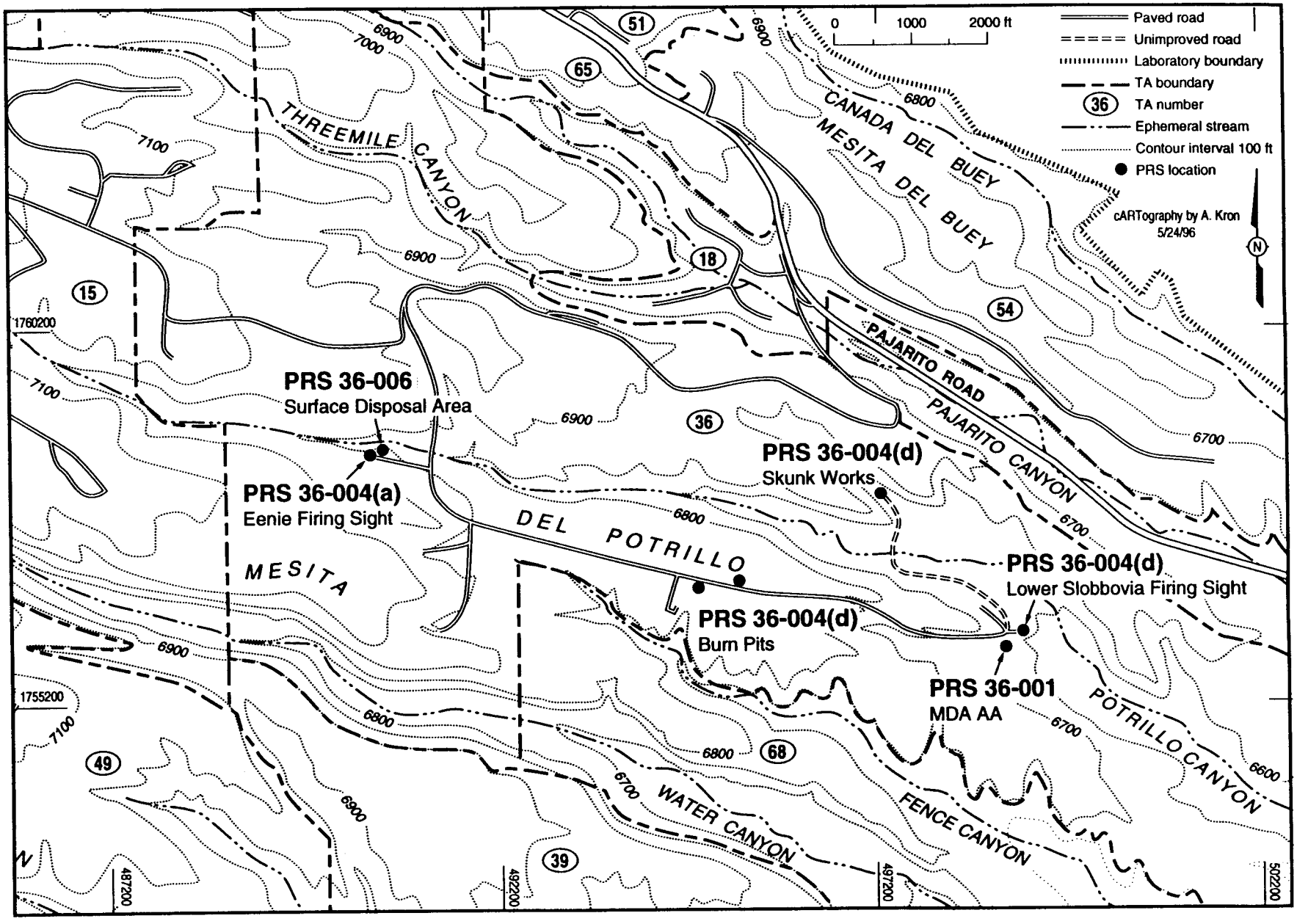


Figure 1.1-3 Locations of PRSs 36-001, Material Disposal Area AA; 36-004(d), Burn Pits; 36-004(d), Skunk Works; 36-006, Surface Disposal Area.

Metals, specifically mercury, lead, barium, and silver are chemicals of potential concern (COPCs) at TA-36. Different types of HE are expected as COPCs along with HE's residual products. Volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) may have been used in many operations and are COPCs at these sites. Uranium or depleted uranium is the only known radionuclide used or disposed of at these sites. Analyses were conducted for total uranium in some samples and for the isotopes of uranium in other samples collected at these sites.

1.2 RFI Overview

The overall objectives of the field investigations at these four sites, as stated in the RFI Work Plan (LANL 1993, 1088), were

- to determine the nature and extent of contamination, if any, from releases at the PRSs;
- to determine the need for corrective action; and
- to satisfy those regulatory requirements that pertain to OU 1130 contained in the Laboratory's permit to operate under RCRA (LANL 1993, 1088).

The permit also includes site-specific requirements in Module VIII, which contains the Hazardous and Solid Waste Amendments (HSWA) corrective action requirements for the Laboratory.

A general conceptual model was developed to identify potential contaminant migration pathways and any potential human receptors. The model identified chemicals potentially present, characterized the release of contamination, determined migratory pathways, and identified human receptors (LANL 1993, 1088).

Regulated substances have been identified from archival information and include: uranium, metals, and HE at MDA AA; uranium, metals, VOCs, SVOCs, and HE at the Burn Pits and Skunk Works; and uranium, beryllium, lead, and mercury at SDA (LANL 1993, 1088 and Jansen 1995, 44186). The pathway for exposure to the worker in the model can occur through ingestion, inhalation, dermal contact, or external radiation, both at the surface or during excavation, but would be expected to pose a minimum threat to workers.

PRS 36-004(d), Lower Slobbovia, is an active firing site, and the investigation and correction actions at the site have been deferred until decommissioning. Investigations at Skunk Works and Burn Pits, areas within PRS 36-004(d), have been conducted in response to an EPA Notice of Deficiency (NOD) on the RFI Work Plan for Operable Unit 1130 (Jansen 1995, 46002; Jansen and Taylor 1995, 44186; and McInroy 1994, 34994). Investigation results at Skunk Works and Burn Pits do not affect the deferred action status of the Lower Slobbovia Firing Site.

1.3 Field Activities

The field work for these sites began in the summer of 1993. MDA AA was surveyed using geophysical techniques in an attempt to locate the trenches. Although geophysical information was used to locate two sampling locations in 1994, it became apparent during drilling activities that better delineation of the trenches was necessary to meet sampling data quality objectives. In 1995, a grid was used to systematically define the extent of the trench area by drilling for ash and debris. Biased samples were taken from nine of the boreholes at MDA AA in 1995 and submitted to the fixed analytical laboratory.

In 1994, geophysics and radiological surveys were also conducted to locate the Burn Pits at Lower Slobbovia Firing Site. The survey information did not reveal subsurface anomalies at the expected locations and the Burn Pits were not located. In 1995 the field team learned the actual location of the Burn Pits by conducting more specific interviews with a former employee. Burn Pits were sampled from November 1995 through February 1996. Skunk Works and SDA, near Eenie Firing site, were also surveyed and sampled in late 1995.

Approximately 55 samples were taken during the Phase I field activities. Sample collections were biased, when possible, based upon visual, radiological, and geophysical surveys, the HE spot test, soil pH, and x-ray fluorescence (XRF) analyses. Only soil and sediment samples were collected during this field work. Methods of sample collection included spade and scoop, hand auger, and sample collection from split spoons.

Land surveys were performed to set grid points and sample locations.

All applicable Environmental Restoration ER-SOPs (LANL, 0875) were followed unless otherwise noted in Chapters 3 or 5 of this document. Appendix E is a list of applicable procedures and analytical methods used in this investigation.

Appendix A provides the information on analytical results of sampling and the radiological and geophysical results.

2.0 ENVIRONMENTAL SETTING

The environmental setting of the Laboratory is described in Section 2.4 of the Installation Work Plan for Environmental Restoration (IWP) (LANL 1995, 1164). A discussion of the OU 1130-specific environmental setting, including climate, geology, hydrology, and a conceptual hydrogeologic model is presented in the RFI Work Plan (LANL 1993, 1088). A summary is presented in the following sections. This description provides the information required to evaluate potential contaminant transport pathways and conceptual exposure models at OU 1130.

2.1 Climate

Los Alamos County has a semiarid, temperate, mountain climate. The high altitude, light winds, clear skies, and dry atmosphere allow summer temperatures to range from 45° F to 95° F. During the winter, temperatures typically range from 15° F to 50° F. The average annual rainfall at OU 1130 is estimated to range from 14 to 16 in. Of this total, 40% occurs as brief, intense thunderstorms during July and August. Stream flow in canyons can occur as a result of these storms. Spring snowmelt runoff may also induce stream flow in the area canyons.

2.2 Geology

2.2.1 General Geology

The generalized stratigraphy of OU 1130 has been inferred from three wells (Figure 2.2.1-1), PM-2, PM-4, and DT-10, drilled in the general vicinity. The mesas on the Pajarito Plateau are immediately underlain by the Bandelier Tuff, which outcrops occasionally on mesa tops and is exposed along canyon walls. The major rock groups in the Bandelier Tuff that are likely to underlie OU 1130 are shown in Figure 2.2.1-2. Information from the wells was used to construct the stratigraphic columns as a schematic representation of the OU. The stratigraphic units that are important to OU 1130 are discussed briefly, beginning with the units highest in the column (i.e., the youngest) and progressing downward.

The top portion of Bandelier Tuff is the Tshirege Member, which underlies the mesa tops over most of OU 1130. The Tshirege Member is an ash-flow and airfall sequence from an explosive geologic event dated at 1.1 million years ago. The member is divided into several sub-units that can be correlated across the entire outcrop area of Bandelier Tuff (Crowe et al. 1978, 0041).

The Otowi Member underlies the Tshirege Member unconformably, and Guaje Pumice Bed forms the base of the Otowi Member. Cerro Toledo Rhyolite occurs between the Otowi and Tshirege Members in some locations in Los Alamos County, but it is not distinguished in PM-4 (Purtymun et al. 1983, 0712), DT-10, or PM-2 (Cooper et al. 1965, 0495). The Tschicoma Formation, the Puye Formation, and the Chino Mesa basalts underlie the Bandelier Tuff at depths to about 1000 ft below ground surface. The top of the main aquifer is located in the Chino Mesa basalts at approximately 1000 ft. Test boreholes have not penetrated these units.

A detailed discussion of the geology of the entire Los Alamos area can be found in Section 2.5.1 of the IWP (LANL 1995, 1164).

2.2.2 Soils

OU 1130 contains at least 18 different kinds of soils, each of which is described and mapped by Nyhan et al. (1978, 0161). Sanjue-Arriba complex is present in the area of Lower Slobbovia Firing Site, including PRS 36-001 and Skunk Works. The Sanjue-Arriba complex consists of well-drained soils greater than 60 in. deep. The surface layer consists of approximately 8 in. of gravely sandy loam or loamy sand. Permeability of the Sanjue soils is high, and the erodibility is moderate. Permeability of the Arriba

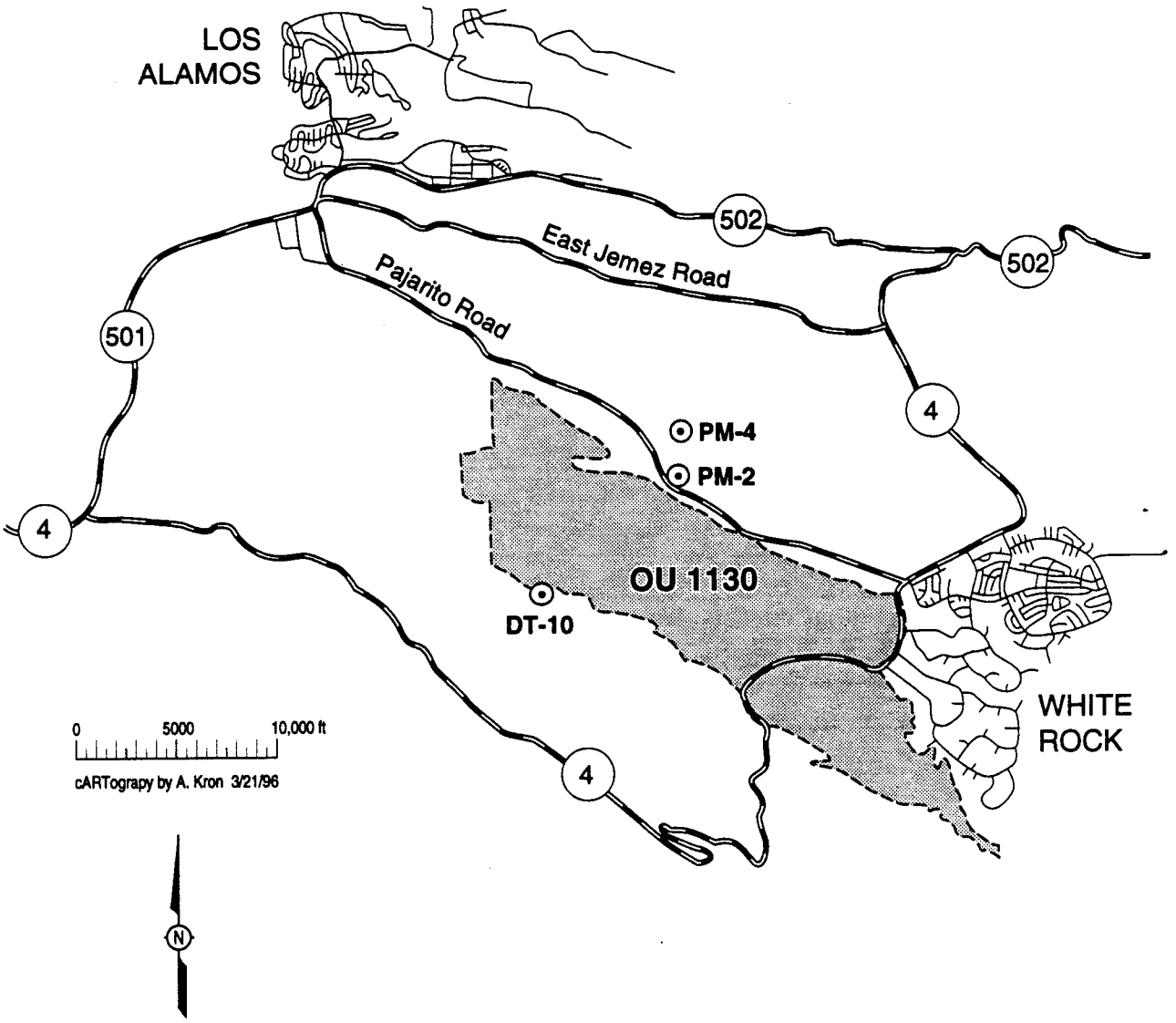


Figure 2.2.1-1 Map showing the locations of wells PM-2, PM-4, and DT-10

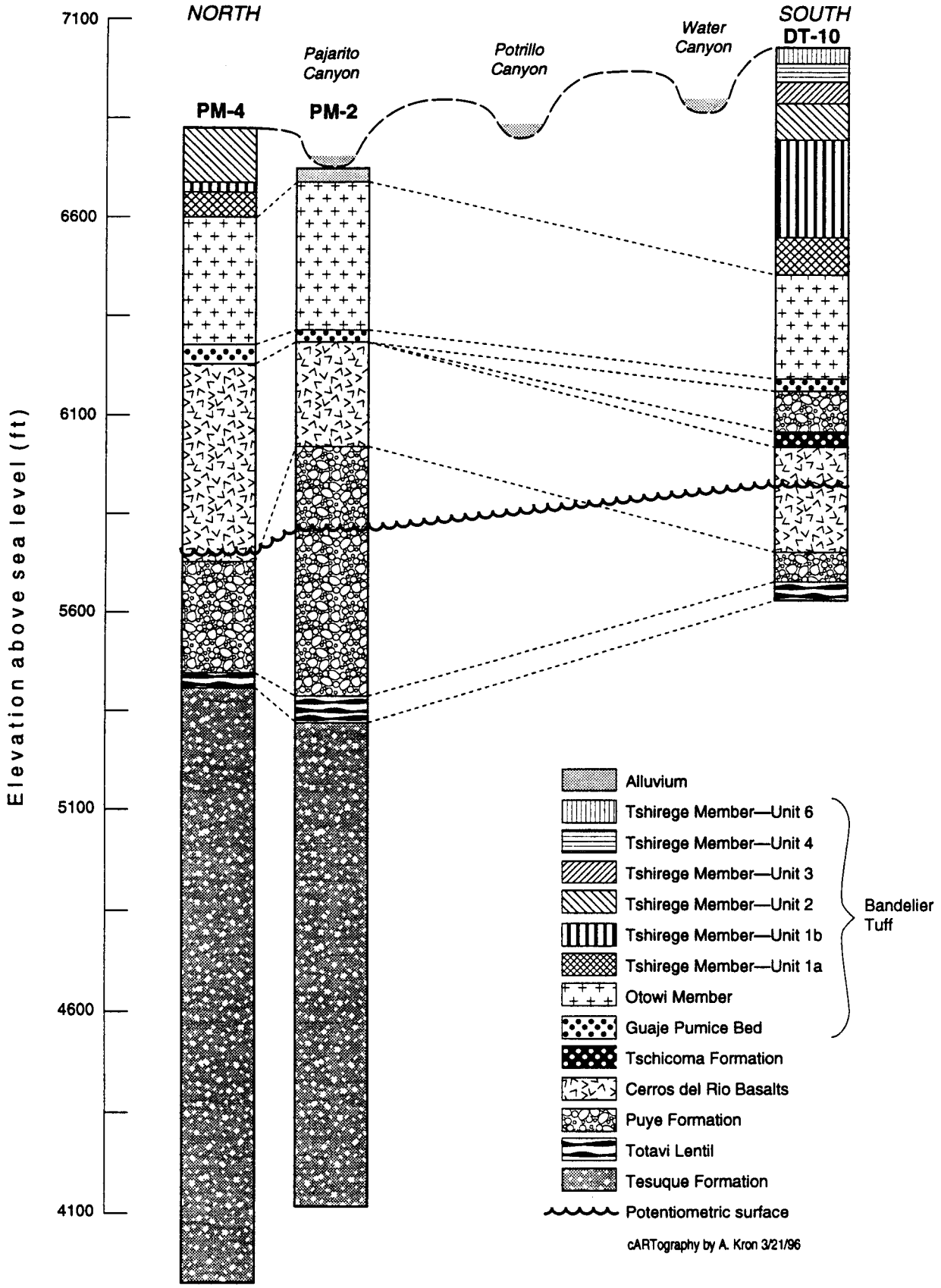


Figure 2.2.1-2 Generalized stratigraphy of formerly designated OU 1130

soils is moderate with a moderately high erodibility. Ground surface slope can vary from 16% to 40% (Nyhan 1078, 0161).

Totavi sand is present in the upper sections of Potrillo Canyon including PRS 36-006 and PRS 36-004(d), Burn Pits. The surface layer consists of 20 in. of gravely loamy sand or sandy loam. Permeability of this soil is very high, and the grade ranges from 0% to 5%; therefore, surface runoff is slow (Nyhan et at. 1989, 0161).

A discussion of the soils in the Los Alamos area can be found in Section 2.5.1.3 of the IWP (LANL 1995, 1164).

2.2.3 Sedimentation and Erosion

At OU 1130, sediment deposition and erosion by surface water occurs in response to snowmelt and storm-water runoff events. Periods of runoff can produce erosion, sediment transport, and deposition. In areas like the Boneyard, where the natural soil surface has been disturbed through use, erosion is generally accelerated (Graf 1975, 0847; Nyhan and Lane 1986, 0159).

Active erosional processes on the Pajarito Plateau are addressed in Section 2.5.1.6 of the IWP (LANL 1995, 1164).

2.3 Hydrology

The hydrology of the Pajarito Plateau is addressed in Section 2.5.2 of the IWP (LANL 1995, 1164). Summaries of surface water and groundwater hydrology are presented below.

2.3.1 Surface Water

The Fence Canyon, Potrillo Canyon, and Water Canyon watersheds, each with an established stream channel drainage network, exist within OU 1130. Additionally, part of the Pajarito Canyon watershed lies within the OU. Watershed locations are shown in Figure 2.3.1-1. Water and Pajarito Canyons receive flow from springs and flow directly into the Rio Grande. Other canyons that feed the major canyons flow ephemerally in response to rainfall and snowmelt.

2.3.2 Groundwater

Saturated groundwater occurs in three modes on the Pajarito Plateau: shallow alluvial groundwater bodies in canyon bottoms; isolated perched horizons in conglomerates and basalts at depths between 120 and 200 ft; and the main aquifer underlying the entire plateau.

The only aquifer in Los Alamos capable of providing a municipal and industrial water supply is the main aquifer. The water in the main aquifer generally moves eastward across the plateau toward the Rio Grande, with some discharge into the Rio Grande through seeps and springs (Purtymun 1984, 0196). The depth to the main aquifer varies from about 875 to over 1000 ft below ground surface in the area of the PRSs in this report (LANL 1993, 1088).

No wells reach into the main aquifer beneath OU 1130. Inferences regarding the portion of the main aquifer beneath the OU are derived from information on supply wells PM-2 and PM-4 and test well DT-10. The main aquifer is within the basaltic rocks of Chino Mesa which is not represented in the stratigraphic figure.

A discussion of groundwater on the Pajarito Plateau is presented in Section 2.5.2.2 of the IWP (LANL 1995, 1164).

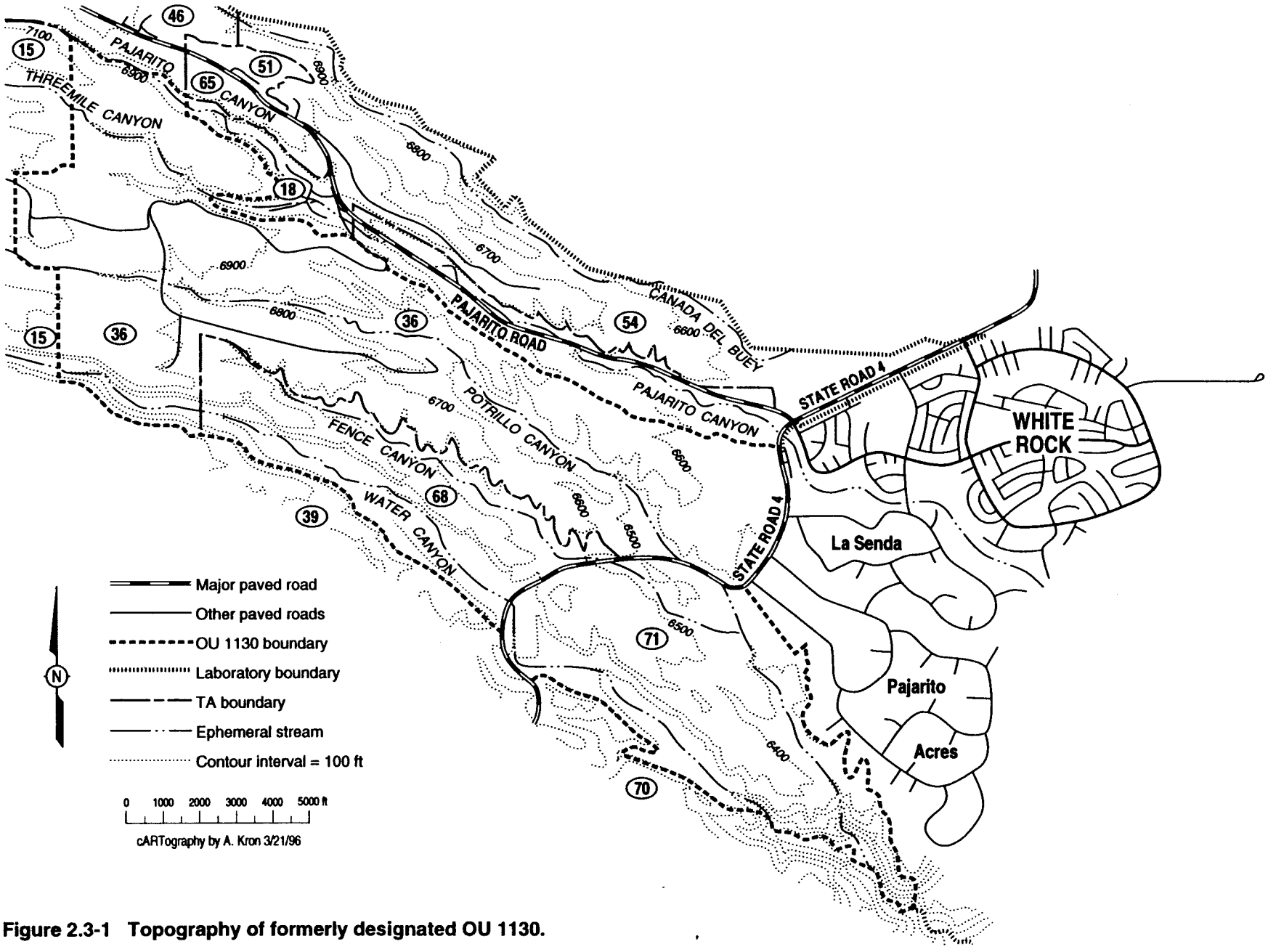


Figure 2.3-1 Topography of formerly designated OU 1130.

2.4 Biological Survey

Biological resource field surveys have been conducted at OU 1130 for compliance with the Federal Endangered Species Act (as amended) (US Senate 1983); the New Mexico Wildlife Conservation Act (NM Game and Fish Department 1978); the New Mexico Endangered Plant Species Act (Kerr 1985); Executive Order 11990, "Protection of Wetlands" (The White House 1977, 0635); Executive Order 11988, "Floodplain Management" (The White House 1977, 0634); Compliance with Floodplain/Wetlands Environmental Review Requirements (DOE 1979, 0633); and DOE Order 5400.1, General Environmental Protection Program (DOE 1988, 0075).

The Environmental Protection Group conducted biological surveys at TA-36 in the sampling areas to determine whether precautions were needed to protect threatened, endangered, or sensitive species (Bennett 1994, 38511). The area was found to contain suitable habitat for a protected species, the northern goshawk. The use of heavy equipment in TA-36 during the summer months required the field team to notify the biological team 30 days prior to field activities to schedule a survey.

The field team was instructed to limit off-road travel; to avoid walking in a stream bed or along the bank and causing bank collapse; and to minimize disturbance to vegetated areas at the SDA near Eenie (Risberg 1995).

Each PRS also was evaluated to determine the potential for ecological receptors to be exposed to any COPCs associated with the site. The assessment assigns scores that indicate overall landscape conditions at the site and site-specific conditions that influence the accessibility of any COPCs to ecological receptors. Results of the evaluation are provided in Table 2.4-1.

TABLE 2.4-1
SUMMARY OF SCREENING ASSESSMENT TO CATEGORIZE LANDSCAPE CONDITIONS AND RECEPTOR ACCESS POTENTIAL TO COPCs AT EACH PRS

Report Section	PRS #	Landscape Condition[a]	Receptor Access[b]	Description
5.1	36-001	2	2	MDA AA
5.2	36-004(d)	2	3	Skunk Works
5.3	36-004(d)	2	3	Burn Pits
5.4	36-006	2	3	Surface Disposal Area

[a] 1 = heavily disturbed/developed, 2 = moderately disturbed, 3 = lightly disturbed or not disturbed

[b] 0 = no potential for receptor access to COPCs or for COPC transport, 1 = low potential for access or transport, 2 = moderate potential for access or transport, 3 = high potential for access or transport

2.5 Cultural Survey

A cultural resource survey has been conducted at various areas in OU 1130, as required by the National Historic Preservation Act (amended) (USC 1992). The methods and techniques used for this survey conformed to those specified in the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (National Park Service 1983, 0632).

The ER Project has approval to work in a number of PRSs, including PRS 36-001 and PRS 36-004(d). The survey conducted in the Burn Pit areas along Potrillo Drive indicated a number of archeological sites in the vicinity. PRS 36-006 required monitoring during testing (LANL 1994, 38512).

For the 1995 excavation work permit, Laboratory archaeologists surveyed the Burn Pit areas north and south of Potrillo Drive. The archaeologists stated that if archaeological remains were discovered during augering or subsurface sampling in the north pit, all work at the site must stop and the archaeologists were to be notified. The archeologists suggested that vehicular off-road travel in the area be minimized. At the south site, there were no known archaeological concerns.

The area around and including Skunk Works had not been surveyed by the Laboratory archaeologists. Therefore, they stated that if archaeological remains were discovered, the team must stop work and notify the archaeologists. The team minimized disturbances to the area by using hand augering in place of drilling at Skunk Works.

No archaeological sites were disturbed by field activities at any of the PRSs in this report.

3.0 APPROACH TO DATA ASSESSMENT AND ANALYSES

The decision approach used for data assessment and analysis involves a series of quantitative steps that occur after the field investigation, chemical analysis, and data reporting are complete. These steps begin with routine data validation and continue with more focused data validation, if necessary. Routine validation involves validating each data item against specific targets and adding qualifier flags to the data signifying a potential deficiency. Focused validation consists of analyzing quality assurance/quality control (QA/QC) data for their potential impact on the succeeding data assessment steps (i.e., comparing site data with background concentration data, verifying the identities of detected organic chemicals, comparing site data with screening action levels (SAL) for human health impacts, and performing human health or ecological risk assessments, when necessary). The following subsections provide overviews of the methods used to complete these quantitative steps.

3.1 Sample Analyses

All samples requiring chemical and radiological analysis underwent chain-of-custody documentation and were submitted to the fixed analytical laboratory. Each soil sample was screened in the field. Screening for radioactivity was accomplished with a Ludlum model 2221 scaler/ratemeter with a 44-10 2X2 scintillator. Analyses were conducted using the methods indicated in Appendix E of this report.

3.1.1 Analytical Methods

All samples were analyzed using EPA SW-846 methods or equivalent and/or radiological methods as described in Quality Control Data Use (document in preparation). Methods used for analysis are indicated in Appendix E.

3.1.2 Data Validation

Data verification and validation procedures are used to determine whether data packages have been generated according to specifications, are of known quality, and contain the information necessary to determine data sufficiency for decision making.

Data verification is a check of data deliverables against a set of stated requirements to ensure that what has been ordered has been delivered, thus indicating that the laboratories can be paid. All analytical data generated in support of the ER Project is verified.

Data validation is the process of determining whether individual results can be reliably used to support the decision-making process. During the process, validators determine whether data should be qualified or used with caution because of the potential impact of noted flaws or the failure to achieve precision or bias constraints.

Routine data validation is the comparison of quality indicators (such as surrogate recovery, measurements of method blanks, holding times, differences between replicate measurements) with clearly defined limits to determine whether limitations may need to be placed on the use of the data. Routine validation is most suitable for routine analyses and for those nonroutine analyses for which clearly defined limits have been established.

The focused data validation process addresses those characteristics of the data (e.g., precision and bias) that directly affect the decision(s) to be based on the data. The same data set may undergo different focused validations for different decisions.

3.2 Background Comparisons

Once the data validation process is complete and the site data are finalized, the next step in the process is to compare site data with available background data. The results of a focused data validation should exclude from consideration for background comparison any contaminant that is identified as an artifact of analytical laboratory or field contamination, analytical interference, or improper analyte identification or quantitation. The purpose of this decision step is to determine whether chemicals that have natural or anthropogenic background distributions should be retained as COPCs or eliminated from further consideration. Background data are available from two sources: 1) soil samples collected throughout Los Alamos County for which chemical analyses were performed for certain inorganic (metal) chemicals and naturally occurring radioactive chemicals (Longmire et al. 1995, 1142 and 1266); and 2) background concentrations of radioactive chemicals associated with global fallout from atmospheric nuclear testing (e.g., plutonium, cesium, strontium, and tritium) reported in Laboratory environmental surveillance reports (most recently Environmental Protection Group 1994, 1179). At OU 1130 all samples were collected in soil above the tuff, and background comparisons were made using background data for the soil.

Comparisons between site data and background data are initially performed by comparing each observed concentration datum with an upper tolerance limit (UTL) estimated from background data. Further statistical comparisons are performed for the analytes that exceed their UTLs to determine whether statistically significant differences exist between the observed site and background data sets. The Gehan/Wilcoxon Rank Sum test (Gehan 1965, 1296), the Quantile test (Gilbert and Simpson 1992, 0974), and the Slippage test (Gilbert and Simpson 1990, 0972) are used for these evaluations. The Gehan modification of the Wilcoxon Rank Sum test is best suited for assessing complete shifts in distribution, whereas the Quantile test is better suited for assessing partial shifts. The Slippage test determines the probability of the observed number of site concentrations being greater than the maximum background concentration, given that the site data originate from the same distribution as the background data. Among the three tests, most types of differences between distributions can be determined. Observed significance levels (p-values) are reported for the tests. The p-value is the probability of observing data at least as different from the typical background data as the actual, observed site data if the site concentration distribution is the same as background. If a p-value is less than 0.05, then there is reason to suspect that there is a difference between the background and site distributions; otherwise, no difference is indicated and the site concentrations are not statistically different than background. These tests are only performed for PRSs that have at least four samples, and only for the analytes that have adequate background data sets. For example, mercury data is not subjected to these tests because the background data set is almost entirely composed of non-detected data. The p-values for any analytes that are shown not to be statistically different from background are included in Chapter 5 where comparisons to background are discussed. Histograms, smoothed density images, and box plots for all analytes subjected to these analyses are presented in Appendix D. Details of statistical methods used to generate UTLs from the background sets are presented in Ryti et al. (1996, 1298).

If a chemical has a reported concentration that exceeds its UTL or fails other statistical background comparison tests (i.e., the site data are statistically greater than background data), then that chemical is carried forward to the screening assessment process. If a chemical does not have a reported concentration that exceeds the UTL, then that chemical is removed from further consideration.

The ER Project has developed UTLs for the most commonly sampled chemicals and the most commonly analyzed media. For chemicals and/or media not included in the Longmire data (or in other Laboratory databases), UTLs will be developed by the Decision Support Council as needed.

In general, some of the inorganics analyzed as part of the analytical suite were not subjected to the data comparison because they were not considered to be COPCs at any PRS investigated. These inorganics, which include aluminum, calcium, iron, magnesium, potassium, and sodium, occur naturally in soil.

3.3 Evaluation of Radionuclide Data

The analytical results for radionuclides are reported as activity concentrations in either pCi/g or pCi/L. The values are determined from the measurement of the radioactivity in the sample using a radiation detection instrument (e.g., an alpha particle spectrophotometer or a gamma ray spectrophotometer). Because the radioactive decay process is random and governed by statistical probabilities, the measured value is not constant, but will vary with each measurement of the sample. The variance or sample uncertainty is reported along with the analytical result for each sample as a ± value called "sigma" (σ), which is the standard deviation of the result. The ER Program has established 3σ (± 3 times the standard deviation) as a screening tool. The 3σ value provides 99% certainty that the true value of the sample is within this range. Any reported value less than or equal to 3σ is considered to be non-detect for that analyte; values greater than 3σ are considered to be detected values.

If no background UTL is available for a radionuclide of concern, the reported concentration was compared with that for a radionuclide with which (under natural conditions) it would be in secular equilibrium. If the radionuclide of concern was found to be in secular equilibrium with its associated radionuclide, the radionuclide of concern was considered to be naturally occurring and not present as a result of Laboratory-related activities. Secular equilibrium is assumed for the following specific isotopes: thorium-232~thorium-228~radium-228; uranium-238~thorium-234; and uranium-234~thorium-230~radium-226.

Radionuclide data received from the analytical laboratory were evaluated for the presence of DOE-introduced radionuclides. The evaluation process examines each reported radionuclide based on its origin (i.e., whether it is naturally occurring or man-made). The natural radionuclides of cosmic or primordial origin (e.g., potassium-40) are identified first and are usually eliminated.

Isotopes in the three existing natural radioactive decay series (uranium, thorium, and actinium) are compared with background and can be screened out unless their activity levels or isotopic ratios are significantly different from those found in naturally occurring radionuclides.

The environmental legacy of former global atmospheric nuclear weapons testing include the following man-made radionuclides: tritium, cobalt-60, and isotopes of uranium, neptunium, plutonium, and americium. Depleted uranium (DU), which is 99.75% uranium-238, is also considered man-made, in that it has been depleted of most of its uranium-234 and uranium-235 in the gaseous diffusion process. For natural uranium, the activity ratio of uranium-238 to uranium-234 is ~1:1; for DU, the ratio is ~10:1 for the oldest DU (~50 years old), and ~100:1 for DU that is ~3 years old. Thus, using the measured isotopic activities, the presence of natural or depleted uranium can be ascertained. Natural and depleted uranium have been used in a variety of experiments at the Laboratory and are expected contaminants at the firing sites in former OU 1130.

3.4 Evaluation of Organic Constituents

Background data are not available for organic chemicals. This preliminary evaluation of organic chemicals considers detected chemicals and chemicals that were analyzed for but not detected in any sample. The purpose of this decision step is to determine whether organic chemicals should be retained as COPCs or eliminated from further consideration based on detection status. Detection status is determined by the analytical laboratory on a sample-by-sample, analyte-by-analyte basis. Estimated quantitation limits (EQL) have been established for each analyte as reporting limits when the analyte is not detected. It should be noted that the EQLs reported for individual samples are dependent on a number of factors and can vary from sample to sample and from analysis to analysis. Therefore, the sample-specific EQL for a chemical must be used in this comparison.

If an organic chemical is reported as detected, then that chemical is generally carried forward through the screening assessment process. If a chemical is not reported as detected in any sample analyses, then that chemical is generally removed from further consideration. Exceptions to these general rules may be

made if site-specific process knowledge so indicates. A chemical that is detected may be removed from further consideration if it can be determined that its presence is not a result of Laboratory operations, and a chemical that is not detected in any sample may be carried through the decision process if the chemical can be expected to be present at the site based on historical operations.

3.5 Human Health Assessment

3.5.1 Screening Assessment

The screening assessment consists of sequential decisions that are used to determine whether chemicals have been released to the environment as a result of historical Laboratory operations at levels that may be hazardous to human health or the environment. The decisions include the following:

- Can reported concentrations be attributed solely to positive analytical laboratory or field bias?
- Are site data greater than background?
- Is the maximum site concentration greater than the SAL?

The purpose of this decision step is to determine whether chemicals should be retained as COPCs or eliminated from further consideration based on comparisons with SALs. This is the last step in the screening assessment process for human health concerns. If COPCs remain after this step, then further action may be proposed. If no COPCs remain after this step, then no further action (NFA) may be proposed based on human health concerns. SALs are medium-specific concentrations that are calculated using chemical-specific toxicity information and conservative, default exposure assumptions. A complete description of the methods used to generate SALs is provided in "Risk-Based Corrective Action Process" (LANL/SNL 1996, 1277). For those chemicals for which SALs are available, each observed concentration datum is compared with the chemical's SAL. If a chemical has a reported concentration greater than its SAL, then that chemical is retained as a COPC pending further analysis. If a chemical does not have a reported concentration greater than its SAL, then that chemical is generally removed from further consideration. If more than one chemical is present at the site, this decision is deferred pending the results of the multiple chemical evaluation (described below). The decision to retain a chemical as a COPC when a SAL is not available is made on a case-by-case basis, taking into account the availability of process knowledge and toxicological information.

It is possible that COPCs should be retained because of the combined adverse health effects of several chemicals. This possibility is evaluated in the multiple chemical evaluation (MCE), in which the reported concentration for each chemical is divided by its respective SAL, and the resulting normalized values are incorporated into a simple additive model. If the sum of the normalized values (i.e., the total normalized value) is less than 1, then the chemicals are removed from further consideration. If the total normalized value is greater than 1, then chemicals having an individual normalized value greater than or equal to 0.1 are retained as COPCs pending further evaluation.

Only those chemicals that exceed background concentration thresholds (certain inorganics and radionuclides) or are detected (organics) in at least one sample are included in the MCE. These chemicals are divided into three classes: noncarcinogens, chemical carcinogens, and radionuclides. Additive effects are assumed within each class, but each class is evaluated separately. For further information on the calculation of MCEs see "Risk-Based Corrective Action Process" (LANL/SNL 1996, 1277).

The screening assessment described in "Technical Approach to RFI Reports" (LANL in preparation, 1281) was followed.

3.5.2 Risk Assessment

The human health risk assessments presented in Chapter 5 follow the guidance document "Risk-Based Corrective Action Process" (LANL/SNL 1996, 1277). The human health risk assessment process consists of the following four steps:

- identification of chemicals of potential concern;
- exposure assessment;
- toxicity assessment; and
- risk characterization.

3.6 Ecological Assessment

An ecological risk assessment will be conducted when an approach has been approved by our regulators. Threatened and endangered species and sensitive habitats have been identified based on field surveys (Section 2.4). A qualitative habitat screening model was applied to each PRS to evaluate the potential for exposure to ecological receptors, and the results are given in Table 2.4-1. The model evaluates potential ecological risk by ranking general landscape condition (development and disturbance) and the potential for receptors to access ecological COPCs, as described in "Risk-Based Corrective Action Process" (LANL/SNL 1996, 1277).

4.0 RESULTS OF QUALITY ASSURANCE/QUALITY CONTROL ACTIVITIES

Samples were collected, processed, and analyzed in accordance with the Environmental Restoration Quality Assurance/Quality Control (QA/QC) program documented in the Site-Specific Quality Assurance Project Plan (QAPjP), Annex II of the RFI Work Plan for OU 1130 (LANL 1993, 1088). A variety of QA/QC samples are used to determine the quality and usability of the data generated from the various analyses. These samples included laboratory duplicates, internal standards, laboratory blanks, spikes, surrogates, and laboratory control samples (LCS). The assessment of the QA/QC samples and the potential effect these results may have on data usability were evaluated for all samples presented in this report.

The QA/QC data associated with this investigation indicated that of the nearly 7,000 pieces of analytical data collected at the three PRSs, 99.5% are acceptable and defensible. None of the radiochemistry data are considered unusable; however, data that are less than 3σ of the mean are considered usable as nondetects only. Similarly, less than 1% of the inorganic and organic data were affected because of blank contamination problems and are usable as nondetects. Approximately 16% of the data are qualified as estimated undetected (UJ) or estimated (J), which does not affect usability of these data. Less than 1% of the data are considered unusable because of QA/QC problems. The data quality is sufficient to support the decision-making process. The QA/QC mechanisms were effective in ensuring the reliability of measured data within expected limits of sampling and analytical error.

The QA/QC problems are presented in Appendix B, Tables B-1 (MDA AA), B-2 (Skunk Works), B-3 (Burn Pits), and B-4 (SDA) according to analytical suite and batch number, respectively.

4.1 Analyses for PRS 36-001, MDA AA

4.1.1 Inorganic Analyses

Thirty-one samples were analyzed for inorganics. Mercury in sixteen samples, beryllium and selenium in six samples, antimony and thallium in two samples, and silver in one sample are qualified as J because the sample results were detected below the estimated quantitation limits (EQLs). The values have a high degree of uncertainty because they are near or within the instrument "noise" range. The data are usable as estimated values, but should be used with caution because they cannot be accurately quantified.

Antimony and zinc in three samples, and copper, manganese, selenium, and zinc in three samples had percent recoveries in the spike samples below the established limit (<75%). The data are qualified as UJ, J- (estimated with low bias), or PM (professional judgment and manual review of the raw data needed). The antimony and zinc data from the first set of three samples are usable because the antimony recovery was <2% below the limit and would be detected and quantified if present, while the zinc data were detected an order of magnitude or more below the screening action level (SAL) so the bias did not affect the data comparison. The copper, manganese, selenium, and zinc in the second set of three samples are usable because the recoveries were either slightly below the limit (<3%) so the analyte would be detected and quantified if present, or the spike levels were too low to compensate for the concentrations already present in the samples, and therefore the recoveries could not be determined. In the latter instance, the data are qualified as estimated and are detected well below their background UTLs or an order of magnitude or more below their SALs, so the bias associated with the spike sample has no effect on data comparison.

The duplicates of cadmium, chromium, copper, and zinc in three samples had Relative Percent Differences (RPDs) outside of the established limit (>20%) and are qualified as P (professional judgment needed). Professional judgement, following a review of the data, suggests that the chromium and copper data should not be qualified because the RPDs are within EPA's control limits of ±35%, or ±2X the Contract Required Detection Limit (CRDL). The zinc data should be qualified as J and are usable because the duplicate result is within the range of concentrations detected. The cadmium data are unusable and

should be qualified as R (unusable) because the RPD indicates large imprecision and inaccuracy in the analysis.

Aluminum, chromium, iron, and sodium in five samples had percent recoveries in the blind QC samples outside of established limits (75% to 125%) and are qualified as J. The data are usable because the recoveries for aluminum, chromium, and iron were >50%, and these analytes are either one-third to one-half of the background UTLs or an order of magnitude below SALs so the bias did not affect the data comparisons. The sodium data are usable because the results are biased high.

Antimony in five samples and thallium in fifteen samples had percent recoveries in the LCS outside of established limits (80% to 120%). Data are qualified as UJ or J and are usable because recovery for antimony was either <2% below the limit, so it would be detected and quantified if present, or the results for antimony and thallium were biased high.

Barium, manganese, and zinc in one sample, and antimony, chromium, and silver in another sample had matrix spike/matrix spike duplicate recoveries outside of established limits and are qualified as J. The barium, manganese, and zinc in the one sample and the silver data in the other sample are usable because the spike levels were too low to compensate for the concentrations already present in the samples, and therefore the percent recoveries could not be determined. The data are qualified as estimated and are detected well below their background UTLs, so the bias associated with the spike sample did not effect the data comparisons. The chromium data in the other sample are usable because the results are biased high, while the antimony data are usable because the percent recovery was >50% and was detected well below the SAL, and therefore the bias did not affect the data comparison.

The holding time of 28 days was exceeded by 21 to 31 days for eight mercury samples; the data are qualified as J if detected. The data are usable because the holding time was not grossly exceeded (i.e., more then twice the recommended holding time) and the samples were properly stored.

Several inorganics were detected in the laboratory blanks at or below the MDLs (Table B-1). The sample concentrations are greater than 5X the blank values and are considered valid. Data are not qualified and are usable as detected values.

All other inorganic data are considered usable as reported.

4.1.2 Organic Analyses

4.1.2.1 SVOCs

Thirty-one samples were analyzed for SVOCs. Anthracene, bis(2-ethylhexyl)phthalate, and fluoranthene in one sample are J qualified because they were detected below the EQL. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.

Anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, 4-chloro-3-methylphenol, 2-chloronaphthalene, chrysene, dibenzofuran, diethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 4-methylphenol, naphthalene, pentachlorophenol, pyrene, 1,2,4-trichlorobenzene, and 2,4,6-trichlorophenol in one sample and anthracene, 2-chlorophenol, 2-methylphenol, naphthalene, and 1,2,4-trichlorobenzene in three other samples had percent recoveries in the blind QC sample outside of established limits (<50%) and are qualified as UJ. The data are usable because the recoveries are sufficient to detect and quantify the analytes if present, and the surrogate recoveries were acceptable. In addition, 1,2-dichlorobenzene, hexachloroethane, and 2-methylphenol in one sample and 1,2-dichlorobenzene in three samples had percent recoveries in the blind QC samples <10% and are qualified as R. The data are unusable and are not used in the screening assessment.

Despite the unusable data, the site was adequately characterized for SVOCs by the Phase I sampling activities because these SVOCs are not expected to be present as a result of site activities, and the remaining SVOC data were sufficient to determine whether these analytes are present at the site.

The internal standard, perylene-d12, had low area response for one sample and the data quantified by this standard are qualified as UJ. The data are usable as nondetects because the internal standard response was sufficient to detect and quantify the analytes if present and the surrogate recoveries were acceptable.

Pentachlorophenol in ten samples and 4-nitrophenol in seven samples had percent recoveries in the LCSs outside of established limits (75% to 125%) and are qualified as UJ. The data are usable because the recoveries were either <2%, or only 4% below the limit for pentachlorophenol and 4-nitrophenol, respectively; and therefore, the analytes would be detected and quantified if present.

All SVOCs in two samples and the SVOC laboratory duplicates in another sample had some surrogate recoveries outside of established limits and are qualified as UJ. The duplicate surrogate recoveries for nitrobenzene-d5 and p-terphenyl-d14 were zero. The surrogate recoveries for 3,4,6 tribromophenol, nitrobenzene-d5, and p-terphenyl-d14 were zero, and the recoveries for 2-flourophenol and nitrobenzene-d5 in other samples were zero because of matrix interference. The data in all samples are usable because recoveries for the remaining surrogates were acceptable, and therefore, the analytes would be detected and quantified if present.

All other SVOC data are considered to be usable as reported.

4.1.2.2 VOCs

Thirty-one samples were analyzed for VOCs. Acetone and methylene chloride in ten samples each, and benzene, styrene, toluene, and trichlorofluoromethane in one sample each are J qualified because they were detected below the EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.

All of the internal standards in the initial analysis for VOCs of one sample had area counts below the established limits. Area counts that varied by more than a factor of two (–50% to +100%) from the associated 12-hr calibration standard are qualified as J,PM if detected, and UJ if undetected. Further review of the data indicated that the J qualifier should be retained for the detected values. The internal standard 1,4-dichlorobenzene-d4, had a very low area count (<2%), resulting in the nondetect data associated with this standard being qualified as R and detects qualified as J,PM. Further review of the data indicated that the J qualifier should be retained for the detected values. Re-analysis of the sample found no change in the internal standard area counts. However, dilution and re-analysis of the sample found only two internal standards outside of the established limits. The diluted sample should be used in the screening assessment and the data associated with the two internal standards are qualified as UJ or J. Another sample analyzed for VOCs had two internal standards with area counts below the established limits and the data qualified as described above. Further review of the data indicated that the J qualifier should be retained for the detected values. Re-analysis of the sample resulted in no change in the area counts, so the initial analysis was used in the screening assessment. All VOCs in a third sample had all four internal standard area counts outside of control limits and are qualified as UJ. The data associated with these internal standards are usable because the surrogate recoveries were established in all cases, so the analytes would be detected and quantified if present.

Surrogate recoveries for bromofluorobenzene, dibromofluoromethane, and toluene-d8 for two samples were above established limits (115%, 108%, and 110%, respectively). All of the detected target compounds are qualified as J+ (estimated with high bias), while the nondetects are not qualified. All of the VOCs in four other samples also had surrogate recoveries outside of established limits because of matrix

interference problems and are qualified as UJ or J. The data affected by the surrogate recoveries are usable because the results are biased high.

Methylene chloride was detected in the laboratory blanks at or below the MDLs. The sample concentrations were less than 10X the blank values, indicating the presence of methylene chloride may be due to blank contamination. The sample results were either qualified as U or are not qualified and are usable as nondetects in the screening assessment. In addition, acetone in four samples and methylene chloride in one sample were detected at concentrations either below the EQLs or slightly above the EQLs. Because these analytes are not expected to be present as a result of site activity and are common laboratory contaminants, the data are considered nondetects and are usable as such.

All other VOC data are considered to be usable as reported.

4.1.2.3 HE

Thirty-one samples were analyzed for HE. HMX in one sample and HMX and RDX in another sample are J qualified because they were detected below the EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.

Nitrobenzene in four samples had percent recoveries in the blind QC samples below the established limit (<50%) and are qualified as UJ. The data are usable because the recoveries were sufficient to detect and quantify the analyte if present.

HMX and 2,4-dinitrotoluene in three samples had percent recoveries in LCS outside of established limits (>125%). Data are not qualified because no detections of these analytes were found.

The analytical holding time (40 days) for two HE samples was exceeded by 115 days. The data are <EQL and are qualified as R because the holding time was grossly exceeded (more than twice the holding time) and are not used in the screening assessment. Despite the unusable data, the site was adequately characterized for HE by the Phase I sampling activities because the remaining 29 samples were sufficient to determine whether HE was present at the site.

All other HE data are considered to be usable as reported.

4.1.3 Radionuclide Analyses

Eight samples were analyzed for total uranium and twenty-three samples were analyzed for isotopic uranium. The total uranium results are usable as reported. The minimum detectable activity (MDA) for uranium-234, uranium-235, and uranium-238 in one sample and its duplicate, uranium-234 and uranium-238 in two samples, uranium-234 in three samples, and uranium-238 in two samples were above the EQLs and are qualified as PM. Further review of the data package indicated that the data should be unqualified because the sample results were above the detection limits. All other isotopic uranium data are usable as reported.

4.2 Analyses for PRS 36-004(d), Skunk Works

4.2.1 Inorganic Analyses

Seven samples were analyzed for inorganics; all inorganic data are usable as reported.

4.2.2 Organic Analyses

Seven samples were analyzed for SVOCs, VOCs, and HE.

4.2.2.1 SVOCs

Bis(2-ethylhexyl)phthalate in two samples and di-n-butyl phthalate in three samples are qualified as J because the sample results were detected below the EQLs. The values have a high degree of uncertainty because they are near or within the instrument "noise" range. The data are usable as estimated values, but should be used with caution because they cannot be accurately quantified.

4-Chloro-3-methyl phenol and pentachlorophenol in all samples had matrix spike/matrix spike duplicate recoveries outside of established limits (less than 37% and 30%, respectively). The data should be qualified as UJ and are usable because the recoveries were sufficient to detect and quantify the analytes if present.

Bis(2-ethylhexyl)phthalate in three samples is incorrectly qualified with a B, but should instead be qualified with a V to indicate that the analyte was detected in the laboratory blank. The sample values were less than 10X the blank value so the data are usable as nondetects due to blank contamination.

All other SVOC data are considered to be usable as reported.

4.2.2.2 VOCs

All VOC data are considered to be usable as reported.

4.2.2.3 HE

All HE data are considered to be usable as reported.

4.2.3 Radionuclide Analyses

Seven samples were analyzed for isotopic uranium; all data are considered usable as reported.

4.3 Analyses for PRS 36-004(d), Burn Pits

4.3.1 Inorganic Analyses

Eleven samples were analyzed for inorganics. Antimony and manganese in all samples, and selenium and thallium in seven samples are qualified as UJ if undetected and either J- or J+ if detected because percent recoveries in the spike sample were outside of established limits (75% to 125%). The antimony, selenium, and thallium data are usable because recoveries were sufficient (>40%) to detect and quantify the analytes if present. For the detected analytes, the sample values were below the background UTLs and the bias did not affect the data comparisons. The manganese data are usable because the results are biased high.

The duplicates for beryllium, calcium, silver, and manganese in seven samples had RPDs outside of control limits (>20%) and are qualified as P. A more detailed review of the data indicated that manganese and silver RPDs were within the EPA's control limits for soils (35% or ± 2X CRDL) and should not be qualified. The beryllium and calcium data should be qualified as J because of the RPDs. The high RPDs are indicative of the soil heterogeneity and does not affect usability.

Arsenic, beryllium, and sodium were detected in the laboratory blank. The sample value for arsenic in one sample and the sample values for beryllium and sodium in all samples were detected above EQL but are

<5X the blank values and are qualified as U. These data are usable as nondetects in the screening assessment.

All other inorganic data are considered usable as reported.

4.3.2 Organic Analyses

Eleven samples were analyzed for SVOCs, VOCs, and HE.

4.3.2.1 SVOCs

The SVOC data are considered to be usable as reported.

4.3.2.2 VOCs

The area count for one internal standard (1,4-dichlorobenzene-d4) was <50% for one sample. All VOC data for this sample are qualified as UJ and are usable because the other internal standards were acceptable and the area count was <2% below the lower limit. Therefore, the instrument sensitivity and response were stable enough to detect and quantify the analytes. In addition, acetone and methylene chloride were detected in three soil samples at concentrations either below the EQLs or slightly above the EQLs. Because these analytes are not expected to be present as a result of site activities and are common laboratory contaminants, the data are considered to be nondetects and are usable as such.

All other VOC data are considered to be usable as reported.

4.3.2.3 HE

The HE data for all samples are qualified as PM because the LCS was spiked with only eight analytes rather than the entire suite of fourteen HE analytes. A review of the data indicated that the percent recoveries in the LCS are acceptable and that the analytes spiked into the LCS are sufficient to determine the accuracy of the method and provide information on laboratory performance. Therefore, the data should not be qualified and are usable as reported.

4.3.3 Radionuclide Analyses

Eleven samples were analyzed by gamma spectrophotometry and for isotopic uranium; all data are considered usable as reported.

4.4 Analyses for PRS 36-006, SDA

4.4.1 Inorganic Analyses

Six samples were analyzed for inorganics. Antimony, copper, and iron in all samples are qualified as UJ if undetected and either J- or J+ if detected because percent recoveries in the spike sample were outside of established limits (75% to 125%). The data are usable because antimony recoveries were sufficient (>50%) to detect and quantify the analyte if present. Selenium and thallium data were either below the background UTLs or the SALs so the bias did not affect the data comparisons.

The duplicates for manganese and zinc in all samples had RPDs outside of control limits (>20%) and are qualified as P. A more detailed review of the data indicated that the RPDs were within EPA's control limits for soils (35% or ±2X CRDL) and should not be qualified.

All other inorganic data are considered usable as reported.

4.4.2 Organic Analyses

Six samples were analyzed for SVOCs, VOCs, and HE.

4.4.2.1 SVOCs

The SVOC data are considered to be usable as reported.

4.4.2.2 VOCs

The area counts for two internal standards (chlorobenzene-d5 and 1,4-dichlorobenzene-d4) were <50% for four and three samples, respectively. The data are qualified as UJ if nondetects and J,PM if detected. Further review of the data indicated that the J qualifier should be retained for the detected values. The data are usable because the other internal standards were acceptable and the area counts were slightly below the lower limits. Therefore, the instrument sensitivity and response were stable enough to detect and quantify the analytes if present. The detected values were orders of magnitude below the SALs so the bias did not affect the data comparisons. In addition, methylene chloride was detected in one soil sample at a concentration below the EQL. Because this analyte is not expected to be present as a result of site activities and is a common laboratory contaminant, the datum is considered to be a nondetect and is usable as such.

All other VOC data are considered to be usable as reported.

4.4.2.3 HE

The HE data for all samples are qualified as PM because the LCS was spiked with only eight analytes rather than the entire suite of fourteen HE analytes. A review of the data indicated that the percent recoveries in the LCS are acceptable and that the analytes spiked into the LCS are sufficient to determine the accuracy of the method and provide information on laboratory performance. Therefore, the data should not be qualified and are usable as reported.

4.4.3 Radionuclide Analyses

Six samples were analyzed for isotopic uranium; all data are considered usable as reported.

5.0 SPECIFIC RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 PRS 36-001, MDA AA

MDA AA was reported to be a series of trenches located near the Lower Slobbovia Firing Site in TA-36. These trenches were used for the burning and disposal of HE test debris. COPCs at the site included uranium, metals, and explosives located within the ash. Boreholes were drilled to determine the boundaries of the MDA. Analytical results indicate the presence of uranium, copper, 3,3'-dichlorobenzidine, and lead above SALs, however, a risk assessment using an industrial use scenario showed that COPCs do not present a significant hazard. Based on the NFA Criterion 5, a Class III permit modification is requested to remove this site from the HSWA Module of the Laboratory's RCRA operating permit.

5.1.1 History

MDA AA was reported to be a series of up to four trenches that were used for burning and final disposal of HE test debris. The first trench was dug for the MDA in the mid-1960s. The exact number of trenches was not identified, but two to four trenches were indicated near the Lower Slobbovia Firing Site in the historical research. Operations at the trenches consisted of collecting and loading shot residue and debris on a truck, dumping the debris into the trench, and burning it. The debris that was burned contained wood, nails, sand contaminated with barium, uranium, other metals, plastics, and residual HE. When a trench was filled with burned debris, it was covered with about 4 ft of soil. The site was closed on May 12, 1989 (LANL 1993, 1088). COPCs at the site are uranium, metals, and HE.

5.1.2 Description

MDA AA is located in a level area south of the Lower Slobbovia Firing Site in Potrillo Canyon. The area is approximately 300 ft southwest of the firing site control bunker, TA-36-12, 150 ft southwest of the x-ray device (TA-36-86), and within the hazard radius for the Lower Slobbovia Firing Site. A couple of trees that were visible in photographs taken almost ten years ago (LANL 1986, 13-0062) are still distinguishable in the disposal area, but otherwise the growth over the disposal area is mainly grasses and a few young trees. Small drainage areas occur along the eastern and southern boundaries of the disposal area.

5.1.3 Previous Investigations

In 1987, the Environmental Surveillance Group collected six samples from the active trench (McInroy 1987, 5618). The metal concentrations were at the toxicity characteristic limits established in 40 CFR 261.24 (LANL 1993, 1088).

In 1988, three grab soil samples were collected from the bottom of the active trench at depths between 0 and 6 in. The samples, collected from each end and from the middle of the trench, were analyzed for VOCs, metals, explosives, uranium and thorium isotopes, and gamma-emitting radionuclides (EG&G 1989, 13-0044). Holding times were exceeded for these samples, and the data are provisional. Except for cadmium, all the analytes were near the background levels for that analyte (Ferenbaugh et al. 1990, 0099; Purtymun et al. 1987, 0211). The cadmium at 4.6 ppm was less than its screening action level of 80 ppm. Depleted uranium was also present at levels suggesting that low concentrations may be present within the trench. Older trenches may be similarly contaminated.

5.1.4 Field Investigation

Objectives of the Phase I investigation were to delineate all of the trenches at MDA AA, to collect more representative data for establishing the level and extent of contamination in the trenches, and for conducting screening and baseline risk assessments. Earlier samples, as indicated above, had exceeded

holding times (LANL 1993, 1088). Samples were to be taken from soil overlying the ash and debris, from the ash and debris, and from soil or tuff underlying the trenches. Additionally, if erosion channels had penetrated the trenches, these channels would be sampled to determine if a release had occurred from the buried waste. Tuff was never encountered and all samples were taken from soil or soil, ash, and debris matrix.

Prefield activities included historical investigations and interviews. Aerial photographs indicated two well-defined trenches in the southern end of the general PRS area (LASL 1958, 13-0068; LASL 1979, 13-0092; and LANL 1986, 13-0062). Discussions with employees indicated that the trenches could extend as far north as the embankment near Potrillo Drive (LANL 1993, 1088).

5.1.4.1 Land Surveys

A land survey was performed to set grid points for a 250 ft by 300 ft grid using established Global Positioning System survey monuments with coordinates published in the LANL Survey Monument Network Manual (LANL 1993). A Sokkia Set IIIB Total Station with SDR Data Collector was used to conduct the survey. Data were downloaded from the survey equipment Sokkia Link and DCA 12.0 PC-based civil and surveying software. The data control points were then adjusted as required by New Mexico state surveying regulations. The grid points were used to record sample and drilling locations.

5.1.4.2 Geophysical Surveys

In 1993 geophysical surveys were conducted at MDA AA in an attempt to locate the lateral boundaries of the trenches. Electromagnetic (EM) and magnetometer/gradiometer (MAG) data were collected during this survey.

EM data were used to establish terrain conductivity. The EM consisted of a Geonics EM31-DL ground conductivity meter and an Omnidata data logger. This instrumentation is affected by buried metallic debris, differences in moisture content, and lithologic character of subsurface materials. These measurements can be used to delineate trench fill material and determine the presence of buried objects.

Instrumentation for the magnetic gradient, the MAG, consisted of a GEM GSM-19 proton precession magnetometer/gradiometer. This measures the earth's resultant magnetic field at a particular location. Magnetic field values depend on such factors as: geographical location, magnetic susceptibility of shallow and deep subsurface materials, localized buried objects, or subsurface features.

Results of the two methods concurred or identified the same general area of anomalies. However, two areas on the south and north boundaries of the anomalous zone are represented by MAG anomalies where EM anomalies were not detected. All data are available as indicated in Appendix A.

Many anomalies occur in the area, but most of the high intensity anomaly locations coincided with locations of surface structures, features, and storage areas. Anomalies along the eastern border of the area are associated with a culvert, TA-36-86, and with TA-36-184. Other anomalies in the center and northwestern section of the MDA are associated with miscellaneous metal on the ground surface. Anomalies in the southwestern section are also associated with metal surface debris.

A number of anomalies occur near the center of the investigated area. Some of these are adjacent to surface objects, but most of the anomalous areas are far enough away from these objects so as not to be caused by the surface structures or features. This anomalous zone represents target anomalies and was interpreted as the trenches. The western end of the anomalous zone was difficult to determine, and separate trenches were not identified. Either the trenches were located too close together for geophysics to resolve separate trenches, or the anomalous zone may represent one nonrectangular trench or pit.

In 1994, ground penetrating radar (GPR) surveys were performed over the anomalous zone to attempt to achieve better resolution of the possible subsurface trenches in the area. Three north-south trending GPR traverses were performed using both 500 megahertz and 300 megahertz antennas. The grid markers from the land survey grid were used for distance markers along each traverse.

Depth of penetration was limited, but the GPR data indicated numerous buried objects along each traverse. The apparent random location of buried objects did not support the identification of distinct trenches. The results of this survey supported the EM and MAG survey from 1993.

5.1.4.3 Radiological Surveys

During the delineation drilling, surveys were made of all the retrieved material. Because of the known drilling depth, any depth of elevated readings could be estimated based on the depth of the drill. One location, borehole 2664, was used as a bias sample location at 36-3131, based on the results of the radiological survey.

5.1.4.4 Delineation Drilling

Because geophysical surveys proved inconclusive in specifically delineating the former trenches, an extensive drilling effort was conducted in 1995.

To determine the locations of the trenches and to select sample locations that were unquestionably biased towards sampling the greatest quantity and variety of the trench material, a plan for exploratory drilling was developed and implemented. The exploratory delineation and drilling effort began in 1994 by establishing a grid of approximately 100 surveyed points over the PRS boundary. The grid served as a consistent pattern and base map for plotting results from the exploratory drilling. Figure 5.1.4.4-1 shows the locations of the boreholes.

During the 1994 field season, four boreholes were drilled. Three boreholes encountered ash and other debris. One borehole, 36-3126, was drilled to a depth of 27 ft in an unsuccessful attempt to reach groundwater. Additional boreholes were not drilled because the field season ended. Drilling continued in 1995, and approximately 84 exploratory boreholes were drilled and plotted. Cuttings from each borehole were visually inspected for ash or debris, and 21 drilling sites showed evidence of ash and/or debris. The cuttings were field screened for radioactivity, VOCs, and at select locations, for metals.

Ash, debris, and soil were distributed unevenly within the trench area. Distribution of volume, depth, and surface area was widely varied. At location 36-3125, a 1994 borehole, a large volume of ash was found, but 4 ft away, no ash was found in the borehole. Therefore, the trenches were not definitively located, but delineation drilling did provide the general bounds for the trenches.

The general bounds for two trench areas were defined and referred to as the northern trench area and the southern trench area (Figure 5.1.4.4-1). The size and shape of the trench areas vary significantly from each other. The northern area is approximately 80 ft long and 40 ft wide. The southern trench is a parallelogram approximately 120 ft long and 20 to 30 ft wide. Although the latter trench extends toward the east, where the erosion gullies and drainage culvert are located, no evidence of ash or debris were noted in the gullies or drainage. Erosion channels have not violated the integrity of the trench cover at this time.

Generally, trench materials were encountered at a depth of 3 to 4 ft below ground surface. Trench floors were found to range from 8 to 13 ft below ground surface in the northern area, and from 3 to 12 ft below ground surface in the southern area. Materials from the trenches varied considerably and included unburned wood, charred wood, plastics, wire, nails, broken glass, cloth, rope, light porous ash, and dense ash. The compaction of the fill material varied, too; large void spaces and loosely compacted material were encountered during drilling.

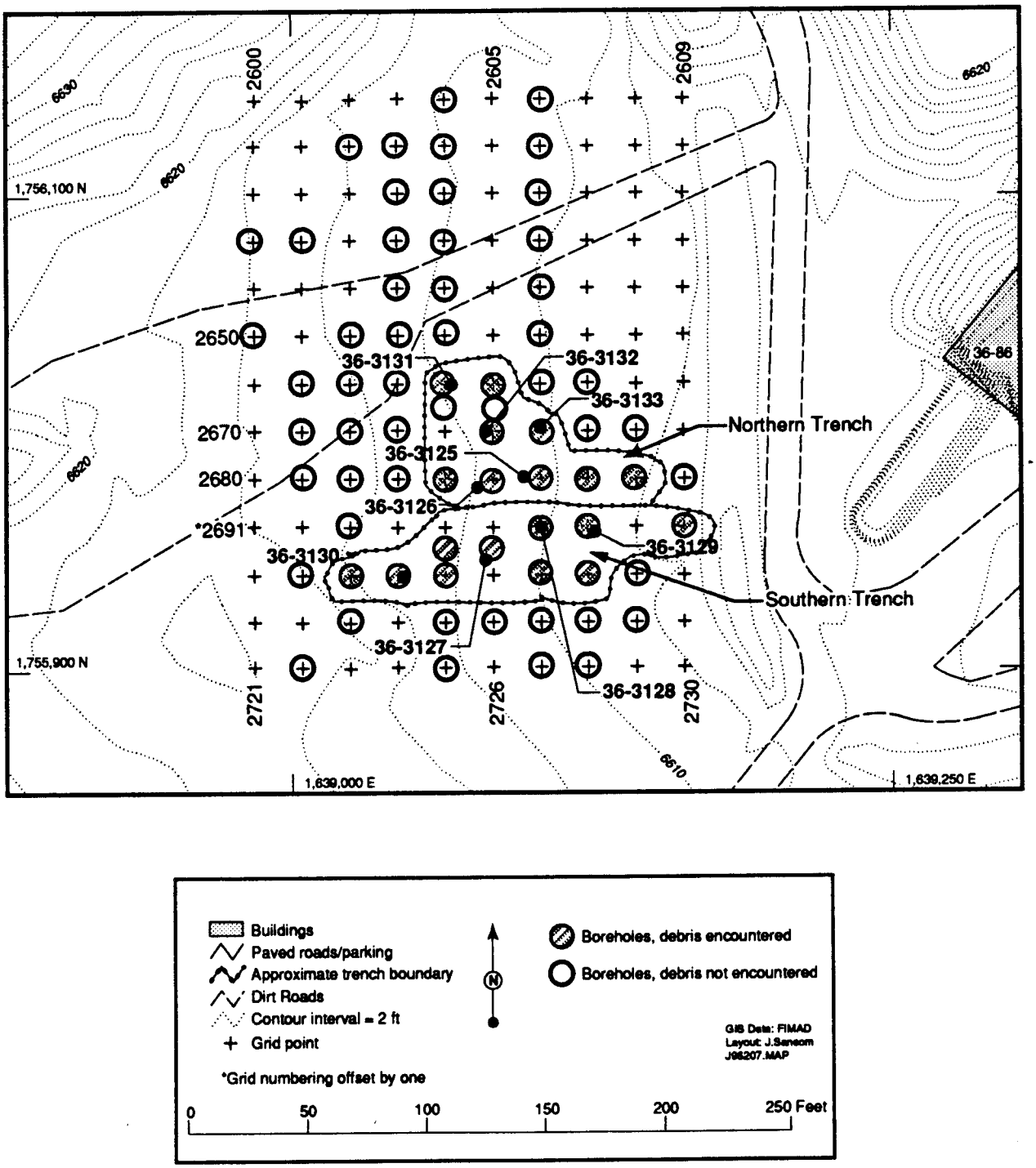


Figure 5.1.4.4-1 PRS 36-001 with borehole locations, locations where ash and debris was encountered, and sampling locations

5.1.4.5 Sample Collection

The RFI Work Plan required sampling each trench at four locations at discrete vertical intervals (LANL 1993, 1088). In accordance with the requirements, each trench area was drilled and sampled in four locations. Each borehole was sampled at two discrete intervals from the ash and debris zone, and at another interval approximately 2 ft beneath the base of the trench. All samples were soil and ash; tuff was not encountered. In addition, a sample from the overlying fill was taken in 1994 at borehole 36-3126, and two samples in 1995, at 36-3129 and 36-3133.

Southern Trench

Sample locations were selected from the results of the 1995 delineation drilling effort. Boreholes exhibiting elevated screening results for VOCs, radioactivity, metals, or variability visual indicators were compiled and reviewed. From this grouping, the following four borehole locations were selected within the southern trench area:

Borehole 2696(b) (36-3127) showed elevated HNu readings of 5 to 20 ppm compared to 0 to 1 ppm at other exploratory boreholes. A large volume of unburned ash and debris was present in the cuttings.

Borehole 2697 (36-3128) showed evidence of unburned debris, including Styrofoam, ceramics, glass, and metals, at 7 to 10 ft below ground surface. This borehole was chosen for sampling based on the quantity and diversity of debris present.

Borehole 2698 (36-3129) had significant amounts of burned material, differing from the amounts of unburned material in other boreholes. Few cuttings were produced, probably due to large amounts of void space, which absorbed the cuttings as the drill advanced.

Borehole 2704 (36-3130) showed a significant volume of burned wood. This borehole was chosen for sampling based on the spatial distribution relative to other boreholes selected for sampling.

Northern Trench

Using the same procedure, three delineation locations were selected for sampling within the northern trench area. Two boreholes drilled and sampled in 1994 were situated in the northern trench area. These boreholes were included in the grouping selected from the 1995 drilling to fulfill the RFI Work Plan requirements for sampling.

Borehole 36-3125 was drilled during the 1994 season based on the results of the geophysics surveys. Two areas exhibiting ash and debris were sampled, and the underlying soil was also sampled at a depth of 13 to 14 ft.

Borehole 36-3126, also a 1994 season borehole based on the results of the geophysics surveys, was sampled at varying depths including a depth of 20 to 22 ft, exceeding the data quality objectives of the RFI Work Plan, which specified sampling 2 ft below the base of the trench. Underlying tuff was not encountered even at this depth.

Borehole 2664 (36-3131) was drilled during the 1995 season. The cuttings included oily ash at 3 ft and charred wood at 5 ft. This was the only location that had oily material. The cuttings exhibited elevated radioactivity levels of 500 counts per minute (cpm) for beta and gamma, when radioactivity levels in the surrounding area were typically at 200 cpm.

Borehole 2675 (36-3132) cuttings encountered material at 4 ft that was well burned. No debris was present, which was different than the material in any other location.

Borehole 2676 (36-3133) cuttings showed significant quantities of ash and debris from 3 to 10 ft. Samples analyzed by XRF indicated elevated levels of uranium, lead, and mercury.

Samples were not taken from gullies. Samples were proposed to be collected from erosion channels if evidence of debris from the trenches was present, but the erosion channels had not reached ash or debris from the trenches.

Figure 5.1.4.4-1 presents the PRS 36-001 site with the delineation grid, and the borehole locations where ash and debris were encountered. Figure 5.1.4.5-1 presents the sample locations and sampling results for PRS 36-001. The sample summary tables for the 1994 and the 1995-1996 sampling seasons are indicated in Tables 5.1.4.5-1 and 5.1.4.5-2, respectively.

TABLE 5.1.4.5-1
SAMPLE SUMMARY FOR MDA AA, 1994 SEASON

Location ID	Sample ID	Depth (ft)	Matrix	VOCs	SVOCs	Metals Mercury	Total U	HE
36-3125	AAB1952	5.5 - 7.0	Subsurface soil, ash, debris	19378*	19378*	19875*	20060*	19378*
36-3125	AAB1953	8.0 - 10.0	Subsurface soil, ash, debris	19387	19387	19876	20063	19389
36-3125	AAB1954	13.0 - 14.0	Subsurface soil	19387	19387	19876	20063	19389
36-3126	AAB1950	2.0 - 4.0	Subsurface soil, ash, debris	19461	19461	20057	20065	19461
36-3126	AAB1951	2.0 - 4.0	Subsurface soil, ash, debris	19461	19461	20057	20065	19461
36-3126	AAB1955	6.0 - 8.0	Subsurface soil, ash, debris	19461	19461	20057	20065	19461
36-3126	AAB1956	8.0 - 10.0	Subsurface soil, ash, debris	19504	19504	20056	20066	19504
36-3126	AAB1957	20.0 - 22.0	Subsurface soil	19504	19504	20056	20066	19504

* Numbers refer to request numbers.

5.1.4.6 Deviations from the RFI Work Plan Sampling Strategies

The RFI Work Plan called for two samples to be taken from the ash and debris layer from each sampled borehole. Because the amount of ash was too small to collect two samples, in some cases, only one sample was taken from the ash. The second sample was taken from the soil directly below the ash. The location below the ash was chosen based on the theory that if contaminants, principally metals, solvents, or oils, had leached from the ash zone, they would be present in the soil directly below the ash.

Every effort was made to meet the RFI Work Plan criteria of sampling approximately 2 ft below the base of the trenches. However, due to difficulties in sample recovery and ascertaining the exact depth of the trench floors, two underlying soil locations were collected slightly deeper, approximately 3 to 4 ft below the trench floor.

The use of the XRF was not called out in the RFI Work Plan but was used to screen select borehole cuttings for metals and uranium. This information was used to bias sample locations.

Isotopic analyses were requested for the uranium samples that were taken in the 1995 sampling effort. This change was made because isotopic analysis provides more information than the total uranium analysis with only a slightly higher cost. Borehole samples taken in 1994 were analyzed for total uranium.

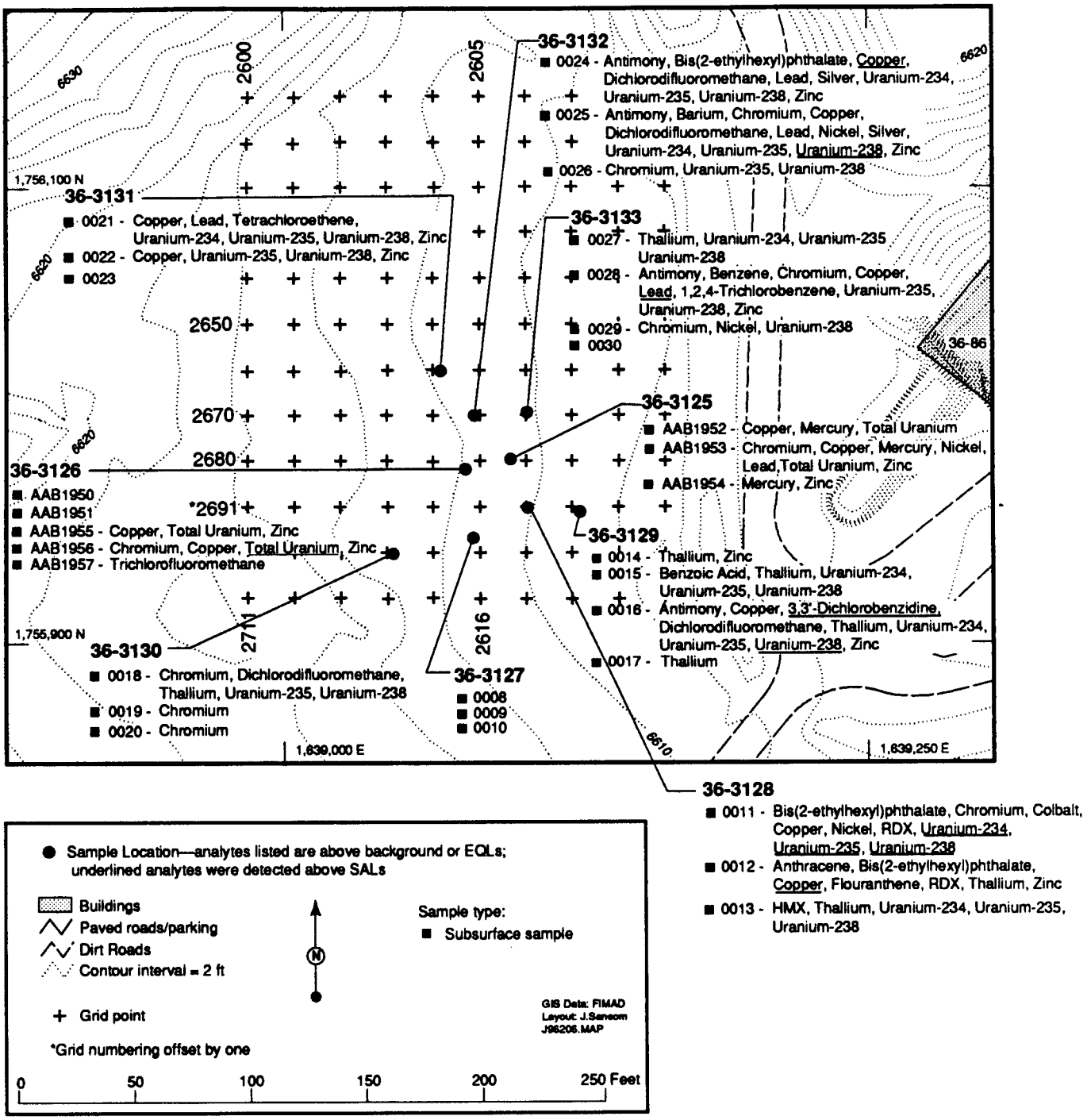


Figure 5.1.4.5-1 PRS 36-001, showing sample locations and results

TABLE 5.1.4.5-2
SAMPLE SUMMARY FOR MDA AA, 1995-1996 SEASON

Location ID	Sample ID	Depth (ft)	Matrix	VOCs	SVOCs	Metals Mercury	Iso U	HE
36-3127	0236-96-0008	9.8 - 10.8	Subsurface soil, ash, debris	1808*	1808*	1809* 1809	1810*	1808*
36-3127	0236-96-0009	10.8 - 13.3	Subsurface soil, ash, debris	1808	1808	1809 1809	1810	1808
36-3127	0236-96-0010	14.3 - 16.7	Subsurface soil	1808	1808	1809 1809	1810	1808
36-3128	0236-96-0011	3.2 - 5.8	Subsurface soil, ash, debris	80429	80680	80451 80340	80412	80521
36-3128	0236-96-0012	6.8 - 10.3	Subsurface soil, ash, debris	80727	80680	80800 80666	80412	80692
36-3128	0236-96-0013	12.4 - 13.5	Subsurface soil	80727	80680	80800 80666	80412	80692
36-3129	0236-96-0014	0.5 - 2.2	Subsurface soil, ash, debris	80727	80680	80800 80870	80869	80692
36-3129	0236-96-0015	4.5 - 6.6	Subsurface soil, ash, debris	80727	80680	80800 80870	80869	80692
36-3129	0236-96-0016	8.3 - 9.6	Subsurface soil, ash, debris	80727	80680	80800 80870	80869	80692
36-3129	0236-96-0017	12.3 - 14.4	Subsurface soil	80727	80680	80800 80870	80869	80692
36-3130	0236-96-0018	4.4 - 5.0	Subsurface soil, ash, debris	81149	81346	81050 80870	80869	81056
36-3130	0236-96-0019	5.0 - 6.8	Subsurface soil, ash, debris	81149	81346	81050 80870	80869	81056
36-3130	0236-96-0020	7.0 - 9.1	Subsurface soil, ash, debris	81149	81346	81050 80870	80869	81056
36-3131	0236-96-0021	3.3 - 5.5	Subsurface soil, ash, debris	1791	1791	1792 1792	1793	1791
36-3131	0236-96-0022	5.5 - 7.6	Subsurface soil, ash, debris	1791	1791	1792 1792	1793	1791
36-3131	0236-96-0023	9.2 - 11.7	Subsurface soil	1791	1791	1792 1792	1793	1791
36-3132	0236-96-0024	3.9 - 5.9	Subsurface soil, ash, debris	81149	81346	81050 81089	80869	81056
36-3132	0236-96-0025	5.9 - 7.3	Subsurface soil, ash, debris	81149	81346	81050 81089	80869	81056
36-3132	0236-96-0026	10.0 - 11.4	Subsurface soil	81149	81346	81050 81089	80869	81056
36-3133	0236-96-0027	0.5 - 2.2	Subsurface soil, ash, debris	81149	81346	81050 81089	80869	81056
36-3133	0236-96-0028	6.2 - 7.1	Subsurface soil, ash, debris	81149	81346	81050 81089	80869	81056
36-3133	0236-96-0029	7.1 - 8.3	Subsurface soil, ash, debris	81149	81346	81050 81089	80869	81056
36-3133	0236-96-0030	9.2 - 10.5	Subsurface soil	81149	81346	81050 81089	80869	81056

* Numbers refer to request numbers or sampling batch.

5.1.5 Background Comparisons

The location of samples with analyte values exceeding background UTLs are shown in Figure 5.1.4.5-1.

Inorganics

Antimony, barium, chromium, cobalt, copper, lead, mercury, nickel, silver, thallium, total uranium, and zinc were detected in subsurface soil samples at concentrations above soil background UTLs. The data are summarized in Table 5.1.5-1. Further background analysis showed that the distribution of barium was not statistically different from background (Gehan: p-value = 0.7985; Quantile: p-value = 0.7971; Slippage: p-value = 0.0000). Therefore, barium is eliminated from further consideration. Although the p-value for cobalt (Gehan: p-value = 1.0000; Quantile: p-value = 0.9945; Slippage: p-value = 0.1512) indicates no statistically significant difference between site and background distribution, cobalt is carried forward for SAL comparison because of the single large outlier in the site data set. See Section 3.2 for a discussion of these tests.

The remaining inorganics (10) detected at concentrations greater than background are carried forward to the SAL comparison stage. The other inorganics that were either undetected or with concentrations less than background UTLs were not retained as COPCs.

Radionuclides

Uranium-234, uranium-235, uranium-238, and total uranium were detected in subsurface soil samples above background UTLs (Table 5.1.5-2), and were carried forward to the SAL comparison stage. Total uranium was analyzed for in only eight samples from the 1994 field season. All uranium analyses after this time were for isotopic uranium. The isotopic ratios indicated that nearly all the uranium detected during the 1996 field season was depleted uranium. Therefore, the total uranium detected during 1994 is assumed to be depieted uranium, although isotopic data are not available. No other radionuclides were analyzed at this PRS.

5.1.6 Evaluation of Organic Constituents

Eleven organics were detected above the EQLs in the subsurface soil (Table 5.1.6-1), and carried forward to the SAL comparison stage. The organics that were undetected or detected below the EQLs were not retained as COPCs.

Two common laboratory contaminants — acetone and methylene chloride — were detected at concentrations either below the EQL or slightly above the EQL. Because these analytes are not expected to be present as a result of site activities and are common laboratory contaminants, the data are considered to be nondetects and were eliminated from further evaluation at this site.

5.1.7 Human Health Assessment

5.1.7.1 Screening Assessment

Antimony, chromium, cobalt, mercury, nickel, silver, thallium, total uranium, and zinc were detected at concentrations below their SALs and were submitted to an MCE. Copper and lead exceeded their respective SALs, and on that basis were retained as COPCs (Table 5.1.7-1). No other inorganics were detected at concentrations above SAL.

Uranium-234, uranium-235, uranium-238, and total uranium were detected at concentrations greater than their respective SALs and were retained as COPCs (Table 5.1.7-2).

TABLE 5.1.5-1
INORGANICS WITH CONCENTRATIONS GREATER THAN BACKGROUND UTLs FOR PRS 36-001, MDA AA

Sample ID	Location ID	Depth (ft)	Antimony (mg/kg)	Barium[1] (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Thallium (mg/kg)	Total U (mg/kg)	Zinc (mg/kg)
UTL	N/A	N/A	1	315	19.3	19.2	15.5	23.3	0.1	15.2	Not Available	1.0	5.45	50.8
SAL	N/A	N/A	31	5300	210	4600	2800	400	23	1500	380	5.4	230*	23000
AAB 1952	36-3125	5.5-7	ND	139 (D)	12.2	4.6 (D)	17	10.5 (D)	0.36 (J)	10.3 (D)	ND	ND	10.0	54.8 (D)
AAB 1953	36-3125	8-10	0.39 (D)	127(D)	31	3.4	131	233 (D)	0.39	18.5 (D)	ND	ND	15.1	73.6 (D)
AAB 1954	36-3125	13-14	ND	105	6.1	ND	ND	9.1	0.37 (J)	ND	ND	ND	4.54	51.2
AAB 1955	36-3126	6-8	ND	270	9.5	ND	18.3	10	ND	13.1	3.6	ND	14.2	105
AAB 1956	36-3126	8-10	ND	126	34.1	2.5(D)	126(D)	9.9	ND	14 (D)	ND	ND	136	95.5 (D)
0236-96-0008	36-3127	9.8-10.8	ND	102	9.9	4.5	281	13.5	ND	17.2	ND	ND	Not Analyzed	167
0236-96-0011	36-3128	3.2-5.8	ND	21	35	556	27.9	0.84	0.005 (J)	450	0.32 (J)	ND	Not Analyzed	25.3
0236-96-0012	36-3128	6.8-10.3	ND	110	8.99	3.16	2920	23.2	0.006 (J)	6.16	ND	1.76 (J)	Not Analyzed	61
0236-96-0013	36-3128	12.4-13.5	ND	68.2 (J)	5.61	2.52	3.98	5.89	0.003 (J)	3.63	ND	1.8 (J)	Not Analyzed	33.4 (J)
0236-96-0014	36-3129	0.5-2.2	ND	59.1	4.84	2.27	3.63	7.08	0.009 (J)	13.3	ND	1.79 (J)	Not Analyzed	63.6
0236-96-0015	36-3129	4.5-6.6	0.26 (J)	66.2	5.01	2.35	4.2	7.07	0.012 (J)	4.03	ND	1.56 (J)	Not Analyzed	34.4
0236-96-0016	36-3129	8.3-9.6	5.73 (J)	202	10.8	2.17	201	121	0.017 (J)	8.95	ND	2.31 (J)	Not Analyzed	231
0236-96-0017	36-3129	148-173	0.18 (J)	114	7.55	3.89	4.29	8.81	0.02 (J)	5.21	ND	1.99 (J)	Not Analyzed	28.7
0236-96-0020	36-3130	7.0-9.1	ND	147	30.1	4.14	5.45	8.81	0.015 (J)	16.7	ND	ND	Not Analyzed	23.7
0236-96-0018	36-3130	53-60	0.125 (J)	88.8	20.5	2.83	13.5	7.65	0.014 (J)	12.1	ND	1.36 (J)	Not Analyzed	47.5
0236-96-0019	36-3130	60-81	ND	156	19.5	4.6	6.76	9.87	0.017 (J)	12	ND	ND	Not Analyzed	30.3
0236-96-0021	36-3131	3.3-5.5	ND	220	9.6	3.9	718	58.7	0.02	11.3	ND	ND	Not Analyzed	242 (J)
0236-96-0022	36-3131	5.5-7.6	ND	183	10.2	5.2	43.1	18.8	0.03	7.8	ND	ND	Not Analyzed	77.6
0236-96-0024	36-3132	3.9-5.9	4.87 (J)	297	15 (J)	1.92	21300	38.8	0.078	5.69	250 (J)	ND	Not Analyzed	76.1 (D)
0236-96-0025	36-3132	5.9-7.3	5.14	329	62.9	17.3	2240	146	0.026 (J)	101	33.1	ND	Not Analyzed	998
0236-96-0026	36-3132	120-137	ND	120	21.6	3.85	6.7	9.02	0.015 (J)	13.1	ND	ND	Not Analyzed	33.1
0236-96-0027	36-3133	0.5-2.2	ND	72.2	14.2	2.64	6.27	7.72	0.014(J)	8.59	ND	2.24 (J)	Not Analyzed	32.7
0236-96-0028	36-3133	7.2-7.1	16.6	131	29.6	2.64	552	1850	0.01 (J)	10.2	0.333(J)	ND	Not Analyzed	588
0236-96-0029	36-3133	7.2-8.3	0.103 (J)	139	50.8	4.09	7.84	12	0.016 (J)	24.9	ND	ND	Not Analyzed	38.4

ND = Not detected N/A = Not Applicable Double border = Concentration exceed background UTL Shaded box = Concentration exceeded SAL

(D) = The maximum concentration from original or laboratory duplicate (J) = Estimated value * Uranium SAL of 230 mg/kg is based on systemic effects.

[1] Barium was detected at a concentration greater than its Laboratory background UTL in one sample (sample 0236-95-0025), though it is shown through statistical background comparison tests to be consistent with background levels.

TABLE 5.1.5-2
RADIONUCLIDES WITH CONCENTRATIONS GREATER THAN BACKGROUND UTLs FOR PRS 36-001, MDA AA

Sample ID	Depth (ft)	Uranium-234 (pCi/g)	Uranium-235 (pCi/g)	Uranium-238 (pCi/g)	Total Uranium (mg/kg)
LANL UTL	N/A	1.94	0.084	1.82	5.45
SAL	N/A	13	10	67	130*
AAB 1952	5.5 - 7	Not analyzed	Not analyzed	Not analyzed	10.0
AAB 1953	8 - 10	Not analyzed	Not analyzed	Not analyzed	15.1
AAB 1955	6 - 8	Not analyzed	Not analyzed	Not analyzed	14.2
AAA 1956	8 - 10	Not analyzed	Not analyzed	Not analyzed	136
0236-96-0011	3.2 - 5.8	354	48.6	2420	Not analyzed
0236-96-0013	12.4 - 13.5	6.97	0.88	42.8	Not analyzed
0236-96-0015	4.5 - 6.6	2.04	0.29	10.1	Not analyzed
0236-96-0016	8.3 - 9.6	13.2	1.64	97.7	Not analyzed
0236-96-0018	4.4 - 5.0	ND	0.12	2.4	Not analyzed
0236-96-0021	3.3 - 5.5	2.95	0.33	17.5	Not analyzed
0236-96-0022	5.5 - 7.6	ND	0.09	3.86	Not analyzed
0236-96-0024	3.9 - 5.9	8.84	1.25	62.1	Not analyzed
0236-96-0025	5.9 - 7.3	10.3	1.18	73.5	Not analyzed
0236-96-0026	10.0 - 11.4	ND	0.14	2.92	Not analyzed
0236-96-0027	0.5 - 2.2	7.05	0.78	5.38	Not analyzed
0236-96-0028	6.2 - 7.1	ND	0.18	5.5	Not analyzed
0236-96-0029	7.1 - 8.3	ND	ND	2.74	Not analyzed

ND= Not detected N/A = Not applicable
Double border = Chemical exceed background UTL
Shaded box = Chemical exceeded SAL
* Uranium SAL of 130 mg/kg is for depleted uranium and is based on radiation dose

Nine organics were detected at concentrations below their respective SALs and were submitted to the MCE. One organic, 3,3'-dichlorobenzidine (a carcinogen), was detected at a concentration of 32.9 mg/kg in one subsurface soil sample above its SAL of 0.99 mg/kg and was retained as a COPC.

Trichlorofluoromethane was detected in one sample in a concentration slightly above its EQL, but has no SAL. Because it is not expected to be present as a result of site activities and is detected at a concentration just above the EQL (0.01 mg/kg), it was not retained as a COPC at this site.

TABLE 5.1.6-1
SOIL CONCENTRATIONS OF ORGANIC ANALYTES WITH VALUES GREATER THAN EQLs FOR PRS 36-001, MDA AA

Sample ID	Depth (ft)	Anthracene (mg/kg)	Benzoic Acid (mg/kg)	Bis(2-ethyl-hexyl) phthalate (mg/kg)	3,3'-Dichloro-benzidine (mg/kg)	Dichloro-difluoro-methane (mg/kg)
SAL	N/A	19	100000	32	0.99	110
EQL	N/A	0.33	0.33	0.33	0.33	0.01
AAB 1957	240 - 264	ND	ND	ND	ND	ND
0236-96-0008	118 - 130	ND	ND	ND	ND	ND
0236-96-0011	3.2 - 5.8	ND	ND	3.95	ND	ND
0236-96-0012	6.8 - 10.3	2.03 (J)	ND	1.73 (J)	ND	ND
0236-96-0015	4.5 - 6.6	ND	1.07	ND	ND	ND
0236-96-0016	8.3 - 9.6	ND	ND	ND	32.9	0.054
0236-96-0018	4.4 - 5.0	ND	ND	ND	ND	0.026
0236-96-0021	3.3 - 5.5	ND	ND	ND	ND	ND
0236-96-0024	3.9 - 5.9	ND	ND	1.16	ND	0.046 (J)
0236-96-0025	5.9 - 7.3	ND	ND	ND	ND	0.019 (J)
0236-96-0028	6.2 - 7.1	ND	ND	ND	ND	ND

Sample ID	Depth (ft)	Fluor-anthene (mg/kg)	HMX (mg/kg)	RDX (mg/kg)	Tetrachloro-ethene* (mg/kg)	1,2,4-Trichloro-benzene (mg/kg)	Trichlorofluoro-methane (mg/kg)
SAL	N/A	2600	3300	4	7.0	620	No SAL
EQL	N/A	0.33	0.11	0.11	0.01	0.33	0.01
AAB 1957	240 - 264	ND	ND	ND	ND	ND	0.013
0236-96-0008	118 - 130	ND	ND	ND	0.023 (J)	ND	ND
0236-96-0011	3.2 - 5.8	ND	0.8 (J)	2.24	ND	Not analyzed	ND
0236-96-0012	6.8 - 10.3	1.97	ND	0.69 (J)	ND	ND	ND
0236-96-0015	4.5 - 6.6	ND	ND	ND	ND	Not analyzed	ND
0236-96-0016	8.3 - 9.6	ND	ND	ND	ND	Not analyzed	ND
0236-96-0018	4.4 - 5.0	ND	ND	ND	ND	Not analyzed	ND
0236-96-0021	3.3 - 5.5	ND	ND	ND	0.054 (J)	ND	ND
0236-96-0024	3.9 - 5.9	ND	ND	ND	ND	Not analyzed	0.002 (J)
0236-96-0025	5.9 - 7.3	ND	ND	ND	ND	Not analyzed	ND
0236-96-0028	6.2 - 7.1	ND	ND	ND	ND	0.83 (D)	ND

N/A = Not applicable ND = Not detected (J) = Estimated value

(D) = The maximum concentration from original or laboratory duplicate

* Tetrachloroethene synonymous with tetrachlorethylene

TABLE 5.1.7-1
INORGANICS WITH CONCENTRATIONS GREATER THAN SALs, PRS 36-001, MDA AA

Sample ID	Location ID	Depth (ft)	Copper (mg/kg)	Lead (mg/kg)
SAL	N/A	N/A	2800	400
0236-96-0012	36-3128	6.8 - 10.3	2920	23.2
0236-96-0024	36-3132	3.9 - 5.9	21300	38.8
0236-96-0028	36-3133	6.2 - 7.1	552	1850

N/A = Not applicable
(D) = Duplicate

TABLE 5.1.7-2
RADIONUCLIDES WITH ACTIVITIES IN SOIL THAT EXCEED SALs, PRS 36-001, MDA AA

Sample ID	Location ID	Depth (ft)	Uranium-234 (pCi/g)	Uranium-235 (pCi/g)	Uranium-238 (pCi/g)	Total U (mg/kg)
SAL	N/A	N/A	13	10	67	130
AAB 1956	36-3126	N/A	Not analyzed	Not analyzed	Not analyzed	136
0236-96-0011	36-3128	3.2 - 5.8	354	48.6	2420	Not analyzed
0236-96-0016	36-3129	8.3 - 9.6	13.2	1.64	97.7	Not analyzed
0236-96-0025	36-3132	5.9 - 7.3	10.3	1.18	73.5	Not analyzed

N/A = Not Applicable

Multiple Chemical Evaluation

The MCE included fifteen analytes in the noncarcinogenic effects category (Table 5.1.7-3). The sum of the maximum normalized concentrations is 2.72, which is above the target value of 1.0. Eight analytes, anthracene, antimony, chromium, cobalt, nickel, silver, thallium, and uranium are retained as COPCs because their normalized concentration contributed 0.1 or more to the sum. These analytes are further evaluated in the human health risk assessment. The remaining analytes are not retained as COPCs.

The MCE included three analytes in the carcinogenic effects category (Table 5.1.7-3). The sum of the maximum normalized concentration is 0.69, which is less than the target value of 1.0. Therefore, these analytes are not retained as COPCs.

5.1.7.2 Risk Assessment

Based on the Phase I sampling results and the RFI human health screening assessment, the following analytes were retained as COPCs: anthracene, antimony, chromium, cobalt, copper, 3,3'-dichlorobenzidine, lead, nickel, silver, thallium, U-234, U-235, U-238, and total uranium. A noncarcinogenic hazard and carcinogenic risk were calculated using Laboratory site-specific PRGs based on the guidance set forth in the Risk Assessment Guidance for Superfund (RAGS), Part B (EPA 1991), and was based on the most realistic assumptions of current and future land use. Isotopic uranium was evaluated using RESRAD 5.61.

Land Use Scenarios

Current: Land use within OU 1130 is likely to be continued Laboratory operations (LANL 1994a, 1171). On-site construction workers are assumed to be the human receptors. Therefore, an intrusive industrial

TABLE 5.1.7-3
MCE FOR PRS 36-001, MDA AA

NONCARCINOGENIC - SUBSOIL	
Analyte	**Maximum Normalized Concentrations**
Anthracene	0.107
Antimony	0.184
Benzoic Acid	0.000
Chromium	0.300
Cobalt	0.121
Dichlorodifluoromethane	0.001
Fluoranthene	0.001
HMX	0.0001
Mercury	0.0170
Nickel	0.300
Silver	0.658
Thallium	0.428
Total Uranium	0.590
1,2,4-Trichlorobenzene	0.001
Zinc	0.010
Total	2.72

CARCINOGENIC - SUBSOIL	
Bis(2-ethylhexyl)phthalate	0.123
RDX	0.560
Tetrachloroethene	0.008
Total	0.691

[1] Analytes set in bold are those that are retained as COPCs

scenario was used to estimate risk under continued Laboratory use because the highest concentration of the COPCs were detected at depth. (It is possible that PRS 36-001 will be developed and require intrusive work [e.g., the laying of electrical conduit or installation of plumbing.])

Future: The future site use is assumed to be continued Laboratory operations and, therefore, no other exposure scenarios were evaluated.

Site Conceptual Model

The site conceptual model illustrates how contaminants may move from PRS 36-001 to human or environmental receptor(s) and, therefore, identifies complete exposure pathways. The contaminant source is the MDA, and it is covered with 2 ft of clean fill. The primary release mechanisms are infiltration to groundwater, fugitive dust, and surface runoff. Contaminated media are subsurface soil, biota, and air. Exposure routes include incidental ingestion, inhalation, and dermal contact with soil and dust for the intrusive industrial scenario. Groundwater was not evaluated because the drinking water sources for the receptors of concern are not from the area.

Exposure Assessment

Exposure point concentrations were derived for the ten COPCs based on their 95% upper confidence limit (UCL) of the arithmetic mean. The data set used to calculate the 95% UCL consisted of eight

boreholes (based on an exposure area of 575 m^2) with a total of 28 sample points; all data below 12 ft were eliminated. The data set was used as the worst case scenario and is representative of the MDA AA with no data from the surrounding area. Because the data set did not follow any known distribution, a non-parametric method was used to calculate the 95% UCL on the arithmetic mean and one-half of the detection limit was conservatively used for nondetects. Two boreholes had a sample collected in the clean fill (top 2 ft of the MDA AA), but this did not have an overall effect on the exposure point concentration estimates for the COPCs in question.

The exposure point concentrations used for antimony, anthracene, thallium, and total uranium were the maximum site concentrations within the data set mentioned above. The maximum concentrations were used because of the high occurrence of nondetects for antimony, anthracene, and thallium, and the limited number of sample results for total uranium. The total uranium exposure point concentration was taken from the 1994 data set and was included in the risk assessment because one detect was greater than the SAL. Appendix C presents the exposure point concentrations used in the risk assessment for MDA AA.

Under the intrusive industrial exposure scenario, the receptors of concern are construction workers who may be on-site for no more than 8 hours, 90 days per year for one year. The potential exposure routes for this scenario include incidental ingestion of soil, inhalation of dust, and dermal contact with soil. Appendix C presents the methodology used to derive site-specific PRGs.

Toxicity Assessment

This section summarizes the toxicity of each of the 14 chemicals of concern. Appendix C presents a summary of the toxicity criteria used in the risk assessment.

Anthracene

Anthracene is considered to be a noncarcinogenic polycyclic aromatic hydrocarbon (PAH) (EPA 1996). The intestinal absorption of anthracene is highly dependent on the presence of bile in the stomach (Rahman et al. 1986). The efficiency of absorption without bile (as a percentage of absorption with exogenous bile) was 70.8% administered in corn oil. Percutaneous absorption of radiolabeled anthracene (9.3 mg/cm^3) was estimated to be approximately 52.3% of the administered dose. Over time, the permeation of anthracene significantly decreased, suggesting that anthracene was dermally absorbed in a dose-dependent manner. Diffusion of anthracene through the skin (stratum corneum) depended on the amount of anthracene on the skin's surface. Anthracene has been shown to potentiate the skin damage elicited by sunlight exposure and may be considered a photosensitizer in hairless mice (Forbes et al. 1976). Mice subchronically administered anthracene via gavage exhibited no adverse effects at the highest dose administered (EPA 1989). EPA (1996) derived a chronic oral reference dose (RfD) of $3x10^{-1}$mg/kg/day based upon no observed adverse effects in mice exposed to 10,000 mg/kg/day by gavage for 90 days (EPA 1989). An uncertainty factor of 3,000 was used to calculate the RfD.

Antimony

Antimony is a metal which occurs both in the trivalent and pentavalent oxidation states (EPA 1980a). Absorption of this metal via oral routes of exposure is low (10% for antimony, tartrate; 1% for all other forms) (ATSDR 1990). Organic antimony is more toxic than the inorganic compounds due to increased absorption. Humans and animals exposed acutely by oral or inhalation exposures to either the trivalent or pentavalent forms of antimony displayed electrocardiogram (ECG) changes and myocardial lesions (EPA 1980a). Pneumoconiosis has been observed in humans exposed by acute inhalation and dermatitis has occurred in individuals exposed either orally or dermally. EPA (1996) derived a chronic oral RfD of $4x10^{-4}$ mg/kg/day for antimony (as potassium antimony tartrate) based on a chronic oral study (Schroeder et al. 1970) in which rats given the metal in drinking water had altered blood glucose and blood cholesterol

levels and decreased lifespan. An uncertainty factor of 1,000 and a LOAEL of 0.35 mg/kg/day were used to derive the RfD.

Chromium

Chromium exists in two states, as chromium (III) and as chromium (VI). Following oral exposure, absorption of chromium (III) has been reported to be 0.4% while absorption of chromium (VI) has been observed to be as high as 10% (ATSDR 1991a). However, chromium (VI) is rapidly reduced to chromium (III) after penetration of biological membranes and in the gastric environment (ATSDR 1991a). Chromium is an essential micronutrient and is not toxic in trace quantities (EPA 1980b). Alterations in liver enzyme activities were noted in rats administered and oral dose of 13.5 mg chromium (VI)/kg/day for 20 days (Kumar et al. 1985). Rats subchronically administered higher concentration s of chromium VI (98 mg/kg/day) have exhibited adverse effects on renal function (Diaz-Mayans et al. 1986). No significant changes, however, were detected in the livers or kidneys of rats exposed to 2.7 mg/kg/day or 3.5 mg/kg/day chromium (III) or chromium (VI), respectively in the drinking eater for one year (MacKenzie et al. 1958, ATSDR 1991a). Central nervous system (CNS) effects including hypoactivity have been reported in rats when exposed to subchronic levels of 98 mg/kg/day chromium VI in drinking water (Diaz-Mayans et al. 1986). Furthermore, epidemiological studies of worker populations have clearly established that inhaled chromium (VI) is a human carcinogen; the respiratory passages and the lungs are the target organs (Mancuso 1975, EPA 1984a). Inhalation of chromium (III) or ingestion of chromium (VI) or (III) has not been associated with carcinogenicity in humans or experimental animals (EPA 1984a). Oral exposure of pregnant mice (gestational days 1 to 19) to 57 mg chromium (VI)/kg/day resulted in embryolethal effects (e.g., increased resorptions and postimplantation loss), reduced ossification and gross anomalies. (Trivedi et al. 1989). Chromium (III) does not appear to cause fetotoxic or teratogenic effects in rate (ATSDR 1991a). EPA (1996) classified inhaled chromium (VI) in Group A--Human Carcinogen by the inhalation route. Inhaled chromium (III) and ingested chromium (III) and (VI) have not been classified with respect to carcinogenicity (EPA 1996). EPA (1996) derived a chronic oral reference dose (RfD) of $5x10^{-3}$ mg/kg/day for chromium (VI) based on a study by MacKenzie et al. (1958) in which no adverse effects were observed in rats exposed to 2.4 mg chromium (VI)/kg/day in drinking water for 1 year. A safety factor of 500 was used to derive the RfD. EPA (1996) developed an oral RfD of 1 mg/kg/day for chromium (III) based on a study in which rats were exposed to chromic oxide baked in bread. No effects due to chromic oxide treatment were observed at any dose level (Ivankovic and Preussman 1975); however, hepatotoxicity was the effect of concern. An uncertainty factor of 1,000 was used to calculate the RfD. For this risk assessment, total chromium was assumed to be chromium III based on historical information.

Cobalt

Cobalt is an essential trace element in human nutrition. Cobalt is generally well absorbed following ingestion. Acute ingestion of large doses by humans produces gastrointestinal disturbances (vomiting, diarrhea) and a sensation of warmth. Signs of acute poisoning in animals fed cobalt salts consist of diarrhea, loss of appetite, paralysis of hind legs, cutaneous vasodilation, and reduced body temperature prior to death. Large doses produced anuria, while smaller doses resulted in albuminuria (Stokinger 1981). In animals, subchronic oral exposures result in disturbed conditioned reflexes and alterations in hematopoiesis (NRC 1977). In humans, chronic oral exposure to cobalt in high doses can cause goiter, decreased thyroid function, increased heart and respiratory rates and blood lipid changes (Hammond and Beliles 1980). Chronic exposure to cobalt dust has been reported to produce respiratory disease in workers (Stokinger 1981). Cobalt salts included in a beer formulation at concentrations 1.2 to 1.5 mg/liter were reported to be responsible for a number of deaths due to congestive heart failure (NRC 1977). Cobalt administered to laboratory rodents produced adverse teratogenic effects including craniofacial developmental abnormalities in mice (Leonard et al. 1984) and decreased body weight in rats (Shepard 1986). Cobalt has been reported to cause sarcomas at the site of injection in rats (Gilman 1962, Heath 1960); however, the results of carcinogenesis studies performed by other routes of exposure have been

negative. EPA has not classified cobalt on the basis of its carcinogenicity. A provisional oral RfD of $6x10^{-2}$ mg/kg/day was derived by EPA's Environmental Criteria and Assessment Office.

Copper

Copper is an essential element. A daily copper intake of 2 mg is considered to be adequate for normal health and nutrition; the minimum daily requirement is 10 mg/kg (EPA 1985a). In humans, absorption of copper (as copper acetate) following oral exposure is approximately 60% (15 to 97% range) and is influenced by competition with other metals and the level of dietary protein and ascorbic acid in both humans and animals (EPA 1984b). Copper is absorbed following inhalation exposures, although quantitative data on the extent of absorption are unavailable (EPA 1984b). EPA (1995) reported the drinking water standard of 1.3 mg/liter for both chronic and subchronic exposures based on local gastrointestinal irritation (EPA 1987). Assuming a 70-kg adult ingests 2 liters of water per day, this concentration is equivalent to a dose of $3.7x10^{-2}$ mg/kg/day. However, EPA (1987) concluded toxicity data were inadequate for the calculation of an RfD for copper.

3,3'-Dichlorobenzidine

Very little information is available which quantifies the degree and rate of absorption of 3,3'-dichlorobenzidine (3.3'-DCB) in experimental animals or in humans, although absorption can be inferred from urinary excretion of workers exposed occupationally to 3,3'-DCB (Meigs et al. 1954). The acute toxicity of 3.3'-DCB in experimental animals appears to be quite low. The limited data on the systemic toxicity of 3,3'-DCB indicate that it causes liver damage in animals (EPA 1980c). 3,3'-DCB is mutagenic with and without metabolic activation, in bacterial tester strains. Transplacental effects have been observed in studies with experimental animals (IARC 1982, EPA 1980c). There is sufficient evidence that 3,3'-DCB is carcinogenic in several species of animals. Following oral administration, it has produced liver tumors in mice, hepatocellular carcinomas in dogs, mammary tumors, zymbal gland carcinomas and granulocytic leukemia in rats (Stula et al. 1975), and carcinomas of the urinary bladder in hamsters and dogs (EPA 1980c). EPA (1996) classified 3,3'-DCB in group B2 (Probable Human Carcinogen). This category applies to those chemicals for which there is sufficient evidence of carcinogenicity in animals, but inadequate evidence form human studies. EPA (1996) derived a oral cancer slope factor of $4.5x10^{-1}$ $(mg/kg/day)^{-1}$ based on and increased incidence of mammary tumors in rats exposed to 3.3'-DCB in their diet for a lifetime (Stula et al. 1975).

Lead

Absorption of lead from the gastrointestinal tract of adult humans is estimated at 6% to 45%. The extent and rate of gastrointestinal absorption area affected by fasting and the solubility of a particular lead salt in gastric acid (ATSDR 1991b). In children, absorption from non-paint sources ranges from 30% to 50% (Hammond and Beliles 1980, EPA 1986a). There are other interpretations of the data (Duggan 1983) that suggest this may be as high as 70%. For adult humans, the deposition rate of particulate airborne lead is 30% to 50%, and essentially all of the lead deposited is absorbed (EPA 1986a, Morrow et al. 1980). Lead is stored in the body in the kidney, liver, and bone (EPA 1984c). The major adverse effects in humans caused by lead include alterations in the hematopoietic and nervous systems. The toxic effects are generally related to the concentration of this metal in blood. Blood concentration levels of over 80 mg/dl (decaliter or 10 liters) in children and over 100 mg/dl in sensitive adults can cause severe, irreversible brain damage, encephalopathy, and possible death. The Centers for Disease Control (CDC 1985) have used the value of 25 mg/dl as an acceptable level of blood lead. Recent information (EPA 1988), however, indicates that physiological and/or biochemical effects can occur even at lower levels. These include enzyme inhibition (16 mg/dl), elevated erythrocyte protoporphyrin (15 mg/dl), interference with Vitamin D metabolism, cognitive dysfunction in infants (10 to 15 mg/dl), electrophysiological dysfunction (6 mg/dl), and reduced childhood growth (4 mg/dl). Decreased fertility, fetotoxic effects, and skeletal malformations have been observed in experimental animals exposed to lead (EPA 1984c). Chronic oral

ingestion of certain lead salts (lead acetate, lead phosphate, lead subacetate) has been associated in experimental animals with increased renal tumors. Doses of lead that induced kidney tumors were high and were beyond the lethal dose in humans (EPA 1985a).

EPA (1996) classified certain lead salts in Group B2 (Probable Human Carcinogen), although no cancer slope factor was established. This category applies to those agents for which there is sufficient evidence of carcinogenicity in animals and inadequate evidence of carcinogenicity in humans. EPA (1996) considered it inappropriate to develop an RfD for inorganic lead and lead compounds, since many of the health effects associated with lead intake (particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development) occur essentially without a threshold.

Nickel

Nickel compounds can be absorbed following inhalation, ingestion, or dermal exposure. The amount absorbed depends on the dose administered and the chemical and physical form of the particular nickel compound (EPA 1986b). The oral absorption of dietary nickel ranges from <1-4.3% in humans, which is much less than nickel sulfate given in the drinking water (27%) (ATSDR 1991c). Studies in rats and dogs indicate that 1-10% of nickel (nickel, nickel sulfate hexahydrate, or nickel chloride) in the diet or by gavage is absorbed (ATSDR 1991c). In humans, about 35% of inhaled nickel is absorbed into the blood from the respiratory tract, and the soluble compounds (i.e., nickel chloride, nickel sulfate) are more readily absorbed than the insoluble compounds (nickel oxide, nickel subsulfide) (ATDSR 1991c). Several studies in humans indicate that nickel can penetrate the skin (55-77%); however, it could not be determined if the nickel had been absorbed into the bloodstream. Dermal exposure of humans to nickel produces allergic contact dermatitis (EPA 1986b). Nickel refinery dust and nickel subsulfide are both categorized in Group A—Human Carcinogens by inhalation (EPA 1996). This classification is based on an increased incidence of lung and nasal tumors observed in workers occupationally exposed to nickel refinery dust (EPA 1986). There is inadequate evidence for carcinogenicity of nickel refinery dust and nickel subsulfide by the oral route. These materials have inhalation cancer unit risks of 2.4×10^{-4} and 4.8×10^{-4} $(mg/m^3)^{-1}$, respectively (EPA 1996). EPA (1996) derived an oral RfD for nickel soluble salts of 2×10^{-2} mg/kg/day for chronic exposures based on a study by Ambrose et al. (1976) in which rats administered 5 mg/kg/day (NOAEL) nickel (as nickel sulfate) in the diet for two years did not experience decreased weight gain which was observed in animals administered 50 mg/kg/day (LOAEL). A safety factor of 300 was used to calculate the oral RfD.

Silver

Silver in various forms is absorbed to a limited extent following oral and inhalation exposures (EPA 1985b). The acute toxic effects in humans following oral exposure to silver include corrosive damage to the gastrointestinal tract leading to shock, convulsions, and death. In animals, acute exposure has been shown to affect the central nervous system and to cause respiratory paralysis (Hill and Pillsbury 1939). The primary effect of silver in humans following chronic exposures is angyria, a permanent bluish-metallic discoloration of the skin and mucous membranes, which can be either localized or generalized. Silver also accumulates in the blood vessels and connective tissue (EPA 1985b). EPA (1996) derived a chronic RfD for silver of 5×10^{-3} mg/kg/day based on the human case report of Gaul and Staud (1935). In this study, a lowest observed adverse effect level (LOAEL) of 0.014 mg/kg/day was identified for angyria. An uncertainty factor of 3 was used to calculate the RfD.

Thallium

Thallium and its salts are readily and rapidly absorbed through the skin, lungs, and mucous membranes of the mouth and gastrointestinal tract. Percutaneous absorption has also been reported to occur through rubber gloves (Rumack 1986). Thallium is acutely toxic to humans regardless of the chemical form of the compound or route of administration. Hundreds of cases of thallotoxicosis due to ingestion of thallium-

based pesticides have been reported (ACGIH 1986). Children poisoned by thallium ingestion have exhibited neurological abnormalities including mental retardation and psychoses (ACGIH 1986). The effects of thallium toxicity are similar in humans and animals. The most commonly noted response to thallium exposure is alopecia, but neurological and gastrointestinal findings are frequently found. Such effects include ataxia, lethargy, painful extremities, peripheral neuropathies, convulsions, endocrine disorders, psychoses, nausea, vomiting, and abdominal pains (Bank 1980). EPA (1996) derived RfDs for certain thallium salts (i.e., thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium selenite and thallium sulfate) of between $8\text{-}9 \times 10^{-5}$ mg/kg/day based on the same EPA (1986) 90-day subchronic rat study. The same endpoints of toxicity were observed and an uncertainty factor of 3,000 was used to derive the chronic RfDs.

Uranium

In general, uranium compounds are not easily absorbed across the human gastrointestinal tract. Soluble uranium compounds demonstrate the best absorption. Recent uranium metabolic models estimated absorption from the gastrointestinal tract to the blood to be 0.6 percent (Wrenn et al. 1987). Although human data concerning absorption by dermal exposure are sparse, water-insoluble uranium compounds were not absorbed in significant quantities across the skin (Yuile 1973) and are not believed to pose a significant risk to humans by this exposure route. Approximately 70 percent of an intake of uranium has been estimated to be excreted by the kidneys within 24 hours of intake (Berlin and Rudell 1979). Uranium that is not excreted is stored in the kidneys and bones. Exposure to uranium, a chemical toxicant, leads to nephritis in the kidneys. In an extensive chronic feeding study performed on laboratory animals (i.e., rabbits, rats, and dogs), renal damage was the observed effect (Maynard and Hodge 1949). Uranium can induce cancer as a result of intake into the body through inhalation or ingestion pathways. However, past epidemiological studies have failed to conclusively demonstrate health effects from chronic exposure to uranium dust by uranium mine and mill workers. The induction of cancer results when organs and tissues of the body are exposed to alpha particles emitted from decaying uranium atoms. Alpha particles are not an external exposure hazard because they do not penetrate sensitive tissues from outside the body. The outer layers of skin stop the alpha particles before they can penetrate and damage inner-layered tissue. The type of uranium (i.e., natural, enriched, or depleted) under consideration is important because different types of uranium have different amounts of radioactivity per unit mass. The most probable radiogenic effect is an increase in bone sarcomas. In this assessment, the uranium PRG for depleted uranium based on isotopic ratios and industrial exposure scenario was derived using RESRAD 5.61.

Risk Characterization

A human health risk assessment was performed for ten COPCs) (i.e., anthracene, antimony, chromium, cobalt, copper, nickel, silver, thallium, total uranium and lead) via a multiple chemical PRG analysis. The three uranium isotopes and 3,3'-dichlorobenzidine were evaluated by comparing them individually to their respective PRGs. The site-specific PRGs were calculated based on an intrusive industrial scenario using standard EPA default parameters and site-specific assumptions. The site-specific PRG calculation for noncarcinogens was based on a hazard index of 1 (see Appendix C), while the carcinogenic PRG was based on a cancer risk of 1E-06. The total hazard ratio for the noncarcinogenic COPCs was calculated to be 0.5, which is less than one. The carcinogenic risk ratio was calculated to be 6E-08 which is below the EPA required 1E-06 target risk.

The PRG for depleted uranium (DU) was derived from the effective dose equivalent (EDE) calculated by the RESRAD computer program, version 5.61, for a commercial/industrial exposure scenario. Depleted uranium consists of 90.1% U-238, 1.4% U-235, and 8.5% U-234 (by activity). The calculated EDE was 0.0428 mrem/yr per pCi/g of DU in the soil; the derived PRG for an allowable EDE of 30 mrem/yr was, therefore, 701 pCi/g.

The 95% UCLs of the arithmetic mean of the contaminated zone sample values were: U-238 = 134 pCi/g, U-235 = 2.31 pCi/g, and U-234 = 15.2 pCi/g (Appendix F), for a total of 151.5 pCi/g of DU. This concentration In the soil would give an EDE of 0.0428 x 151.5 = 6.48 mrem/yr.

The risk to the worker from these EDE values is based on a dose-to-risk conversion factor of 4×10^{-7} cancer deaths per mrem (DOE 1993). A dose of 30 mrem/yr equates to a risk of 1.2×10^{-5}; 6.48 mrem gives a risk of 2.6×10^{-6}.

Uncertainty

Site Conditions

The likelihood is high that the assumed site conditions used to estimate exposure and risk under the industrial exposure scenario will remain the same in the future. The likelihood is moderate that the hazard index is not greater than that calculated as a result of the exclusion of some chemicals in the risk assessment. Benzoic acid, dichlorodifluoromethane, fluoranthene, HMX, mercury 1,2,4-trichlorobenzene, and zinc were eliminated from the risk assessment based on their contribution to the MCE analysis. The concentrations of these chemicals would not significantly alter the noncarcinogenic hazard estimate. In addition, bis(2-ethylhexyl)phthalate, RDX, and tetrachloroethene were eliminated from the risk assessment based on their MCE analysis. The concentrations of these chemicals would not significantly alter the carcinogenic risk estimate.

The likelihood is high that the reasonable maximum exposure point concentrations do not reflect the contaminant likely to be encountered by a receptor because the exposure area is covered by 2 ft of clean fill.

Toxicology of COPCs

There is inherent uncertainty in the derivation of any toxicity criteria. There are uncertainties in extrapolating both from animals to humans and from high to low doses. In addition, there are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns, and other cultural factors (EPA 1986d).

There is high uncertainty in assessing the toxicity of a mixture of chemicals. In this assessment, the effects of exposure to each contaminant present has been added together. This approach to assessing risk associated with mixtures of chemicals assumes that there are no synergistic or antagonistic interactions among the chemicals considered and that all chemicals have the same toxic endpoints and mechanisms of action. The hazard index was not greater than one; therefore, a more critical review of noncarcinogenic effects was unwarranted. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. However, suitable data are not currently available to rigorously characterize the effects of chemical mixtures similar to those at PRS 36-001. Therefore, the methodology presented is assumed to be the most conservative approach.

Exposure Characteristics

There is inherent uncertainty in the estimation of exposure. The estimation of exposure and risk is deterministic. A deterministic evaluation is based on the assumption that a receptor will be exposed and estimates the exposure, health hazard, and risk once exposed. The probability of exposure is not accounted for. In addition, the calculated exposure, health hazard and risk is based on reasonable maximum exposure.

There are also uncertainties associated with the assumptions used to evaluate the inhalation and dermal pathways. The inhalation component of the PRG algorithms incorporates a particle emission factor (PEF). The PEF relates the contaminant concentration in soil with the concentration of respirable particles (PM_{10}) in the air due to fugitive dust emissions from surface contamination (EPA 1991). The model was conservatively developed by Cowherd (1985) for quick assessments and assumes a relatively continuous and constant potential for emission over an extended period of time (e.g., years) due to wind erosion. The dermal component of the PRG algorithms also contributes a high degree of uncertainty. EPA has not developed specific dermal toxicity criteria and, therefore, oral toxicity criteria were modified using an oral absorption fraction obtained from the literature [e.g., Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles]. In addition, if toxicity criteria were not available for a particular chemical, then that exposure pathway was eliminated from the algorithm for that chemical.

5.1.8 Ecological Assessment

The general landscape condition around MDA AA is moderately developed and disturbed (Table 2.4-1) and there is moderate potential for receptors to come in contact with COPCs associated with the site (8 metals and 9 organics, Sections 5.1.5 and 5.1.6). Therefore, this PRS will be included as an ecological COPC source in the ecological risk assessment. An ecological risk assessment will be conducted when that approach has been approved by our regulators. Threatened and endangered species and /or sensitive habitat listed in Chapter 2 will be evaluated in the ecological risk assessment.

5.1.9 Extent of Contamination

The extent of contamination has been defined for inorganic chemicals, VOCs and SVOCs, isotopic uranium, and HE. Nine borehole locations (i.e., surface, subsurface) were taken of the previously listed analytical suites. Based on the screening assessment, 14 COPCs were retained and evaluated for their risk to human health and the environment.

5.1.10 Conclusions and Recommendations

The Phase I investigation determined the extent of contamination associated with the MDA. Nine inorganic chemicals (antimony, chromium, cobalt, copper, lead, nickel, silver, thallium, and total uranium) and two organic analytes (anthracene and 3,3'-dichlorobenzidine) were carried forward as COPCs for further evaluation. Uranium-234, uranium-235, and uranium-238, as well as total uranium in an earlier sample, were detected above their respective background UTLs and SALs and, therefore, were retained as COPCs. The risk assessment consisted of a site-specific PRG evaluation and multiple chemical PRG analysis of noncarcinogens. The results of the analysis show that the noncarcinogenic hazard is less than one (0.5), and the non-radionuclide carcinogenic risk is less than 1E-06 (6E-08). The 95 % UCL of the arithmetic means for the uranium isotope were less than an industrial PRG derived for depleted uranium (701 pCi/g). Based on the NFA Criterion 5, a Class III permit modification is requested to remove this site from the HSWA Module of the Laboratory's RCRA operating permit.

5.2 PRS 36-004(d), Skunk Works

Skunk Works is located about 2,300 ft upgradient and west of Lower Slobbovia Firing Site and within its hazard radius. Skunk Works was used as a firing site for small explosive tests in the 1950s. The COPCs associated with this site were HE, VOCs, SVOCs, metals, and isotopic uranium (LANL 1993, 1088). Investigations at this site are in response to an NOD from EPA (Jansen and Taylor 1995, 46002; Jansen and Taylor 1995, 44186; and McInroy 1994, 34994). Disposition of this site does not include the Lower Slobbovia Firing Site. Analytical results detected the presence of lead, zinc, and uranium, but no COPCs are retained. Using Criterion 5, NFA is recommended for this site based on the results of the screening assessment. However, a request for a permit modification will be made after Lower Slobbovia Firing Site at PRS 36-004(d) is changed to inactive status.

5.2.1 History

The Skunk Works was used as a small firing site in the early to mid-1950s. Several buildings were moved in and out between the 1950s and 1991. Several hundred experiments may have been performed during 1957 or 1958. The majority of experiments used microwave measurements to analyze explosion temperatures. Test shots were performed on the ground, but only small amounts of explosives were used; the largest test used only 0.5 to 0.75 lb of explosives. Archival review indicates that the shots were detonated adjacent to the eastmost building, one of two buildings still remaining onsite (LANL 1993, 1088).

Liquid, solid, and gaseous explosives were used for the tests, but the explosives and detonators were stored at Lower Slobbovia. Lead-acid batteries were used to power the equipment, and a 5-ft by 5 1/2-ft below ground surface storage room located at Skunk Works was used to store the spent batteries. No radioactive materials were used at Skunk Works. COPCs at Skunk Works included were VOCs, SVOCs, HE, and metals (Jansen 1995, 44186). Uranium was not known to be used at the site, but because uranium was used at most firing sites, it was considered as a COPC. The two buildings located on site had been used to prepare uranium at TA-15 before they were brought to Skunk Works.

5.2.2 Description

Skunk Works is located in a canyon about 2,300 ft upgradient and west of Lower Slobbovia Firing Site (Figure 1.1-3). Skunk Works is located by following a dirt road northwest from the Lower Slobbovia Firing Site to a narrow canyon; the road ends at the two small abandoned buildings, which are located on a ridge. Just northeast of the first building is the battery storage room, a covered below-grade wooden structure, which was 5 ft by 5-1/2 ft by 5 ft deep. This room and the soil beneath it was expected to be contaminated with lead, but the room and soil showed no evidence of spills or leaks. Based on historical research, a level area about 10 ft by 10 ft northwest of the buildings was believed to have been a firing site. A shallow depression about 22 ft by 22 ft was noted further up the canyon from the buildings.

5.2.3 Previous Investigations

No previous investigations have been performed at this site.

5.2.4 Field Investigations

The objective of Phase I was to determine whether the Skunk Works was contaminated. According to the NOD, if concentrations of COPCs were below SALs, an NFA would be proposed. If concentrations exceed SALs, consideration would be given to a Phase II investigation and/or a baseline risk assessment (Jansen 1995, 44186).

Contamination due to firing activities was expected to be greatest near the firing point with transport of contaminants to the drainage also possible. A small depression was noted during the walk-through that may have also been used for firing activities. COPCs could have accumulated in the sediment catchment areas within the drainage channels. Also, leakage from the batteries may have contaminated the soils lining the storage room, although no visible evidence of this has been noted.

Field activities at Skunk Works were conducted in late 1995.

5.2.4.1 Land Survey

A land survey was performed at the site to determine the sample locations. See Section 5.1.4.1 for a description of the procedures, equipment, and controls used.

5.2.4.2 Radiological Screening

A radiological survey was conducted on the sides of the buildings using two Ludlum Model 2221 Scalar/Rate Meter single-channel analyzers, one with an Eberline SPA-3 scintillation probe and one with a Ludlum Model 44-9 pancake geiger-mueller detector. The sides of the buildings were completely screened for beta and gamma radioactivity, and if positive results were noted, portions of the buildings would have been removed and sampled. However, no radioactivity above background was noted.

5.2.4.3 Field Screening

Field walk-throughs were conducted to locate areas of staining, to delineate drainage pathways, and to select biased sample locations. All areas that were thought to be possible collection areas for contaminants were either slated for sampling or XRF analysis for metals. The XRF was to be used for biasing sample collection; locations that yielded results that were above background level results from XRF analyses would have been used as a sample location. Using this biasing method provided a more thorough overall characterization rather than relying on random or visual biasing to select sample locations. XRF was used at the firing site location, the depression, the drainage areas, and the battery storage area.

During the walk-through, the team noted that slight drainage areas were located such that surface water from the firing pad area could migrate toward the depression to the west along the unimproved road to the southeast. Most other surface water in the vicinity of the buildings and battery storage area would drain to the southeast along the unimproved road. A small berm precluded surface water migration to the well-defined drainage channel south of the site. Six locations in the drainage area were selected for XRF testing. Staining was not noted in the area.

The archival research had indicated that the firing pad was adjacent to TA-36-45, but no marked features were seen. The area was sampled by dividing it into quadrants for field screening, and sample material was collected from the center of each quadrant and the center at a depth of 2 in. and again at 3 ft. Surface samples were screened for VOCs, HE, radiation, and pH, and by XRF. Subsurface samples were only screened by XRF and pH only. No elevated results were noted.

The depression to the west was also divided into quadrants. The center of each quadrant and the center of the depression were sampled at depths of 3 in. and 3 ft. Surface samples were screened for VOCs, HE, radiation, and pH, and by XRF. Subsurface samples were screened by XRF and for pH and VOCs only. All results were within background levels.

Three sample locations in the dirt floor of the battery room were identified and sampled at floor surfaces and at a depth of 2 ft. Samples were field screened for VOCs, radiation, and pH and by XRF. All results were within background levels.

No metal concentrations above background were detected using the XRF. Other XRF tests conducted on material 40 ft west and upgradient of the buildings were also negative. Figure 5.2.4.3-1 indicates the locations at Skunk Works for which XRF testing was performed.

Laser Induced Breakdown Spectroscopy (LIBS) had been proposed as a field analytical tool in the Sampling and Analysis Plan for the site (Jansen and Taylor 1995, 44186). However, EPA Region VI rejected the use of the LIBS in a notice of deficiency (NOD) (Jansen and Taylor 1995, 46002). Therefore, the XRF was used as a field screening tool at Skunk Works.

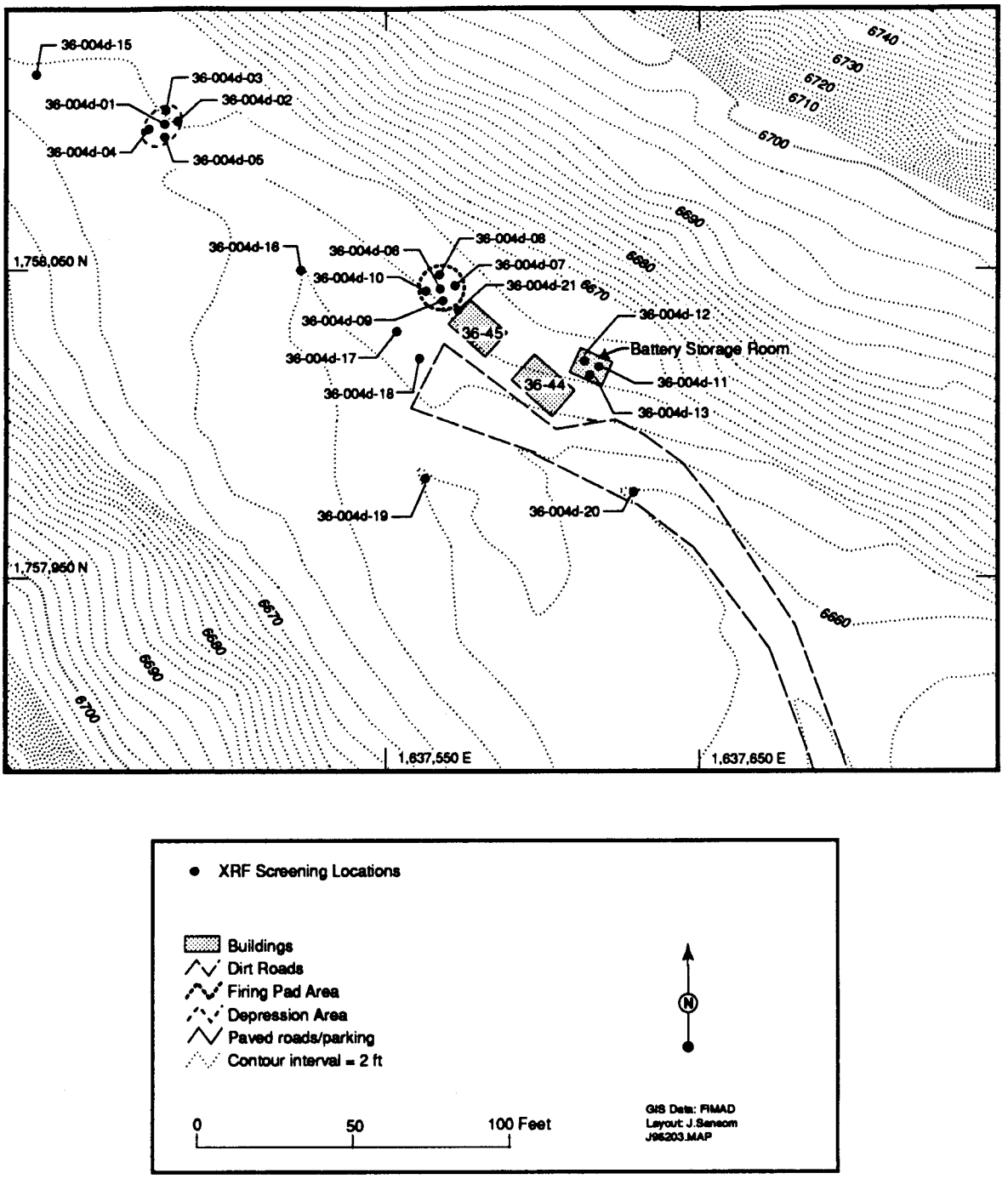


Figure 5.2.4.3-1 Skunk Works, showing XRF testing locations

The HE spot test was used extensively for health and safety requirements. No positive results were obtained. If the HE test would have yielded positive results, additional samples would have been taken.

Soil pH was measured from surface and subsurface soil at the location of the floor of the battery storage room in 1995. Acidic results could have indicated the presence of leakage from lead-acid batteries, but the pH results were within normal range.

Adjacent to the firing pad at TA-36-45 was a small pile of sand, likely to have come from sandbags that were used in blasts. Material was collected from this area and field screened for VOCs, HE, radiation, and pH, and by XRF. No elevated results were noted.

5.2.4.4 Sample Collection

The following locations were selected for analytical sample collection based on the results from the extensive field screening conducted at Skunk Works in 1995:

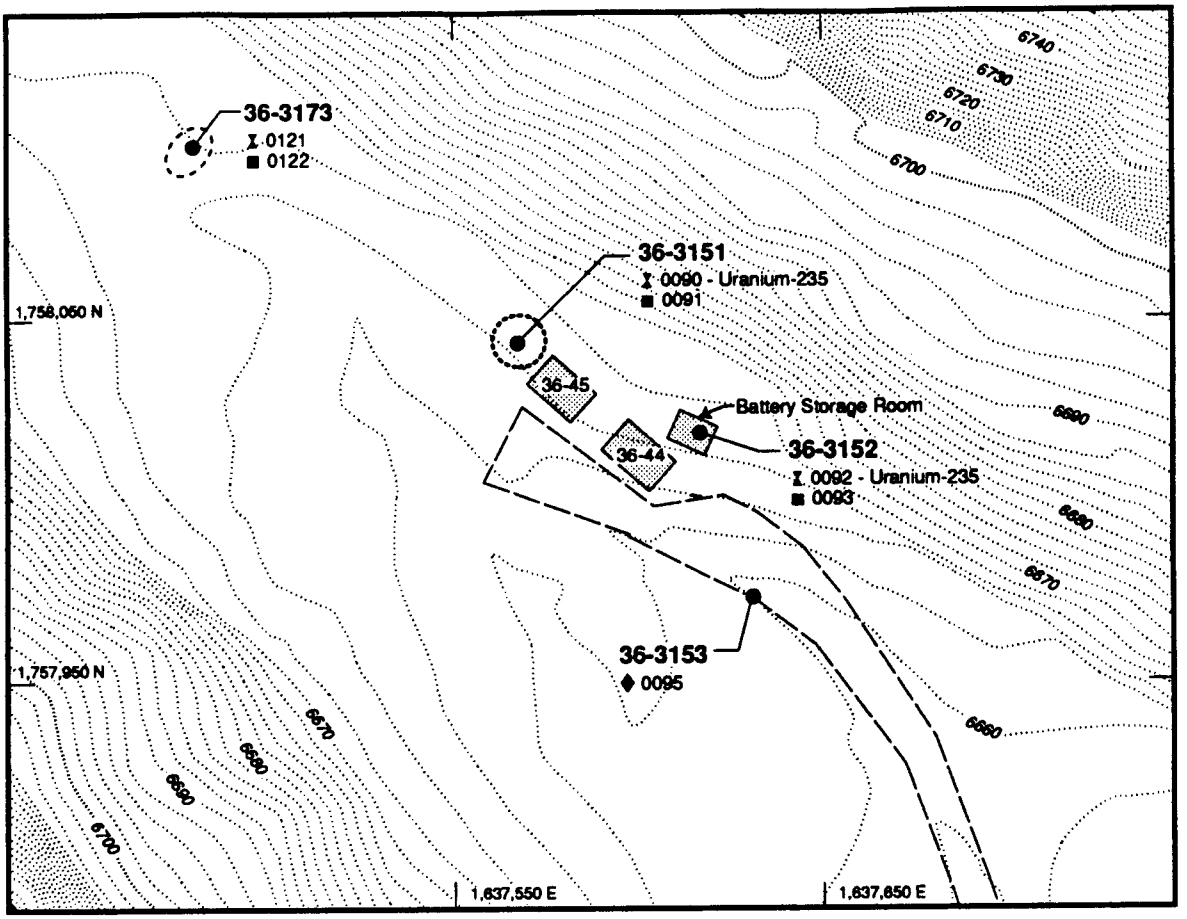
- Center of the depression. The five screening locations did not exhibit elevated screening results. The center of the depression was chosen for sampling because it was the lowest point during firing activities where sediments or residuals from former activities would collect.
- Center of the firing pad. The five screening locations did not exhibit elevated screening results. The center of the depression was chosen for sampling because it was the lowest point where sediments or residuals from the former firing activities would subsequently collect.
- Northeast corner of the battery storage room. The six screening samples did not exhibit elevated screening results; therefore, a sample location was selected from the northeast corner of the battery room. Although the battery room appeared well-maintained, the shelves in this corner had some slight discoloration. Hand-auger samples were taken from ground level and 2 ft below the floor.
- Drainage area southeast of the structures. The six screening locations did not exhibit elevated results. The surface water migration pathway, chosen for sampling, was sampled at the first slightly level area downgradient from the battery room, buildings, and firing pad.

Figure 5.2.4.4-1 indicates the site and sample locations and Table 5.2.4.4-1 is the Sample Summary Table.

5.2.4.5 Deviations from the RFI Work Plan Sampling Strategies

Hand augering was substituted for drilling because of the difficulties in bringing the drill rig to the site along the narrow road and maneuvering the drill to the battery storage room. Additionally, if metals had been present, they would not have migrated much; usually such particles adhere to soil particles. Therefore, the field team leader decided that hand augering would be an acceptable deviation at Skunk Works.

The soil/tuff interface at Skunk Works was determined to be approximately 5 1/2 ft below ground surface. Samples were collected at a depth of approximately 2 ft, below ground surface, in the underlying soils. The reasons for sample collection at 2 ft rather than at the soil/tuff interface as proposed in the sampling plan, was primarily because metals would tend to be stationary near the surface adhering to silted clays, and because VOCs that are detected at this depth would be without significant volatilization to the atmosphere or diffusion in downward migration.



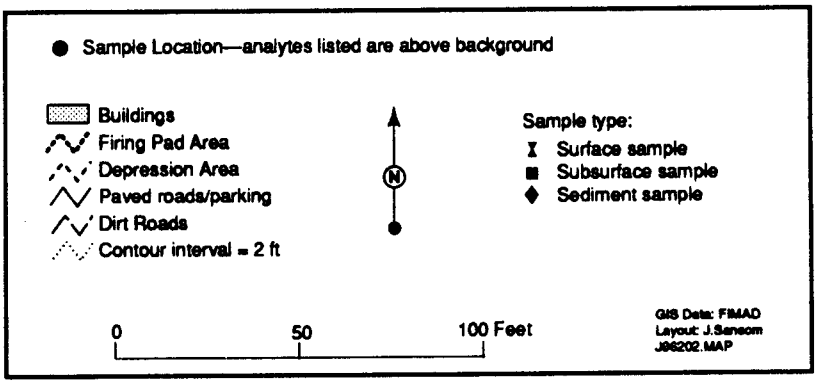


Figure 5.2.4.4-1 Skunk Works, showing sample locations and results

TABLE 5.2.4.4-1
SAMPLE SUMMARY FOR SKUNK WORKS

Location ID	Sample ID	Depth (in)	Matrix	VOCs	SVOCs	Metals Mercury	Iso U	HE
36-3151	0236-95-0090	0 - 6	Surface soil	597*	752*	696 & 711 719*	456*	575*
36-3151	0236-95-0091	12 - 16	Subsurface soil	597	752	696 & 711 719	456	575
36-3152	0236-95-0092	0 - 6	Surface soil	597	752	696 & 711 719	456	575
36-3152	0236-95-0093	6 -18	Subsurface soil	597	752	696 & 711 719	456	575
36-3153	0236-95-0095	0 - 6	Sediment	597	752	696 & 711 719	456	575
36-3173	0236-95-0121	0 - 6	Surface soil	597	752	696 & 711 719	456	575
36-3173	0236-95-0122	18 - 23	Subsurface soil	597	752	696 & 711 719	456	575

* Numbers refer to sampling batch; all batch numbers are preceded by 6529.

Samples were taken and analyzed for isotopic uranium in place of total uranium because the results would be more definitive for relatively low additional cost.

5.2.5 Background Comparisons

The location of samples with analyte values exceeding background UTLs are shown in Figure 5.2.4.4-1.

Inorganics

Copper, lead, and zinc were detected at concentrations greater than their background UTLs (Table 5.2.5-1). None of these analytes are carried forward to the SAL comparison stage because further evaluation showed no statistically significant difference between the distribution of site data concentrations for these analytes and the associated distributions of Laboratory background. Results from the statistical tests are shown in Table 5.2.5-2. Therefore, these inorganics are not retained as COPCs. See Section 3.2 for a discussion of the statistical tests for comparing site distributions to background distributions. The plots comparing site data to LANL background are shown in Appendix D.

The other inorganics that were either undetected or with concentrations less than background UTLs were not retained as COPCs.

Radionuclides

Uranium-235 was detected in two surface soil samples at concentrations of 0.1 pCi/g, which was above the background UTL of 0.084 pCi/g and was carried forward to the SAL comparison stage. Uranium-235 was also reported as undetected (U) with an MDL of 0.2 pCi/g in two samples. These samples were not carried forward in the evaluation. Uranium-234 and uranium-238 were detected at concentrations below background UTLs and were not retained as COPCs.

5.2.6 Evaluation of Organic Constituents

No organics were detected above the EQL, and therefore, they were not retained as COPCs. Bis(2-ethylhexyl)phthalate and di-n-butyl phthalate, which are common laboratory contaminants, were detected below the EQLs and are not retained as COPCs.

TABLE 5.2.5-1
INORGANICS WITH CONCENTRATIONS GREATER THAN BACKGROUND UTLs FOR SKUNK WORKS

Sample ID	Location ID	Depth (in)	Copper	Lead	Zinc
UTL	N/A	N/A	15.5	23.3	50.8
SAL	N/A	N/A	2800	400	23000
0236-95-0090	36-3151	0 - 6	5.8	27.4	70.3
0236-95-0122	36-3173	18 - 23	17.8	7	26.8

N/A = Not applicable

TABLE 5.2.5-2
P-VALUES FROM STATISTICAL TESTS FOR BACKGROUND COMPARISONS FOR SKUNK WORKS[1]

Analyte	Gehan test	Quantile test	Slippage test
Copper	0.9190	0.7944	0.0387
Lead	0.9675	0.7965	0.0000
Zinc	0.1918	0.4280	0.0000

[1] See Section 3.2 for a discussion of p-values.

5.2.7 Human Health Assessment

5.2.7.1 Screening Assessment

No inorganics were detected above background and no organics were detected above EQLs at Skunk Works. Therefore, no inorganics or organics were carried forward to the SAL comparison stage and were not retained as COPCs.

Uranium-235 was detected below its SAL of 10 pCi/g. It was not submitted to the MCE because it was the only chemical in the radionuclide effects category above background, and, therefore, was not retained as a COPC.

5.2.7.2 Risk Assessment

No human health risk assessment was performed because no COPCs were retained as a result of the screening assessment.

5.2.8 Ecological Assessment

No inorganic substances were detected at levels above background UTLs (Section 5.2.5), and no organic constituents were detected above EQLs (Section 5.2.6). These constituents are eliminated as COPCs, and no further ecological evaluation is required.

5.2.9 Extent of Contamination

No human health COPCs are retained at this site. Therefore, this section is not applicable.

5.2.10 Conclusions and Recommendations

The Phase I investigation determined that COPCs were not detected at Skunk Works. Inorganic chemicals were reported to be within the Laboratory background distribution, and no organics were

detected above the EQL. Therefore, none were carried forward for further evaluation. Uranium-235 was detected above background UTL, but was below its SAL by two orders of magnitude, and it was not retained as a COPC.

Skunk Works has been characterized and no COPCs were retained based on sample results and screening assessment. No further action is recommended for this site based on Criterion 5. However, request for permit modification will be made after Lower Slobbovia Firing Site at PRS 36-004(d) has changed to inactive status.

5.3 PRS 36-004(d), Burn Pits

Burn Pits were used for the burning and disposal of HE test debris before MDA AA (PRS 36-001) was established (Figure 1.1-3). The areas are outside the hazard radius of Lower Slobbovia Firing Site, along Potrillo Drive, on the mesa top. COPCs at the site included HE, VOCs, SVOCs, metals, and isotopic uranium. Investigations at this site are in response to an NOD from EPA (Jansen and Taylor 1995, 46002; Jansen and Taylor 1995, 44186; and McInroy 1994, 34994). Disposition of this site does not include the firing site, Lower Slobbovia. Analytical results indicate the presence of organics and uranium, but no COPCs are retained. Using Criterion 5, NFA is recommended for this site based on the results of the screening assessment. However, request for permit modification will be made after Lower Slobbovia Firing Site at PRS 36-004(d) is changed to inactive status.

5.3.1 History

Before MDA AA was established in the mid-1960s, the groups conducting the explosives tests used two areas for burning and disposal of explosive tests residue and debris. These areas were bermed enclosures made from soil excavated during construction of the road and dumped north and south of the road. Presumably, operations consisted of collecting and loading shot residue in a truck, dumping it into the depressions, and burning it, as was later done at MDA AA. After MDA AA was opened, these sites were no longer used. COPCs associated with the site include HE, SVOCs, VOCs, metals, and isotopic uranium.

In the summer of 1993, radiological surveys were also conducted near the Lower Slobbovia Firing Site to be used in conjunction with the geophysical surveys to determine the location of the Burn Pits and possible sample locations. Surveys were conducted using the instrumentation as described in Sections 5.1.4.2 and 5.2.4.2.

Radiological measurements were made every 10 ft on a 200-ft by 200-ft grid at the site. A few points to the south and east of the shot pad indicated slightly elevated readings. These elevated readings were to be used to bias sample locations. However, this survey did not locate the Burn Pits, because the Burn Pits were not located within the Lower Slobbovia Firing Site area.

The geophysical survey was also conducted near the Lower Slobbovia Firing Site. The survey was conducted on a 400 ft^2 grid using the same instruments and techniques as for the survey at MDA AA. See Section 5.1.4.2 of this report for details. The RFI Work Plan had specified that a 10 ft grid be used for the geophysical survey, but the grid was enhanced by using a 5-ft interval system to gain more precision.

MAG anomalies occur in the area, but they usually were found to coincide with surface features, debris, and utilities. An anomalous zone appeared in the general vicinity as the blackened area in a photograph (LASL 1979, 13-0092) and was suspected to be the burn pits. The EM survey was not as sensitive as the MAG survey, but it indicated an anomalous area in the same area that was earlier suspected to be the Burn Pits.

The 1993 surveys did not locate the Burn Pits, because, as it was learned, the Burn Pits were actually located outside the Lower Slobbovia Firing Site area. A retired employee was contacted and questioned more thoroughly, and he led the sample team to the Burn Pits locations in the summer of 1995.

5.3.2 Description

The location of the Burn Pits was not known, and the first objective of the field work was to locate the pits. A 1958 aerial photograph of Lower Slobbovia (LASL 1958, 13-0068) suggested that the pits were due south of TA-36-13, an instrument chamber. Two blackened spots that appeared to be shallow pits could be seen in the photograph. Field activities using radiological and geophysics surveys in 1994 failed to locate the Burn Pits within the firing site, and the field team surmised that the depressions noted in the early aerial photograph were the results of explosives testing.

The Burn Pits are actually located outside the firing hazard radius for Lower Slobbovia along Potrillo Drive on the mesa well away from initial areas of investigation. The largest area was made from excavated soil dumped north of Potrillo Drive during the construction of the road. Soil had been dumped in a circular area in a forested area, and soil provided a bowl that was a protected location to use for residue dumping and burning (Henke 1995, 49327). The raised berms and the interior of the depression were overgrown with brush and young trees. Outside the bermed area the fill could be easily detected as the lighter-colored soil and rocks contrasted with the surrounding soil. The diameter of the bermed area was about 40 ft, and the berms themselves were about 10 ft wide.

Smaller areas south of the road, also in areas of excess excavated soil, were reportedly used for burning. The location was about 300 ft west of the entrance to Moe magazine. One area was in a depression surrounded by young trees, which had not been present in the early 1960s. This area was not used extensively, nor was it well-defined. A second small area south of the road was determined from an informal geomorphic study together with a study of a site photograph. A slight drainage area made its way from the depressions to lower elevation and Fence Canyon (Figure 1.1-3).

5.3.3 Previous Investigations

No previous investigations have been performed at this site.

5.3.4 Field Investigations

Objectives of the Phase I investigations included locating the Burn Pits and collecting samples to establish presence or absence of contamination in the Burn Pits. Additionally, drainage channels leading away from the Burn Pits were to be sampled to determine if a release had occurred from the ash and other debris in the Burn Pits.

Hand-augering was used in all exploration and sampling efforts. Twelve locations in the north Burn Pit were explored by hand augering to:

- locate areas which contained the greatest amount of ash and/or elevated field screening results for HE, VOCs, and radiation;
- determine if the berm itself was made up of construction fill or burned material; and
- ascertain the depth of the soil/tuff interface.

The Phase I objectives for the investigations of the Burn Pits and the suspected COPCs remained as indicated in the RFI Work Plan (LANL 1993, 1088) even though the location of the Burn Pits were different than was expected.

5.3.4.1 Land Survey

A land survey was performed at the sites to locate the sample locations. See Section 5.1.4.1 for a description of the procedures, equipment, and controls used for that survey.

5.3.4.2 Geophysical Surveys

Geophysical surveys were not necessary at the Burn Pits after they had been located.

5.3.4.3 Radiological Surveys

A radiological survey was conducted at the actual sites of the Burn Pits. Measurements were taken every 10 ft on an 80 ft by 80 ft grid at the north burn pit and every 10 ft on a 40 ft by 50 ft grid at the south burn pit. All readings were within background range.

5.3.4.4 Sample Collection

Based on the information from the former employee, the Burn Pits were located north and south of Potrillo Drive. The areas were examined for staining and nearby drainage patterns.

Drilling for samples was not done at the Burn Pits as was proposed in the RFI Work Plan (LANL 1993, 1088). Instead, hand augering was used to locate ash at the north Burn Pit to provide biased sample locations. As the hand augering progressed through the fill, aluminum sleeves were put in place to line the hole protecting the lower samples from being contaminated by ash from higher levels. Material from the debris included ash charred wood and unburned wood (perhaps part of a tree). Samples were collected from areas that exhibited the largest volume of ash and charred material and from material in low-lying areas that would have been likely to collect runoff.

From the twelve exploratory locations the soil/tuff interface were determined to be approximately 6 to 6-1/2 ft below the fill material. Screening results from these boreholes were all negative. Three sample locations were selected based on the volume of ash encountered during the exploratory efforts. Two intervals within each borehole were selected for sampling; the ash interval and 2 ft below the base of the ash. One sample was collected from the soil/tuff interface, potentially the most contaminated location based on the quantity of ash and its position in the lowest point in the depression.

The berm was also hand augered to determine if it contained burned material, but only construction fill material was present. Neither the berm nor the drainage pathway north of the berm was sampled. If contaminants were found to be present in the burn area, another sampling effort would have been conducted to determine the extent of the contamination.

The small sites south of the road appeared undisturbed, and no ash was visible. Surface and subsurface samples were collected from two locations by using information from the former employee together with information from aerial photographs. A sample was taken from the center of two depressions, one identified as a burn area by the retired employee, and another sample was taken from a similar area, though not identified as a burn area.

A summary of the samples taken at the Burn Pits is given in Table 5.3.4.4-1. Figure 5.3.4.4-1 shows the sample locations for the north Burn Pit, and Figure 5.3.4.4-2 shows the sample locations for the south Burn Pit.

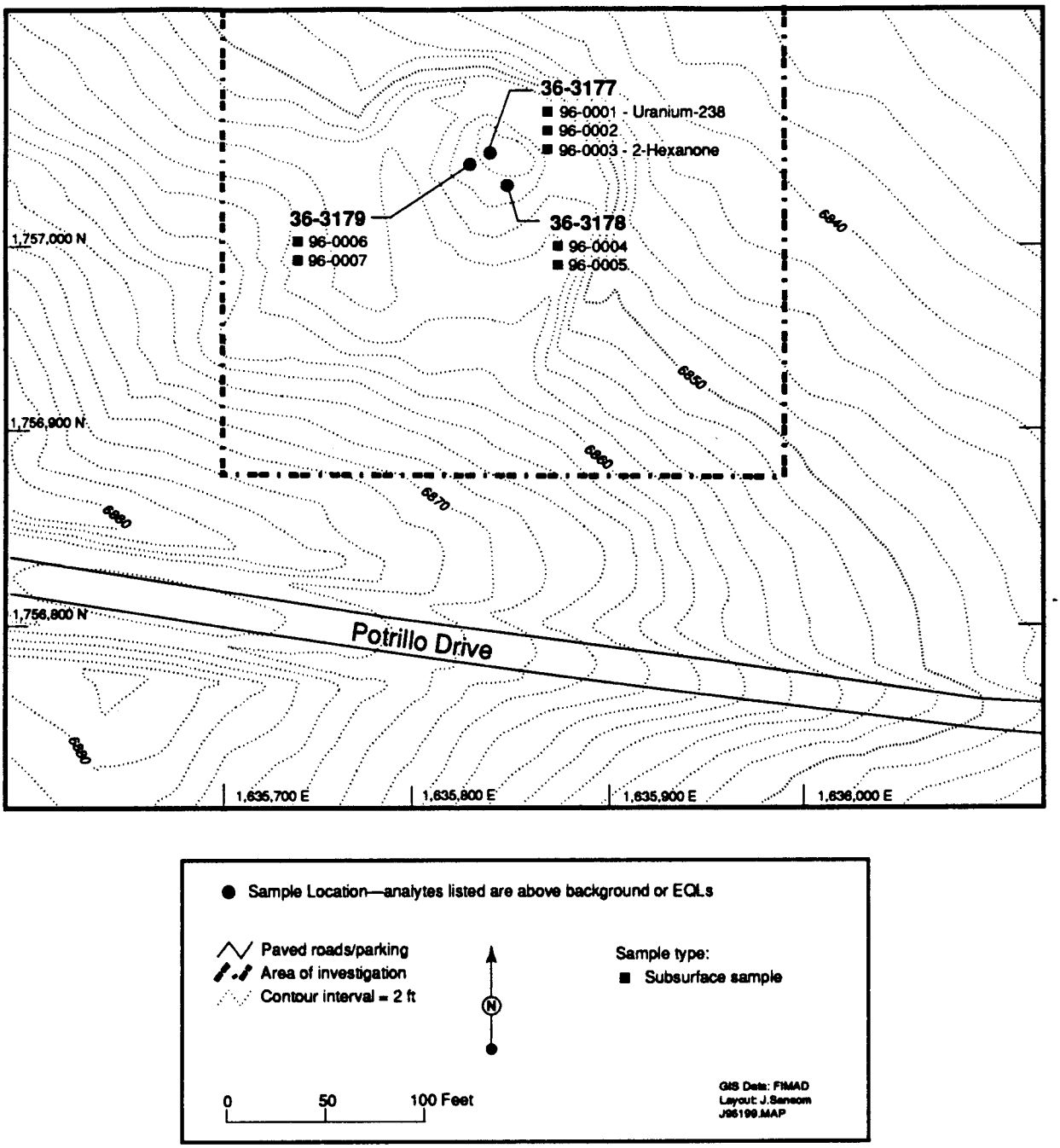
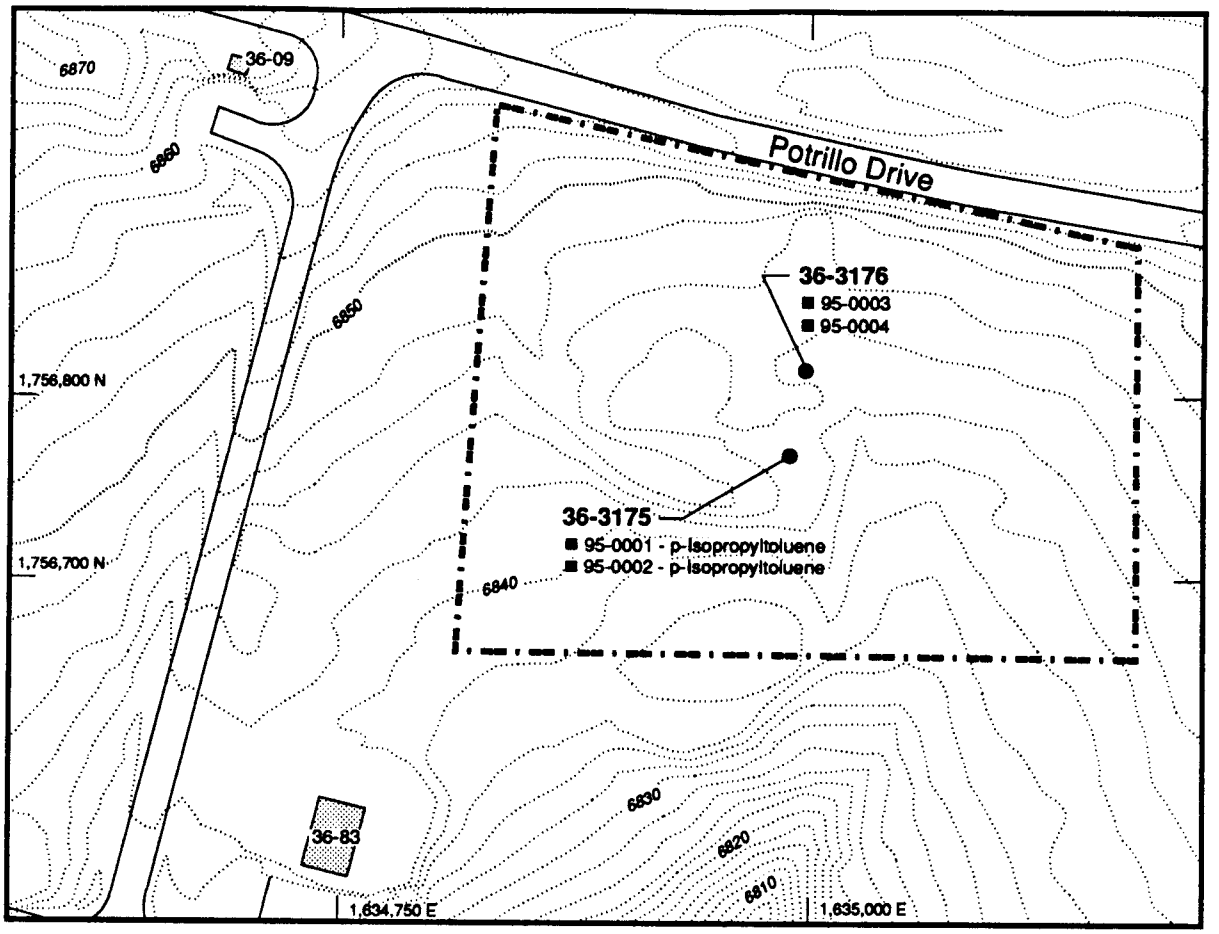


Figure 5.3.4.4-1 Burn Pit (north), showing sample locations and results



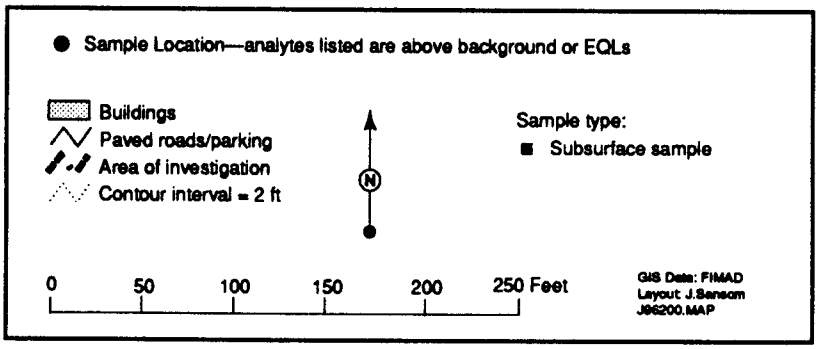


Figure 5.3.4.4-2 Burn Pit (south), showing sample locations and results

TABLE 5.3.4.4-1
SAMPLE SUMMARY FOR BURN PITS

Location ID	Sample ID	Depth (in)	Matrix	VOCs	SVOCs	Gamma Spec	Metals Mercury	Iso U	HE
36-3175	0236-95-0001	6 - 13	Subsurface soil	1698*	1692*	1700*	1699*	1700*	1698*
36-3175	0236-95-0002	26 - 33	Subsurface soil	1698	1692	1700	1699	1700	1698
36-3176	0236-95-0003	6 - 12	Subsurface soil	1698	1692	1700	1699	1700	1698
36-3176	0236-95-0004	24 - 31	Subsurface soil	1698	1692	1700	1699	1700	1698
36-3177	0236-96-0001	24 - 31	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3177	0236-96-0002	53 - 61	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3177	0236-96-0003	67 - 76	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3178	0236-96-0004	4 - 13	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3178	0236-96-0005	38 - 44	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3179	0236-96-0006	13 - 20	Subsurface soil	1725	1725	1728	1726	1728	1727
36-3179	0236-96-0007	40 - 50	Subsurface soil	1725	1725	1728	1726	1728	1727

* Numbers refer to analytical batch.

5.3.4.5 Deviations from the RFI Work Plan Sampling Strategies

Random samples were not taken because a better assessment could be provided using information from the known contaminated areas. Every sample taken within the bermed area in the north Burn Pit included ash.

Hand augering was substituted for drilling as proposed in the sampling plan because the ease of use in the disturbed soil. Also, more exploratory boreholes could be hand augered quickly and cost effectively, and the increased number would increase the possibility of finding contaminated soil.

A third sample was not taken at the south Burn Pit because its area was undisturbed, appeared clean, did not constitute a defined structure for burning activity, and according to the former employee, was scarcely used for burning. However, more samples were taken overall for analysis than were specified in the RFI Work Plan. Additionally, analyses for both isotopic and gamma spectroscopy for uranium were requested. Uranium was known to be used at the sites, and additional cost for these analyses was small in contrast to resampling, if uranium had been present.

5.3.5 Background Comparisons

The location of samples with analyte values exceeding background UTLs are shown in Figures 5.3.4.4-1 and 5.3.4.4-2.

Inorganics

No inorganic compounds were detected at concentrations above background UTLs; therefore, they were not retained as COPCs.

Radionuclides

Uranium-238 was detected in one subsurface soil sample (sample #0236-96-0061) (24 to 31 in.) at a concentration of 2.69 pCi/g, which is above its background UTL of 1.82 pCi/g, and was submitted to the SAL comparison. Uranium-234 and uranium-238 were detected at concentrations below background UTLs and were not retained as COPCs. The other radionuclides were also not retained as COPCs.

5.3.6 Evaluation of Organic Constituents

Acetone and methylene chloride were detected in three soil samples, each at concentrations either below the EQLs (0.01 mg/kg) or slightly above the EQLs. Because these analytes are not expected to be present as a result of site activities and are common laboratory contaminants, the data are considered to be nondetects and were eliminated from further evaluation at this site (refer to Section 4.3.2).

Hexanone (2-) in one subsurface soil sample and p-isopropyltoluene in two subsurface soil samples were detected at concentrations of 0.034 mg/kg, and 0.031 and 0.011 mg/kg, respectively, slightly above the EQL (0.01 mg/kg). Although these analytes are not common laboratory contaminants, they are not expected to be present as a result of site activities and are only slightly above the EQL. Therefore, they are eliminated from further consideration at this site.

The other organics that were undetected or detected below the EQLs were not retained as COPCs.

5.3.7 Human Health Assessment

5.3.7.1 Screening Assessment

No inorganics were detected above background UTLs and no organics were detected and retained above EQLs at the Burn Pits. Therefore, no inorganic or organic compounds were retained as COPCs.

The uranium-238 sample value detected above background was below its SAL of 67 pCi/g. It was not submitted to the MCE because it was the only chemical in the radionuclide effects category above background, and, therefore, is not retained as a COPC.

5.3.7.2 Risk Assessment

No human health risk assessment was performed because no COPCs were retained as a result of the screening assessment.

5.3.8 Ecological Assessment

No inorganic substances were detected at levels above background UTLs (Section 5.3.5). Several organic constituents were detected above EQLs but were eliminated as COPCs in Section 5.3.6. These constituents are eliminated as COPCs, and no further ecological evaluation is required.

5.3.9 Extent of Contamination

No human health COPCs are retained at this site. Therefore, this section is not applicable.

5.3.10 Conclusions and Recommendations

The Phase I investigation determined that contamination is not present in the Burn Pits. No inorganics were detected above background UTLs and are not retained as COPCs. Organics reported slightly above the EQL were not retained because they were not expected to be present as a result of Laboratory activities or were common laboratory contaminants. Uranium-238 was the only radionuclide detected above background UTL, but was well below its SAL and was not retained.

The Burn Pits have been characterized and no COPCs are retained as a result of the screening assessment. Based on Criterion 5, NFA is recommended for this site. However, request for permit modification will be made after Lower Slobbovia Firing Site at PRS 36-004(d) has been changed to inactive status.

5.4 PRS 36-006, Surface Disposal Area (SDA)

SDA is an area near Eenie Firing Site (Figure 1.1-3) where debris was pushed over the canyon wall into a narrow arroyo. The area was used to dispose of cables and other residuals from explosives testing at the Eenie firing pad, 100 ft away. COPCs associated with the site are HE, VOCs, SVOCs, metals, and isotopic uranium. Chromium was detected at concentrations above the SAL, but was not retained based on an evaluation of PRGs using an industrial exposure scenario. No further action is recommended for this site, and based on NFA Policy Criterion 5, a Class III permit modification is requested to remove this site from the HSWA Module of the Laboratory's RCRA permit.

5.4.1 History

PRS 36-006, SDA, is an abandoned debris pile located in Potrillo Canyon. Cables, metal, concrete, and waste residuals from explosives testing performed at TA-36 firing sites was transported to the edge of the steep canyon wall and off-loaded into the canyon from approximately 1955 to 1970. Solid and liquid explosives and depleted uranium were used in these tests (Jansen 1995, 44186). COPCs at the site are HE, VOCs, SVOCs, metals, and isotopic uranium.

5.4.2 Description

SDA is an undeveloped area along the steeply sloping Potrillo Canyon wall about 100 ft from Eenie Firing Site. Debris occurs in a wedge extending down the canyon wall. The area of the pile is about 75 ft along the mesa top and about 100 ft down the slope into the canyon. Cable, pipes, culvert, and other debris are visible from the edge of the canyon wall. Ash and burned material are visible in the entire firing site area, and an asphalt curb runs along the lip of the canyon, presumably to prevent trucks from backing up too far at the canyon wall. The soil surface is not visible beneath the debris, and below the SDA the soil-tuff interface was visible because the canyon wall is so steep. SDA is no longer used for disposal. However Eenie Firing Site is only 100 feet away, and SDA may continue to receive debris from current explosives testing.

5.4.3 Previous Investigation

No previous investigations have been performed at this site. However, sampling has been performed downstream of the site in the drainage channel. Results from initial sediment sampling from the stream channel at Eenie Firing Site indicated that total uranium concentrations ranged from 1.3 to 60.9 ppm (Becker 1991, 0699).

5.4.4 Field Investigation

The objective of the reconnaissance sampling of SDA was to determine if contaminants attributable to the debris are present in the surface and subsurface soil. Offsite migration of the contaminants was also

assessed by sampling in the narrow drainage area below the SDA. Data gathered was assessed to determine if contaminants are present at levels of concern. COPCs are the same as COPCs at the firing sites, from where the debris originated. These include: solid and liquid explosive residues, metals, and depleted uranium.

5.4.4.1 Land Survey

A land survey was performed to locate the sampling locations. See Section 5.1.4.1 for a description of the procedures, equipment, and controls used.

5.4.4.2 Field Screening

Extensive field screening was conducted to bias sampling locations. Locations for field screening by XRF are as follows:

- three locations within the active firing pad and mesa drainage pathway;
- three background locations within 300 ft of the firing site radius;
- one location upgradient from SDA arroyo drainage locations;
- three locations at the main drainage from where the firing pad drainage enters the arroyo (upgradient of SDA);
- five locations at the base of the main SDA debris pile; and
- four random locations within the debris piles.

Samples were obtained from these locations at depths ranging from the surface (0 to 6 in.) to approximately 4 ft. Samples from most locations were screened using the HE spot test; by XRF; and were analyzed by a field test kit for pH. Samples were also screened for VOCs and radionuclides (Figure 5.4.4.2-1).

The LIBS had been proposed as a field analytical tool in the Sampling and Analysis Plan (Jansen and Taylor, 1995, 44186). However, EPA Region VI rejected the use of the LIBS in an NOD. Therefore, the XRF was used as a field screening tool at SDA (Jansen and Taylor 1995, 46002).

5.4.4.3 Radiological Surveys

The area below the SDA was screened for beta-gamma to bias sample locations. However, all results were within background levels. See Section 5.2.4.2 for a description of the conduct of the radiation survey and equipment used. Surveying for alpha was not conducted because the moisture in the soil prevents the meter from detecting alpha, and plutonium, the most common alpha-emitter at the Laboratory, was not used at this site.

5.4.4.4 Sample Collection

As stated in the RFI Work Plan (LANL 1993, 1088), the main migration pathway for contaminants originating from the debris is the surface water pathway. Considering this pathway, biased sampling locations were selected based on information gathered during the visual and geomorphic surveys and field screening results:

- The intersection of the main drainage culvert from the firing pad with Potrillo Canyon arroyo. This upgradient drainage location, 36-3147, served to identify background constituents not attributable to the debris pile.
- Two locations selected at the base of the debris pile were chosen based on field screening results. 36-3145 was based on the possible presence of uranium, and 36-3146 was selected to provide information on the contamination from differing types of

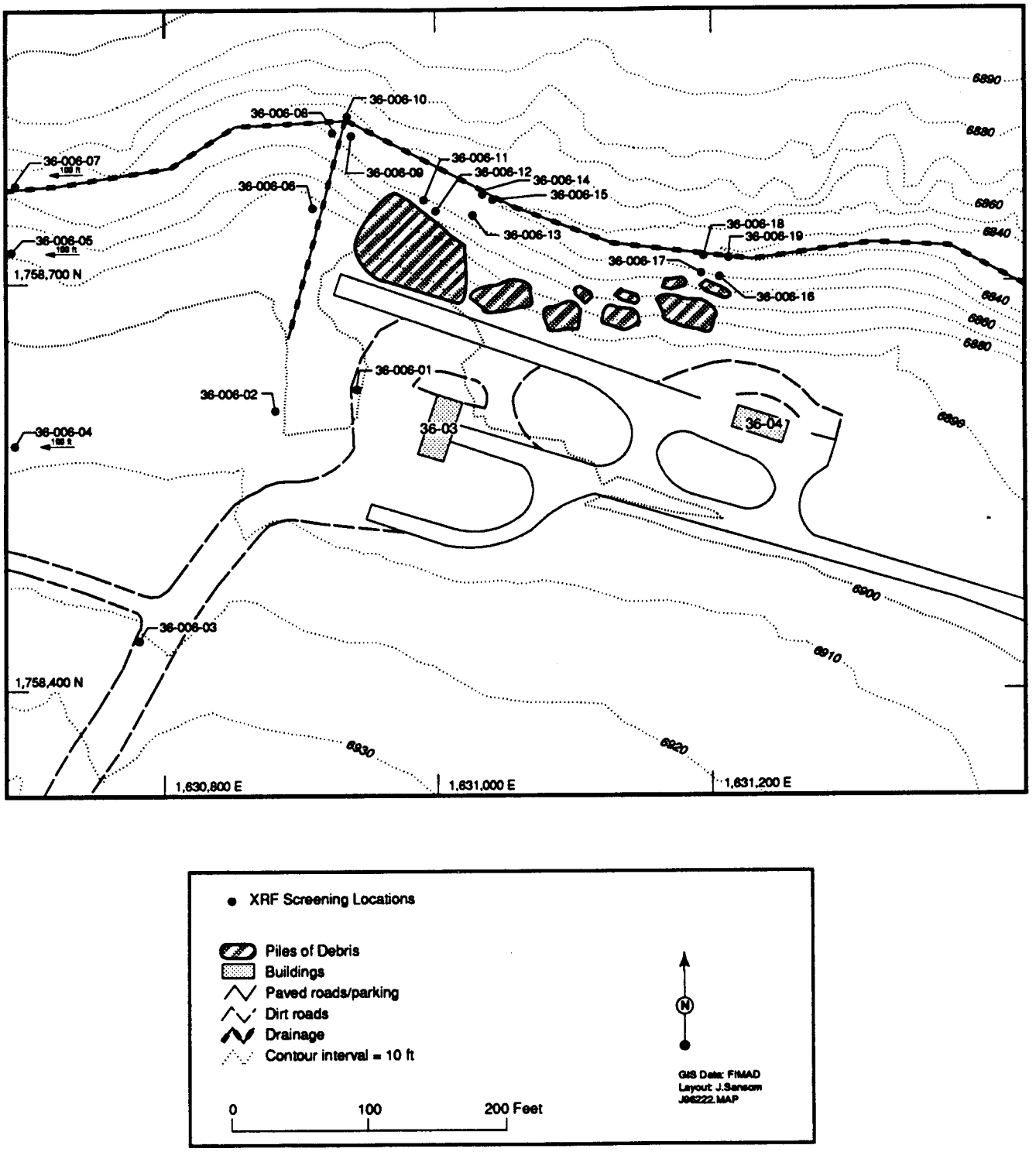


Figure 5.4.4.2-1 PRS 36-006, showing XRF screening locations

waste present at the site. Each location was sampled at the surface and at the soil/tuff interface. The surface sample reflected the nature of recent non-mobile material eroding from the debris pile and resting on the soil surface. The subsurface sample addressed debris leaching or percolating into the shallow layer along the canyon wall and migrating along the soil/tuff interface toward the canyon floor. Due to the more impermeable nature of the tuff as compared with the overlying soil, the interface serves as a likely migration pathway.

- Location 36-3149 was chosen for sampling because it was the first sediment catchment downgradient of the debris piles.

All results were within the background range except for a positive lead reading and uranium results of 461 ppm and 288 ppm, respectively, at XRF sample location 36-006-11 directly below SDA (Figure 5.4.4.2-1). Table 5.4.4.4-1 is the Sample Summary Table, and Figure 5.4.4.4-1 indicates the site with the sample locations.

Samples were analyzed for VOCs, SVOCs, metals, isotopic uranium, and HE.

TABLE 5.4.4.4-1
SAMPLE SUMMARY TABLE FOR SDA

Location ID	Sample ID	Depth (in)	Matrix	VOCs	SVOCs	Metals Mercury	Iso U	HE
36-3145	0236-95-0083	0 - 4	Surface soil	1712*	1712*	1713*	1714*	1711*
36-3145	0236-95-0087	16 - 24	Subsurface soil	1712	1712	1713	1714	1711
36-3146	0236-95-0084	0 - 4	Surface soil	1712	1712	1713	1714	1711
36-3146	0236-95-0123	16 - 24	Subsurface soil	1712	1712	1713	1714	1711
36-3147	0236-95-0086	0 - 4	Surface soil	1712	1712	1713	1714	1711
36-3149	0236-95-0088	0 - 4	Sediment	1712	1712	1713	1714	1711

* Numbers refer to sampling batch.

5.4.4.5 Deviations from the RFI Work Plan Sampling Strategies

The area directly below SDA on the canyon wall was not sampled. Because the soil-tuff interface was directly below the SDA, not enough material was available for sampling. The thick overlay of cables in the SDA also prohibited samples from being taken directly underneath the SDA. The debris itself was screened but not sampled. If contamination and migration have occurred, they would have been detected downgradient. Field quality control samples were not taken; analytical laboratory QC samples were considered sufficient for QA.

The HE spot test was not used on the subsurface samples. The subsurface in these locations have not been disturbed by human activity, and HE would not be present in the subsurface soil.

5.4.5 Background Comparisons

The location of the sample with an analyte value exceeding background UTLs is shown in Figure 5.4.4.4-1.

Inorganics

Barium, chromium, copper, lead, nickel, and zinc were detected at concentrations greater than their background UTLs (Table 5.4.5-1). P-values from the background statistical tests comparing site

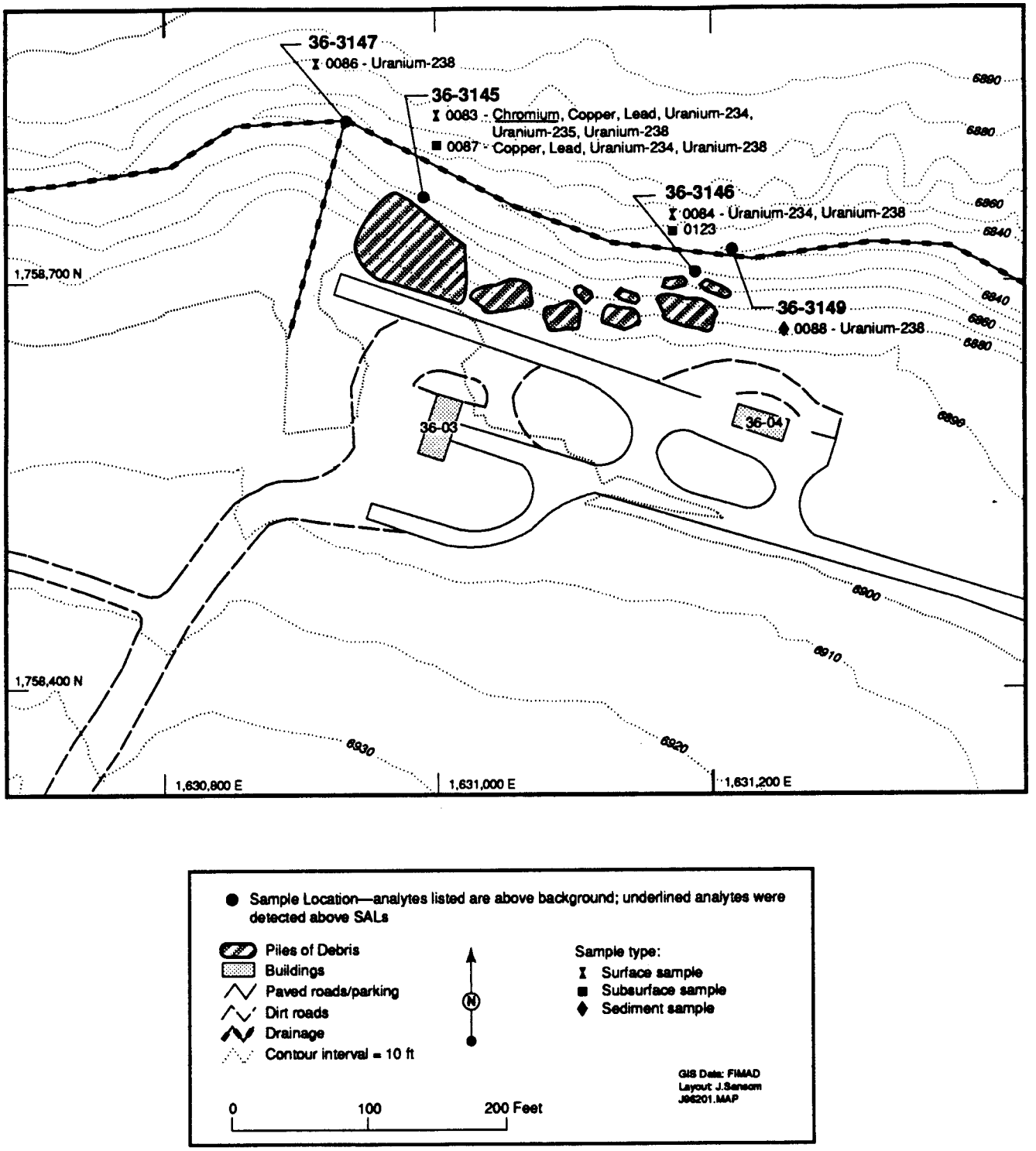


Figure 5.4.4.4-1 PRS 36-006, showing sample locations and results

concentrations with Laboratory background concentrations are shown in Table 5.4.5-2. The p-values for the Gehan and Quantile tests indicate that the site concentrations are consistent with background concentrations, but the Slippage p-values indicate the presence of outliers in the site distributions. This is shown graphically in the plots in Appendix D, which show at least one outlier for every analyte. The outliers are consistently associated with two samples (0236-95-0087 and 0236-95-0083). The reliability of the Gehan and Quantile tests for this PRS are called into question because of the small sample size; four samples are the minimum required to perform the statistical background tests. In this case, six samples are not enough to make the test results reliable. See Section 3.2 for further discussion of the statistical tests used to compare site and background concentration distributions.

All of the analytes that are detected greater than their background UTLs are carried forward for SAL comparison. These analytes are barium, chromium, copper, lead, nickel, and zinc.

TABLE 5.4.5-1
INORGANICS WITH CONCENTRATIONS GREATER THAN BACKGROUND UTLs FOR PRS 36-006

Sample ID	Location ID	Depth (in)	Barium	Chromium	Copper	Lead	Nickel	Zinc
UTL	N/A	N/A	315	19.3	15.5	23.3	15.2	50.8
SAL	N/A	N/A	5300	210	2800	400	1500	23000
0236-95-0083	36-3145	0 - 4	150	410	52(J)	200	200	45
0236-95-0087	36-3145	6 - 24	380	6.5	55(J)	54	6.5	150

N/A = Not applicable (J) = Estimated value
Double border = Chemical exceeded background UTL
Shaded box = Chemical exceeded SAL

TABLE 5.4.5-2
P-VALUES FROM THE STATISTICAL TESTS FOR BACKGROUND COMPARISONS FOR PRS 36-006[1]

Analyte	Gehan test	Quantile test	Slippage test
Barium	0.8111	0.7496	0.0000
Chromium	0.9748	0.7456	0.0000
Copper	0.1755	0.0954	0.0009
Lead	0.3771	0.3474	0.0000
Nickel	0.8520	0.7434	0.0333
Zinc	0.5032	0.3362	0.0000

[1] See Section 3.2 for a discussion of p-values.

Radionuclides

Uranium-234, uranium-235, and uranium-238 were detected in one surface soil sample at concentrations above background; uranium-234 and uranium-238 were detected in one subsurface soil, one sediment, and two surface soil samples at concentrations greater than background UTLs (Table 5.4.5-3). These analytes were carried forward to the SAL comparison stage. No other radionuclides were analyzed for at this site.

TABLE 5.4.5-3
RADIONUCLIDES WITH CONCENTRATIONS GREATER THAN BACKGROUND UTLs FOR PRS 36-006

Sample ID	Depth (in)	Uranium-234 (pCi/g)	Uranium-235 (pCi/g)	Uranium-238 (pCi/g)
LANL UTL	N/A	1.94	0.084	1.82
SAL	N/A	13	10	67
0236-96-0083	0 - 4	5.9	0.41 (B)	32.4
0236-96-0084	0 - 4	2.9	ND	4.9
0236-96-0086	0 - 4	1.6	ND	5.1
0236-96-0087	16 - 24	2.9	ND	9.8
0236-96-0088*	0 - 4	1.9	ND	2.8

N/A = Not Applicable
(B) = Reported value obtained from a reading that was less than Required Detection Limit (RDL) but greater than or equal to the actual Detection Limit (DL)
Double border = Chemical exceeded background UTL
* Sediment sample

5.4.6 Evaluation of Organic Constituents

No organics compounds were detected above the EQLs. All organics that were undetected or detected below the EQLs are not retained as COPCs.

5.4.7 Human Health Assessment

5.4.7.1 Screening Assessment

Barium, copper, lead, nickel, and zinc were detected at concentrations at less than their respective SALs and were submitted to an MCE. Chromium was detected at concentrations greater than its SAL of 210 mg/kg and was retained as a COPC.

No organics were detected above EQLs and none were retained as COPCs.

Uranium-234, uranium-235, and uranium-238 were detected at concentrations less than their respective SALs. The maximum concentrations of the three uranium isotopes detected at this PRS add up to 38.7 pCi/g or 96.8 mg/kg of total uranium. The isotopic ratio of uranium-238 to uranium-235 for this sample indicates that the uranium detected is depleted uranium (DU). The isotopic ratio that indicates DU is 70:1 and the ratio for sample 0236-96-0083 is 79:1. As a result, the total uranium value of 96.8 mg/kg is compared to the SAL for DU (130 mg/kg). Because the total uranium value is less than the DU SAL, the combined effect of the uranium isotopes is not a concern to human health and therefore, the uranium isotopes are not retained as COPCs.

Multiple Chemical Evaluation

The MCE included five analytes in the noncarcinogenic effects category (Table 5.4.7.1-1). The sum of the maximum normalized concentrations of these analytes was 0.7311, which was less than the target value of 1. Therefore, these analytes are not retained as COPCs.

TABLE 5.4.7.1-1
MULTIPLE CHEMICAL EVALUATION FOR PRS 36-006

NONCARCINOGENIC - SOIL	
Analyte	**Maximum Normalized Concentrations**
Barium	0.0717
Copper	0.0196
Lead	0.5000
Nickel	0.1333
Zinc	0.0065
Total	0.7311

5.4.7.2 Risk Assessment

A baseline human health risk assessment was not performed because chromium [assumed to be present as trivalent chromium (III) based on site use] was the only COPC retained as a result of the screening assessment. Therefore, a site-specific PRG was calculated to determine if the detected concentration warranted corrective action. This PRG was calculated based on a nonintrusive industrial (surface soil) scenario using standard EPA default parameters. Because the number of samples is not sufficient to calculate a reasonably accurate 95% UCL of the mean, the maximum site concentration is used in the PRG evaluation. The site-specific PRG calculation for noncarcinogens was based on a hazard index of 1 (see Appendix C). The PRG for chromium III was calculated to be greater than 1 million parts per million, which indicates that chromium III is not a health hazard at any level possible in the environment. The maximum site concentration is 410 mg/kg, which is below the PRG by several orders of magnitude. Therefore, chromium is not retained as a COPC at this site.

5.4.8 Ecological Assessment

The general landscape condition around SDA is moderately developed and disturbed (Table 2.4-1) and there is high potential for receptors to come in contact with COPCs (chromium, copper, zinc, and uranium) associated with the site. Therefore, this PRS will be included as an ecological COPC source in the ecological risk assessment. An ecological risk assessment will be conducted when that approach has been approved by our regulators. Threatened and endangered species and /or sensitive habitat listed in Chapter 2 will be evaluated in the ecological risk assessment.

5.4.9 Extent of Contamination

The sampling conducted at this site was designed to determine whether migration of inorganic chemicals, VOCs and SVOCs, isotopic uranium, and HE had occurred. Six samples at four sampling locations (i.e., surface, subsurface, and sediment) were collected to characterize the site to determine if there had been any movement of possible contaminants. Based on the results of the screening assessment, no human health COPCs are retained at this site.

5.4.10 Conclusions and Recommendations

The Phase I investigation determined the extent of contamination associated with PRS 36-006. Only chromium was detected above SAL, and was submitted to a site-specific PRG evaluation. It was eliminated from further consideration at this stage because it was markedly below the risk-based PRG for chromium III (the most likely form of chromium present). The isotopes of uranium were detected above background UTL and were not retained as COPCs based on the SAL comparison. No organics were detected above EQLs and were, therefore, not retained as COPCs.

PRS 36-006 has been characterized and no COPCs are retained based on the results of the screening assessment and PRG evaluation. No further action is recommended for this site, and based on NFA Policy Criterion 5, a Class III permit modification is requested to remove this site from the HSWA Module of the Laboratory's RCRA permit.

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APPENDIX A

ANALYTICAL DATA

All analytical data are available on FIMAD.

Geophysics maps are available at the ER Records Processing Facility, Document Numbers ER 53963, ER 53964, ER 53965, ER 53966, ER 53967, ER 53968, and ER 53969.

Radiation survey data are available at the ER Records Processing Facility, Document Number ER 54432.

APPENDIX B

DATA QUALITY ASSESSMENT

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES

SUITE	REQUEST NUMBER	COMMENTS
Inorganics	1792 (three samples)[1]	Antimony and zinc percent recoveries in the spike sample were outside of established limits (<75%) and the data are qualified as UJ and PM, respectively. The antimony data are usable because the recovery was <2% below the limit and therefore would be detected and quantified if present. The zinc data should be re-qualified as J and are usable because LCS recovery was acceptable and despite the low bias the data are an order of magnitude or more below the SAL.
	1809 (three samples)	Copper, manganese, selenium, and zinc recoveries in the spike sample were outside of established limits (<75%). The selenium data are qualified as UJ and are usable because the recovery was <3% below the limit so the analyte would be detected and quantified if present. The copper, manganese and zinc are qualified as J- (result >EDL). All of the data are usable because the spike levels were too low, i.e., less than or comparable to the concentrations present in the samples, and the recoveries could not be determined. The data for these analytes were either well below background UTLs or at least on order of magnitude below their SALs. As a result, the bias does not affect the data comparison.
		The duplicate of cadmium, chromium, copper, and zinc had RPDs outside of control limits (>20%) and are qualified as P. The chromium and copper data should not be qualified because the RPD is within 35% or is ± 2X CRDL, which is acceptable for soils. The zinc data should be qualified as J and the qualified data are usable because the duplicate result is within the range of analyte concentrations. The cadmium data are unusable because the RPD indicates large imprecision and accuracy in the analysis of this analyte. The cadmium data for all the samples should be qualified as R and not used in the screening assessment.
	19875 (one sample)	The holding time for mercury (28 days) was exceeded by 22 days. The results greater than the detection limit are qualified as J, while results less than the detection limit are not qualified. The data are usable because the holding time was not grossly exceeded (i.e., more then twice the recommended holding time) and the samples were properly stored.
	19876 (two samples)	The holding time for mercury (28 days) was exceeded by 31 days. The results greater than the detection limit are qualified as J, while results less than the detection limit are not qualified. The data are usable because the holding time was not grossly exceeded (i.e., more then twice the recommended holding time) and the samples were properly stored.
	20056 (two samples)	The holding time for mercury (28 days) was exceeded by 21 days. The results greater than the detection limit are qualified as J, while results less than the detection limit are not qualified. The data are usable because the holding time was not grossly exceeded (i.e., more then twice the recommended holding time) and the samples were properly stored.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES (Continued)

SUITE	BATCH NUMBER	COMMENTS
Inorganics	20057 (three samples)	The holding time for mercury (28 days) was exceeded by 26 days. The results greater than the detection limit are qualified as J, while results less than the detection limit are not qualified. The data are usable because the holding time was not grossly exceeded (i.e., more then twice the recommended holding time) and the samples were properly stored.
	20056 (two samples)	Aluminum, iron, sodium, and chromium in both samples are qualified as J because percent recoveries in the blind QC sample were outside of established limits (75 - 125%). The data are usable because the recoveries for aluminum, iron, and chromium were >50%, and these analytes are detected and quantified and are at least one-third the background UTLs or an order of magnitude below SALs. The sodium data are usable because the results are biased high.
	20057 (three samples)	Aluminum, iron, sodium, and chromium in both samples are qualified as J because percent recoveries in the blind QC sample were outside of established limits (75 - 125%). The data are usable because the recoveries for aluminum, iron, and chromium were >50%, and these analytes are detected and quantified and are an order of magnitude below to one-half the background UTLs. The sodium data are usable because the results are biased high.
	80451 (one sample)	Beryllium and silver are qualified as J because they were below the EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.
	80800 (five samples)	Selenium in four samples, antimony and beryllium in two samples each; same as above.
	81050 (ten samples)	Beryllium in three samples, selenium and thallium in two samples each, antimony and silver in one sample each same as above.
	80340 (one sample)	Mercury; same as above.
	80666 (two samples)	Mercury in both samples; same as above.
	80870 (seven samples)	Mercury in all the samples; same as above.
	81089 (seven samples)	Mercury in six samples; same as above.
	80451 (one sample)	Antimony and thallium had recoveries in the LCS outside of established limits (80 - 120%). Data are qualified as UJ, and are usable because recovery for antimony was <2% below the limit so it would be detected and quantified if present and the result for thallium is biased high.
	80800 (five samples)	Antimony and thallium in all the samples same as above. Data are qualified as either UJ or J, and are usable because the results are biased high.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES
(Continued)

SUITE	BATCH NUMBER	COMMENTS
Inorganics	81050 (ten samples)[1]	Thallium in all the samples had recoveries in the LCS outside of established limits. Data are qualified as either UJ or J, and are usable because the results are biased high.
	80800 (five samples)	Barium, manganese, and zinc in one sample had matrix spike/matrix spike duplicate recoveries outside of established limits. Data are qualified as J and are usable because the spike levels were too low, i.e., less than or comparable to the concentrations present in the samples, and the recoveries could not be determined. The data are well below the background UTLs so the bias does not affect the data comparison.
	81050 (ten samples)	Antimony, chromium, and silver in one sample same as above. Data are qualified as J and are usable because the chromium result is biased high, the silver spike level was too low, i.e., less than the concentration in the sample, so the recovery could not be determined, and antimony recovery was 50% but was detected above the background at almost one-eighth its SAL.
	80451 (one sample)	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, and zinc were detected in the laboratory blank at or below the MDLs. Sample values are greater than 5X the blank values and are considered valid. Data are not qualified and are usable as detected values.
	80800 (five samples)	Aluminum, antimony, arsenic, barium, chromium, cobalt, lead, manganese, nickel, thallium, vanadium, and zinc; same as above.
	81050 (ten samples)	Aluminum, barium, beryllium, cadmium, chromium, lead, manganese, nickel, selenium, and zinc; same as above.
	80340 (one sample)	Mercury; same as above.
	80870 (seven samples)	Mercury in all samples; same as above.
	81089 (seven samples)	Mercury in all samples; same as above.
SVOC	19378 (one sample)	1,2-Dichlorobenzene, hexachloroethane, and 2-methylphenol had percent recoveries in the blind QC sample <10% and are qualified as R. The data are unusable and are not used in the screening assessment.
		Anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, 4-chloro-3-methylphenol, 2-chloronaphthalene, chrysene, dibenzofuran, diethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 4-methylphenol, naphthalene, pentachlorophenol, pyrene, 1,2,4-trichlorobenzene, and 2,4,6-trichlorophenol had percent recoveries in the blind QC sample outside of established limits (<50%) and are qualified as UJ. The data are usable because the recoveries are sufficient to detect and quantify the analytes if present and the surrogate recoveries were acceptable.
	19461 (three samples)	1,2-Dichlorobenzene had percent recovery in the blind QC sample <10% and is qualified as R. The data are unusable and are not used in the screening assessment.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES (Continued)

SUITE	BATCH NUMBER	COMMENTS
SVOC	19461 (three samples)[1]	Anthracene, 2-chlorophenol, 2-methylphenol, naphthalene, and 1,2,4-trichlorobenzene had percent recoveries in the blind QC sample outside of established limits (<50%) and are qualified as UJ. The data are usable because the recoveries are sufficient to detect and quantify the analytes if present and the surrogate recoveries were acceptable.
	19504 (two samples)	The internal standard, perylene-d12, had low internal standard area response for one sample and the data that are quantified by this standard are qualified as UJ. The data are usable as nondetects because the internal standard response was sufficient to detect and quantify the analytes if present, the instrument sensitivity and responsiveness were not affected, and the surrogate recoveries were acceptable.
	80680 (seven samples)	Anthracene, bis(2-ethylhexyl)phthalate, and fluoranthene in one sample are J qualified because they were below EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.
	80680 (seven samples)	4-Nitrophenol in all samples had recovery in the LCS outside of established limits (75 - 120%) and is qualified as UJ. Data are usable because the recovery was only 4% below the limit, and therefore it would be detected and quantified if present.
	81346 (ten samples)	Pentachlorophenol in all the samples same as above. Data are usable because the recovery was <2% below the limit, and therefore it would be detected and quantified if present.
	80680 (seven samples)	All SVOC laboratory duplicates in one sample had surrogate recoveries of 0% in two of the duplicated surrogates and are qualified as UJ. Data are usable because the other surrogate recoveries were acceptable.
	81346 (ten samples)	All SVOCs in one sample had surrogate recoveries of 0% for three surrogates and 146% for one surrogate and are qualified as UJ. The data are usable because the other surrogate recoveries were acceptable and the one surrogate recovery was high, and therefore the target analytes would be detected and quantified if present or are biased high.
		All SVOCs in one sample had surrogate recoveries of 0% for two surrogates due to matrix interference and are qualified as UJ. The data are usable because recoveries for the other surrogates were acceptable, and therefore the analytes would be detected and quantified if present.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES (Continued)

SUITE	REQUEST NUMBER	COMMENTS
VOC	19387 (two samples)[1]	All VOCs in one sample had all four internal standards outside of control limits and are qualified as UJ. The data are usable because the surrogate recoveries were acceptable, and therefore the analytes would be detected and quantified if present.
	1791 (three samples)	All of the internal standards for one sample had area counts below the established limits. Area counts that varied by more than a factor of two (-50% to +100%) from the associated 12-hr. calibration standard are qualified as J,PM if detected and as UJ if undetected. Further review of the data indicated that the J qualifier should be retained for the detected values. The internal standard 1,4-dichlorobenzene-d4 had a very low area count (<2%) and the nondetect data associated with this standard are qualified as R and detects are qualified as J,PM. Further review of the data indicated that the J qualifier should be retained for the detected values. Re-analysis of the sample found no change in the internal standard area counts. Dilution and re-analysis of the sample found only two internal standards outside of the established limits. The diluted sample should be used in the screening assessment and the data are usable because the instrument sensitivity and response are stable enough to detect and quantify the analytes.
	1808 (three samples)	Two of the internal standards had area counts below the established limits for one sample. Area counts that varied by more than a factor of two (-50% to +100%) from the associated 12 hr. calibration standard are qualified as J,PM if detected and UJ if not detected. Further review of the data indicated that the J qualifier should be retained for the detected values. Re-analysis of the sample found no change in the area counts so the initial analysis is used in the screening assessment. The data qualified as UJ or J are usable because the instrument sensitivity and response are stable enough to detect and quantify the analytes.
	1791 (three samples)	The percent recoveries for two surrogates were outside of established limits for one sample. The detected target compounds are qualified as J+, nondetects are not qualified. The data are usable because the results are biased high.
	1808 (three samples)	The percent recovery for one surrogate was outside of established limits for one sample. The detected target compounds are qualified as J+, nondetects are not qualified. The data are usable because the results are biased high.
	80727 (six samples)	All VOCs in two samples had surrogate recoveries outside of established limits because of matrix interference and are qualified as UJ or J. The data are usable because the results are biased high.
	81149 (ten samples)	All VOCs in two samples had surrogate recoveries outside of established limits because of matrix interference and are qualified as UJ or J. The data are usable because the results are biased high.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES (Continued)

SUITE	BATCH NUMBER	COMMENTS
VOC	80727 (six samples)[1]	Methylene chloride in three samples and acetone in one sample are J qualified because they were below EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.
	81149 (ten samples)	Acetone in nine samples, methylene chloride in seven samples, and benzene, styrene, toluene, and trichlorofluoromethane in one sample each same as above.
	1791 (three samples)	Methylene chloride was detected in the laboratory blank. The sample concentrations were less than 10X the blank value. The sample results > EQL have the EQL raised to the sample result, while sample results < EQL have the sample result raised to the EQL. All data are qualified as U and are used as nondetects in the screening assessment due to blank contamination.
	80429 (one sample)	Methylene chloride was detected in the laboratory blank. The sample value was less than 10X the blank value. The value is not qualified and is usable as a nondetect in the screening assessment due to blank contamination.
	80727 (six samples)	Methylene chloride in all samples same as above. Sample concentrations are less than 10X the blank value. The values are not qualified and are used as nondetects in the screening assessment due to blank contamination.
	81149 (ten samples)	Methylene chloride in all samples same as above. Sample concentrations are less than 10X the blank value. The values are not qualified and are usable as nondetects in the screening assessment due to blank contamination.
	1791 (three samples)	Acetone was detected in three soil samples at concentrations above the EQL. Because this analyte is not expected to be present as a result of site activity and is a common laboratory contaminant, the data are considered nondetects and are usable as such.
	1808 (three samples)	Acetone and methylene chloride were detected in one soil sample and three soil samples, respectively, at concentrations either below the EQLs or slightly above the EQLs. Because these analytes are not expected to be present as a result of site activity and are common laboratory contaminants, the data are considered nondetects and are usable as such.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-1
DATA QUALITY EVALUATION FOR PRS 36-001 (MDA AA) SAMPLES (Continued)

SUITE	REQUEST NUMBER	COMMENTS
HE	19387 (one sample)[1]	Nitrobenzene had percent recovery in the blind QC sample below the established limit (<50%) and is qualified as UJ. The data are usable because the recovery was sufficient to detect and quantify the analyte if present.
	19461 (three samples)	Nitrobenzene had percent recovery in the blind QC sample below the established limit (<50%) and is qualified as UJ. The data are usable because the recovery was sufficient to detect and quantify the analyte if present.
	19389 (two samples)	The analytical holding time (40 days) was exceeded by 115 days. The data are <EQL and are qualified as R because the holding time was grossly exceeded (more than twice the holding time). The data are not used in the screening assessment.
	1808 (three samples)	HMX and 2,4-dinitrotoluene had percent recoveries in LCS outside of established limits (>125%). Data are not qualified because no detections were found.
	80521 (one sample)	HMX in one sample is J qualified because it was below the EQL. The sample result has a high degree of uncertainty because the value cannot be accurately distinguished from instrument "noise" levels. As a result, the datum is usable as an estimated value, but should be used with caution in the screening assessment because it cannot be accurately quantified.
	80692 (six samples)	RDX and HMX in one sample each; same as above.
Radionuclide	1793 (three samples)	The minimum detectable activity (MDA) for uranium-234, uranium-235, and uranium-238 in one sample and its duplicate, and uranium-234 and uranium-238 in two samples were above the EQLs and are qualified as PM. Further review of the data package indicated that the data should be unqualified because the sample results were above the detection limits.
	1810 (three samples)	The minimum detectable activity (MDA) for uranium-234 in all samples and uranium-238 in two samples was above the EQL and are qualified as PM. Further review of the data package indicated that the data should be unqualified because the sample results were above the detection limits.

[1] Number in parenthesis is the total number of samples in each batch for this PRS.

TABLE B-2
DATA QUALITY EVALUATION FOR SKUNK WORKS SAMPLES

SUITE	REQUEST NUMBER	COMMENTS
SVOC	6529752 (seven samples)[1]	Bis(2-ethylhexyl)phthalate in two samples and di-n-butyl phthalate in three samples are J qualified because they were below the EQLs. The sample results have a high degree of uncertainty because the values cannot be accurately distinguished from instrument "noise" levels. As a result, the data are usable as estimated values, but should be used with caution in the screening assessment because they cannot be accurately quantified.
		4-Chloro-3-methyl phenol and pentachlorophenol had matrix spike/matrix spike duplicate recoveries outside of established limits (37% and 30 %, respectively). The data should be qualified as UJ and are usable because the recoveries were 3% and 10%, respectively, below the limits, and therefore the analytes would be detected and quantified if present.
		Bis(2-ethylhexyl)phthalate in three samples is incorrectly qualified as B. The data should be qualified as V, indicating that this analyte was detected in the laboratory blank at a concentration less than 10X the blank value. These data are usable as nondetects due to blank contamination.

[1] Number in parenthesis is the total number of samples in each request for this PRS.

TABLE B-3
DATA QUALITY EVALUATION FOR BURN PIT SAMPLES

SUITE	REQUEST NUMBER	COMMENTS
Inorganic	1699 (four samples)[1]	Antimony and manganese percent recoveries in the spike sample were outside of established limits (75% -125%). The antimony data are qualified as UJ for sample results < EQL and J- for sample results > EQL. The manganese data are qualified as J+ for sample results > EQL. The antimony data are usable because the recovery was <1% below the limit so the analyte would be detected and quantified if present or be below the background UTL when detected. The manganese data are usable because the results were biased high.
	1726 (seven samples)	Antimony, selenium, thallium, and manganese had percent recoveries in the spike sample outside of established limits (75% - 125%). The antimony, selenium, and thallium data are qualified as UJ if the sample results are < EQL and J- if the sample results are > EQL. The manganese data are qualified as J+ if the sample results are > EQL. The antimony and selenium data are usable because the recoveries were > 40%, and therefore the analytes would be detected and quantified if present. The thallium data were usable because the recovery was 1% below the limit so the analyte would be detected and quantified if present. The manganese data are usable because the results were biased high.
		The duplicate of beryllium, calcium, silver, and manganese had Relative Percent Differences (RPDs) outside of control limits (>20%) and are qualified as P (professional judgment needed). Upon further review of the data, the silver and manganese data should not be qualified because the RPDs are within EPA's control limits for soils of 35% or ± 2X CRDL. The beryllium and calcium data should be qualified as J and the qualified data are usable because the RPDs are indicative of the heterogeneity of the soil.
	1699 (four samples)	Arsenic, beryllium, and sodium were detected in the laboratory blank. Arsenic in one sample, beryllium and sodium in all samples were detected above the EQL but <5X the blank values and are qualified as U. The data are usable as nondetects in the screening assessment.
VOC	1698 (four samples)	The area count for the internal standard 1,4-dichlorobenzene-d4 is outside of established limits (<50%) and the data are qualified as UJ. The data are usable because the other internal standards were established and 1,4-dichlorobenzene-d4 was <2% below the limit. As a result, the instrument sensitivity and response are stable enough to detect and quantify the analytes if present.
	1725 (seven samples)	Acetone and methylene chloride were detected in three soil samples each at concentrations either below the EQLs or slightly above the EQLs. Because these analytes are not expected to be present as a result of site activity and are common laboratory contaminants, the data are considered nondetects and are usable as such.
HE	1727 (seven samples)[1]	All HE data for all samples qualified as PM because only eight analytes were run with the Laboratory Control Sample (LCS). Further review of the data indicates that the percent recoveries were established and the spikes should accurately predict the recovery of those analytes that are missing. The use of eight analytes versus all analytes in the LCS is standard practice and provides sufficient data on the accuracy of the analytical method and laboratory performance. Therefore, the data should not be qualified.

[1] Number in parenthesis is the total number of samples in each request for this PRS.

TABLE B-4
DATA QUALITY EVALUATION FOR PRS 36-006 (SDA) SAMPLES

SUITE	REQUEST NUMBER	COMMENTS
Inorganic	1713 (six samples)[1]	Antimony, copper, and iron in all samples had percent recoveries in the spike sample outside of established limits (<75%). Antimony data are qualified as UJ, while copper and iron data are qualified as J-. The data are usable because the recoveries were >50%, so antimony would be detected and quantified if present, and copper and iron are either below background UTLs or above background but well below SALs.
		The duplicates of manganese and zinc had RPDs outside of the 20% control limit and are qualified as P (professional judgment needed). The data should not be qualified because the RPDs are within EPA's control limits for soils of 35% or ± 2X CRDL.
VOC	1712 (six samples)	The area counts for the internal standards chlorobenzene-d5 and 1,4-dichlorobenzene-d4 are outside of established limits (<50%) for four samples and three samples, respectively. The data are qualified as UJ if nondetects and J,PM if detected. Further review of the data indicated that the J qualifier should be retained for the detected values. The data are usable because the other internal standards were acceptable and the area counts were only slightly below the limits. As a result, the instrument sensitivity and response are stable enough to detect and quantify the analytes if present.
		The percent recoveries for one or two surrogates were outside of established limits for four samples. The detected target compounds are qualified as J+; nondetects are not qualified. The data are usable because the results are biased high.
		Methylene chloride was detected at a concentration below its EQL in one sample. Because this analyte is not expected to be present as a result of site activity and is a common laboratory contaminant, the datum is considered a nondetect and is usable as such.
HE	1711 (six samples)	All HE data for all samples qualified as PM because only eight analytes were spiked in the LCS. Further review of the data indicates that the percent recoveries were acceptable and the spikes should accurately predict the recovery of those analytes that are missing. The use of eight analytes versus all analytes in the LCS is standard practice and provides sufficient data on the accuracy of the analytical method and laboratory performance. Therefore, the data should not be qualified.

[1] Number in parenthesis is the total number of samples in each request for this PRS.

APPENDIX C

METHODOLOGIES FOR DEVELOPING SITE-SPECIFIC PRELIMINARY REMEDIATION GOALS

APPENDIX C

METHODOLOGIES FOR DEVELOPING SITE-SPECIFIC PRELIMINARY REMEDIATION GOALS

C.1 Approach to PRG Development

Preliminary remediation goals (PRG) were calculated for several analytes from the PRSs investigated for this report to determine if these analytes posed an unacceptable risk to human health. Risk-based cleanup levels were calculated for those chemicals that failed the screening assessment comparison to SALs, including the analysis of multiple chemicals, as documented in this RFI Report for PRS 36-006, SDA and 36-001, MDA AA.

C.2 PRG Equations

Site-specific PRGs have been calculated using the modified EPA equations and Laboratory site-specific input parameters presented in this appendix. These are based on a healthy working adult under a continued laboratory operations land-use scenario.

Under the non-intrusive industrial land-use scenario, risk resulting from exposure to chemicals in soil is assumed to result from incidental ingestion of soil and inhalation of particulates from soil. PRS 36-006 was evaluated under a non-instrusive industrial land-use scenario because contamination was found in the surface soil (0 to 6 in.). The non-intrusive PRGs are protective of maintenance or office workers who are not actively digging to place/replace sewer lines or to construct buildings. Under the intrusive industrial land-use scenario, risk resulting from exposure to chemicals in soil is assumed to result from incidental ingestion of soil, inhalation of particulates from soil, and dermal contact with soil. PRS 36-001 was evaluated under an intrusive industrial land-use scenario because contamination was found in the subsurface soil (below 2 ft). The intrusive PRGs are for subsurface contamination scenarios in which a construction worker is assumed to be digging below ground surface.

Calculation of PRGs are consistent with Risk Assessment Guidance for Superfund (RAGS) Part B (EPA 1991a, 0302) [Note: all references in this appendix are included in Section 6.] and also considers updates to the RAGS Part B equations (EPA 1991, 1994). The PRGs were developed using the most current sources of EPA-approved toxicity criteria, such as the Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Table (HEAST), and the Environmental Criteria and Assessment Office (ECAO). The equations incorporate EPA default parameters and Laboratory site-specific parameters that are based on the type of industrial exposure activities expected after cleanup and the physical properties of the COPCs.

Equations 1 and 2 were used to estimate the concentration in soil that is most protective of the non-intrusive industrial land-use scenario. Equations 3 and 4 were used to estimate the soil concentration that is most protective of the intrusive land-use scenario. The PRGs are calculated for both carcinogenic and noncarcinogenic chemicals, respectively. The equations for each class of chemicals are similar but use different site-specific input parameters. The methodologies calculate a soil concentration for carcinogens from a target cancer risk of $1x10^{-6}$ (i.e., 1 in 1,000,000). PRGs for noncarcinogenic chemicals are calculated for industrial scenario for a target hazard quotient of 1. The equations for soil combine across all pathways for direct exposure.

Equation 1: Soil Concentration Protective of Individuals Exposed to Carcinogenic Constituents in Non-intrusive Industrial Land-use Scenario

$$C(\text{mg/kg}) = \frac{TR \times BW_a \times AT_c \times 365 \text{ d/y}}{EF_o \times ED_o \left[\frac{IRS_o \times CSF_o}{10^6 \text{ mg/kg}} + IRA_a \times CSF_i \times (\frac{1}{VF_s} + \frac{1}{PEF}) \right]}$$

Where:

C (mg/kg) = Preliminary remedial goal for soil based on exposure to carcinogenic constituents (mg/kg)

TR = Target cancer risk (unitless)
Considered to be 1×10^{-6}

BW_a = Body weight, adult (kg)
Considered to be 70 kg (EPA 1991b)

AT_c = Averaging Time - cancer (years)
Considered to be 70 years (EPA 1991b)

EF_o = Exposure Frequency - occupational (d/y)
Considered to be 250 d/y (EPA 1991a)

ED_o = Exposure duration - occupational (years)
Considered to be 25 years (EPA 1991b)

IRS_o = Soil ingestion - occupational (mg/day)
Considered to be 50 mg/day (EPA 1991b)

CSF_o = Cancer slope factor-oral $(\text{mg/kg-d})^{-1}$ (IRIS, HEAST, or ECAO)

IRA_a = Inhalation rate - adult (mg/day)
Considered to be 20 m^3/day (EPA 1991b)

CSF_i = Cancer slope factor-inhalation $(\text{mg/kg-d})^{-1}$ (IRIS, HEAST, or ECAO)

VF_s = Volatilization factor for soil (mg/kg)
Considered to be zero for chemicals with MW> 200 g/mole and Henry's Law Constant $<1 \times 10^{-5}$ atm-m^3/mole

PEF = Particulate emission factor (mg/kg)
Considered to be $1.11 \times 10^{+7}$ (m^3/kg) (LANL 1993)

Equation 2: Soil Concentration Protective of Individuals Exposed to Non-carcinogenic Constituents in Non-intrusive Industrial Land-use Scenario

$$C(\text{mg/kg}) = \frac{THQ \times BW_a \times ED_o \times 365 \text{ d/y}}{EF_o \times ED_o \left[(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6 \text{ mg/kg}}) + \frac{1}{RfD_i} \times (\frac{IRA_a}{VF_s} + \frac{IRA_a}{PEF}) \right]}$$

Where:

C(mg/kg) = Preliminary remedial goal for soil based on exposure to noncarcinogenic constituents (mg/kg)

THQ = Target hazard quotient (unitless)
Considered to be 1

BW_a = Body weight, adult (kg)
Considered to be 70 kg (EPA 1991b)

ED_o = Exposure duration - occupational (years)
Considered to be 25 years (EPA 1991b)

EF_o = Exposure Frequency - occupational (d/y)
Considered to be 250 d/y (EPA 1991a)

RfD_o = Reference dose-oral (mg/kg-d) (IRIS, HEAST, or ECAO)

IRS_o = Soil ingestion - occupational (mg/day)
Considered to be 50 mg/day (EPA 1991b)

RfD_i = Reference dose inhalation (mg/kg-d) (IRIS, HEAST, or ECAO)

IRA_a = Inhalation rate - adult (mg/day)
Considered to be 20 m^3/day (EPA 1991b)

VF_s = Volatilization factor for soil (mg/kg)
Considered to be zero for chemicals with MW> 200 g/mole and Henry's Law Constant <1 x 10^{-5} atm-m^3/mole

PEF = Particulate emission factor (mg/kg)
Considered to be 1.11 x 10^{+7} (m^3/kg) (LANL 1993)

Equation 3: Soil Concentration Protective of Individuals Exposed to Carcinogenic Constituents in Intrusive Industrial Land-use Scenario

$$C(mg/kg) = \frac{TR \times BW_a \times AT_c \times 365\ d/y}{EF_o \times ED_o \left[\frac{IRS_o \times CSF_o}{10^6\ mg/kg} + IRA_a \times CSF_i \times \left(\frac{1}{VF_s} + \frac{1}{PEF}\right) + \frac{SA \times AF \times ABS \times CSF_d}{10^6\ mg/kg} \right]}$$

Where:

C (mg/kg) = Preliminary remedial goal for soil based on exposure to carcinogenic constituents (mg/kg)

TR = Target cancer risk (unitless)
Considered to be 1 x 10^{-6}

BW_a = Body weight, adult (kg)

Considered to be 70 kg (EPA 1991b)

AT_c = Averaging Time - cancer (years)
Considered to be 70 years (EPA 1991b)

EF_o = Exposure Frequency - occupational (d/y)
Considered to be 90 d/y (LANL 1993)

ED_o = Exposure duration - occupational (years)
Considered to be 1 year (LANL 1993)

IRS_o = Soil ingestion - occupational (mg/day)
Considered to be 480 mg/day (LANL 1993)

CSF_o = Cancer slope factor-oral $(mg/kg\text{-}d)^{-1}$ (IRIS, HEAST, or ECAO)

IRA_a = Inhalation rate - adult (mg/day)
Considered to be 20 m^3/day (EPA 1991b)

CSF_i = Cancer slope factor-inhalation $(mg/kg\text{-}d)^{-1}$ (IRIS, HEAST, or ECAO)

VF_s = Volatilization factor for soil (mg/kg)
Considered to be zero for chemicals with MW> 200 g/mole and Henry's Law Constant $<1 \times 10^{-5}$ atm-m^3/mole

PEF = Particulate emission factor (mg/kg)
Considered to be $1.32 \times 10^{+9}$ (m^3/kg) (LANL 1993)

SA = Skin surface area - occupational (cm^2)
Considered to be 3,200 cm^2 (LANL 1993)

AF = Skin adherence factor (mg/cm^2)
Considered to be 0.2 mg/cm^2 (LANL 1993)

ABS = Skin absorption (unitless)
Considered to be 0.1 for organics and 0.01 for inorganics (LANL 1993)

CSF_d = Cancer slope factor - dermal $(mg/kg\text{-}d)^{-1}$ (by adjustment to CSF_o)

Equation 4: Soil Concentration Protective of Individuals Exposed to Non-carcinogenic Constituents in Intrusive Industrial Land-use Scenario

$$C(mg/kg) = \frac{THQ \times BW_a \times ED_o \times 365\ d/y}{EF_o \times ED_o \left[\left(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6\ mg/kg}\right) + \frac{1}{RfD_i} \times \left(\frac{IRA_a}{VF_s} + \frac{IRA_a}{PEF}\right) + \frac{1}{RfD_d} \times \frac{SA \times AF \times ABS}{10^6\ mg/kg} \right]}$$

Where:

C(mg/kg) = Preliminary remedial goal for soil based on exposure to noncarcinogenic constituents (mg/kg)

THQ = Target hazard quotient (unitless)
Considered to be 1

BW_a = Body weight, adult (kg)
Considered to be 70 kg (EPA 1991b)

ED_o = Exposure duration - occupational (years)
Considered to be 1 year (LANL 1993)

EF_o = Exposure Frequency - occupational (d/y)
Considered to be 90 d/y (LANL 1993)

RfD_o = Reference dose-oral (mg/kg-d) (IRIS, HEAST, or ECAO)

IRS_o = Soil ingestion - occupational (mg/day)
Considered to be 480 mg/day (LANL 1993)

RfD_i = Reference dose inhalation (mg/kg-d) (IRIS, HEAST, or ECAO)

IRA_a = Inhalation rate - adult (mg/day)
Considered to be 20 m^3/day (EPA 1991b)

VF_s = Volatilization factor for soil (mg/kg)
Considered to be zero for chemicals with MW> 200 g/mole and Henry's Law Constant <1 x 10^{-5} atm-m^3/mole

PEF = Particulate emission factor (mg/kg)
Considered to be 1.32 x 10^{+9} (m^3/kg) (LANL 1993)

SA = Skin surface area - occupational (cm^2)
Considered to be 3,200 cm^2 (LANL 1993)

AF = Skin adherence factor (mg/cm^2)
Considered to be 0.2 mg/cm^2 (LANL 1993)

ABS = Skin absorption (unitless)
Considered to be 0.1 for organics and 0.01 for inorganics (LANL 1993)

RfD_d = Reference dose - dermal (mg/kg-d) (by adjustment to RfD_o)

C.3 Multiple Chemical PRG Analysis

When two or more COPCs are present at a site at concentrations at or below their respective PRGs, a multiple chemical PRG risk analysis is conducted for carcinogenic risk and noncarcinogenic health hazard. The multiple chemical PRG risk analysis is estimated by adding together the fractional contributions (i.e., site-specific concentration / PRG) of each chemical. For carcinogenic cancer risk estimates, the fractional contribution of each is added together and multiplied by 1x10^{-6} target cancer risk:

$$\textit{Multiple PRG Risk} = [(conc_X / PRG_X) + (conc_Y / PRG_Y) + (conc_Z / PRG_Z)] \times 10^{-6}$$

If the multiple chemical PRG risk is at or below the target value of 10^{-6}, the site will be considered to not present a carcinogenic risk.

For noncarcinogenic hazard estimates, the fractional contribution of each will be added together and compared with a target hazard index of 1:

$$PRG\ Hazard\ Index = [(conc_X / PRG_X) + (conc_Y / PRG_Y) + (conc_Z / PRG_Z)]$$

If the PRG hazard index is at or below the target hazard index of 1, then the site will be considered to not pose a toxic effect.

C.4 Site-Specific PRG Analyses

C.4.1 PRS 36-006, SDA

C.4.1.1 Land Use

The anticipated future use of PRS 36-006 is primarily industrial/commercial under a continued Laboratory operation. The non-intrusive industrial land-use scenario was evaluated because chromium (assumed to be present as chromium III) was detected in the surface soil (0 to 6 in.) at the site.

C.4.1.2 PRG Assessment

Chromium failed the screening assessment at PRS 36-006 and was carried forward for further evaluation based on comparison with a site-specific PRG. Calculation of the site-specific PRG was based on the Laboratory's expected land use. Table C-1 and Table C-2 summarize the toxicity criteria for chromium III used to calculate the cleanup level. Table C-3 shows the site specific PRG for chromium III. The PRG for chromium III was calculated using Equation 2 for noncarcinogenic effects; the PRG is 2.04E+06 mg/kg. No carcinogenic effect is noted for trivalent chromium.

C.4.2 PRS 36-001, MDA

C.4.2.1 Land Use

The anticipated future use of PRS 36-001 is primarily industrial/commercial under a continued Laboratory operation. The intrusive industrial land-use scenario was evaluated because the COPCs were detected in the subsurface soil (below 2 ft) at the site.

C.4.2.2 PRG Assessment

A multiple chemical PRG analysis was conducted for ten COPCs retained at PRS 36-001. 3,3'-dichlorobenzidine was evaluated for carcinogenic risk while the other noncarcinogenic COPCs were evaluated by a multiple chemical PRG analysis. The site-specific PRGs were calculated based on an intrusive industrial scenario using standard EPA default parameters and site-specific assumptions (LANL 1993). The total hazard ratio for the noncarcinogenic COPCs was calculated to be 0.5. The carcinogenic risk ratio for 3,3'-dichlorobenzidine, was calculated to be 6E-08. Table C-4 summarizes the multiple chemical PRG analysis for PRS 36-001.

The human risk from exposure to low doses of ionizing radiation is that of cancer inductions and is expressed in terms of the probability of developing cancer. The acceptable annual dose to a worker at a remediated site is 30 mrem/yr. For PRS 36-001, the soil concentration of depleted uranium that will result in an exposure of 30 mrem/yr is 701 pCi/g (Appendix F). Based on this concentration, worker cancer risk

is 1.2×10^{-5}. The 95% UCL of the arithmetic mean concentration for U-238 (134 pCi/g) produces a worker dose that is about five times less (6.48 mrem/yr) than the acceptable annual dose and a worker cancer risk of 2.6×10^{-6}.

TABLE C-1
ORAL AND INHALATION TOXICITY CRITERIA[1]

Chemical	Oral Reference Dose (RfD) (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	Inhalation RfD (mg/kg/day)	Inhalation Slope Factor $(mg/kg/day)^{-1}$
Anthracene	3E-01	N/A	N/A	N/A
Antimony	4E-04	N/A	N/A	N/A
Chromium III	1E+00	N/A	N/A	N/A
Cobalt	6E-02	N/A	N/A	N/A
Copper	4E-02	N/A	N/A	N/A
3,3'-Dichlorobenzidine	NA	4.5E-01	N/A	N/A
Nickel	2E-02	N/A	N/A	N/A
Silver	5E-03	N/A	N/A	N/A
Thallium	9E-05	N/A	N/A	N/A
Uranium (soluble salts)	3E-03	N/A	N/A	N/A

N/A = Not applicable

[1]Lead and isotopic uranium not included on table because their PRGs were derived separately.

TABLE C-2
DERMAL TOXICITY CRITERIA[1]

Chemical	Oral Absorption Fraction (Unitless)	Dermal (RfD) (mg/kg/day)	Dermal Slope Factor $(mg/kg/day)^{-1}$
Anthracene	1	3E-01	N/A
Antimony	0.1	4E-05	N/A
Chromium III[2]	0.004	4E-03	N/A
Cobalt	1	6E-02	N/A
Copper	0.97	3.9E-02	N/A
3,3'-Dichlorobenzidine	1	N/A	4.5E-01
Nickel	0.1	2E-03	N/A
Silver	0.1	5E-04	N/A
Thallium	1	9E-05	N/A
Uranium (soluble salts)	1	3E-03	N/A

N/A = Not applicable

[1]Lead and isotopic uranium not included on table because their PRGs were derived separately.

[2]Total chromium was assumed to be chromium III based on historical information.

TABLE C-3
PRG SUMMARY TABLE

Chemical	Noncancer PRG (mg/kg)	Cancer PRG (mg/kg)	PRG (lower of two) (mg/kg)
PRS 36-006 (Non-intrusive Soil Scenario)[1]			
Chromium III	2.04E+06	N/A	2.04E+06
PRS 36-001 (Intrusive Soil Scenario)[2]			
Anthracene	1.57E+02	N/A	1.57E+02
Antimony	2.09E+02	N/A	2.09E+02
Chromium III	1.36+05	N/A	1.36+05
Cobalt	3.50E+04	N/A	3.50E+04
Copper	2.33E+04	N/A	2.33E+04
3,3'-Dichlorobenzidine	N/A	8.12E+01	8.12E+01
Lead[3]	1E+03	N/A	1E+03
Nickel	1.04E+04	N/A	1.04E+04
Silver	2.61E+03	N/A	2.61E+03
Thallium	5.25E+01	N/A	5.25E+01
Uranium (soluable salts)	1.75E+03	N/A	1.75E+03

[1] Non-intrusive includes incidental ingestion and inhalation of soil routes of exposure.

[2] Intrusive includes incidental ingestion, inhalation, and dermal contact with soil exposure routes.

[3] PRG based on EPA guidance and was not derived using PRG equations.

N/A = Not applicable

TABLE C-4
MULTIPLE CHEMICAL PRG ANALYSIS FOR 36-001, MDA AA

Chemical	Exposure Point Concentration (mg/kg)[1]	Intrusive Industrial PRG (mg/kg)	PRG Ratio
Non-Carcinogens			**Hazard Index**
Anthracene	1.00	1.57E+02	6.37E-06
Antimony	3.37	2.09E+02	1.61E-02
Chromium III	24.4	1.35E+05	1.81E-04
Cobalt	70.4	3.50E+04	2.01E-03
Copper	2,960	2.33E+04	1.27E-01
Lead	263	1.0E+03	2.63E-01
Nickel	69.0	1.04E+04	6.63-03
Silver	33.3	2.61E+03	1.28E-02
Thallium	1.70	5.25E+01	3.24E-02
Total Uranium	136	1.75E+03	7.77E-02
Hazard Index			**5.4E-01**
Carcinogens			**Risk**
3,3'-Dichlorobenzidine	5.00	8.12E+01	6.16E-08
Cancer Risk			**6E-08**

[1]Exposure point concentration is discussed in Section 5.4.7.2.

APPENDIX D

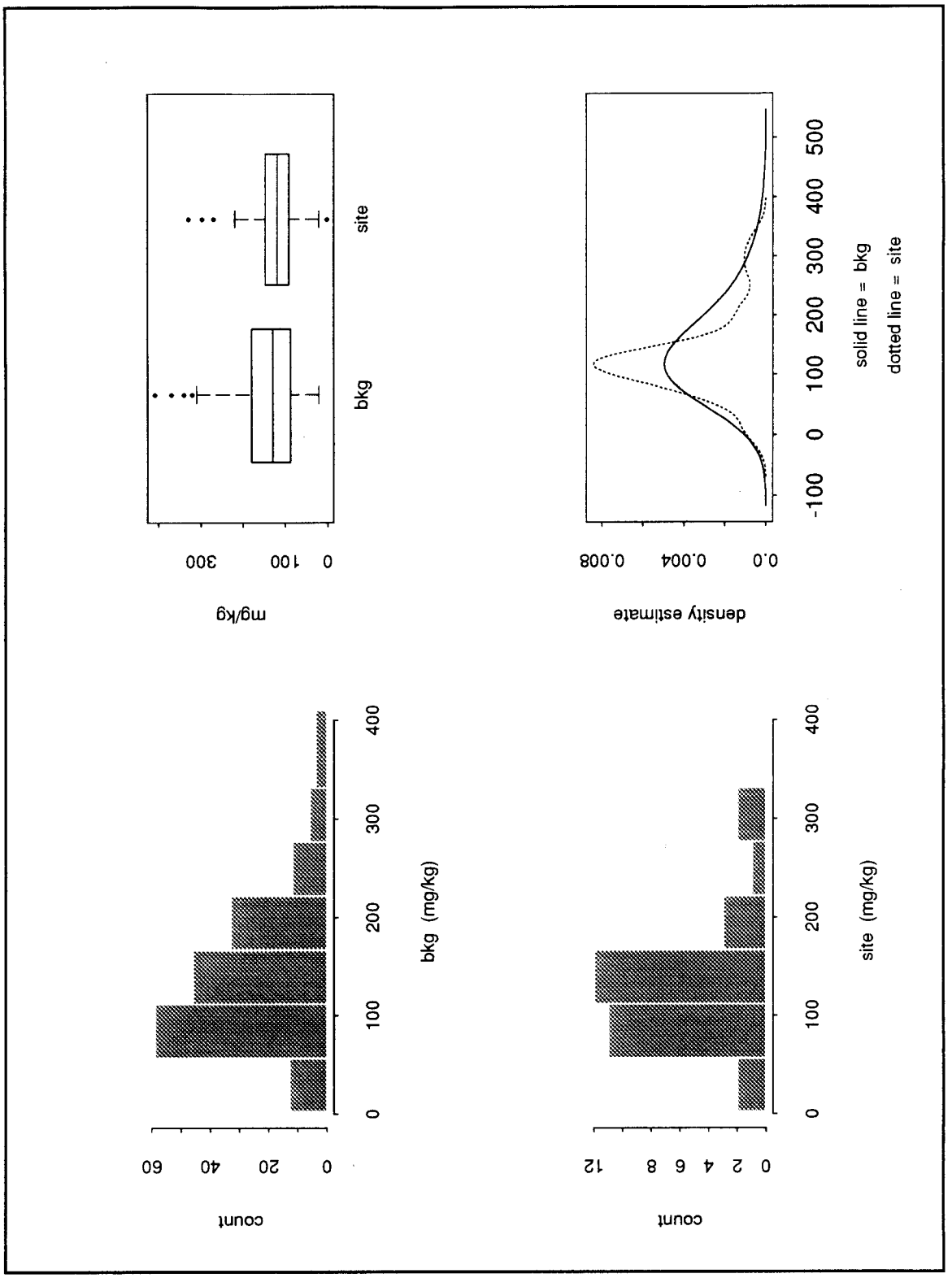
DISTRIBUTIONAL COMPARISONS WITH BACKGROUND

APPENDIX D

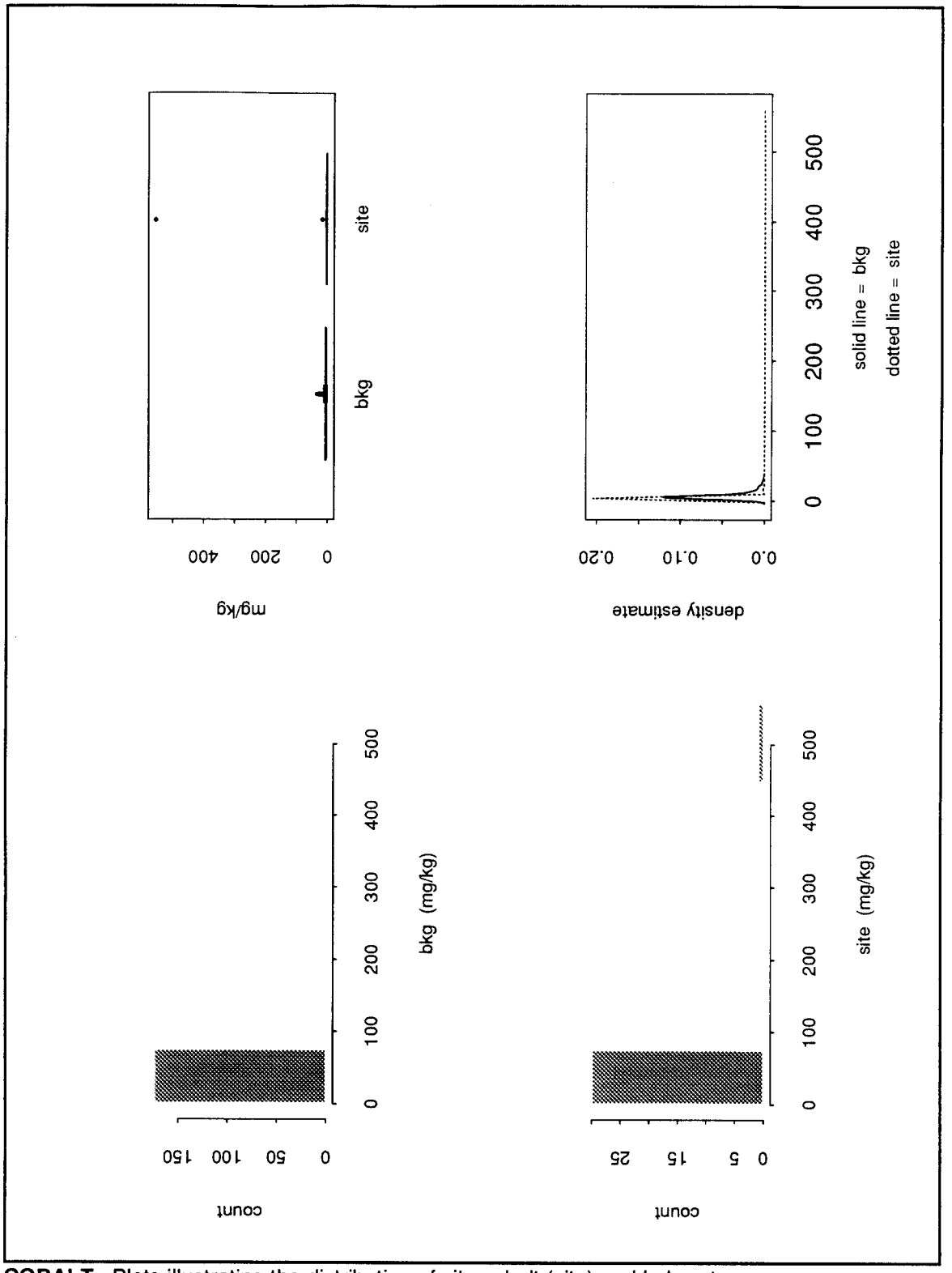
DISTRIBUTIONAL COMPARISONS WITH BACKGROUND

This appendix includes graphical representations of the distributions of data for each analyte that has an exceedence of its Laboratory background upper tolerance limit (UTL) by PRS. The four displays on each page are:

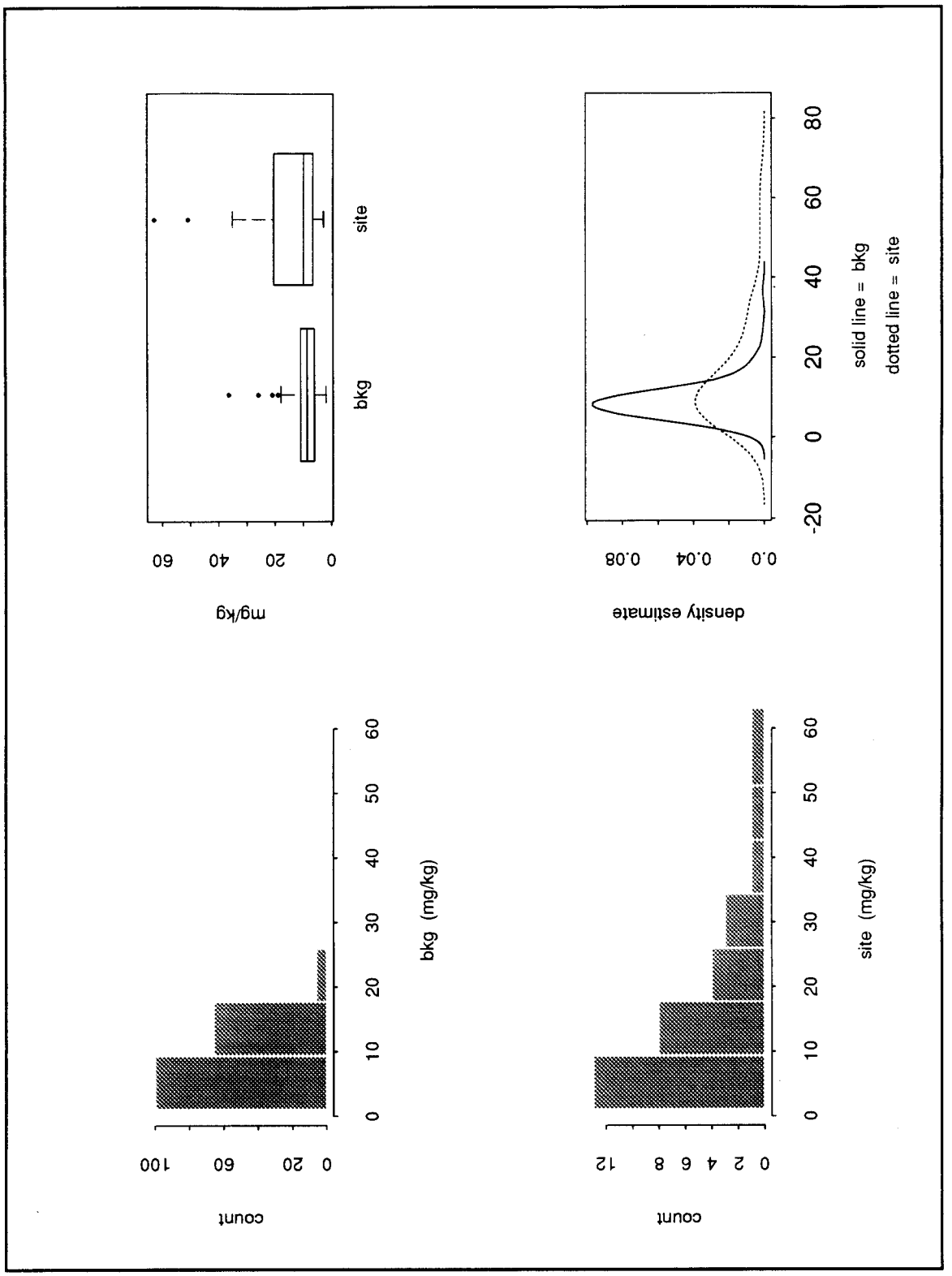
- In the upper left corner—the histogram of the Laboratory background data is presented for the analyte being considered. The horizontal axis gives the observed concentrations in mg/kg, while the vertical axis gives the number of observations in each concentration class.
- In the lower left corner—the histogram of the site data for the analyte being considered. The axes are the same as for the Laboratory background data histogram.
- In the upper right corner—density functions of both the Laboratory background data and the site data for the analyte being considered. The density functions are smoothed, normalized "histograms" where the horizontal axis is again concentrations in mg/kg. The vertical axis is essentially equivalent to the probability of observing any particular concentration. Because these are continuous distributions, the probabilities are actually the areas under the curve within some interval of concentrations.
- In the lower right corner—box plots of both the Laboratory background data and the site data for the analyte being considered. The white line in the middle of each plot shows the median of the data set. The dark areas of these plots are the regions between the 25th percentiles and the 75th percentiles. The square brackets give an interval outside of which data may be considered to be significantly different from the rest of the data set. The vertical axis is concentrations of the observed data in mg/kg.



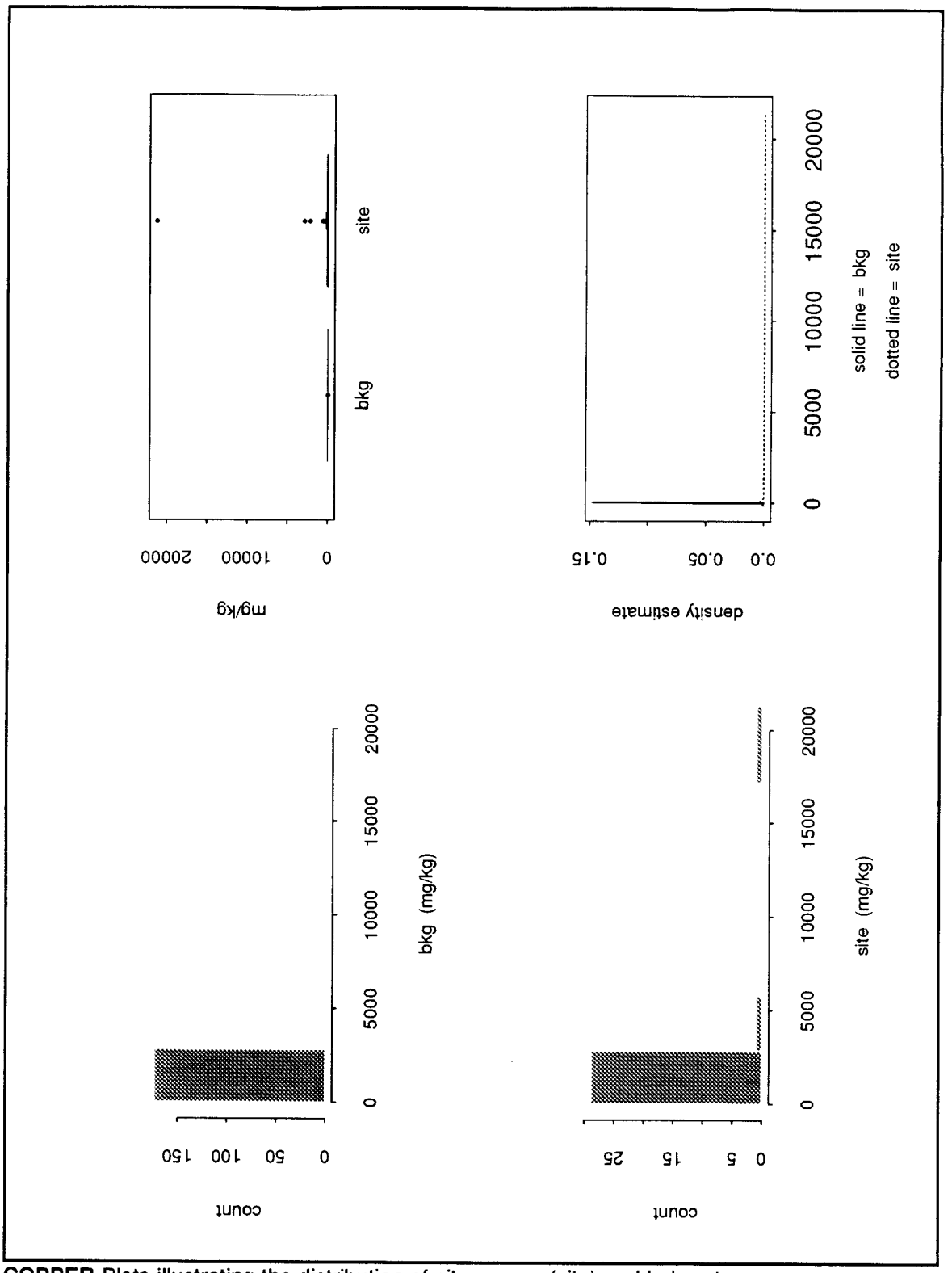
BARIUM Plots illustrating the distribution of site barium (site) and Laboratory background barium (bkg) for PRS 36-001.



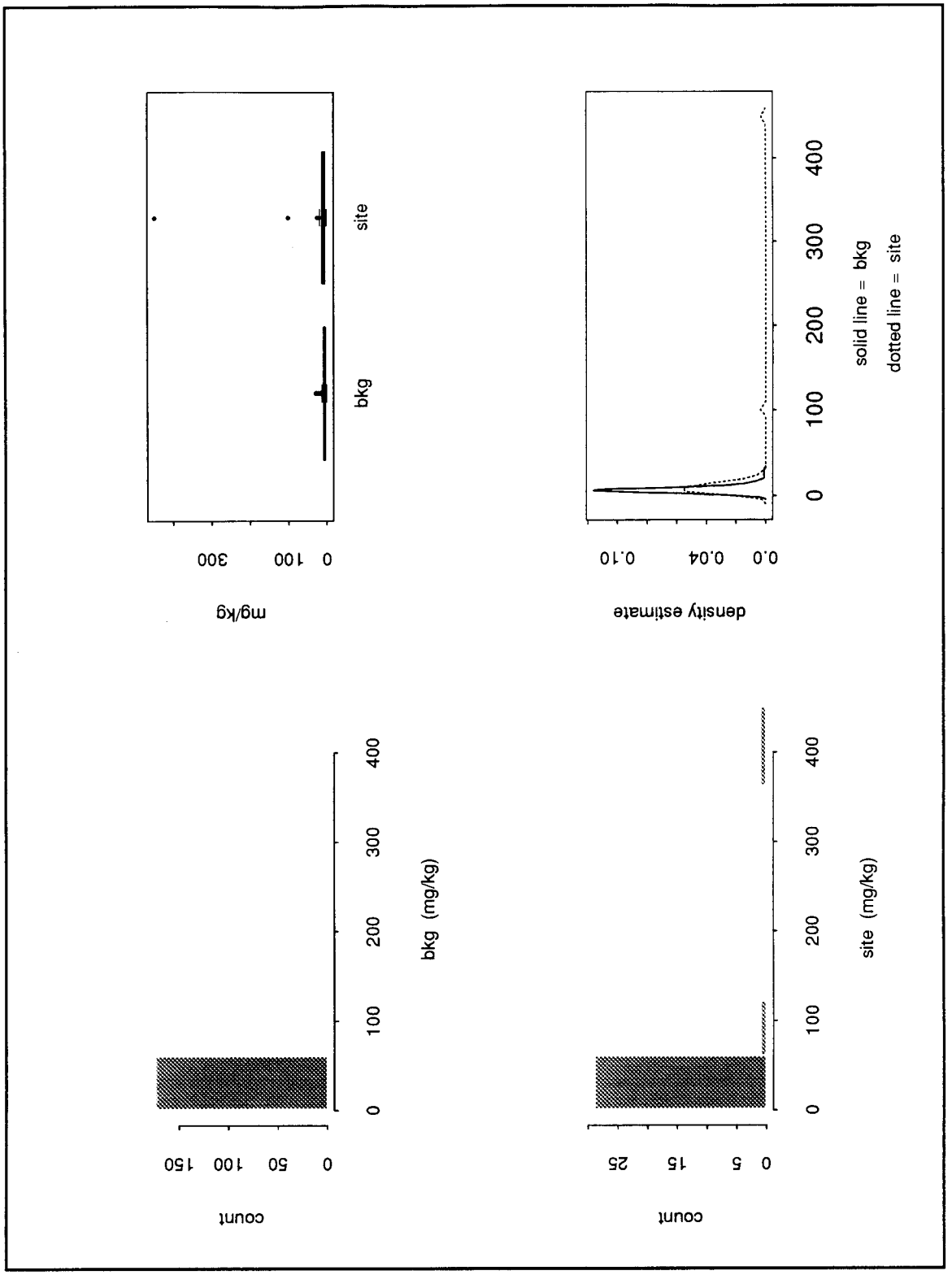
COBALT. Plots illustrating the distribution of site cobalt (site) and Laboratory background cobalt (bkg) for PRS 36-001.



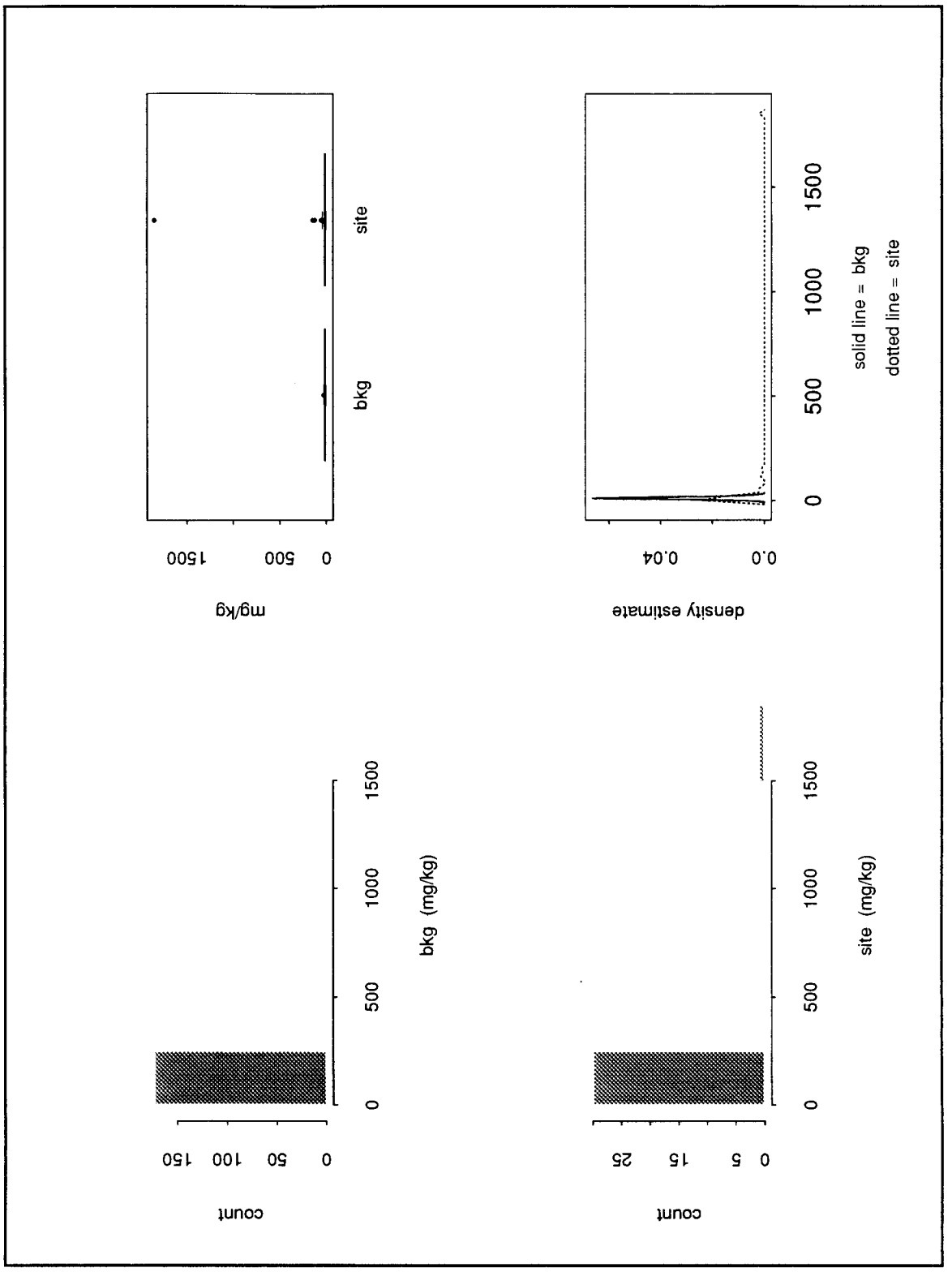
CHROMIUM Plots illustrating the distribution of site chromium (site) and Laboratory background chromium (bkg) for PRS 36-001.



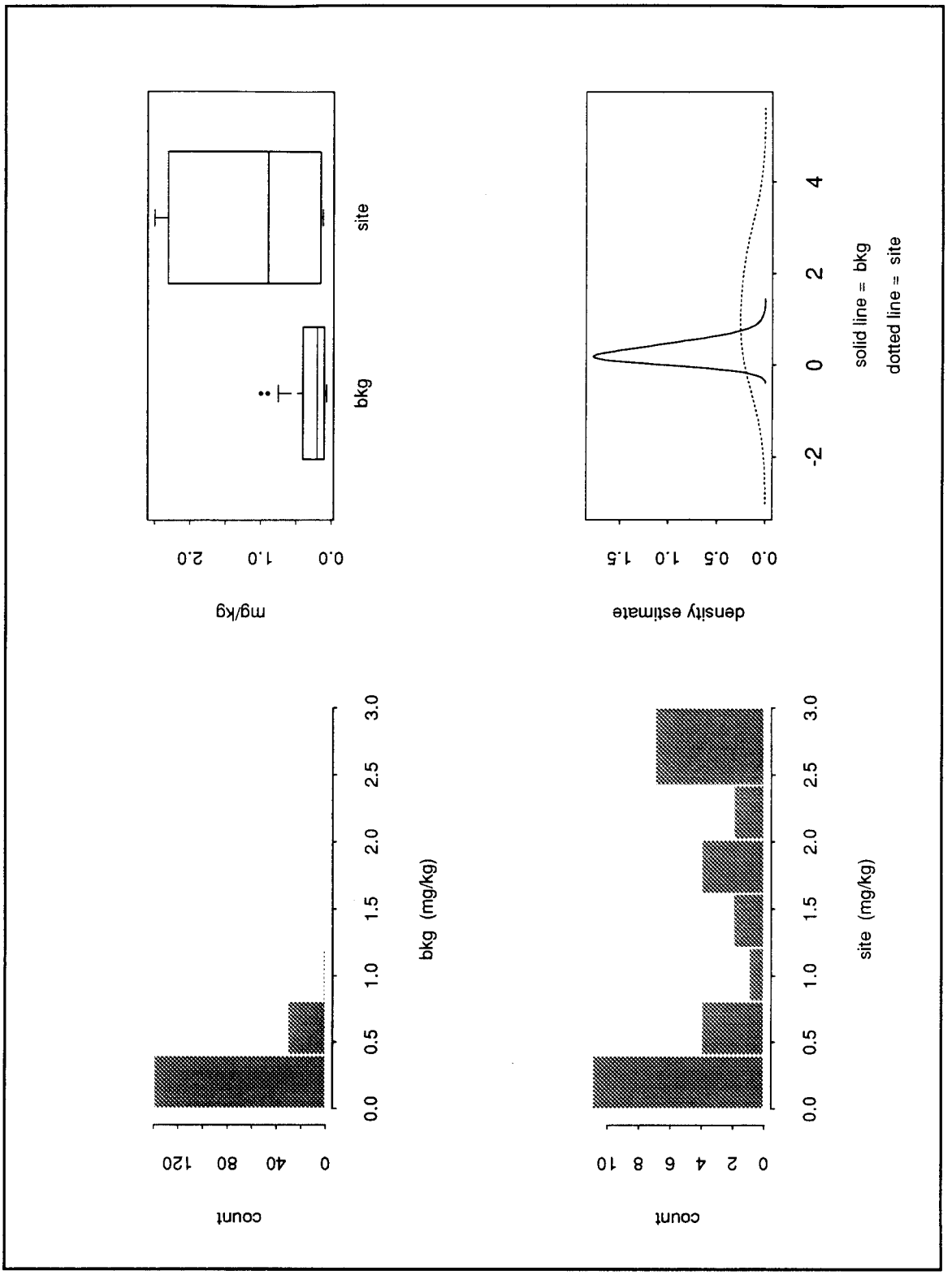
COPPER Plots illustrating the distribution of site copper (site) and Laboratory background copper (bkg) for PRS 36-001.



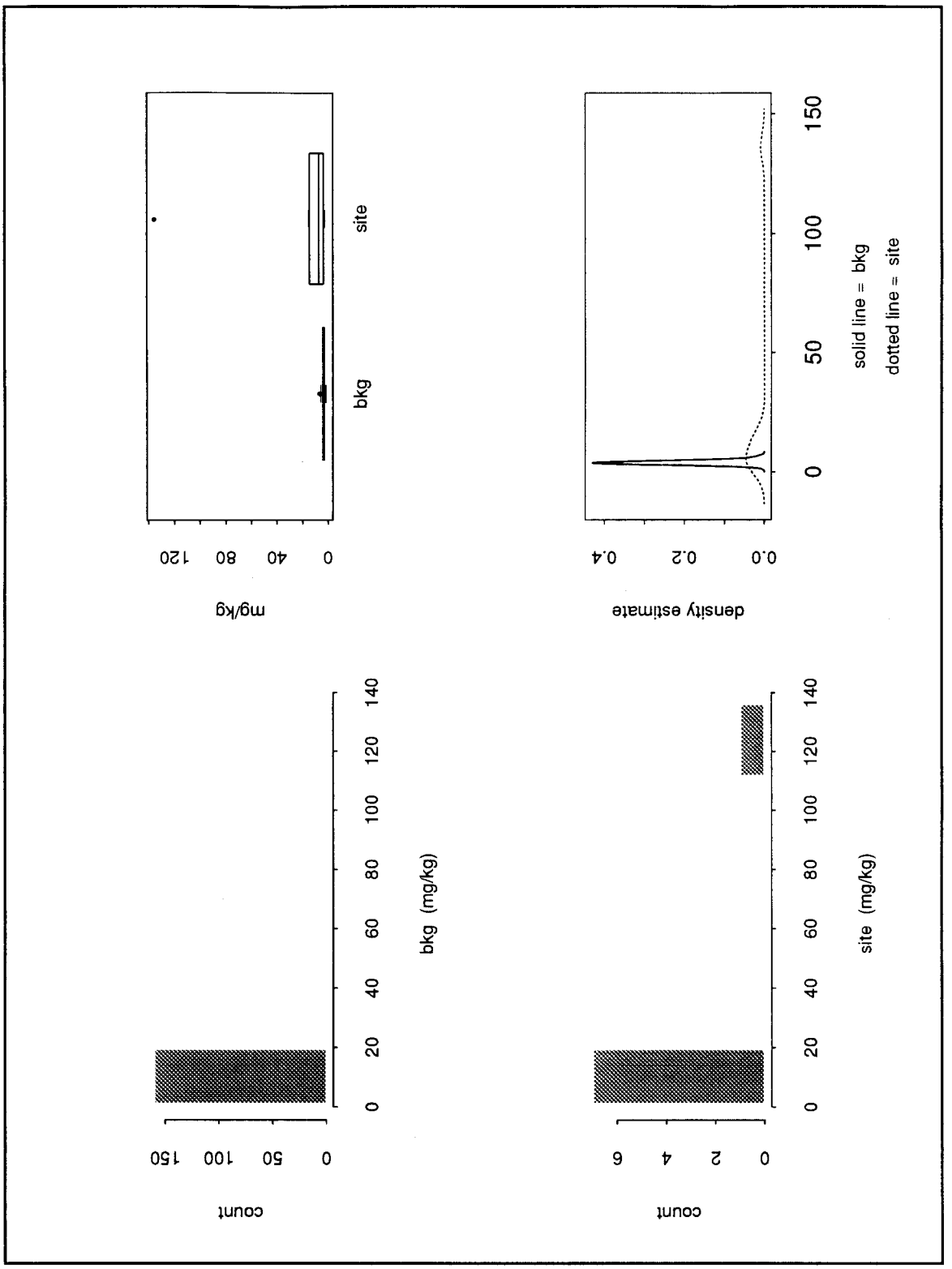
NICKEL Plots illustrating the distribution of site nickel (site) and Laboratory background nickel (bkg) for PRS 36-001.



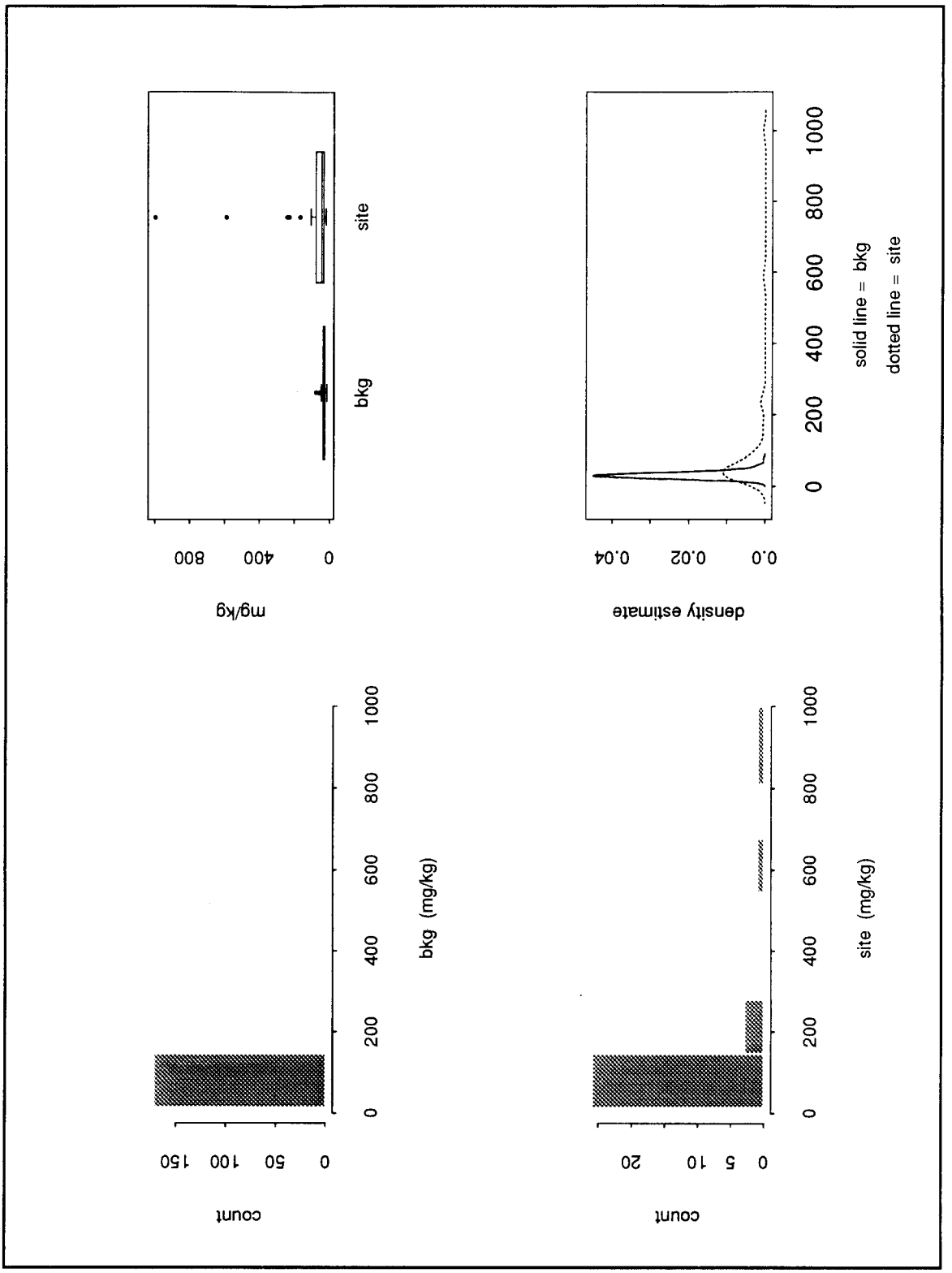
LEAD Plots illustrating the distribution of site lead (site) and Laboratory background lead (bkg) for PRS 36-001.



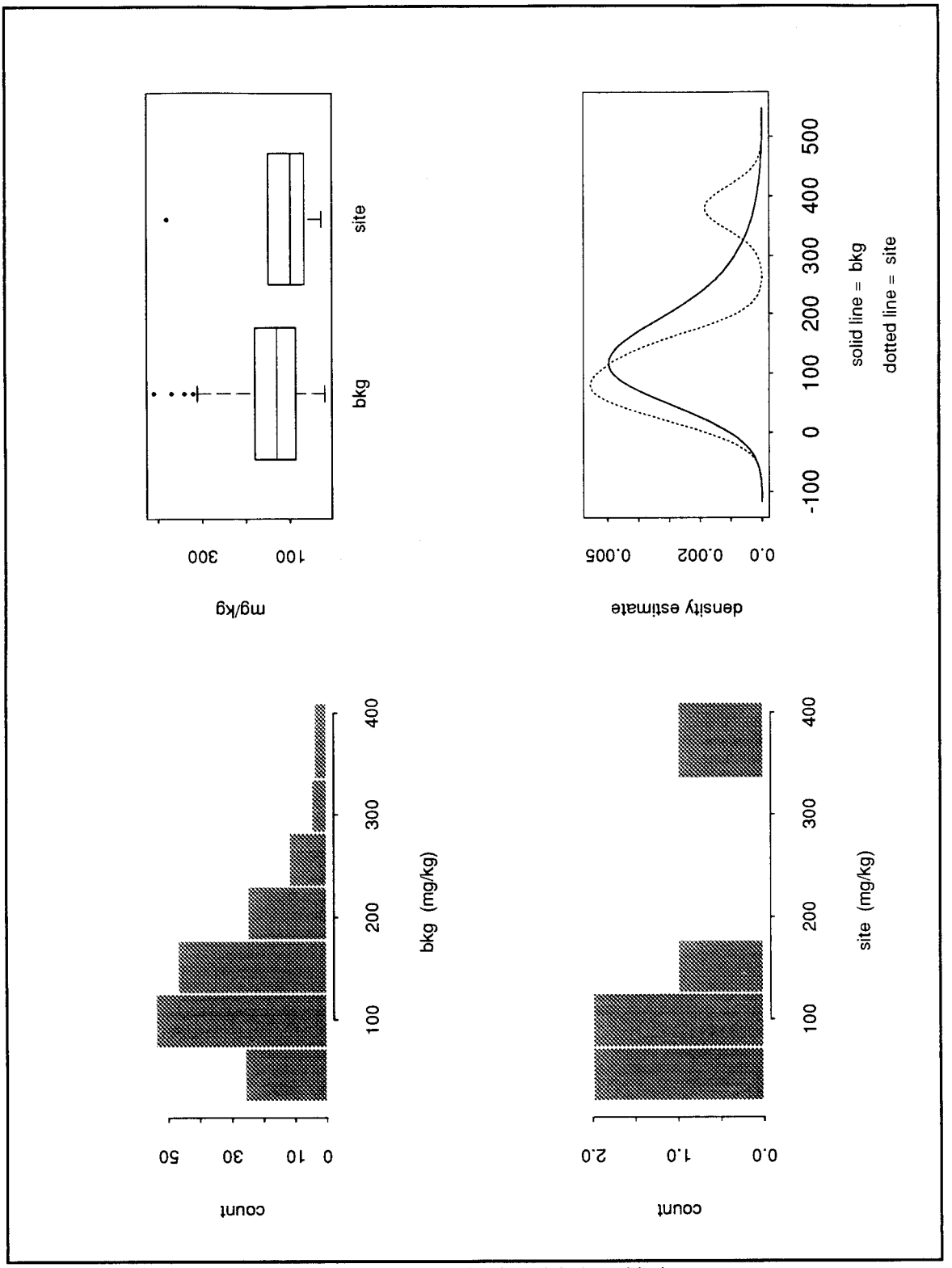
THALLIUM Plots illustrating the distribution of site thallium (site) and Laboratory background thallium (bkg) for PRS 36-001.



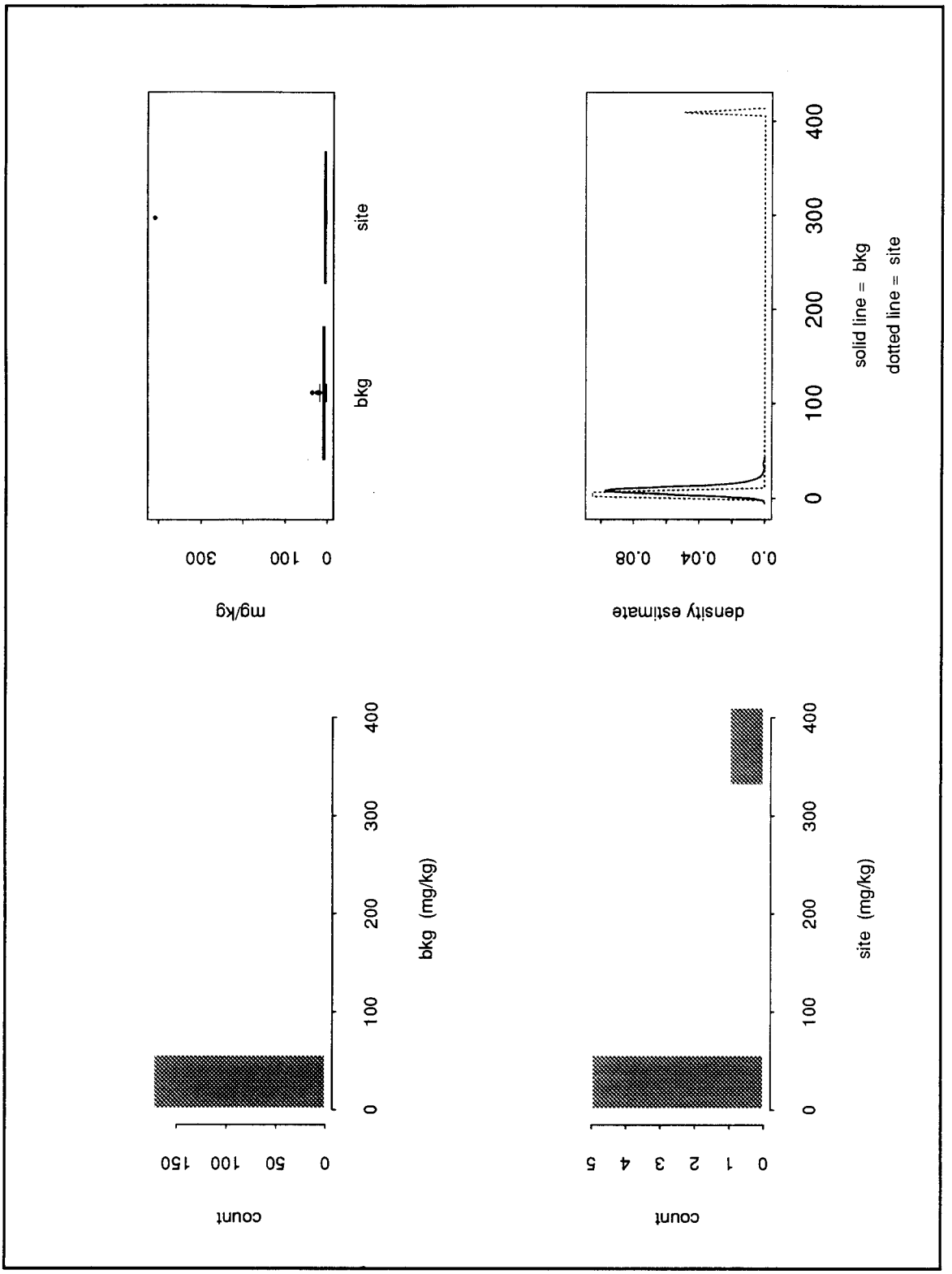
TOTAL URANIUM Plots illustrating the distribution of site total uranium(site) and Laboratory background total uranium (bkg) for PRS 36-001.



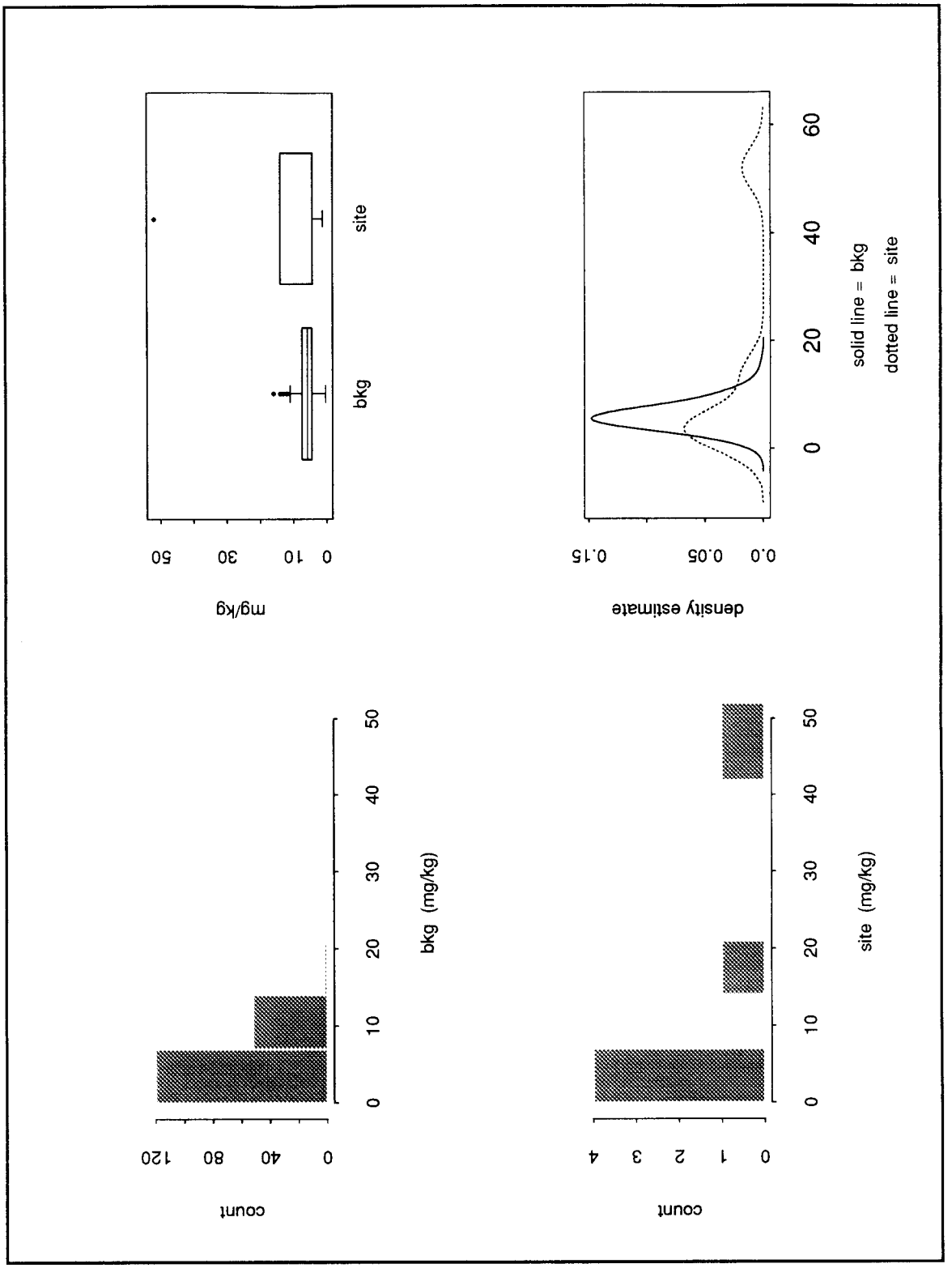
ZINC Plots illustrating the distribution of site zinc (site) and Laboratory background zinc (bkg) for PRS 36-001.



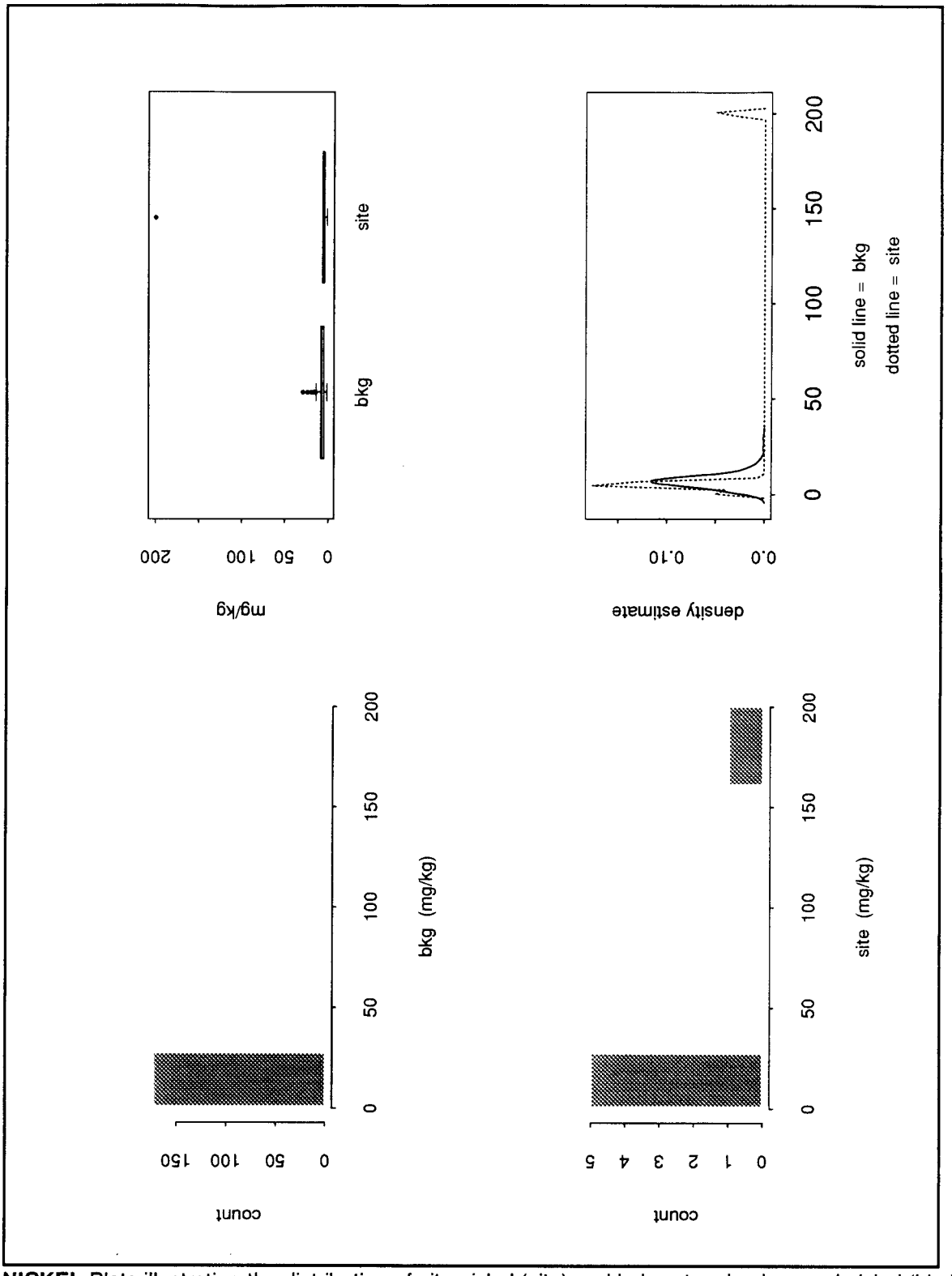
BARIUM Plots illustrating the distribution of site barium (site) and Laboratory background barium (bkg) for PRS 36-006.



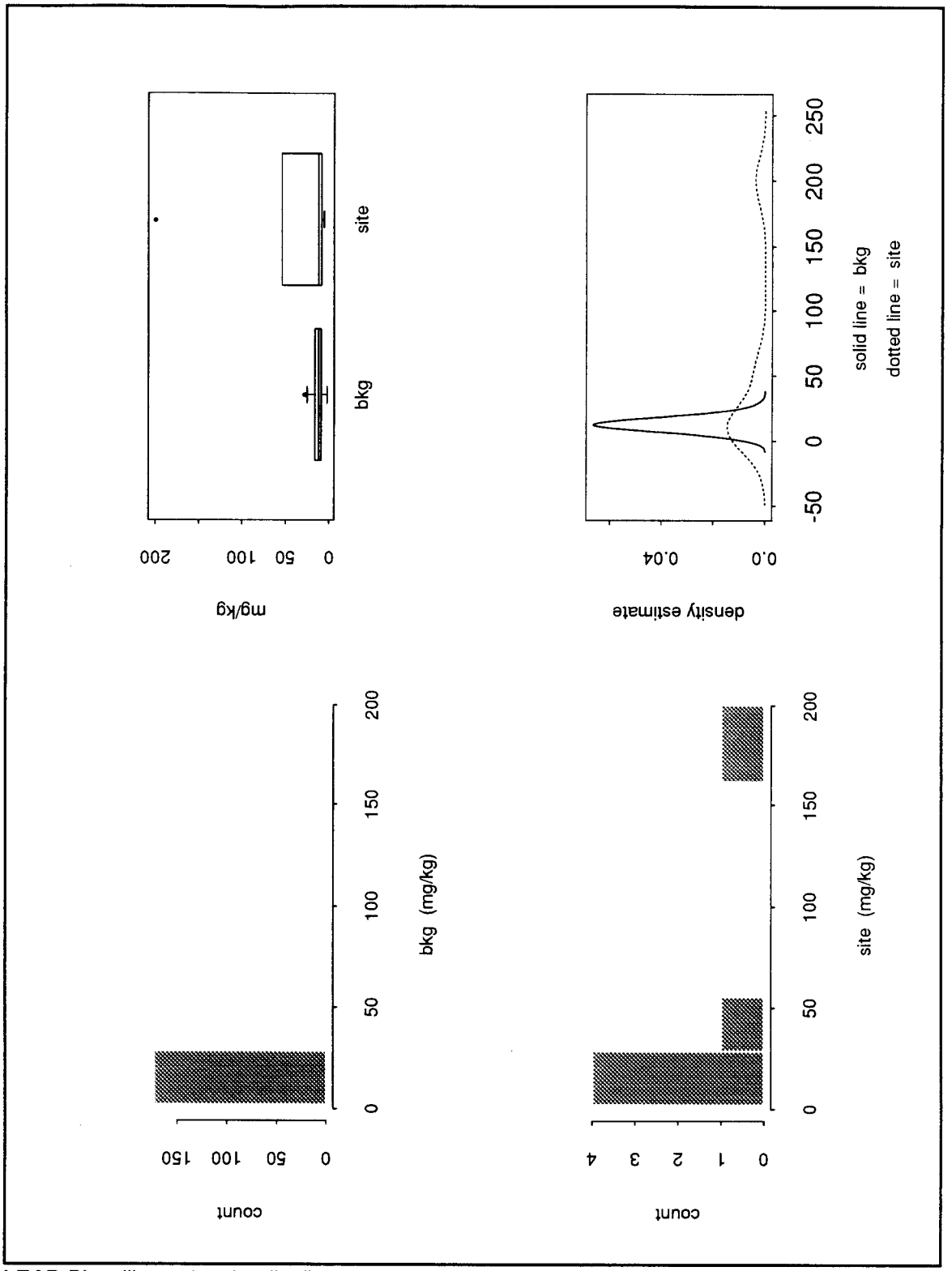
CHROMIUM Plots illustrating the distribution of site chromium (site) and Laboratory background chromium (bkg) for PRS 36-006.



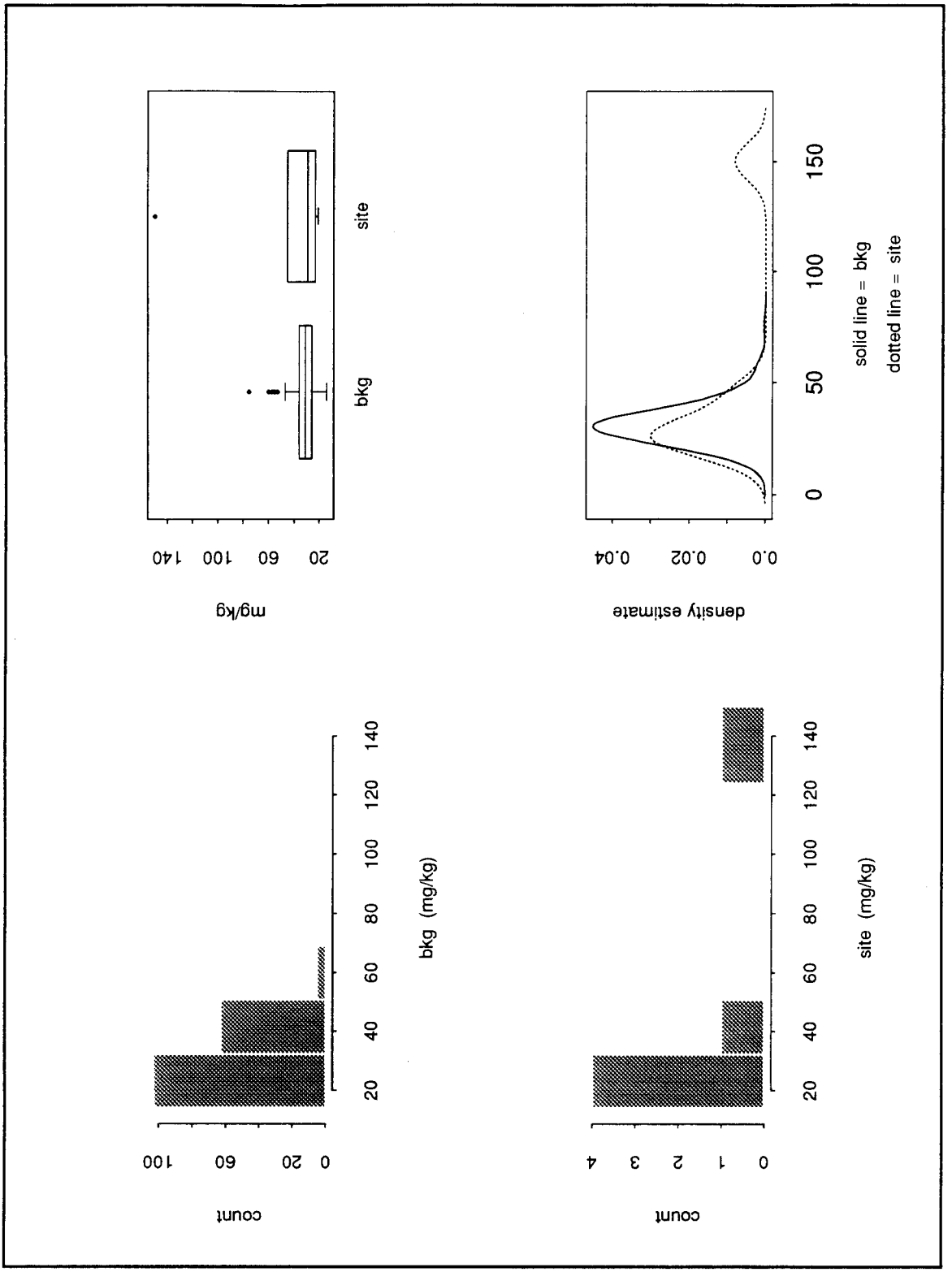
COPPER Plots illustrating the distribution of site copper (site) and Laboratory background copper (bkg) for PRS 36-006.



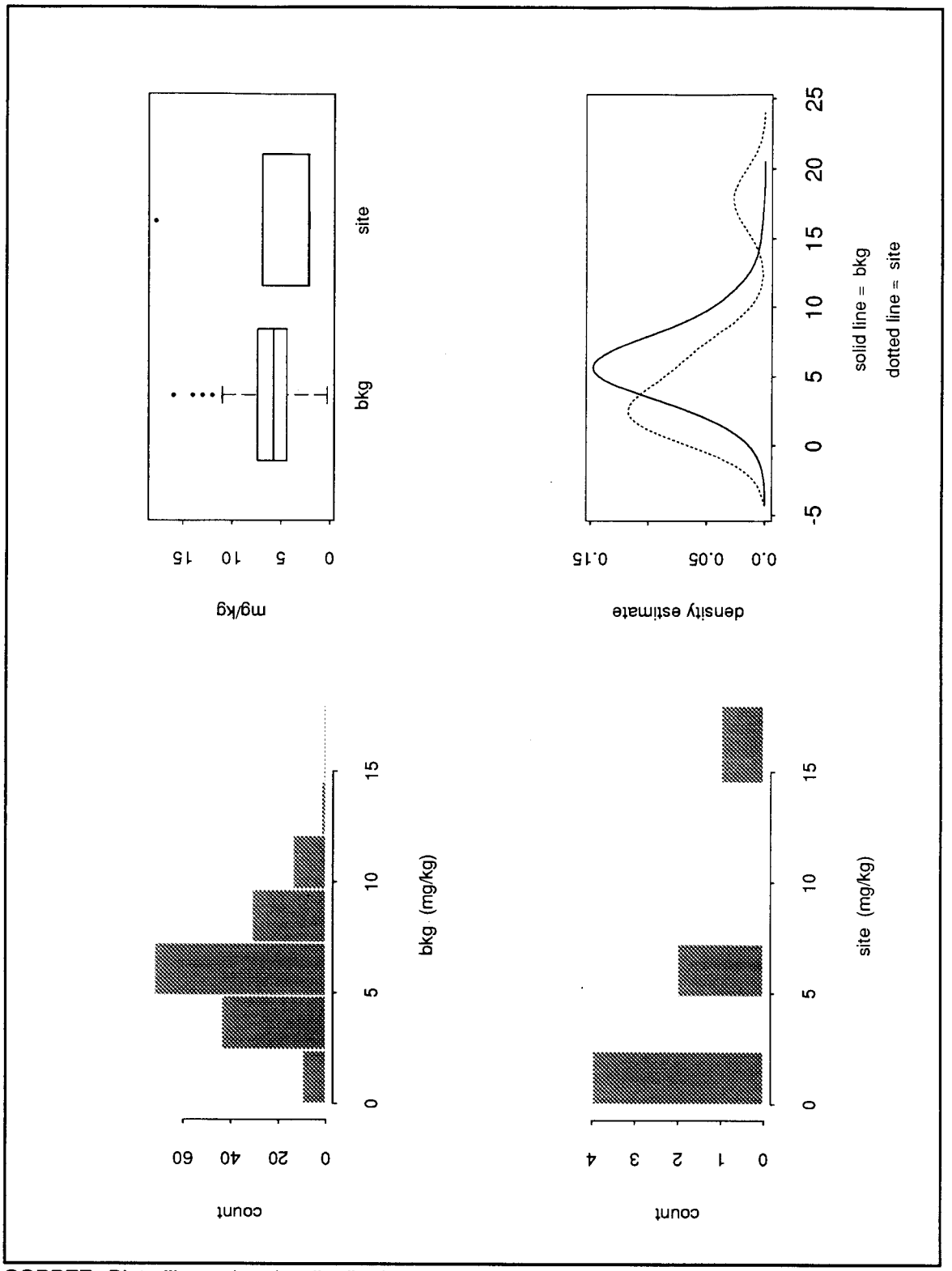
NICKEL Plots illustrating the distribution of site nickel (site) and Laboratory background nickel (bkg) for PRS 36-001.



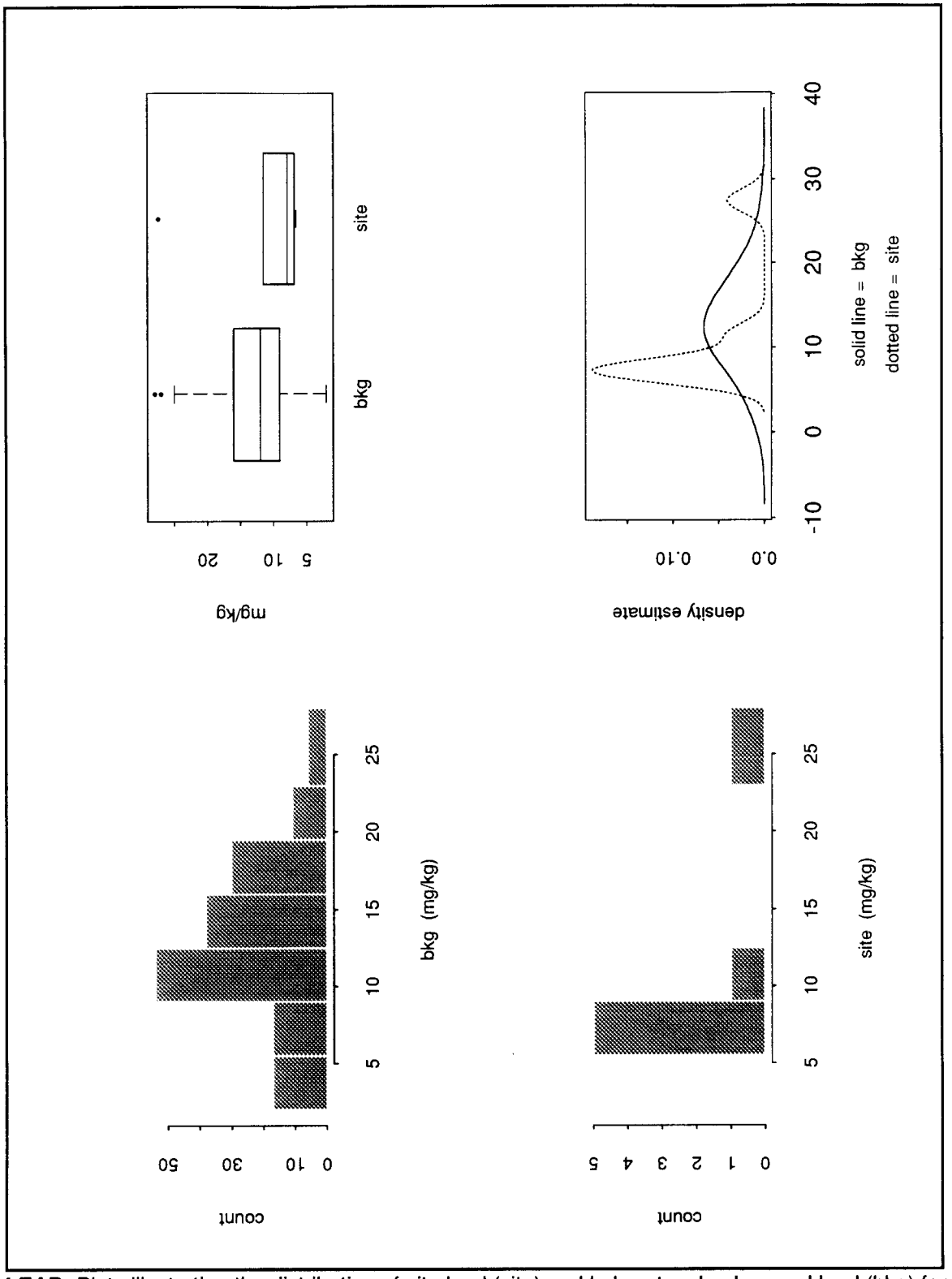
LEAD Plots illustrating the distribution of site lead (site) and Laboratory background lead (bkg) for PRS 36-006.



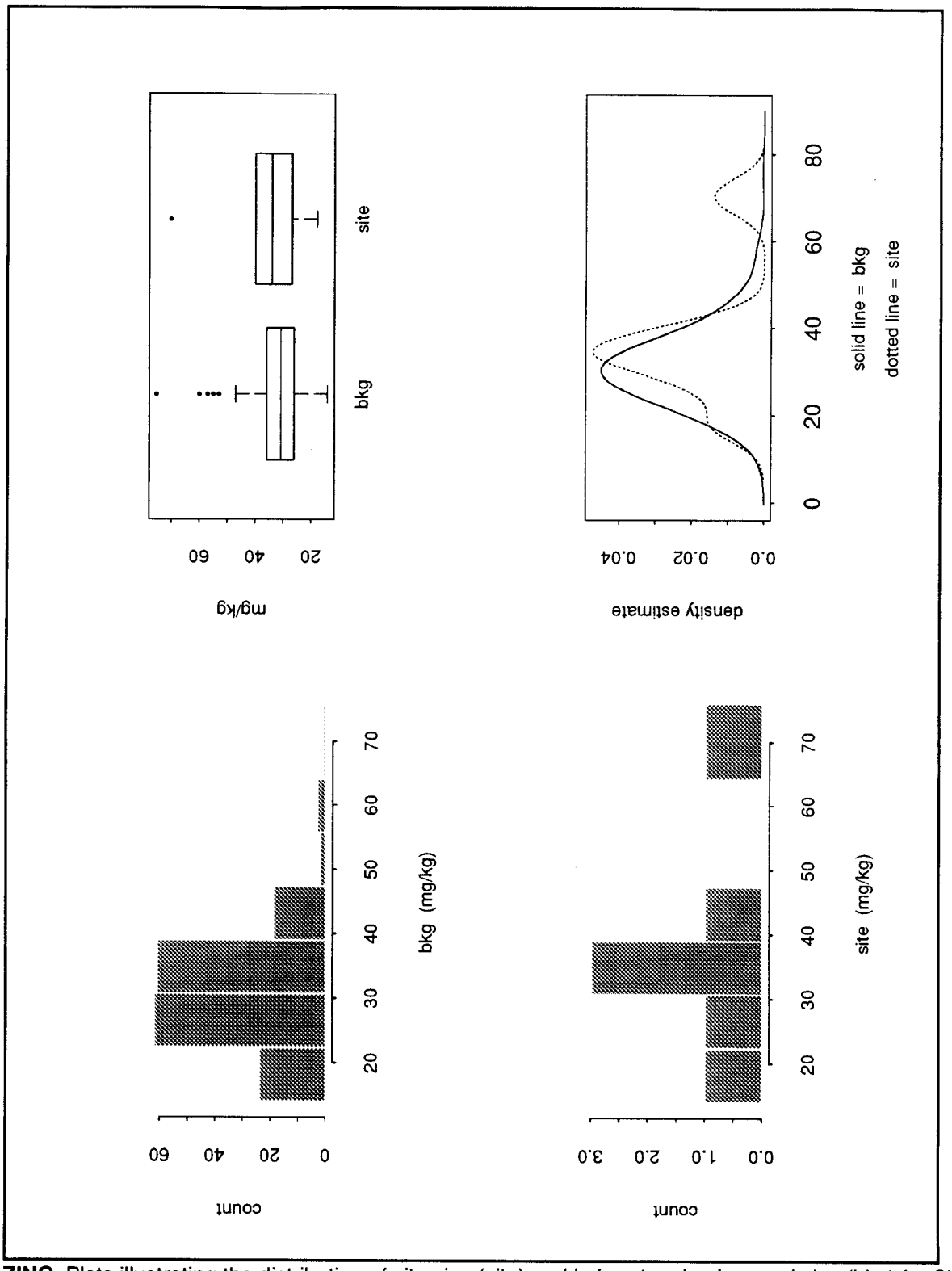
ZINC Plots illustrating the distribution of site lead (site) and Laboratory background lead (bkg) for PRS 36-006.



COPPER Plots illustrating the distribution of site copper (site) and Laboratory background copper (bkg) for Skunk Works.



LEAD Plots illustrating the distribution of site lead (site) and Laboratory background lead (bkg) for Skunk Works.



ZINC Plots illustrating the distribution of site zinc (site) and Laboratory background zinc (bkg) for Skunk Works.

APPENDIX E

PROCEDURES AND METHODS USED FOR SAMPLES

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The following ER Project procedures were used at the sampling site:

- LANL-ER-SOP-03.01, Land Surveying Procedures
- LANL-ER-SOP-03.02, General Surface Geophysics
- LANL-ER-SOP-06.09, Spade and Scoop Method of Collection of Soil Samples
- LANL-ER-SOP-06.10, Hand Auger and Thin-Wall Tube Sampler
- LANL-ER-SOP-06.24, Sample Collection from Split-Spoon Samplers and Shelby Tube Samplers
- LANL-ER-SOP-10.06, High Explosives Field Spot Test
- LANL-ER-SOP-10.07, Field Monitoring for Surface and Volume Radioactivity Levels
- LANL-ER-SOP-10.08, Operation of the Spectrace 9000 Field-Portable X-Ray Fluorescence Instrument

The following analytical methods were used for analyzing the samples according to EPA requirements (EPA, 1222):

- EPA SW-846 Method 6010, for metals
- EPA SW-846 Method 8260, for VOCs
- EPA SW-846 Method 8270, for SVOCs
- EPA SW-846 Method 8330, for HE
- EPA SW-846 Method 7471, for mercury

The following radioanalyses were conducted:

- KPA ASTM Z2907, for uranium
- DOE HASL 300, for isotopic uranium
- DOE HASL 300, for gamma spectroscopy

APPENDIX F

RESRAD DATA FOR PRS 36-001

APPENDIX F

RESRAD DATA FOR PRS 36-001

The RESRAD program was run using scenario-specific exposure parameters taken from Derivation and Use of Radionuclide Soil Cleanup Guidelines. LANL Environmental Restoration Project, April 4, 1996.

Depleted uranium (DU) is the soil contaminant. The uranium isotopic concentrations for DU are:

U-238 = 0.901 pCi/g
U-235 = 0.014 pCi/g
U-234 = 0.085 pCi/g.

The contaminated zone dimensions were 575 m^2 in area and a thickness of 3 m.

For the requested Commercial/Industrial Scenario the resultant EDE is **0.0428 mrem/yr/pCi/g of soil**. The concentration of DU to which the contaminated soil must be cleaned-up to maintain a radiation dose limit of 30 mrem per year is therefore.

$$30 \text{ mrem/yr} \times \frac{1}{0.0428 \text{ mrem/yr/pCi/g}} = \mathbf{701 \text{ pCi/g}}.$$

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RESRAD Data for PRS 36-001

The RESRAD program was run using scenario-specific exposure parameters taken from Derivation and Use of Radionuclide Soil Cleanup Guidelines, LANL Environmental Restoration Project, April 4, 1996.

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$$30 \text{ mrem/yr} \times \frac{1}{0.0428 \text{ mrem/yr/pCi/g}} = \mathbf{701 \ pCi/g.}$$

Dose Conversion Factor (and Related) Parameter Summary
File: DOSFAC.BIN

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(8)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(7)
1	U-238+D	2.690E-04	2.690E-04	DCF3(8)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: DOSFAC.BIN

Menu	Parameter	Current Value	Default	Parameter Name
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	5.750E+02	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	3.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	3.000E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): U-234	8.500E-02	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	1.400E-02	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	9.010E-01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone effective porosity	2.000E-01	2.000E-01	---	EPCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	4.400E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Humidity in air (g/cm**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	9.990E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	4.800E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	0.000E+00	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	5.200E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	2.700E+07	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	3.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	3.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.050E+00	5.300E+00	---	BSZ
4	Water table drop rate (m/yr)	3.000E-01	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R015	Unsat. zone 2, thickness (m)	not used	0.000E+00	---	H(2)
R015	Unsat. zone 2, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(2)
R015	Unsat. zone 2, total porosity	not used	4.000E-01	---	TPUZ(2)
R015	Unsat. zone 2, effective porosity	not used	2.000E-01	---	EPUZ(2)
R015	Unsat. zone 2, soil-specific b parameter	not used	5.300E+00	---	BUZ(2)
R015	Unsat. zone 2, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(2)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.587E-07	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.587E-07	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.587E-07	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Unsaturated zone 2 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,2)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.392E-06	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.587E-07	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Unsaturated zone 2 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,2)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.797E-07	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,2)
16	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
.016	Leach rate (/yr)	0.000E+00	0.000E+00	6.850E-07	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.000E-10	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R017	Inhalation rate (m**3/yr)	1.490E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	9.000E-05	2.000E-04	---	MLINH
R017	Dilution length for airborne dust, inhalation (m)	3.000E+00	3.000E+00	---	LM
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	1.840E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	4.600E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	1 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	0.000E+00	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	0.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	0.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	not used	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	not used	1.000E+00	---	STOR_T(2)
STOR	Milk	not used	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	not used	2.000E+01	---	STOR_T(4)
STOR	Fish	not used	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	not used	7.000E+00	---	STOR_T(6)
STOR	Well water	not used	1.000E+00	---	STOR_T(7)
STOR	Surface water	not used	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	not used	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	1.500E-01	1.500E-01	---	FLOOR
R021	Bulk density of building foundation (g/cm**3)	2.400E+00	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	4.000E-01	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	3.000E-02	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	3.000E-07	3.000E-07	---	DIFFL
R021	in contaminated zone soil	2.000E-06	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	2.000E+00	2.000E+00	---	HMIX
R021	Average annual wind speed (m/sec)	3.000E+00	2.000E+00	---	WIND
R021	Average building air exchange rate (1/hr)	1.000E+00	5.000E-01	---	REXG
R021	Height of the building (room) (m)	2.500E+00	2.500E+00	---	HRM
R021	Building interior area factor	0.000E+00	0.000E+00	code computed (time dependent)	FAI
R021	Building depth below ground surface (m)	-1.000E+00	-1.000E+00	code computed (time dependent)	DMFL
R021	Emanating power of Rn-222 gas	2.500E-01	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	575.00 square meters	U-234	8.500E-02
Thickness:	3.00 meters	U-235	1.400E-02
Cover Depth:	0.00 meters	U-238	9.010E-01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 30 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	3.908E-02	3.908E-02	3.908E-02	3.908E-02	3.909E-02	3.916E-02	3.955E-02	4.279E-02
M(t):	1.303E-03	1.303E-03	1.303E-03	1.303E-03	1.303E-03	1.305E-03	1.318E-03	1.426E-03

Maximum TDOSE(t): 4.279E-02 mrem/yr at t = 1.000E+03 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	frac
U-234	5.493E-06	0.0001	1.599E-03	0.0409	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-04	0.0030
U-235	1.680E-03	0.0430	2.455E-04	0.0063	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.804E-05	0.0005
U-238	1.909E-02	0.4885	1.516E-02	0.3878	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.078E-02	0.5316	1.700E-02	0.4350	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.304E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.721E-	0440
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.943E-03	0.0497
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9062
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.908E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	5.493E-06	0.0001	1.599E-03	0.0409	3.412E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-04	0.0030
U-235	1.680E-03	0.0430	2.455E-04	0.0063	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.806E-05	0.0005
U-238	1.909E-02	0.4885	1.516E-02	0.3878	3.533E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.078E-02	0.5316	1.700E-02	0.4350	3.412E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.304E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.721E-03	0.0440
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.944E-03	0.0497
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9062
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.908E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	5.496E-06	0.0001	1.599E-03	0.0409	3.070E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-04	0.0030
U-235	1.680E-03	0.0430	2.457E-04	0.0063	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.809E-05	0.0005
U-238	1.909E-02	0.4885	1.516E-02	0.3878	9.217E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.078E-02	0.5316	1.700E-02	0.4350	3.070E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.304E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.721E-03	0.0440
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.944E-03	0.0497
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9062
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.908E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	5.523E-06	0.0001	1.600E-03	0.0409	3.407E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-04	0.0030
U-235	1.680E-03	0.0430	2.464E-04	0.0063	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.823E-05	0.0005
U-238	1.909E-02	0.4885	1.516E-02	0.3878	3.414E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.078E-02	0.5316	1.700E-02	0.4350	3.407E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.304E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.722E-03	0.0441
-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.945E-03	0.0498
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9062
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.908E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	5.753E-06	0.0001	1.600E-03	0.0409	3.057E-06	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.162E-04	0.0030
U-235	1.681E-03	0.0430	2.501E-04	0.0064	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.872E-05	0.0005
U-238	1.909E-02	0.4884	1.516E-02	0.3877	9.197E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.078E-02	0.5315	1.701E-02	0.4350	3.058E-06	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.305E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.725E-0[illegible]	[illegible]
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.950E-03	0.0499
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9060
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.909E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	8.332E-06	0.0002	1.602E-03	0.0409	3.358E-05	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.163E-04	0.0030
U-235	1.687E-03	0.0431	2.707E-04	0.0069	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.103E-05	0.0005
U-238	1.909E-02	0.4875	1.516E-02	0.3871	3.376E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.170E-03	0.0299
Total	2.079E-02	0.5308	1.703E-02	0.4349	3.362E-05	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.308E-03	0.0334

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
34	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.761E-03	0.0450
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.979E-03	0.0505
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.9045
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.916E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.023E-05	0.0008	1.608E-03	0.0407	2.931E-04	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.171E-04	0.0030
U-235	1.707E-03	0.0432	3.375E-04	0.0085	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.824E-05	0.0007
U-238	1.909E-02	0.4826	1.517E-02	0.3835	8.906E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.171E-03	0.0296
Total	2.082E-02	0.5266	1.711E-02	0.4327	2.940E-04	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.316E-03	0.0333

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.049E-0[illegible]	[illegible]18
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.073E-03	0.0524
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.542E-02	0.8958
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.955E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	2.541E-04	0.0059	1.629E-03	0.0381	2.911E-03	0.0680	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.234E-04	0.0029
U-235	1.776E-03	0.0415	5.704E-04	0.0133	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.328E-05	0.0012
U-238	1.908E-02	0.4459	1.519E-02	0.3550	3.021E-05	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.172E-03	0.0274
Total	2.111E-02	0.4933	1.739E-02	0.4064	2.941E-03	0.0687	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.349E-03	0.0315

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.918E-03	0.1149
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.400E-03	0.0561
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.547E-02	0.8290
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.279E-02	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	2.025E-02	2.025E-02	2.025E-02	2.025E-02	2.024E-02	2.024E-02	2.022E-02	2.017E-02
U-234	Th-230	1.000E+00	0.000E+00	4.439E-07	1.332E-06	4.439E-06	1.331E-05	4.436E-05	1.329E-04	4.411E-04
U-234	Ra-226	1.000E+00	0.000E+00	4.353E-08	3.916E-07	4.347E-06	3.900E-05	4.285E-04	3.740E-03	3.718E-02
U-234	Pb-210	1.000E+00	0.000E+00	7.892E-13	2.098E-11	7.365E-10	1.722E-08	4.203E-07	5.365E-06	6.261E-05
U-234	ΣDSR(j)		2.025E-02	2.025E-02	2.025E-02	2.026E-02	2.030E-02	2.071E-02	2.410E-02	5.786E-02
U-235	U-235	1.000E+00	1.388E-01	1.388E-01	1.388E-01	1.388E-01	1.388E-01	1.388E-01	1.388E-01	1.387E-01
U-235	Pa-231	1.000E+00	0.000E+00	5.580E-06	1.674E-05	5.580E-05	1.674E-04	5.574E-04	1.668E-03	5.517E-03
U-235	Ac-227	1.000E+00	0.000E+00	4.477E-07	3.945E-06	4.080E-05	3.034E-04	1.985E-03	7.610E-03	2.722E-02
U-235	ΣDSR(j)		1.388E-01	1.388E-01	1.388E-01	1.389E-01	1.393E-01	1.413E-01	1.481E-01	1.714E-01
U-238	U-238	1.000E+00	3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.930E-02	3.927E-02
U-238	U-234	1.000E+00	0.000E+00	5.740E-08	1.722E-07	5.740E-07	1.722E-06	5.739E-06	1.721E-05	5.726E-05
U-238	Th-230	1.000E+00	0.000E+00	6.292E-13	5.663E-12	6.292E-11	5.662E-10	6.289E-09	5.655E-08	6.263E-07
U-238	Ra-226	1.000E+00	0.000E+00	4.252E-14	1.109E-12	4.109E-11	1.107E-09	4.064E-08	1.072E-06	3.640E-05
U-238	Pb-210	1.000E+00	0.000E+00	0.000E+00	4.829E-17	5.303E-15	3.821E-13	3.341E-11	1.405E-09	5.938E-08
U-238	ΣDSR(j)		3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.931E-02	3.932E-02	3.937E-02

Branch Fraction is the cumulative factor for the j'th principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 30 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	1.482E+03	1.482E+03	1.482E+03	1.481E+03	1.478E+03	1.448E+03	1.245E+03	5.185E+02
U-235	2.161E+02	2.161E+02	2.161E+02	2.160E+02	2.154E+02	2.122E+02	2.026E+02	1.750E+02
U-238	7.632E+02	7.632E+02	7.632E+02	7.632E+02	7.632E+02	7.631E+02	7.630E+02	7.621E+02

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 1.000E+03 years

Nuclide (i)	Initial pCi/g	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
U-234	8.500E-02	1.000E+03	5.786E-02	5.185E+02	5.786E-02	5.185E+02
U-235	1.400E-02	1.000E+03	1.714E-01	1.750E+02	1.714E-01	1.750E+02
U-238	9.010E-01	1.000E+03	3.937E-02	7.621E+02	3.937E-02	7.621E+02

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	1.721E-03	1.721E-03	1.721E-03	1.721E-03	1.721E-03	1.720E-03	1.719E-03	1.714E-03
U-234	U-238	1.000E+00	0.000E+00	5.172E-08	1.552E-07	5.172E-07	1.551E-06	5.171E-06	1.550E-05	5.159E-05
U-234	ΣDOSE(j):		1.721E-03	1.721E-03	1.721E-03	1.721E-03	1.722E-03	1.726E-03	1.735E-03	1.766E-03
Th-230	U-234	1.000E+00	0.000E+00	3.773E-08	1.132E-07	3.773E-07	1.132E-06	3.771E-06	1.130E-05	3.749E-05
Th-230	U-238	1.000E+00	0.000E+00	5.669E-13	5.102E-12	5.669E-11	5.101E-10	5.666E-09	5.095E-08	5.643E-07
Th-230	ΣDOSE(j):		0.000E+00	3.773E-08	1.132E-07	3.773E-07	1.132E-06	3.776E-06	1.135E-05	3.805E-05
Ra-226	U-234	1.000E+00	0.000E+00	3.700E-09	3.329E-08	3.695E-07	3.315E-06	3.642E-05	3.179E-04	3.161E-03
Ra-226	U-238	1.000E+00	0.000E+00	3.831E-14	9.995E-13	3.702E-11	9.973E-10	3.662E-08	9.659E-07	3.280E-05
Ra-226	ΣDOSE(j):		0.000E+00	3.700E-09	3.329E-08	3.695E-07	3.316E-06	3.646E-05	3.189E-04	3.193E-03
Pb-210	U-234	1.000E+00	0.000E+00	6.708E-14	1.783E-12	6.260E-11	1.463E-09	3.573E-08	4.560E-07	5.321E-06
Pb-210	U-238	1.000E+00	0.000E+00	0.000E+00	4.351E-17	4.778E-15	3.443E-13	3.010E-11	1.266E-09	5.350E-08
Pb-210	ΣDOSE(j):		0.000E+00	6.708E-14	1.783E-12	6.260E-11	1.464E-09	3.576E-08	4.573E-07	5.375E-06
U-235	U-235	1.000E+00	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.943E-03	1.942E-03
Pa-231	U-235	1.000E+00	0.000E+00	7.813E-08	2.344E-07	7.812E-07	2.343E-06	7.804E-06	2.336E-05	7.723E-05
Ac-227	U-235	1.000E+00	0.000E+00	6.268E-09	5.524E-08	5.712E-07	4.247E-06	2.779E-05	1.065E-04	3.811E-04
U-238	U-238	1.000E+00	3.542E-02	3.542E-02	3.542E-02	3.542E-02	3.542E-02	3.541E-02	3.541E-02	3.538E-02

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	8.500E-02	8.500E-02	8.500E-02	8.500E-02	8.499E-02	8.497E-02	8.490E-02	8.468E-02
U-234	U-238	1.000E+00	0.000E+00	2.554E-06	7.663E-06	2.554E-05	7.662E-05	2.554E-04	7.657E-04	2.548E-03
U-234	ΣS(j):		8.500E-02	8.500E-02	8.501E-02	8.502E-02	8.507E-02	8.522E-02	8.567E-02	8.723E-02
Th-230	U-234	1.000E+00	0.000E+00	7.652E-07	2.295E-06	7.651E-06	2.295E-05	7.647E-05	2.291E-04	7.603E-04
Th-230	U-238	1.000E+00	0.000E+00	1.150E-11	1.035E-10	1.150E-09	1.035E-08	1.149E-07	1.033E-06	1.144E-05
Th-230	ΣS(j):		0.000E+00	7.652E-07	2.296E-06	7.652E-06	2.296E-05	7.658E-05	2.301E-04	7.717E-04
Ra-226	U-234	1.000E+00	0.000E+00	1.657E-10	1.491E-09	1.655E-08	1.485E-07	1.633E-06	1.427E-05	1.435E-04
Ra-226	U-238	1.000E+00	0.000E+00	1.716E-15	4.477E-14	1.658E-12	4.468E-11	1.642E-09	4.336E-08	1.489E-06
Ra-226	ΣS(j):		0.000E+00	1.657E-10	1.491E-09	1.655E-08	1.485E-07	1.635E-06	1.431E-05	1.450E-04
Pb-210	U-234	1.000E+00	0.000E+00	1.704E-12	4.529E-11	1.590E-09	3.717E-08	9.074E-07	1.158E-05	1.352E-04
Pb-210	U-238	1.000E+00	0.000E+00	0.000E+00	1.105E-15	1.213E-13	8.744E-12	7.646E-10	3.216E-08	1.359E-06
Pb-210	ΣS(j):		0.000E+00	1.704E-12	4.529E-11	1.590E-09	3.717E-08	9.081E-07	1.161E-05	1.365E-04
U-235	U-235	1.000E+00	1.400E-02	1.400E-02	1.400E-02	1.400E-02	1.400E-02	1.400E-02	1.400E-02	1.399E-02
Pa-231	U-235	1.000E+00	0.000E+00	2.962E-07	8.886E-07	2.962E-06	8.883E-06	2.959E-05	8.856E-05	2.928E-04
Ac-227	U-235	1.000E+00	0.000E+00	4.665E-09	4.112E-08	4.252E-07	3.161E-06	2.068E-05	7.931E-05	2.837E-04
U-238	U-238	1.000E+00	9.010E-01	9.010E-01	9.010E-01	9.010E-01	9.010E-01	9.009E-01	9.007E-01	9.001E-01

BRF(i) is the branch fraction of the parent nuclide.